PROCESS IN GLASS ART : A STUDY OF SOME TECHNICAL AND CONCEPTUAL ISSUES.

by

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DECLARATION

I declare that

PROCESS IN GLASS ART: A STUDY OF SOME TECHNICAL AND CONCEPTUAL ISSUES. is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

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Signature

1 August 1996
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Date

(D G Hemp)

SUMMARY

Glass has been made and used for centuries but South African artists, isolated for the last three decades, are only now becoming aware of the potential of hot or warm glass as an art medium. In antiquity glass objects were created using various processes but the 'factory' tradition began with the discovery of the blowing iron in the first century AD. The invention of the tank furnace in the late 1950s revolutionised modern production, enabling individual artists to make glass in private studios without blowing teams. The research describes ancient. glassmaking processes and indicates how they have been explored, adapted and used by contemporary artists world wide, challenging craft orientated paradigms, and proving that glass is a viable and important sculpture medium. The practical research demonstrates the application of many processes and relates technical issues to sculptural concepts which are realized through the physical and material properties of glass.

KEYWORDS

Glass - ancient history, modem and contemporary, Studio Glass Movement, technical processes, neon, fused, cast, moulds, blowing, kiln worked, flame worked, laminated, photography.

PREFACE

Research for the MA(FA) degree comprises two components, a theoretical dissertation and practical visual research. Initially, I began the theoretical research to obtain a knowledge of glass-making processes and to gain a clearer understanding of the relevance of my own art works and processes in relation to contemporary glass art. My practical research developed as my concepts and knowledge of ancient and modem processes of working with glass increased, and I have produced a body of work over the years which is both eclectic and innovative. Glass as art material has, for a long period of time, held a deep fascination for me. I firmly believe that glass is one of the most versatile and exciting materials available to the artist of the twentieth century. Much of my research was done to prove to myself, and to other interested artists that glass was a viable and exciting material, and that the complicated technology and chemistry of this unique material could be mastered and used by the individual artist working alone in his or her home studio.

I am fully aware of the difficulties and frustrations of working with glass - it alienates, and is at almost each stage of the process one-removed from the artist; it is totally unyielding; is dangerous; the equipment can be expensive and courage and patience are very necessary parts of the process, but successful results are worth every moment of frustration, exasperation and despair. I feel that working with glass provides a greater challenge for the contemporary artist than working with any other material. Glass has many unique qualities for use by the artist, these include light refraction, transparency, translucency, brittleness, etc.

In doing research for the practical component of my degree I have developed my own unique way of working with glass, and although I have been influenced by several overseas artists, the processes and concepts are my own, and these have been developed over a period to produce objects which fulfil my personal objectives, concepts and needs. To a large extent I have worked in isolation, in a country artistically isolated, with the minimum amount of equipment and personal contact, to produce a body of work which is influenced by the shifting sand dunes, wrecks and other barren areas of Namibia, particularly the Skeleton Coast, at a time when I myself feel isolated and alienated after the tragic death of my son last year.

A great part of the information in this thesis concerns glassmaking in countries outside South Africa as it is there that art glass is most developed. The interest in glass as an art material in South Africa has really only become apparent in the last few years. To date there have been no workshops, courses or institutions giving classes. However, Pretoria Technikon is in the process of starting a glass course in 1996 with the financial support of Consol Glass and technical advice from Wolverhampton Glass School. At the moment there are only a few people working in hot or warm glass, these include Shirley Cloete, Gary Thompson, David Reade, Nelius Britz, Sue Meyer, Liz Lacey, Sharon Trickett and myself, but I am sure that interest in glass as a material will grow and increase in the near future and glass will become as viable and as exciting an art material as bronze, paint, wood or clay, as it has become in many countries overseas including Australia, Japan, America, England, Poland, Czechoslovakia, Germany and Sweden.

Attendance at workshops, or classes is now possible with the introduction of the glass course at the Pretoria Technikon; many more books on the work and processes of contemporary glass artists are readily available and equipment, glass and glass products are available from overseas suppliers, all of which are positive and encouraging moves towards glass being accepted as a viable medium for contemporary South African artists.

I have over this period of my research extended my use of the photographic image. Photographs have been used as documentation, as working drawings and in many cases have been simply enjoyed for themselves as an extension of the glass making process and have become an important aspect of my visual vocabulary. In taking my own photographs I have imposed, consciously or unconsciously, my own style on the photographic image and photographic processes have been explored and adapted to fulfil my specific needs. I have in many photographs isolated a small section of the object or view in front of my lens, reducing the scene to a minimalist form. I have become increasingly interested in the photographic process, how people interpret photographs and how they are used, and the differences between photography and any other visual media - one of the main differences being that in sculpture you have a piece of marble, wood, clay, or wax; in painting an empty canvas but when you take a photograph you have an already-existing object in front of your lens and this object has an existence and a character independent of you and your interpretation of it.

A selection of photographs has been used in conjunction with my glass sculptures for the practical component of my degree which make visible the intricate cross-references between art and photography, which go back to the very beginning of photography.

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(Gardner 1983:186).

ACKNOWLEDGEMENTS

When I began this research there were virtually no publications on art glass processes and the only information I could obtain in South Africa, was from people in the glass industry. Information and help was given to me by Jack Sullivan and Glen Butler of Elmosa Glass in Port Elizabeth who taught me about light bulbs and blowing into moulds; Jack Wallace of Consol Glass who explained the technicalities of glass, mass production and borosilicate glass; Eddie Robinson of Spherical Optics who has been incredibly generous, both in terms of information on lens glasses, and supplying me with reject lenses; Bill Cooper of Trans-Natal Cut Glass, who gave me hours of his time, sharing his love of glass, and explaining processes of engraving and silk-screening on lead crystal glass; Pieter de Beer who generously gave me reject lead crystal glass; Alfred, the glassblower at Trans-Natal and Adi Freeman who both helped me with lampworked glass; in addition Adi lent me books and reference material; Marika Tucker, subject librarian of UNISA library for her invaluable help.

I also thank Ursula Huth with whom I spent time in her studio at Weil im Schonbuch, Germany, who shared so much glass information; Diana Hobson, who willingly and generously told me virtually everything she knew about the pâte de verre process; John Cook of Leicester Polytechnic who took a whole day from his very busy teaching schedule in order to show me around his glass studios and explain the various processes taught to his students; Bertil Vallien, who, unknowingly, has inspired and encouraged me, and given me hope to go on working with glass when the problems seemed insurmountable and Sue Meyer, Nelius Britz, Rhé Wessels and Ingram Anderson who have shared their frustrations and love of glass with me. Thanks to my husband Roger, and son Stephen, who spent hours and hours of their precious overseas trip in 1989, going to glass galleries, catching trains, boats, ferries and buses and walking miles with me in search of glass collections, exhibitions, books on glass processes, and elusive glass artists.

Sincere thanks to my supervisor, Dr Marion Amold, for her support, understanding and encouragement at all stages of my research and for being available at all times with good sound advice, a level head and a razor sharp mind, particularly at those times when I felt I could not go on.

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CONTENTS

INTRODUCTION.

> There is a story that once a ship belonging to some traders in nitrum[1] put in here [the coast of modern Lebanon] and that they scattered along the shore to prepare a meal. Since, however, no stones for supporting their cauldrons were forthcoming, they rested them on lumps of nitrum from their cargo. When these became heated and were completely mingled with the sand on the beach a strange liquid flowed in streams; and this, it is said, was the origin of glass. (Pliny, *Natural History*, XXXVI, 191-2).

These words were written by the Roman author, Pliny the Elder, in the second half of the first century AD to explain the invention of glass. However, the earliest archaeological finds are from approximately 2500 years before Pliny in the Third Millennium BC in Mesopotamia, now known as Iraq and northern Syria. Despite the romance of Pliny's story he gives the three principal ingredients which had been used for making glass in antiquity - soda, silica and lime. In 1993, Dr. David Pye, director of the Center of Glass Research at Alfred University in New York tried to make glass, initially using a recipe based on an ancient cuneiform text. The mixture of sand, ash from sea plants and chalk was heated to about 870°C for two hours but it did not produce glass. Dr Pye then tried Pliny's recipe and in fact made glass - the piece he produced was a rough and crude glass with a blueish-green tinge, which was due to the presence of iron which is present in nearly all sand.

The secret of the versatility of glass lies in its internal structure. Glass Is a liquid that has been cooled below its theoretical freezing point while still retaining the properties and internal structure of a liquid. All liquids except the 'superfluid'[2] liquid helium have some viscosity, that is some stiffness or resistance to flow. At room temperature glass is so viscous that its flow can only be measured with very delicate instruments but it has the structure and all the properties of a liquid if observed on a suitably extended time scale. An unusual feature of glass is the manner in which its viscosity changes as it turns from a cold rigid solid to a hot ductile liquid. Unlike metals which flow or freeze at specific temperatures, glass progressively softens as the temperature rises, going through varying stages of malleability until it flows like thick toffee. When glass is cooled it simply becomes more and more viscous until it is as stiff as an ordinary solid. Each stage of malleability allows the glass to be manipulated into various forms, by different techniques. If suddenly cooled the object retains the shape achieved at that particular point. Glass is thus amenable to a greater number of heat forming techniques than any metal.

To the ordinary man in the street glass is a transparent, useful but brittle material which shatters easily into lethal fragments. Glass is so much part of our everyday lives that it has become almost invisible and unless it breaks or shatters people simply do not 'see' glass anymore. It is used so extensively that we have become conditioned not to see it at all, and in fact we take glass so much for granted that we are liable to forget what a remarkable substance it really is. Glass has many unique and versatile properties and in the last few decades there has been a virtual explosion in glass technology.

Glass fibre optics consist of extremely pure, flexible, coated glass fibres. Fibre optics are used to give clearer images of microscopic objects such as bacterial viruses, and optical instruments are being developed which can show the inner workings of cells. There are more than thirteen million kilometres of glass fibre optics carrying telephone and television signals across the world; tiny glass beads take radiation doses inside the body; glass is used for prosthetic eyeballs, and ceramic glass constitutes the nose cones of missiles and space vehicles. Borosilicate glass has an increased resistance to various kinds of shock. It can withstand sharp blows and sudden changes in temperature; it is used in the production of laboratory equipment and is universally used in any application where glass is subjected to heat stress. Glass is an excellent insulator for heat and electricity. Glass lights our world, 1,8 billion lightbulbs [3] are manufactured each year in the United States alone. Photochromatic glass, with silver halide added to the basic mix, causes the glass to darken when exposed to light and to lighten when withdrawn from the light, and it is used for eye glasses. Safety glass and fire resistant glass are formed when two sheets of glass are laminated with a sheet of material such as polybutyral sandwiched inbetween. Heated and put under pressure, these glass products are commonly used in the aircraft and space industries.

Since the first decades of the century skyscraper architecture has given an added importance to the role of glass. Sheet glass is used today to form almost all the outer skin of buildings. Architectural glass has transformed the appearance of modern cities, and in many ways is the building material of the future; the new Lloyd's of London building has a glass atrium with a sixteen story glass facade which has 12000 square metres of glass. Thousands of prisms were rolled into the glass which add sparkle and excitement to the surface. Glass which has been treated to react to electric currents going through it changes from clear to opaque at the push of a button, giving buildings 'instant curtains' but at present the costs of treating glass this way are exorbitant. More economical is the type of glass which has a reflective coating and additional elements which control the amount of sunlight and heat coming into a room.

Glass plays an indispensable part in almost every branch of modern industry and technology. In 1988 there were more than 500 different kinds of glass being made and used commercially in the United Kingdom alone while the fibre-optic industry in America has developed into a 16-billion dollar business employing 150000 workers. Dr. William Pringle, a former president of the Technology

Group at Corning Incorporated in New York, predicts that in the very near future optical computers could store programs and process information by means of light - pulses from tiny lasers would be used. These pulses, travelling over glass fibres and not copper wire, would function hundreds of times faster than today's electronic computers and hold far more information. Fibre-optic systems using lasers no larger than a grain of sand can transmit 32000 times as much information as the equivalent amount of copper wire. Glass microspheres which are one third of the thickness of a human hair can be injected through a catheter into an artery to carry radiation directly to the tumour of patients suffering from liver cancers. The unique and multifaceted character of glass plus the abundance and low cost of its principal raw material - silica - give glass a special place in technology making it a unique material for the scientist, architect, artist, engineer or designer. Perrot claims:

> No contemporary material can challenge the creative skill and ingenuity of the whole man as an artist/craftsman more than glass. For the individual craftsman it can be called the "new material" offering limitless possibilities of experimentation and creation (Franz 1989:46).

This statement is indeed true but for the artist glass is a challenging and demanding material; the technology alone is daunting. Frustration, danger, alienation are more evident in working with glass than in any other medium. Each stage of the process carries particular hazards and danger, threatening both the artist and the work. Despite its fiery origins glass is not a warm medium. It is cold, hard and brittle and does not invite touching. In addition the artist is physically distanced from each piece at almost every stage of the process, the equipment is expensive and the failure rate high. The Swedish glass artist and designer, Bertil Vallien (born 1938) (1994:59), says 'Glass can be a delusion of the devil. Glass infuriates me! As a material I've never liked the damn stuff, it's wilful, it's cold and unfriendly, and it presents a lot of technical problems'.

Why work with glass? The challenges are greater than most other materials but the rewards are also greater. The glass artist has to overcome and to master the complicated technical and chemical problems inherent in glass making and then capitalise on, and use this knowledge and skill creatively, for glass has many extraordinary and unique properties which can be exploited by artists. These properties make glass one of the most exciting media available today in the quest for original concepts, creativity and communication.

Glass is suitable for monumental as well as for the smallest and most detailed works of art. It is one of the few materials which allow light to pass through, illuminating the piece from within as well as from the outside. Glass gives light, colour, form, texture and a physical presence. Glass reveals, obscures and distorts. As an art medium glass possesses properties of reflection, refraction, transparency, colour, opacity and surface variety and it is exceptionally malleable and can be blown, poured, pressed, cut, glued, moulded, fused, melted or laminated. Glass can take all imaginable shapes and can be decorated by engraving, grinding, painting, etching, sandblasting, enamelling or cutting. It can be used for its abstracted overtones of vessel and body, for its spiritual translucence and its physical properties. The physical properties of glass embody all sorts of dualisms and contradictions thus providing endless metaphorical possibilities for the artist. Thus, through the centuries glass has been used for its many unique properties and its multiple role as vessel, stained glass window, paperweight, or sculptural object.

Only through an understanding of the processes and history of the material can glass objects themselves be fully appreciated. Glass is different from most other materials - paint exists to be squeezed out of a tube and a deeper knowledge of the chemistry of paint would not enhance or enlarge the viewer's understanding of painting.

Chapter one explores the history of early glass-making. As contemporary glass art is largely predicated on processes and uses for glass which are 2000 years old, updated to contemporary concepts, ideas, taste and contemporary techniques, this section forms an important part of my research. Chapter two is about contemporary history, while chapter three consists of research into the processes and uses of glass as a unique and important material for art works in the modern era. My own work, in which conceptual and technical issues are described, is the subject of chapter four. An extensive appendix is included as it is the synthesis of my research into glass processes and constitutes my personal studiowork, experimentation and documentary research. Given the paucity of published information within South Africa on glass processes, I consider the Appendix to be a valuable educational resource.

NOTES

See Appendix for details of processes.

1 Nitrum or natron, an alkali which was used for embalming the dead, is a naturally occurring dehydrating agent, and is a mixture of carbonate, bicarbonate, chloride and sulphate of sodium. Mummification processes which varied according to the period and the wealth of the deceased's family, took approximately 70 days and the most important part was the dehydration of the body by burying it in natron.

2 A superfluid has a very high heat conductivity and it is practically impossible to produce uneven heating in a substance like liquid helium II. Whereas liquid helium I boils violently when exposed to normal temperature

and pressure, superfluid helium is completely motionless under the same circumstances. Hot spots, like the bubbles of gas in a boiling liquid, simply cannot exist in a superfluid. There is also a total lack of friction in a superfluid, and it will pass through extremely small openings with no apparent loss of energy through dissipative forces. When cooled below 2,19K, liquid helium undergoes a sudden and dramatic change of specific heat, viscosity and other physical properties. The temperature at which these changes take place is called the lambda point, and a liquid cooled below its lambda point is called a superfluid.

3 With the invention of the electric lamp large quantities of glass bulbs were needed. In spite of more efficient light sources the filament, or incandescent lamp is used more than any other kind of lamp. In the home it is scarcely challenged as the universal light source, and while offices, factories, public buildings, shops and vehicles adopt more fluorescent lighting, the incandescent lamp seems to have an unlimited future. Initially these were produced on a slow suction machine, but in 1926 a machine called the Corning Ribbon machine was invented which is capable of producing well over 1000 light bulbs per minute.

The incandescent filament lamp is, in its simplest form, a purely functional light source but the fact that an integral part of the lamp is a bulb fashioned from glass enables the designer to adapt and modify the form in different ways.

Internal translucent colour coatings and finishes are applied to lamps to reduce glare; the external application of a silicate suspension resists thermal shock and is used out-of-doors; transparent coloured lacquers are used on lamps for electric fires. Bulbs with silicone-rubber applied to the outside of the bulb which holds the glass fragments together should the bulb break, are used in hospitals and where food is prepared. Dichroic coatings (see Appendix) are also used for interference effects. The internal surface is coated with a series of alternate layers of two different transparent materials, (typical materials are magnesium fluoride and zinc sulphide) chosen for their respective refractive indices, and are used to illuminate refrigerated food displays, slide projectors and in any situation where it is necessary to reduce the heating effect for a given illuminance.

CHAPTER 1

GLASS: THE EARLY HISTORY

As long ago as 7500 BC obsidian,[1] a natural form of glass produced by volcanic action when highly siliceous lava cooled, was used by man in the making of tools. The process by which glass is formed has determined the techniques used by humankind to fashion it for social uses. The history of glass is the history of the processes used by different societies.

Ancient societies needed weapons for their survival. Glass in the form of obsidian was ideal for the making of finely crafted tools, as it exhibits what scientists call a conchoidal fracture (fig. 1).[2] This phenomena was exploited by ancient man to form implements[3] - axes, blades, arrowheads, points, scrapers and chisels have been found in Central and Western Anatolia where there were once large deposits of obsidian. It would appear that obsidian was exported to surrounding areas where pieces of unworked obsidian as well as caches of tools have been found (Wright 1969:37). During the period 7500 BC to 3500 BC obsidian was exchanged for salt, sulphur, food stuffs and fresh water. Sites as far as 800 kilometres away from the source of the obsidian have been discovered, for example at Jericho, where the inhabitants seemed to have used every available piece of obsidian,[4] using the smallest fragments to form microliths.[5] Stone and wooden tools were tipped with carved obsidian points.

The history of man-made glass is shrouded in mystery. Scholars are therefore not sure when glass was first made but it is known that throughout history the great centres of glassmaking have been in rong political, cultural and scientific A synthetic material which can only n a society which already possesses a amount of expertise and established glass was first made in Mesopotamia, ı, but because of the high humidity in ery few glass objects have survived. exts housed in the Royal Library at of the glassmaking in the middle of the nnium BC. At this time ceramic science gy was well established and the working is in an advanced state. Lapidary luding a sophisticated knowledge of olishing to create vessels was also at an ige. Glass was first made within this established framework and most of the iced, including vessels, were modelled :, metal and ceramic prototypes.

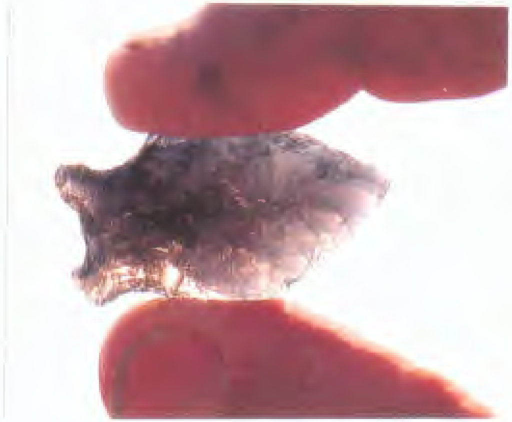

Fig. 1 Flaked obsidian arrowhead showing conchoidal fractures.

as from ceramics that early glass took most of its techniques, it was the metal and nology with which it was most associated. The first use of 'glass' was a vitreous glaze, combination of the silica and the clay body fusing with the alkaline cinders of the r the metallic oxides used to colour the clay body. Prior to 3000 BC Mesopotamian d glazed their pottery; small objects in clay, stone and faience have been discovered had glazed their pottery; small objects in clay, stone and faience have been discovered covered with vitreous blue and green-tinted glazes (fig. 2).

Fig. 2. Hippopotamus. (S.a.). Blue faience decorated with aquatic plants, height 11,5 cm.

The earliest man-made datable glass objects are from the Third Millennium BC and were discovered in ancient Egyptian tombs.[6] There is little doubt however that the Egyptians learnt their glass making skills from the Mesopotamians. Objects found in Egyptian tombs are well preserved because of the extreme dryness, but certainly were made later than the objects recorded in the Royal Library at Nineveh. The gold surface of the sarcophagus of Tutankhamen (Fourteenth Century BC) in the Cairo Museum, is inlaid with small pieces of lapis-lazuli, turquoise and jasper-red glass, parts of the throne are glass and a headrest is made from two large pieces of turquoise glass. It is interesting to note that precious stones and man-made glass were used side by side by the Egyptians, indicating that glass was not considered to be inferior to precious stones (fig. 3). Much of the mystique which surrounded glass probably stemmed from these early associations with precious stones and metals. The Greeks referred to glass as 'lithos chyte' (cast stone), its success depending on how much of a jewel-like quality had been achieved.

Glass vessels do not appear in Egypt before 1500 BC and there is little doubt that the Egyptians learnt the basic skills of making glass vessels from the Mesopotamians. The earliest Egyptian examples

Fig. 3. The mask of Tutankhamun. (c. 1352 BC). Solid gold beaten and burnished. The stripes of the head-dress are of blue glass imitating lapis lazuli.

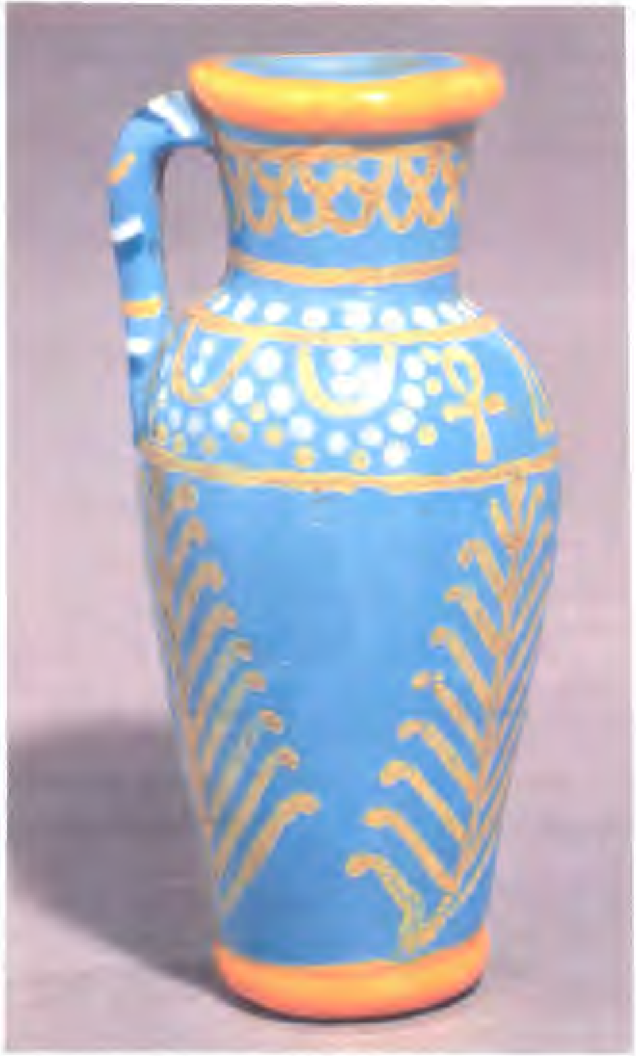

Fig. 4. One of the earliest datable Egyptian glass vessels, its colouring imitating turquoise stone. (18th Dynasty, about 1425 BC). Core-formed jug, with the name Tuthmes on shoulder, height 8,7 cm.

pharaohs and the most important of the Eighteenth Dynasty (1567-1320 BC). He established a large and stable empire: under his rule the boundaries of Egypt were at their widest, stretching from the Euphrates to Nubia. His conquests of the Near East led to the founding of the glass vessel industry in Egypt as the techniques of vessel making were brought to Egypt from those regions. This accounts for the sudden appearance of sophisticated well crafted vessels in Egypt. Brightly coloured, these vessels - made using the sand core method - display a high degree of expertise (fig. 5). Vessels produced by this method were necessarily small, the majority measuring 10-20 cm high, and were intended to hold luxury items such as perfume, oil and cosmetics (fig. 6). They were made for an exclusive market of wealthy patrons and would have been costly and highly prized during life and also used to accompany the dead on the journey to the next world. Amulets worn during life or laid on the mummy after death were also made from glass.

The production of bowls and small vessels continued in Egypt with little change until approximately 1200 BC, but from 1220-1000 BC Egypt was in political and economic turmoil and very little glass was produced as is borne out by the fact that almost no glass apart from glass beads,[7] seals and a few trinkets have been found dating from that time (fig. 7). By 900 BC conditions had improved and glass was once again produced but it was not until the founding of Alexandria by Alexander the Great that glassmaking started to flourish. Alexandria became a centre of culture and learning and one of the most important glassmaking centres.

During the latter half of the First Century BC two events occurred which were to have a profound effect on glass: the invention of the blowing iron, and the rise of the Roman Empire. No one is quite sure how, when and where glass was first blown. The earliest datable pieces of blown glass occur

sels. (6th - 4th BC).

Fig. 6. Kohl vessels in the shape of palm columns still with their original glass applicators. (18th - 19th Dynasty, about 1390-1275 BC). Sand core-formed, left-hand vessel, height 8,7 cm.

Fig. 7. Beads and pendants. *(c. 1220 - 1000 BC).*

in Syria where large quantities of mould-blown glass (cups, flasks and bottles) have been found (fig. 8). The flexibility and importance of blown glass soon became apparent and within a short period of time replaced all the forming methods of the ancient world. Containers, storage jars, bottles used to contain the ashes of the dead, wine glasses and perfume bottles could all be mould blown (that is glass blown into a mould) in minutes and cooled in hours. Blown glass was quickly exploited by the burgeoning Roman industry under the Julio-Claudian emperors (14-68 AD), as it enabled glassmakers to mass produce vast quantities of inexpensive, contamination-free but desirable goods (fig. 8a) for the daily use of all classes of Roman society.[8]

There was also a great demand for decorative, luxury glass and for use in ritualistic burials. Fine pieces of sculptural glass have also been discovered - a few miniature heads of Roman Emperors including a finely crafted portrait bust of the Emperor Augustus (27 BC - 14 AD) and a model of a female torso which is a miniature version of the Aphrodite of Knidos, a life-size sculpture of the Third Century BC which was often copied in the first and second centuries AD. The main emphasis of glassmaking at this time was however on vessels and bowls including the following -

1) Janus flasks decorated with moulded masks in relief, usually on both sides of the body.
2) Victory cups with laurel decorations and inscriptions of celebrations
3) Millefiore bowls
4) Circus cups which had depictions of prize fights or chariot races.
5) Cameo glass vessels
6) Cage cups or vasa diatreta

Fig. 8. Vessel. *(4th century AD). Mould-blown.*

Fig. 8a. Cosmetic bottles. *(3rd - 4th century AD). Blown vessels.*

Two outstanding examples of these vessels are the Portland Vase [9] (fig. 9) and the Lycurgus Cup [10] (figs. 10, 10a), both housed in the British Museum, London, and produced with a skill that both amazes and baffles the modem glass technician and artist.

Within one hundred years glassblowing had spread to most Mediterranean centres under the domination or influence of Rome. Until about 400 AD and the collapse of the Roman Empire all glass is described as 'Roman' - a term which indicates age rather than origin. By 35O AD and the decline of the Roman Empire, political power as well as the main glass making centre had been transferred from Rome to Constantinople. The decline of the Roman Empire had an adverse effect on glassmaking in Europe and production of artistic glass virtually ceased, not to be revived until the Renaissance, 1000 years later. Domestic ware was characterised by a marked deterioration in form, quality and decoration.

Glass manufacture in the East continued on a large scale particularly in Syria, Palestine and Alexandria where glassmakers continued to produce luxury objects for the nobility of Rome. Inevitably glass production was streamlined, glass became cheaper and was generally adapted to daily use. The 'glass' became the normal drinking vessel, its basic form dominated by function.

By the late tenth century a glass industry existed in Venice and in 11O7 Venice established a permanent trading centre at Sidon, the ancient Phoenician trading and glassmaking town. As communications and trade developed throughout Europe, Venice and Genoa became focal points for the trade routes of the world. Venice with its almost impregnable position, with attack from sea or land virtually impossible, was perfectly placed to establish a complex network of trade links with Western Europe, Byzantium and the East. Venetian merchants were the main suppliers of the

Fig. 9. Portland Vase. *(1st century AD). Cameo-glass vessel, height 24 cm.*

Fig. 10. Lycurgus Cup. (4th century AD). Vasa diatreta or cage cup, in transmitted light it is a deep red colour, height 16,5 cm.

Fig. 10a Lycurgus Cup - pea green in reflected light.

Crusades and after the sacking of Constantinople in 1204, rich spoils were transferred to Venice. Byzantine and Islamic glassware was highly regarded for its quality and workmanship which contrasted greatly with the crude techniques of the glass made in the West by the medieval glassmakers at this time.

By the thirteenth century the Venetian glass industry had become fully established and by the Renaissance her supremacy was unchallenged. Venice offers a fascinating example of the links between technology and political and economic power. The importance of the glass industry was acknowledged and protected by a number of laws and social privileges. City records show that glassmakers were powerful and important men, ranking with the nobility in a city that had a highly developed class system. The first records of a glassmaker's guild date from 1271 and strict regulations were enforced which forbade both the migration of Venetian craftsmen and the exporting of materials and techniques. These regulations ensured that Venetian techniques remained secret and discouraged the dissemination of knowledge which might in any way harm the exceedingly profitable glass trade. In 1291 the Authorities of Venice decreed that all the glasshouses were to be moved to the island of Murano, about five kilometres away. Although theoretically instigated to reduce the risk of fire, the transference of the glass industry to one centrally controlled place welded the glassblowers into a tightly knit, proud and secretive community.

In spite of all these precautions knowledge leaked out, glassmakers travelled, and by 1600 glasshouses had been set up all over Europe. There was a great demand for luxury glass throughout Renaissance Europe and a great number of glasshouses were set up, all making glass in the Venetian style, known as '*façon de Venise*' (fig. 11).

Fig 11. Marriage goblet. (1586). Façon de Venise, made in the glasshouse of Jacoppo Verzelini.

Fig. 12. Nef (or ship). (1525-50). Cristallo glass with added details in blue glass and two mould-pressed satyr-mask medallions, height 30,2 cm.

Soon a very different type of glass was being produced in Venice: ingredients, in particular Egyptian soda which had been used by the glassmakers of classical times, were still available and Venetian glassmakers refined and clarified their glass until it was almost transparent. Glass became a material in its own right, no longer being used to imitate clay or metal forms. The Venetians called this new glass '*cristallo*' (fig. 12). This glass together with the increased skill and artistic talent of the glassblowers meant that soon Venetian (or Muranese) glass was considered to be the finest in the Western world. The Venetian guild saw to it that once discovered, the formula for cristallo glass was kept in Murano. There was an overwhelming demand for cristallo glass by the nobility of Europe and Venetian glass was, for a long time, the prerogative of the rich and educated.

At the end of the sixteenth century a new route to the Far East via the Cape was discovered and, her importance on the trade routes undermined, Venice declined until the Republic collapsed in 1797. By the end of the seventeenth century Venice had also lost her important position in the glass industry.

The earliest glass found in Britain was probably brought by the Romans, possibly to use as barter for tin. There is no evidence of glass being made in England during the Roman occupation or for several centuries after the fall of the Roman Empire. In 155O eight glassblowers were taken to England at the request of Edward VI to teach the English the art of Venetian glassmaking but they did not stay long. In 1674 an Englishman, George Ravenscroft (1632-1683), was employed to do research on *façon de Venise*. Ravenscroft at first attempted to simulate Venetian cristallo glass, but failed. Instead he developed a new type of glass called 'lead glass'. This glass was a stable, durable and brilliantly clear glass which had a great reflective quality and was able to sustain deep cutting. The Venetian cristallo glass had looked clear partly on account of its thinness but this new material remained transparent even when it was very thick. Cutting exploited the lustrous and reflective qualities of Ravenscroft's lead glass. By the late seventeenth century, the manufacture of lead glass had become widespread and English glassmaking was at a peak but by 183O glass objects had become fussier and the art generally went into a decline.

In the nineteenth century the enormous expansion of machine production and the surge of industrialisation resulted in a flood of mechanically produced objects. Glass, like so many other materials, saw its processes revolutionized with industrialisation. With the mass market of the nineteenth century came the credo of much modern advertising - that only the most ornate, most unoriginal and most vulgar products would sell. By the time of the Great Exhibition (1851) in London the vast array of manufactured objects exhibited in Sir Joseph Paxton's Crystal Palace [11] represented and even flaunted the degeneration of taste brought about by the emergence of a machine economy. However, the Crystal Palace itself was a revolutionary design. Consisting of a three floored iron and glass building built in accordance with glasshouse fabrication methods, it was itself well suited to machine production. It consisted of mass produced parts and identical units that could be easily assembled on site by unskilled labourers. A structural masterpiece of the industrial age, it moved away from established building practices by taking constructional responsibility and any vestiges of craft and creativity away from craftsmen. The role of the craftsman, once so pivotal to glassmaking, had been totally devalued.

NOTES

1 One of the methods of dating obsidian and flint tools is to study the patina on the surface of the tools. The surface of many geological materials undergoes chemical changes over periods of time which form a visibly distinct surface layer or patina. The amount or degree

of patination is related to time, and archaeologists use this phenomenon to date tools. In 1960, I. Friedman and R.L. Smith discovered another technique based on the cumulative hydration, or absorption of water over the centuries by obsidian, which can be measured microscopically to determine the age of the tools.

2 Glass lacks the crystalline structure normally associated with solids, but instead retains the molecular structure of a liquid. In effect, as glass cools it stiffens until rigid but does so without setting up a network of interlocking crystals customarily associated with that process. In this way glass exhibits what scientists call a conchoidal fracture. This phenomenon was exploited by ancient man in the making of obsidian implements.

3 When the surface of obsidian (or other hard, non resilient and homogeneous minerals such as flint or chert) is struck a sharp blow, usually from another harder stone, the shock waves spread through the obsidian in a cone-shaped pattern, producing a conchoidal fracture. A fragment called a flake is formed, which can be recognised by its bulb of percussion on the inside or bulbar surface. Below the bulb of percussion there are usually faint concentric rings marking the path of the radiating shock waves. Chipped stone tools are produced either by removing the flakes to obtain a core tool or by utilizing one or more of the detached flakes to obtain flake or blade tools which were used as cutting or scraping tools.

4 Archaeological finds indicate that the Catel H0y0ka and Asikli H0y0k communities in Anatolia converted huge pieces of obsidian into finely crafted tools. Here large quantities of well made but unused tools were found in single cell plan buildings, where specific tools were made in specific parts of the building. This suggests that a craft industry could have existed as early as 7500 BC.

5 Lithic technology refers to the manufacture of tools from stone. Stone tools were undoubtedly among the earliest tools used by human societies, and their use predates the evolution of modern man (Homo Sapiens) by more than a million years. Microliths are very small chipped stone tools, sometimes made from the tiny secondary flakes that are the by-products of larger blades or flakes, and were probably used to clean inaccessible areas of animal skins or bones.

6 The earliest wholly glass objects (as opposed to objects covered with glaze or pieces of glass inlay) are beads and a thin green glass rod which have been dated to 2500 BC. It is thought that the making of glass vessels originated in Mesopotamia some time before 2000 BC but only fragments from this time have been discovered. During this early period of glass-making it would seem that most of the objects produced, including vessels, were modelled on their stone, metal and ceramic prototypes. The earliest datable glass sculpture is from the reign of Amenhotep (1436-1411 BC).

7 Beads are one of the most enduring records of the history of man. The oldest beadlike objects have been excavated from a Neanderthal cave in France; made 40000

years ago; these grooved beads were made of animal teeth and bone and were used as pendants. Multiple strings of beads have been excavated and dated from 28000 BC. Twenty thousand years ago beads were symbols of rank and status and assumed their most familiar and enduring function as personal adornment. Beadmaking became a major industry in the advanced civilisations of Mesopotamia and Egypt, where merchants initially traded faience beads, made from silica sand and trona (a natural sodium acid carbonate that reduced the melting point of the silica) and later moulded glass beads, to less advanced cultures. By 700 BC the making of glass beads had spread to the Mediterranean when the Phoenicians began manufacturing beads in the shape of human and animal heads. Venetian glassmakers perfected the technique of millefiore beads and by 1490 beads had become an international commodity. European explorers to Africa and the Americas found that glass beads could be bartered for almost anything, including ivory, gold and coffee. The beads exported to Africa were treasured for centuries and were used as currency, displayed as a sign of rank or for personal adornment. In many places in Africa local glass beads were produced, and were added to beads of natural materials such as amber, shell, bone and various minerals which had been used since before the arrival of the European traders. Beads were produced throughout West Africa and were made by the lost wax process, a technique possibly learnt from ancient Egyptians.

Early in the 1800s the centre of world beadmaking moved to Bohemia and the sale of beads for jewellery soared as the Industrial Revolution created a large consumer middle class.

The development of polymerization (plastic) in the 1870s profoundly affected beadmaking, just as the invention of glass had done thousands of years earlier. By 1920, beads made of plastic were produced, imitating virtually every known bead material whether opaque or transparent; ivory, amber, turquoise, pearl etc.

8 During this period Roman pottery was coarse and heavy and vessels of glass would have been regarded in the same light as very good porcelain is today. It is interesting to note that Egyptian craftsmen were reluctant to learn the techniques of glassblowing which they viewed as being both profane and ungodly.

9 *Portland Vase.* (1st century AD). Cameo-glass vessel, height 24 cm. British Museum, London. (Tait 1991:62).

The Portland Vase was excavated in 1644 in a sarcophagus, probably that of the Emperor Severus, who was killed in AD 235. For many years it was one of the many treasures of the Barberini Palace in Rome. The vase was purchased in 1783 by the Duke of Portland for his wife, the Duchess of Portland. The vase was borrowed by Josiah Wedgewood who made jasper ware versions and replicas of the Portland Vase towards the end of the eighteenth century. It was smashed in 1845, when on loan to the British Museum, was repaired and finally became the property of the British Museum in 1945 at a cost of 30000 guineas. The Portland vase indicates the remarkable technical achievements and skill of ancient glass cutters. (See Appendix CUTTING GLASS).

10 *Lycurgus Cup.* (4th century AD). Vasa diatreta or cage cup, in transmitted light it is a deep red colour, height 16,5cm. British Museum, London. (Tait 1991:92).

Lycurgus Cup is a vasa diatreta or cage cup and represents the culmination of glass cutting in antiquity. It illustrates the story of Lycurgus, King of Thrace who was strangled by vines after taunting the god Dionysos; the figures and vines are carved in relief and then cut away, leaving only small bridges of glass still attached to the background form. The colour of the vase varies from a magenta in transmitted light to green in reflected light. This is thought to have occurred because of minute quantities of gold in the mix. (See Appendix CUTTING GLASS).

11 The revolutionary Crystal Palace erected in Hyde Park, London, to house the first of the great international exhibitions was the first large scale building to be built entirely of prefabricated standardised units of glass and iron. This vast structure had a continuous facade of over 80000 square metres, containing 300000 uniform planes of glass, and took only 8 months to erect. Most constructions of this kind were utility buildings such as railway stations and market halls. The vaulted railway station at St. Pancras in London and the market hall near the Madeleine in Paris are two outstanding examples.

CHAPTER 2

GLASS: THE MODERN ERA

In the late nineteenth century a group of theorists, architects and designers in Victorian Britain founded the Arts and Crafts Movement. They sought ways to provide an alternative to the surge of industrialisation which had resulted in a flood of mechanically produced objects. Members of the Movement worked towards unity in the arts, believing that all creativity was of equal value. The aim of the Arts and Crafts reformers was to re-establish a harmonious relationship between architect, designer and craftsman and to bring handcraftsmanship to the production of well-designed, affordable, everyday objects. Individual expression, joy in making objects by hand, designs that drew inspiration from the past, the creation of hand-made goods in place of machine uniformity, the utility of Gothic design, a return to the country from the industrialised city and a change in the work process were all part of the ideals of the Arts and Crafts Movement. The dream of re-uniting designer and craftsman, the spiritual and the everyday, was taken up by John Ruskin (1819-1900) and William Morris (1834-1896), the two main founders of the Arts and Crafts Movement.

Central to Ruskin's writings is the belief that the craftsmen of the later Middle Ages enjoyed complete freedom of expression. He condemned the machine orientated society of Victorian Britain. The idea that any object or building of value should be created with enjoyment was first voiced in *The Seven Lamps of Architecture* (1849) and was Ruskin's major legacy to the Arts and Crafts Movement. It laid the basis not only for the work of Morris but also for craft guilds later in the century.

Although the Arts and Crafts Movement failed to attain its ambitious goals its ideas brought fundamental changes in the principles of decorative design, and important changes in the development of industrial art and the continuation of craft studios. The moral and political subtext of the Arts and Crafts Movement gave rise to a new prominence for glass amid the general enthusiasm for the design arts. Ironically, however, the movement could only flourish in an age of prosperity created through industrial achievement and the only way to guarantee greater accessibility to the products was through commercial co-operation.[1]

The beginnings of an artistic revival, known internationally as Art Nouveau, can be traced back to the Great Exhibition held in London in 1851. The exhibition consisted of artefacts which were, on the one hand, products of the Industrial Revolution and, on the other hand, essentially imitations of established works of art and little more than mindless repetitions of revived and established trends. A movement of rebellion started against this derivative, 'safe' art of mass produced objects which had little or no aesthetic appeal or value. A new type of art and craftsmanship was needed, one which was completely original in concept and methods of manufacture. The ideals of Morris and Ruskin, combined with the new interest in Oriental art and artefacts, as well as the mysticism of the Pre-Raphaelites provided the sources for the Art Nouveau style. However, in contrast to the Arts and Crafts Movement, Art Nouveau artists and designers shared a desire to create a truly new style, freed from the historical references that had characterised so much of nineteenth century art. They also wanted to use new materials and technologies. The ideal was to create articles of outstanding design and craftsmanship which were to be visually pleasing and functional.[2]

The insubstantiality, the malleability and the flexibility of glass made it the ideal medium with which to exploit the exuberance of Art Nouveau (fig. 13). Drawing inspiration from nature and a belief in man's role within the natural world, a decorative style was created with exaggerated curvilinear shapes echoing plant forms with stems and tendrils twisted in labyrinthine patterns. Works in glass reached a great technical complexity and skill which consolidated the concept of glass as a medium for artistic expression and paved the way for the art glass movement of the twentieth century. The most outstanding works in glass made during this period were designed by three men, two in France - Emile Gallé (1846-1904) and René Lalique (1860-1943) and one in America - Louis Comfort Tiffany (186O-1945). In the work of Gallé, Tiffany and Lalique there is a concern for both the characteristics of glass and the processes that can be used to transform the material. These three men gained fame internationally more or less simultaneously at the turn of the century. The freedom and depth of

Fig. 13. ***Snake handle vessel with crocus and ferns. (1902). Art Noveau vessel, acid-etched, height 44cm.***

expression achieved by them were remarkable by any standards: they initiated new ideas and new directions for glass. All, however, were firmly rooted within the 'factory' tradition, designing works which were then produced in factories.

Behind all Emile Gallé's experiments was the conviction that glass was an infinitely variable and exciting medium. Of all his techniques the most ambitious was his exploitation of the effect of light through multiple layers of glass. His writings display a deep knowledge of glass chemistry and he experimented with layering, colouring and decorating glass, sometimes influenced by ancient methods and other times creating exciting innovations.[3] In early works Gallé decorated the surface of his clear glass with engravings, raised enamelling (fig. 14) and champlevé. Later he thickened the body of the glass in a sculptural way building up the inner glass with cased layers. He then enclosed naturalistic elements between these layers and the outer surface was carved in high relief (fig. 14a). He wrote extensively on the theory that lay behind his work, acknowledging nature as his greatest source of inspiration. In many ways he was the product of an epoch torn between strong ties to the past and an equally strong desire for renewal and the new.[4]

Gallé drew on numerous sources for inspiration. The first Impressionist exhibition of 1874 inspired him to produce vessels which translated his direct impressions of nature and light into glass (fig. 14b), and he also looked at ancient glass and nature. The work of the Symbolist poets was another influence; sometimes Gallé engraved on his vessels a line or verse that had inspired him. Quotations from Mallarme, Baudelaire, Victor Hugo and Edgar Allan Poe were used in this way. The mysterious world imagined by Victor Hugo in Toilers of the Sea became a reality and in many of his works there is beauty and strength, but also a threatening emotive quality, with more than a

Fig. 14. Emile Gallé, Vessel. (1900). Triple - Overlay vase with applied glass elements.

Fig. 14a. Emile Gallé, Bottle vase. *(1880) Carved and enamelled, height 22.9 cm.*

hint of decadence and mystery (fig. 14c).

By 1914 Gallé's factory employed over 300 people, and had outlets in Paris, London and Frankfurt. Glass objects designed by Gallé were carried out by his workforce which consisted of large teams of glass workers or 'gaffers'. A proportion of his output was of highly creative works which are clearly the result of his personal experimentation, attention and overseeing. These works show a synthesis of form and decoration and are, in many cases, perfect examples of Art Nouveau. They were made either to be exhibited on major exhibitions, were for important public commissions, or were intimate pieces made especially for close friends or wealthy patrons.

Gallé's glass was symbolic of the new direction which European arts and crafts were to take. He created a new contemporary style which changed many of the old ideas and influenced a great number of artists including Louis Comfort Tiffany who saw Gallé's work at the Paris Exposition of 1889.

Tiffany was born into a rich and successful family - his father Charles Louis Tiffany had founded the firm Tiffany and Young in 1837. By 187O the name 'Tiffany' was synonymous with luxury jewellery. As a young man Louis travelled widely to further his career as a painter. On returning to America in 187O he decided that he no longer wished to become a painter. He had been exposed to Islamic and oriental art as well as the teachings of William Morris and the English Arts and Crafts Movement and had begun to think seriously about adapting the ancient techniques of using glass in decorative art. To Tiffany, the ancient glass objects unearthed by archaeologists were a revelation and he soon amassed a sizeable collection. He was particularly interested in the textures, patinas and inherent colours of the material. After lying buried for hundreds of years many glass objects

Fig. 14b. Emile Gallé, vessel. (1900). Collaged layers of glass; in reflected light (left) the engraved and textured surface shows a screen of leaves, while in transmitted light only the shadows of the leaves can be seen, height 16,9 cm.

Fig. 14c. Emile Gallé, La Giroflee de Muraille. (1900). Glass vessel with marqueterie sur verre decoration, height 20 cm.

had been affected by the metallic oxides in the soil and the surfaces had taken on a patina, some with a pearl-like iridescent quality, others with a rich deep purple, royal blue and red patina. Often the surfaces were pitted and rough (fig. 15). This surface and colour interested Tiffany who felt that these early pieces were artistically complete, and that neither cutting, etching nor painting would have improved them. This was a philosophy he was to apply throughout his glass-making career and despite the technical difficulties that this presented, Tiffany seldom resorted to additional decoration of his pieces (fig. 16).

Soon after returning to America he formed Louis C. Tiffany and Associated Artists. America was at that time at the height of its industrial and commercial prosperity and there was a new breed of extremely rich people who wanted homes that reflected their lavish and ostentatious lifestyles. For the American noveaux riches Tiffany created extravagant living spaces - wallpaper, carpets, fabrics, light fittings and windows were all designed to give an impression of opulence and elegance.

In 1895 Tiffany founded the Tiffany Glass Company complete with attendant artists, craftsmen, chemists and research workers. A decade of intense experimentation followed. He surrounded himself with outstanding talent and became the ruler of a business empire. One of his finest designers was Clara Driscoll who started to work for Tiffany in 1887. By 1904 she was head of his design department and was also one of the highest paid women in America, earning well over $10000 a year. She won many awards for her designs including a prize at the Paris International Exposition.

Tiffany's gold and lustre wares, inspired by Islamic glass (fig. 17), and his iridescent glass (figs. 18 18a) made him famous. Iridescent glass was not a new discovery; other European firms

Fig. 15. Perfume flask. (705 BC). Glass vessel with patinaed surface and formed by lost-wax casting process but final shape, including central hole, was achieved by grinding and cutting when cold, height 8,8 cm.

Fig. 16. Louis Comfort Tiffany, Vessel. (1900). Glass vessel with iridescent texture, pitted rough surface, height 19,5 cm.

Fig. 17. Mosque lamp. *(1309-10). Syrian enamelled lamp bearing name of Mameluke Sultan of Egypt, Baybars II, height 38 cm.*

Fig. 18. Louis Comfort Tiffany, Vessel. *(1900). Iridescent glass vase, height 20 cm.*

had taken out patents, but Tiffany used it to exceptional advantage. His most successful work was in the use of leaded glass for the manufacture of table lamps and hanging shades - still known today as 'Tiffany lamps' whatever their origin. These first appeared around 1895 and became more and more popular as Edison's electric bulb became widely available. The lamps had a mass appeal that he had underestimated - prototypes were made and hundreds and sometimes thousands were produced and assembled. Most were sold as soon as they were put on the market. Tiffany had moved away from the Arts and Crafts movement's ideals. To Morris, machine technology was anathema; to Tiffany it was a way of making his products available to the widest possible audience in the shortest possible time. He was never against the use of machinery if that was the most efficient means of manufacture but many of the mass produced objects were repetitive and uninspired, and represented a compromise with Tiffany's own high ideals. Neither Tiffany nor Gallé achieved the ideal of combining high creative standards and the demands of mass production. The fairly small proportion of highly creative works which they designed were outstanding and many are interesting examples of Art Nouveau.[5]

A short lived style, Art Nouveau subsided by 1910. Life changed dramatically with the First World War, and so did art. The invention of the internal combustion engine brought the motor car, quickly followed by the submarine and the aeroplane, and new needs began to be met in architecture and the applied arts by new materials and production techniques. The flowing sensuous forms and shapes of Art Nouveau gave way to the square and rectangular of the Art Deco style. The undulating lines of Art Nouveau were now considered as ornamental decoration and the 'decadence' of Art Nouveau was at variance with the powerful egalitarian and socialist philosophies that emerged after the war. Like many of his artistic contemporaries, Tiffany's work was dismissed as decorative and outmoded and his vast output became objects of public indifference and critical derision. Tiffany lamps, vases and other examples of his work that had once sold for hundreds of dollars were auctioned off for a few dollars or thrown away. Many of his stained glass windows were destroyed by once enthusiastic owners who now considered them ostentatious and theatrical. His interiors were redesigned.

The revival of Tiffany's glassware coincided with the reappraisal of Art Nouveau, starting as early as 1949 with the opening of a gallery devoted to Art Nouveau at the Museum of Modern Art in New York. Within a few years there was a complete reappraisal of the entire genre spurred on by the advent of Abstract Expressionism in the United States. Louis Comfort Tiffany's work was seen as a precursor of Abstract Expressionism, and Jackson Pollock and Robert Motherwell championed Tiffany as an early exponent of pure form and colour in art expressed through free design. The number of collectors of Tiffany glass increased and prices once again spiralled.

In many ways the career of René Lalique was the most remarkable of the three early twentieth century innovative artists. Lalique's career spanned the last decade of the nineteenth century and most of the first half of the twentieth, and he was versatile enough to change his designs to match the prevalent style. He was an extremely talented designer and successful entrepreneur and his clientele ranged from multi-millionaires to members of the middle class with modest incomes. While neither Gallé nor Tiffany achieved a successful compromise between their high creative standards and the demands of mass-production, Lalique successfully adapted his designs to the dictates of commerce. He had a superb sense of design and this enabled him to design objects which could be mass produced without losing any of their high quality.

Initially Lalique's ambition was to become a leading jewellery designer and in 1880 he studied jewellery manufacturing techniques and sculpture at the Ecole Bernard Palissy. Here he designed a large part of his jewellery without using expensive materials.[6] His designs using glass and semi-precious stones are as effective as those designed for gold, silver and precious stones (fig. 19).

Towards the end of the nineteenth century René Lalique began his first tentative experiments into making glass vessels and objects. These experiments were probably a reaction against the many cheap imitations of his jewellery which were flooding the market. As society became increasingly affluent so the demand for luxury items grew. Francois Coty soon realised that a decorative bottle for holding perfume was as important a marketing feature as were the contents and in 1907 Coty commissioned Lalique to design first the labels and stoppers for his perfume bottles, and then the bottles themselves. The perfume bottles which he designed soon became as important, if not more important than the contents (fig. 19a). Although these small perfume bottles, superbly crafted and mass produced were designed for functional use, many are today recognised as works of art in their own right. The actual bottles were sculptures of flowers, nude female dancers, dancing couples, mermaids etc. Many also had 'art nouveau' carved sculptural stoppers depicting sensuous and curvilinear flowers, tendrils, female nudes and nymphs. At this time he was also commissioned to design bottles for Roger et Gallet and d'Orsay[7] and to keep up with the demand he rented, and later bought, a glassworks at Combs La Velle where he employed at least one hundred workers. Here literally thousands of perfume bottles were mass produced. Lalique began to design many other objects - vases (fig. 19b), powder bowls, paper weights, inkwells, and hand mirrors.[8]

Fig. 19. René Lalique, Winter woodland pendant and working drawing. (1899). Central panel of moulded glass with gold enamelled frame.

Fig. 19a. René Lalique, 'Sirenes'. (c. 1909). Glass perfume bottle.

By the late 1920s there was a concerted reaction against the florid exuberance of Art Nouveau and a move towards the abstraction of form. Colour, line and volume became the crucial elements in the manipulation of space (fig. 19c). Art Deco was the art of the machine age. The use of technology was actively encouraged to meet the seemingly insatiable public demand for art objects of good quality and good craftsmanship. There was a total change of mood after the 1914-1918 war, the next decade was one of frivolity - the flappers and the roaring twenties. Pre-war changes in society had produced an equally vigorous response from the art world and a number of movements were founded often challenging the status quo - Cubism in France, the de Styl Movement in Holland, the Constructivists in Russia, the Futurists in Italy and the Vorticists in England. An increasing distinction emerged between the fine object in glass as a luxury domestic decoration, and the work of art in glass in which the artist chose glass as an expressive medium.

Anticipating changes, Lalique demonstrated the full measure of his versatility and opened a second glass factory in 1921. Using industrial methods, but without any loss of quality he mass produced a huge range of relatively inexpensive glass jewellery - pendants, necklaces, cufflinks, buckles and rings. His designs for perfume bottles became rectangular, geometric and more in keeping with Art Deco forms.

As Lalique's fame and popularity spread, other glassmaking factories in Europe began to copy his work and imitations flooded the market. These cheap imitations so angered Lalique that he made his designs more and more technically difficult and intricate. His designs of the late 1920s were so complicated that imitators were virtually unable to copy or to mass produce them. He also designed at this time a whole range of modestly priced functional items, including plates, bowls, glasses

Fig. 19b. René Lalique, 'Bacchantes'. Glass vase with a frieze of naked maidens in high relief which was still being produced in the late 1970s, height 25 cm.

Fig. 19c. René Lalique, 'Victoire'. (c. 1926). Glass car mascot.

decanters, inkwells, ash trays, vases and light fittings, all in the art deco style.[9]

One of Lalique's major works is considered to be the furnishings of St Matthew's Church in Jersey. He designed huge double doors with two angels each over two metres high, a glass cross over three metres high, two glass pillars sculpted with Jersey lilies, the main altar and a glass font. The sanctuary, and chancel are formed by glass screens and a side chapel altar is made entirely of glass panels (fig. 19d). This architectural commission demonstrates the ambiguous status of glass as material and the complexity of processes used to shape and decorate it.

For centuries, glass has been worked in functional and sculptural forms, sometimes moving into the area of art. Traditionally, form was determined by a designer who never touched the glass and rarely, if ever set foot in the factory, and until the industrial revolution the glass industry was based within the small glasshouse or shop. By the twentieth century mechanical innovations led to a decreased need for skilled glassblowers in the factory. As is the case today, only laboratory apparatus, art glass and other specialised glassware were hand made. Emile Gallé, Louis Comfort Tiffany and René Lalique all owned their own factories, and designed within this 'factory' tradition. They designed unique works of art as well as producing large numbers of glass objects which were mass produced. Their works were, on the whole, expensive, complex and time consuming and were only made possible by the factory backing. Artists were sponsored by the factory as a method of generating new ideas and techniques to feed the production lines in their constant search for novelty while the artists or designers used all the equipment and expertise available in the factories for their one-off pieces. Their individual works were thus subsidised by the everyday utilitarian and cheaper factory versions.

Fig. 19d. René Lalique (1934). St Matthew's Church, *Jersey, glass screen in the Lady Chapel, made with a satin finish, height 180 cm.*

In 1911 after a visit to a glassworks at Bar-sur-Seine, Maurice Marinot (1882-1960) became interested in using the glass vessel as a vehicle for his work. Initially his intention was to use glass as his canvas and, using bright enamels he decorated vessels made by the owners of the glassworks, the Viard brothers. He soon found that simply decorating these vessels was not enough, so he set out to learn the traditional skills of the glassblower. Once he had mastered the techniques of glassblowing, Marinot produced a series of monumental and sculptural jars, vessels and bottles. He created veiled effects by trapping minute air bubbles in his vessels and later the simple bold lines in thick walled vessels, influenced by the Art Deco style, were deeply etched with acid (figs. 20 20a).

Marinot approached glass as a sculptor using glass as a new and exciting material and pushed glass beyond the boundaries set by the 'factory tradition'. His approach - that of an individual artist working on his own to create a unique piece of art - made the fundamental act of co-operation and interplay among members of a glass team artistically irrelevant. This break with tradition was a revolutionary change. Marinot's works stand as some of the most creative and forceful statements made in glass at this time. He considered his works to be sculpture with no utilitarian function and placed a relatively high monetary value on them. These pieces, designed and created by Marinot himself, were produced in an established glass workshop using the equipment, help and expertise of a blowing team.

As late as the 1950s the 'factory tradition' of blowing glass still continued. It was still believed that glass could not be worked outside the factory with less than the traditional six-man blowing team. Sidney Waugh's comments (1947:19) still held good within the glass industry:

Fig. 20. Maurice Marinot, Vessel. (1934). Acid-etched with repeated immersions in hydrofluoric acid, height 17 cm.

Fig. 20a. Maurice Marinot, Vessel. (1925). Bubbles in thick clear glass wall.

> It must be emphasised that glassblowing is not within the scope of the amateur or even the most talented artist or craftsman working alone. In the making of fine glass a multiplicity of tools and equipment is required. Furthermore even comparatively simple pieces cannot be produced without a number of artisans working together as a team.

As artists defined new creative challenges this traditional limitation was also to be questioned.

In 1954, in Murano, Egidio Costantini [s.a] conceived the idea of commissioning leading artists to design objects which could be translated into glass. The actual degree of involvement with the glass varied from artist to artist. Most artists sent drawings or models to Costantini who then had them executed in factories in Murano. Other artists travelled to Murano and collaborated in the production with the Italian craftsmen. A minimum of three examples of each design was produced - one for the artist, one for Costantini and one for art patroness Peggy Guggenheim. Artists including Mark Tobey, Pablo Picasso (fig. 21), Max Ernst, Alexander Calder, Hans Arp, Joan Miro and Alberto Giacometti produced glass under Costantini's auspices.

At this time, there were tentative movements by isolated individual artists to use glass outside the factory environment and to work with new processes. Edris Eckhardt (born 1910) was possibly the first American to formulate her own batch mixture. For her earliest experiments in glass making she drew on her knowledge of ceramics and enamelling. These works involved heating and fusing crushed or flat glass in an oven in her kitchen. Eventually she invented her own glass formulae which she melted in a ceramic kiln. Eckhardt was interested in duplicating ancient Roman glass and in the 1950s she started making glass sculpture, using the *cire perdue* method. Her sculpture *Archangel* (1956) (fig. 22) was exhibited at the Corning Museum of Glass exhibition "Glass 1959" and was the only piece of glass sculpture to be accepted. In 1957 the husband and wife team -

Fig. 21. Pablo Picasso and Egidio Costantini, Donna, da Ninfe e Fauni (Woman, from Nymphs and Fauns). (1962). Cast glass, fractured and treated with fluoric acid, height 35,6 cm.

Jasroslava Brychtová (born 1924) and Stanislav Libenský (born 1921) who had done experiments with casting, moulding and melting glass in a small home made furnace, created a work entitled *Free Form with Face* in cast glass (fig. 23). In this piece the viewer is forced to look inside the elongated form where the features float. This work is not unlike an early Cubist painting translated into glass.

Erwin Eisch (born 1927) was trained as an engraver and attended the Akademie der Bildenden Kunste in Munich where he studied industrial design, painting and sculpture. Using a small furnace which he had built himself he produced an important body of sculptural work. Eisch regarded his glass as a very individual and personal statement. His organic work was particularly unusual when viewed against the still firmly entrenched background of 'taste' in Germany, the undecorated functionalism promoted by the Bauhaus. Although he often used the format of the vessel as a starting point, beauty and function were never his objectives. He placed his emphasis on concept rather than on craftsmanship and treated the 'materialness' of glass with freedom and contempt (fig. 24). Rather than taking advantage of the natural light-transmitting qualities of glass, Eisch covered it until it was unrecognisable as glass. Instead of using it abstractly and exploiting optical effects, he patterned the surface with people, animals, stories and personal inscriptions. In 1962 Eisch held his first all glass exhibition at the Glas und Porzellanhaus Tritsschler in Stuttgart. On the walls hung various proclamations, one of which read 'Do not let yourself be lowered by a thing's purpose or function'. This exhibition became known in Germany as a rebellion against good form.

These artists were some of the pioneers of the studio glass movement but they were unusual and worked in isolation. At the time they were regarded as 'adventurous exceptions' (Franz 1989:6) and

Fig. 22. Edris Eckhardt, Archangel. (1956). Cast in a cire perdue mould, height 22 cm.

Fig. 23. Stanislav Libenský and Jaroslavá Brychtová, Free form with face/head 1. (1959). Cast glass with internal modelling, height 35,5 cm.

Fig. 24. Erwin Eisch, Telefon. (1971). Blown in a mould, manipulated while hot, gold lustre decoration, height 15 cm.

their influence was not particularly widespread. It was not until the early 1960s in America, with the invention of a small tank furnace which could be installed in a comparatively small space and had the potential to cater for the needs of the individual glassblower working entirely on his or her own, that glassblowing became a possibility for a large number of individual glass artists.

One of the first major twentieth-century artists to be associated with glass was Marcel Duchamp (1887-1968). Duchamp used and incorporated glass in his work in ways that anticipated by decades issues, attitudes and trends that were to be debated by contemporary glass artists. He did not use glass in traditional ways and neither did he propose a new aesthetic in glass. He took the transparency of glass at face value; for him glass was dematerialised matter that denoted a null, transient or absent state and it was a vehicle that advanced his ideas on perception - conceptually and visually. In works such as *The Bride Stripped Bare by Her Bachelors, Even* (1915-1923); *Glider with Water Mill* (1913); *Paris Air* (1919); *Rotary Glass - Precision Optics* (1921); *Dust Breeding* (1920) for *The Large Glass and Beautiful Breath, Veil Water* (1921), the viewer is challenged to consider differently the elements he has used. One is asked to see past physical matter to understand a higher mental perception:

In his *Notes for the Large Glass*, 1914, Duchamp wrote:

> Paint the final picture on plate glass (thick).
> to be seen through
> the glass.

Painting or Sculpture
Flat container. in glass - [holding]
all sorts of liquids.Coloured, pieces
of wood, of iron, chemical reactions.
Shake the container. and look
through it -

Duchamp's pivotal work, *The Bride Stripped Bare by Her Bachelors, Even,* (1913), was executed on glass. He worked with the paradox of a transparent surface through which the real world could literally be seen. This work is situated in our world - the Philadelphia Museum of Art. Because the glass cannot be looked at without being looked through at the same time, it tends to absorb into its surface everything else which is visible around or behind it; the image on the glass changes all the time and people viewing the work become part of it, as do reflections and parts of the gallery. The surface is an ever-changing readymade and the effect is a vision of the fourth-dimensional world of Duchamp's innermost ideas. In this work the process is on-going; it relates to changing vision and is a direct result of the intrinsic transparency of glass. In addition the viewer is asked to consider an element, often taken for granted - in this case glass - in a totally different way.

Glass gained recognition as a significant material in the conceptual art of the 1960s. Glass and mirror were the key components in Robert Smithson's theoretical investigations of time, process and place. Sight and space are investigated in works by artists such as Robert Morris and Larry Bell who use plate glass and mirrors. In these works the use of glass veered totally away from tradition as its manufactured form was taken for granted while new meanings and uses were assigned to it. The physical manipulation of the material was either additive or entropic and there was no need to form the glass itself and the artists involved did not care to do so.

Just as the years after World War II revitalized art concepts and procedures, so too were they a period of vitality, especially in the United States. During the war, arts and crafts programmes were offered by the armed forces and later the G.I. Bill of Rights included the option of taking a degree in crafts within a university curriculum. Interest in crafts of all types was reawakened and a new awareness of the potential of glass as an art media arose.[10]

Harvey Littleton, professor of ceramics at the University of Wisconsin was determined to do research into the possibilities of an individual artist blowing glass, outside the factory tradition. After several unsuccessful attempts to build a suitable furnace and find a suitable kind of glass to melt in the furnace, he consulted Dominick Labino (1910-1987) director of research at Johns-Manville Fiber Glass Corporation. Labino had had thirty years of experience in the glass industry and the results of his experiments with glass fibre and silica fibre were used in the Mercury, Gemini and Apollo Space Missions, while his tiles were used on the outside of the Space Shuttle, Columbia. Although this work was far removed from using glass as an art medium, he attended the 1961 Toledo Conference and brought a bag of his No. 475 marbles which he had used for making glass fibre. These marbles were easy to handle and melted quickly. Labino, with Littleton, then developed a portable tank furnace and annealing oven. At last glassblowing by the individual became a realistic possibility. The artist was no longer dependent upon the glass industry for the production of glass objects. This event marked the beginning of the glass art studio movement which has had repercussions in many different countries.

By 1964 Littleton was able to demonstrate his portable equipment which had been refined by Labino, to delegates at the World Crafts Council at Columbia University in New York. Labino's invention proved immensely successful and served as a model for the many glass programmes that opened up in America. Today in the United States alone, over one hundred universities and colleges have studio glass courses as part of their Fine Arts departments. Littleton and Labino, with the support of Erwin Eisch in Germany, encouraged the establishment of courses in Europe and Japan. Workshops and courses were set up at the Royal College of Art, and the Glasshouse.

Thus, with the elimination of the traditions that defined and confined it, glass literally burst forth from confining technical processes. This resulted in a vast development of new techniques, new subjects and new aesthetics. Increased awareness of the expressive potential of glass attracted a great number of artists and craftspeople who were looking for new and different ways to manifest their ideas.

NOTES

1 William Morris became increasingly disillusioned by the gulf which had developed between his ideal of a democratic art and the idle privileged classes who purchased his goods. His dream of good design translated into carefully executed cheap products remained just that - a dream. The realization that his labour-intensive products could not be bought by ordinary people upset him.

2 A sense of excitement imbued all the arts with a new-found vibrancy and purpose. This mood touched every sphere of the arts - the music of Richard Strauss; the architecture of Victor Horta, Antoni Gaudi and Charles Rennie Mackintosh; the art of Dante Gabriel Rossetti, Toulouse-Lautrec and Aubrey Beardsley; sculpture by Rodin, as well as ceramics, jewellery and glass.

3 Gallé was inventive; discovering and patenting many colouring agents, corrosive systems and forming devices. His processes included inclusions, marquetry, staining, abrading, enamelling and engraving. Gallé said of engraving and hydrofluoric acid:

'While acid cannot think, cannot shape, or finish, it can nonetheless sculpt; it cuts into certain kinds of glass in a special way that is all its own. I have made use of the aggressive etchings to produce ornamentation with a decidedly archaic characteristic, to scrape away surfaces in which I wished to emphasize a natural rather than a fabricated effect. A satisfied use of this technique can be found in fine, fragile ornaments that are point engraved in a protective varnish and hollowed out with acid. The result resembles the delicate precision of lacework, the exact detail fades out in a way that no other technique can possibly match' (Warmus 1984:54).

4 Gallé created his glass objects during an age of technological, scientific, political and artistic developments - Thomas Edison invented the light bulb in 1879; Alexander Graham Bell spoke on his telephone in 1876; Louis Pasteur developed a vaccine for rabies in 1885; Henry Ford built his first car in 1893; Orville and Wilbur Wright made their first aeroplane flight in 1903; Freud's *Interpretation of Dreams* was published in 1900; in 1896 Henri Becquerel discovered radioactivity while investigating the properies of fluorescent minerals. Becquerel used photographic plates to record this fluorescence.

5 In 1909 Tiffany designed a stained glass curtain for the National Theatre in Mexico City. This was a mammoth project which took a team of twenty workmen more than fifteen months to complete. When finished it comprised nearly a million pieces of glass weighing twenty seven tons. Mountains, flora and fauna, trees and cacti were all translated into glass. Orders followed for other major stained glass works.

6 In 1887 Lalique exhibited some of his designs at the Exposition Nationale des Arts Industriels in Paris. It was here that his designs began to be recognised as outstanding works of art. In 1892 he began to design jewellery for the actress Sarah Bernhardt which immediately gained him an international reputation. He exhibited at the Salon de Paris and in 1897 was awarded the Legion d'Honneur. He became known internationally as a leading jeweller of the Art Nouveau period. In 1905 Queen Alexandra wore his jewellery, confirming his status as a mastercraftsman.

7 Many of Lalique's more unusual perfume bottles were exhibited at the Paris Exposition des Arts Decoratifs et Industriels in 1925 where Lalique also designed a large glass fountain of over fifteen metres high as a centrepiece. The fountain consisted of seventeen tiers of frosted glass panels, each tier was made of octagonal sections supported by eight stylised female figures. This exhibition demonstrated the supremacy of French design and gave rise to the term 'art deco'.

8 Looking glasses, made from highly polished metal discs, have been used since ancient times. The first metal-backed glass mirrors date from the twelfth century, and were small with a reflective backing made from tin or lead. During the fifteenth century convex mirrors were made by glassmakers in Nuremberg who added a metallic mixture into the hot glass globes to coat the interior, the globes were then cut into pieces and framed. The Venetians used the split cylinder method to produce large quantities of mirrors which were exported to France until 1665 when a number of Venetian glassmakers were bribed to leave Venice and to manufacture mirrors in Paris. They manufactured mirrors at a factory called

the 'Manufactory of Glass Mirrors by Venetian Workmen'.
Four huge mirrors will be used to make the world's largest optical telescope, to be placed on the 2660m high Cerro Paranal in the Atacama Desert of Chile. Each mirror, made from a glass ceramic called Zerodur, will be over eight metres in diameter and weigh 24 tons, be less than eighteen centimetres thick and will remain in an annealing oven for four months to ensure that there are no internal. stresses.

9 Lalique also designed over twenty five different individual status-symbol car mascots (many serving a dual purpose as paperweights). These are highly prized collector's items today. The late 1920s and 1930s were also the age of the great passenger liners, and Lalique was commissioned to design many of the interiors - ceilings, light fittings, glass fountains etc. His many commissions included fittings for some of the world's largest passenger liners including the Normandie, Ile de France, Empress of Britain and the Swedish liner Kungsholm.

10 The use of glass as a material for art, and whether it was possible for glass to be formed by the independent artist working alone in his or her studio were publicly discussed at the American Craftsmen's Annual Conference, 1957, Toledo.

CHAPTER 3

PROCESS IN CONTEMPORARY GLASS

Chemically, glass is a generic term for a substance manufactured from a large variety of ingredients. Although most glass contains the same basic simple raw materials - sand, soda and limestone - the term glass does not refer to a specific chemical composition since different types of glass have different chemical and physical properties. Sand, by itself can be fused into a clear crystal substance. This product (fused silica or silica glass) has very useful thermal properties and is used extensively today in industrial processes, but requires very high temperatures of over 1700°C to be formed. When a substance such as soda (Na_2CO_3) is combined chemically with the silica the temperature required for the melting process is lowered by some hundreds of degrees to 800°C. The resulting glass is, however, a simple one soluble in water (water glass or sodium silicate $NaSiO_3$). When limestone ($CaCO_3$) or chalk is added to the sand and soda mixture and fused together a glass is formed which is insoluble in water. Called soda glass, it is used extensively today for glasses, bottles, jars, window glass and electric light bulbs. Sand, soda and limestone remained the basic ingredients of glass until the development of lead glass in the seventeenth century. Today scientists continue to experiment with an ever increasing number of new glass mixtures and in America alone, Corning manufactures seven hundred and fifty different glasses and glass-related products, and keeps hundreds of thousands of glass recipes and formulae on record.

In ancient times four major glass manufacturing processes were used. These have been deduced from physical examination and scientific analysis of ancient pieces:

1. Rod and core forming (fig. 25a)
2. Casting with open/closed moulds (fig. 25b)
3. Blowing (fig. 25c)
4. Blowing into moulds (fig. 25d)

The technique of glassblowing has hardly changed since it was invented in the later half of the First Century BC.

Fig. 25a. Rod and core formed vessels. (150 - 50 BC), height 15 - 16,5 cm.

Fig. 25b. Mould casting. *(2nd century BC). The Israel Museum, Jerusalem.*

Fig. 25c. Cinerary urn. *(late 1st century AD). Blown from a blue glass with a strap handle and nineteen ribs at the base.*

Fig. 25d. Box and lid. *(25-50 AD). Mould-blown (probably in a four-part mould) opaque white glass vessel with a separate lid, round at the top and bottom with eight sides in the middle. Decorated with palmettes, leaves and geometric motifs, height 8,5 cm.*

In 1934 Maurice Marinot observed:

> To be a glassmaker is to blow the transparent substance close to the blinding furnace, by the breath of your lips and by the tools of your craft, to work in the smarting heat and the smoke, eyes watering, hands blackened and scorched. It means organising simple lines out of the actual material by a rhythm analogous to the nature of the glass itself in order then to rediscover within its shining stillness the human breath which will evoke living patterns (Polak 1978:33)

Many of these sentiments are also expressed by artist, Dale Chihuly (born 1941), who is probably the best known contemporary glassmaker.[1] He works within the factory tradition using the traditional blowing team to produce his glass forms. A Fullbright Fellowship and a grant from the Tiffany Foundation enabled him to study glass at the Venini Fabrica on the island of Murano but, as he was neither competent nor skilled enough to blow glass with the Venini glassblowing team, he watched from the sidelines and absorbed many of the secret techniques which were unknown in the United States. He also accepted the collaborative master-and-team approach.

Today Chihuly works within the Venetian glassblowing team tradition directing a team of five to eighteen expert glassblowers. He concentrates on the colour, form and finish of the large glass forms and the making process is a profound element on his creativity. His drawings (fig. 26) assume a life of their own alongside the glass; energetic, gestural lines form images on the paper just as hands would form the glass on the end of the blowing iron in the workshop. He comments, 'First of all I come up with a concept... make drawings while the team is working. The whole process is a very exciting and inspiring one' (Miller 1991:30).

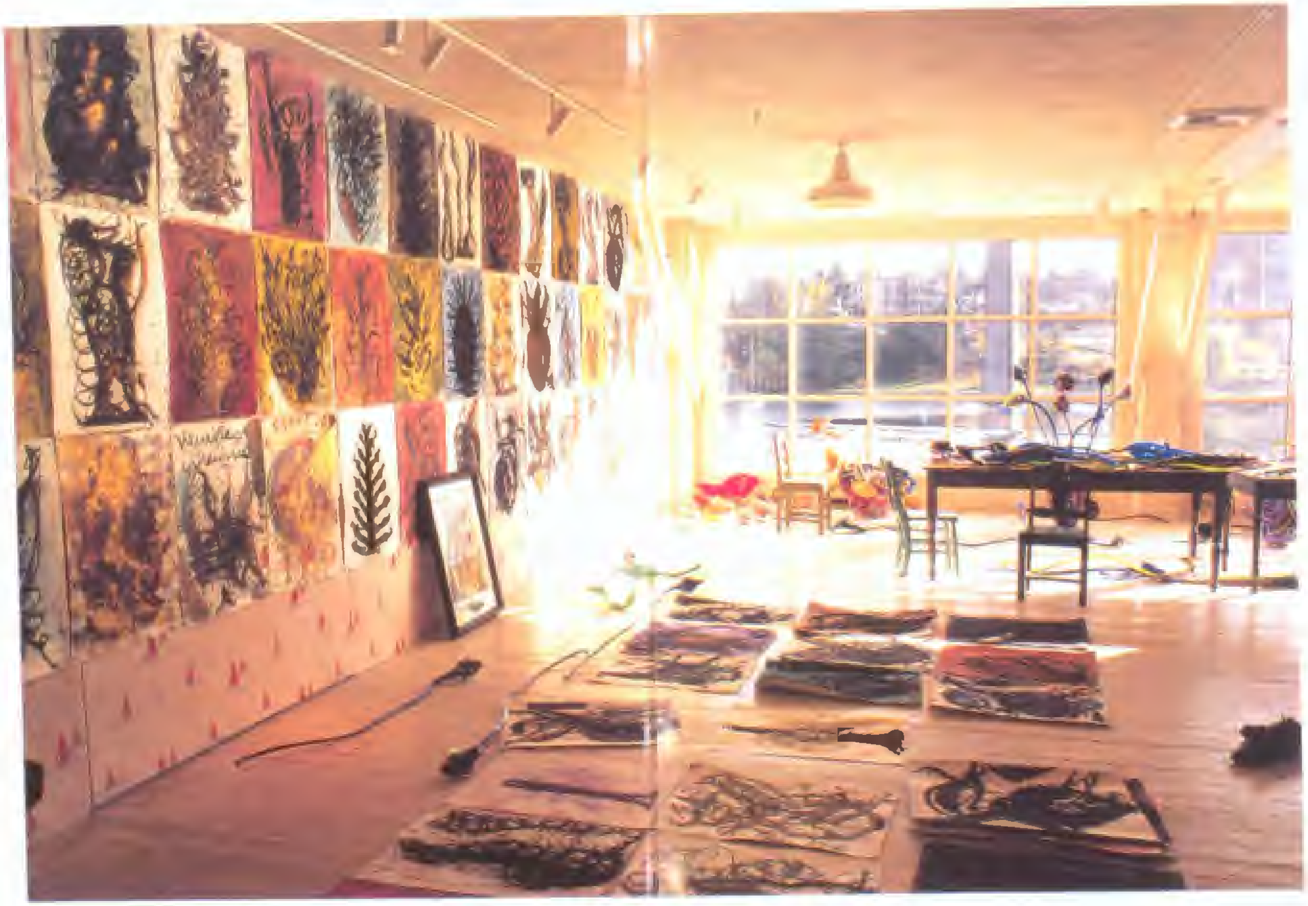

Fig. 26. Dale Chihuly, gestural drawings and boathouse studio.

Glass is a visually seductive and glamorous material and Chihuly is a consummate showman. His glassblowing sessions are theatrical events with artists flown in from around the country, as well as from Murano. There is always specially chosen music and delicious food. The blowing process, with its mesmerising mix of fascination and danger, rigorous physical discipline, performer's flair, teamwork and timing all add greatly to its allure (fig. 26a). No one has exploited this more than Chihuly, whose international recognition as a glass artist is due in many ways to his ability to capitalise on both process and object. He says:

> I have become obsessed with the blowing process. Instead of using traditional glassblowing tools, I began to use fire, gravity and centrifugal force and above all chance to form the glass. I thought it was the hot glass that was so mysterious, but then I realised that the air that went into it was so miraculous. I often wonder how anyone ever thought of the idea of blowing air into molten glass. It doesn't work with any other material (Chihuly 1988:26).

He has also observed:

> Glassblowing is a very spontaneous, fast medium, and you have to respond very quickly. I like working fast, and the team allows me to do that (Miller 1991:30).

The physical and conceptual origins of Chihuly's work are as important as process; they are about glass, how it is made, about the non-functional vessel form and what can be done to it, the physical world to which the forms allude and the fantasies they elicit. His works demand that the material is not taken for granted. His glass is not like any other material and no other material could be used for these objects. Chihuly is interested in the sheer beauty and 'glassiness' of glass, and for him the essence is to exploit the fragility while demonstrating its great strength, to make it more beautiful, more shimmering, translucent, larger, more colourful, more unabashedly decorative, more exciting, more dynamic and more excessive and exuberant than ever before in the history of glass making (fig. 27).

Although Chihuly's personal aesthetic involves working within the traditional means and forms of hot glass, he started the Pilchuck Glass School [2] in 1970 to foster the use of glass to address formalist and content-derived concerns in contemporary art glass. He works with well-known art world figures, established glass artists and European master craftsmen. The main objective of Pilchuck is to try new skills, to share information and techniques and to grow from the experience. The impact of Pilchuck on the studio glass movement around the world is immeasurable. It has proved to be one of the most innovative forces in contemporary glass.

From choice Chihuly works in his boathouse studio and directs the production of his very large flamboyant, brightly coloured glass objects which start off as bubbles at the end of a master glassblower's pontil. These forms are blown as individual forms in large numbers for installations, stage sets or architectural features (fig. 27a). Benefiting from his fine art training he brings into his art a freedom, spontaneity and painterly quality. In his work process is a performance, and he has made sure that all the artists involved in that process are acknowledged.

One of the major glass artists who has given workshops and lectures at Pilchuck Glass School is Swedish artist and designer Bertil Vallien.[3]

Fig. 26a. Dale Chihuly, glass blowing with members of his blowing team.

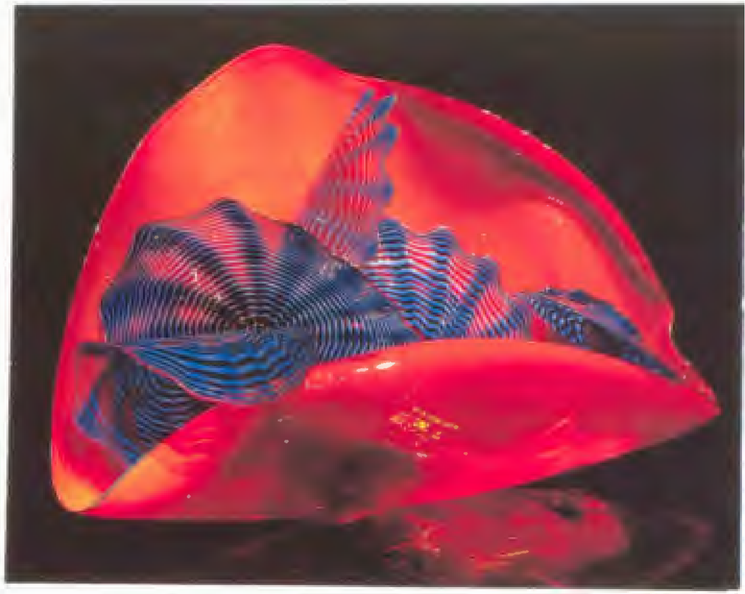

Fig. 27. Dale Chihuly, Saffron stemmed form with royal blue persians. (1988). Blown glass, 58 x 94 x 58 cm.

Fig. 27a. Dale Chihuly, Venturi window for the Seattle Art Museum. (1992). Blown glass, 183 x 427 x 366 cm.

Returning to Sweden in 1963 after studying in the United States, Vallien joined Kosta Boda Glassworks where he still works for six months of the year designing blown-glass products for the commercial market. The remaining six months are spent doing his own work, lecturing and travelling. Vallien is one of the most versatile and imaginative glass artists and designers today who not only designs glass but ceramics, stainless steel and wood. His designs for Kosta Boda fall into three categories

1) All the production glass including the Artist Collection series of tableware
2) Limited edition objects called the Atelje series
3) unique art pieces.

As a chief designer at Kosta Boda he works hard to preserve the age-old craftsmanship and tradition of the factory glassblowers, and at the same time produces innovative and exciting new designs for the Swedish glass industry.

Bertil Vallien has developed and refined a process of sandcasting for making his glass sculptures. He wrote to a friend 'I feel like a saboteur, ... when the studio is filled with these rough, sandy bits of glass instead of bowls and vases for a different market.... un-glassy in the traditional sense' (Lindqvist 1994:59). Like Chihuly, Vallien works with a team of five or six glassworkers and this enables him to produce large works which would be impossible to cast on his own (fig. 28). Sandcasting is a difficult process which takes careful and detailed planning. The actual casting, however, takes place very quickly. Templates are pressed into a mixture of clay, sand, charcoal and water to produce a mould which is powdered with graphite. The graphite prevents the sand mix from sticking to the glass. Molten glass is then poured into the mould. The solid object is placed in an annealing oven for two to three days. Each mould can only be used once as it is destroyed when the solidified glass object is removed. Two of the problems inherent in the sandcasting process are,

Fig. 28. Bertil Vallien. Sandcasting process.

firstly, if the molten glass is not poured into the mould while in a certain state of liquidity (1100°C) it hardens and becomes too brittle to pour, or becomes too 'toffee-like' to flow. Secondly, the sand mix cannot be allowed to become too dry otherwise the form will collapse. If too wet the steam penetrates the glass and large bubbles ruin the sculpture.

Vallien's sculptures show a very different surface quality from the very shiny, transparent glassy forms blown by Dale Chihuly's team of glassworkers. Sandcasting gives the glass surface a rough, dull, sandy quality which negates its 'glassiness'. Vallien sandcasts glass to explore the light-absorbing qualities rather than to exploit the reflective qualities. Areas of clear polished glass form contrasts allowing the viewer to see into the depths of the glass where Vallien places various objects - ribbons of opaque coloured glass, glass shards, a cocoon-like shrouded mummy form, a rounded cylinder form, all of which have symbolic importance. His forms are self-contained, richly coloured and tonal. His subject matter includes boats, the human torso, archaic figures, altars, and bridges. The technical virtuosity and rich metaphorical and allegorical associations of his sculptures rank them among the most significant in contemporary glass art. His work in sandcasting and the use of the boat image have been a major influence on my own work over the years. In *Whisper Wreck*[4] I have sandcast a boat form, but needed a rougher, more 'wreck-like' quality. It is interesting to compare the two different concepts and forms. Vallien's forms are more controlled and have been carefully and painstakingly finished whereas I have deliberately used the process, fractures and the forms just as they come out of the kiln to obtain the results I require (figs. 29 29a).

Fig. 29. Bertil Vallien, Sea of future. (1986). Sandcast, 210 cm.

Fig. 29a. Doreen Hemp, Whisper wreck. (1995). Sandmould, 44 cm.

Vallien's sculptures of 1989 and 1990 show the struggle between freedom and captivity. Symbolic objects and figures are cast into larger forms and tied or held with rings or ropes (fig. 30). He also made a series of sandcast pendulum forms (fig. 30a) and his latest works are the Map and Head Series, which consist of sandcast and moulded slab or glass forms. No material other than glass could give Vallien the same subtle range of refraction and the same play of light. In some of his works the glass content is only hinted at but with great poignancy and intimacy. These works demand that the viewer look past the rough opaque surface deep into the interior, or to relate to the texture and roughness and then concentrate on the deep transparent areas. One has two perceptions when looking at his work - to be outside the work and to see the whole, and also to be drawn inside and be surrounded by the work. Many of his works have a mysterious and provocative quality - both in the surface quality and in the content. They are a complete inversion of one's usual expectations of glass as a material, and as glass in the way it has been used traditionally in art.

One of the most commonly noted aspects of working with blown-glass is the sheer physicality of the process. For many years it was assumed that women could not cope with the process, could not build furnaces, stand the intense heat of the hot glass, handle the heavy weight of the glass or deal with the complicated technology. However only recently have women who have the strength and desire to blow glass in a glass workshop actually been allowed to work at the furnace.[5] Dale Chihuly, in working with a team pioneered an important development in contemporary glass. Women became part of his blowing teams, blew glass at the furnace and proved that they were perfectly capable.[6] Lierke comments:

Fig. 30. Bertil Vallien, Nero. *(1988). Sandcast.*

Fig. 30a. Bertil Vallien, Pendulums. *(1989) Sandcast, 90 - 192 cm.*

> Women have a special relationship to this material that was inaccessible to them for hundreds of years. Women on the way to emancipation, work with a substance that is attempting to free itself from the functional servitude which often overshadows its true material character in order to emerge as an independent artistic medium. Hot glass is feminine! (Lierke 1983:23).[7]

By the 1980s glassblowing was no longer as popular as it had been in the early years of the studio glass movement. There were reasons for the decline of interest: both the equipment and the upkeep of the furnace fire are very expensive; safety laws prevent individual artists from using a continually burning furnace in many suburban areas; only a few artists can master the art of blowing glass and of these not many are able to push past the boundaries of pure virtuoso skills. Ironically, glassblowing - the very technique which had led to a revolution in contemporary glass - is the one process where artistic results are the most difficult to achieve.

The studio glass movement led to an exploration into other methods of working, and a revival of many of the techniques which had been used extensively in the ancient world. Every aspect of glass-making was explored. Lamp-working, fusing, slumping, laminating and casting were just some of the processes explored. Glass became accessible to many more artists, as these 'warm' or kiln-formed processes could be carried out within existing ceramic facilities in private studios. Artists soon became aware that the skills inherent in heat formed glass are not always direct manipulative controls requiring physical strength and manual dexterity such as those needed for glassblowing. Different skills are needed for kiln-working as each kiln-forming method is not one process, but many inter-related procedures and practices.

The process of crushing glass and fusing it in a mould to produce translucent forms dates back 3500 years. After the invention of the blowing iron this method of casting glass was no longer used until it was rediscovered in 1885 by the French artist Henri Cros (1840-1907). Cros, Gabriel Argy-Rousseau (1885-1953), Georges Despret (1862-1952), Francois Decorchemont (1880-1971) and Albert Dammouse (1843-1926) were interested in developing a 'new' glass process for making sculptural forms. They did research into ancient techniques and developed a matte translucent glass - pâte de verre (literally glass paste). These artists seem to have used two methods of casting - one was the lost wax casting (cire perdue) and the other was to layer glass paste in a mould. Cire perdue usually produces a solid form while the second method is used to form hollow vessels or objects.

Henri Isadore Cesar Cros wanted a material that could combine the durability of marble with the subtlety of wax. He did research into the ancient methods of working with glass and particularly with pâte de verre. He was secretive about his techniques and the only archival material available on Cros tells of his speculations into the ancient processes which were used to produce the Portland Vase, but nothing of his own processes. Research indicates that Cros only fired his pieces to the point of fusion, thus preventing the colours from running together. He also placed copper wires inside his objects to prevent cracking but the bubbly surfaces and noticeable cracks show this method did not work. His most successful works in pâte de verre are his reliefs which have a great strength and simplicity. Only in 1968, when Jacques Daum found a way of making pâte de verre that would allow multiple castings to be taken from a sculptor's original with great accuracy did pâte de verre as a process became really viable.[8] High quality pâte de verre was obtained by slowly fusing finely crushed lead crystal in a mould to 1000°C, and then cooling the glass in the kiln for five days (pâte de cristal). Since then Daum continues to make solid pâte de verre sculptures, using the designs of sculptors such as Dali, Picasso, Dan Daily and many others. Daum have made over 30 pâte de verre models of Dali's work alone (fig. 31).

Throughout history, pâte de verre processes and ingredients have varied a great deal but the basic ingredients seem to have been crushed glass, water, fluxes and colouring matter. A unique characteristic of pâte de verre glass is its translucency which is controlled by particle size. Glass crushed to a consistency similar to granulated sugar and mixed to a paste with a binding agent such as sodium silicate or gum arabic and water, and fused in a mould, produces an opaque form, while large pieces of glass yield an almost transparent form. The glass is either brushed onto or packed into a mould and fired slowly until fused. After annealing the mould is broken and washed away. Pâte de verre does not flow when fused - a slow firing fuses the fine grains together producing a rich distinctive crystalline quality not unlike alabaster. There is always a pâte de verre 'haze' in true pâte de verre as the glass has tiny air bubbles trapped in the glass.

Fig. 31. Salvador Dali, Montre molle. (1989). Pâte de verre and metal, height 55 cm.

Diana Hobson (born 1953) is one of many artists who have chosen to work with pâte-de-verre. A graduate from the Royal College of Art, Hobson works alone in her studio in London. In 1980, with the help of a Crafts Council grant she began research into the technique of pâte-de-verre. She investigated the early Roman processes and was given limited access to the writings of Gabriel Argy-Rousseau. With endless experimenting Hobson has created a new art form and extended the boundaries of the pâte de verre process. Her vessels are paper thin and translucent: an insubstantial rumpled shell (fig. 32) made by applying thin layers of glass paste to the sides of a refractory mould, compacting the glass by using the back of a teaspoon. Her method of working (fig. 32a) is a painstakingly slow process, with a very high failure rate. Colour is added in the form of metal oxides. Firing cycles vary from eight to twenty days with temperatures to 800°C. She observes, 'My method of making pâte de verre is very much a hand process and any small subtle changes add up to a change of result ... heroic patience, consistent quality of materials, careful application of glass and accurate control of firing are essential. When a piece fails you look for the reason, but when it works it's magic' (letter from Diana Hobson to Doreen Hemp, April 1989). Sea shells, pebbles, bones and other found objects are carefully and meticulously added to the glass paste to enrich both the surface and the concept. Hobson's work is about energy and tension, and despite its small scale it has great presence. Her recent work includes the addition of objects including feathers and rocks. After working with pâte de verre for many years she feels that she has to '...move away from pure 'process' and to allow the choice of materials and the way they are manipulated to be part of an overall approach to the created image, not dominated by any one element' (Theophilus 1991:46).

Doug Anderson (born 1952) works with the *cire perdue* (lost wax) casting method of making pâte de verre. He casts directly from nature, impressing objects such as leaves, fish, envelopes, and plastic

Fig. 32a. Diana Hobson working.

Fig. 32. Diana Hobson, Progressive series #5. *(1986). Pâte de verre, beach sand and inclusions, height 15,7 cm.*

toys into a plaster and silica mould. Negative imprints are then cast into wax and covered with a mould. The wax is burnt out and the hollow filled with a coloured lead-glass paste or crushed glass. His work is realistic down to the minute details, the pâte de verre and lost wax casting process giving him an exact copy of the original object (fig 33). In 1985 he re-created a 77cm piece of woodland floor exact in every detail with grass, ivy, pinecones and insects (fig. 34).

Fig. 33. Doug Anderson, No you won't - yes I will. (1992). Pate de verre using cire perdue casting process, 6,4 x 33 x 17,8 cm.

Fig. 34. Doug Anderson, Finders creepers (detail). (1986). Cast in a mould using the cire perdue and pate de verre processes, 9,5 x 75 x 37 cm.

Fusing glass is a method of heating and binding two or more pieces of glass together. At temperatures of approximately 840°C - 920°C the glasses merge together so completely that they form a single body of glass. Lamination occurs at lower temperatures of 800°C - 900°C when the glass will bond permanently without merging completely. Stacks of glass pieces may be bonded in this way creating tall sculptural forms (fig. 35). At still lower temperatures of 750°C-800°C glass can be formed over moulds. This method takes advantage of the fact that glass does not melt but softens. This process has been used in *Silent Wreck*[9] (fig. 35a).

Fusing, slumping and laminating glass were used extensively by ancient glassmakers in the Third Century BC and again in the classical world, and were not used again until the nineteenth century. A contemporary glass artist who uses these processes combined with the use of mosaic and cane work is Klaus Moje (born 1936). Moje has taken the ancient Alexandrian and Roman luxury glass concept and updated both its form and technique.

Klaus Moje trained as a glass cutter and grinder in a family workshop in Hamburg. In 1961 he opened a studio in Hamburg with his wife, Isgard, where they worked in stained glass. One of their first commissions was to create a series of meditation windows for a semicircular chapel for Lothar Schreyer of the Bauhaus. When the Mojes opened the *Workshop Gallery Klaus and Isgard Moje* their first exhibition was of the work of Erwin Eisch, the only other person then producing 'contemporary' glass in Germany. The Mojes' art glass was also exhibited in America where they made contact with artists such as Dale Chihuly, and through them established a connection to the American Studio Glass Movement.

Fig. 35. Daniel Rothenfeld, Untitled. (1989). Laminated glass, just under life size.

Fig. 35a. Doreen Hemp, Silent Wreck. (1995). Laminated window/soda glass with copper wire, 7 x 43 x 11 cm.

In 1972 Moje began experimenting with mosaic techniques, fusing and slumping. When he started researching ancient mosaic glass he discovered that he had to develop his own technical vocabulary as no information was available. The ancient methods of cane and mosaic processes were first practiced in Mesopotamia in the Fifteenth Century BC when relatively simple canes were marvered onto the surface of cast or moulded vessels. By the pre-Roman era layers of glass in different colours, shapes and patterns were used. Roman mosaic glass bowls combining canes and 'millefiori' elements are assumed to have been made by placing preformed canes/mosaics over a mould or between two moulds and heating them until they fused together. Glass pieces were cut with a cutting wheel and polished with abrasives such as powdered gemstones or fine emery, and a lot of hard work. The process was revived and developed in Venice in the sixteenth century and during the nineteenth century it was perfected by French glassmakers for making paper weights, perfume bottles etc. Two basic types of canes were made - those to be sliced and viewed in cross section (Millefiori and mosaic) and those intended to be viewed from the side (canes or 'stringers' as they are known today). It is thought that all these canes were manufactured in the same way; a mass of glass was heated and then stretched to become long and narrow. Bowls were made of simple layered 'slices' of cane which were laid in a mould and heated until they fused to form a solid object. Mosaic plaques were also used, sometimes laminated or decorated with shapes made by using Millefiori.

Moje watched Venetian mosaic bowls being made at Murano and saw that when the canes were hot enough they were pushed together with hot irons, the hot glass was then placed over a warmed mould in the kiln. Klaus Moje's first work using this ancient technique consisted of using canes which he purchased from The Hessenglas Company. These canes were then cut, placed in a l together to form a mosaic bowl. His first bowl was seen and purchased by the Museum fur Kunst und Gewerbe in provided the encouragement Moje nue. Moje then cut his coloured glass aics or strips with a diamond saw, nto a very controlled geometric design and fused them together in a ceramic ely controlled temperature. A second, ire firing slumped the flat-glass slowly The final stages involved many tedious g to smooth the rim or create a matte upper surface of the bowls (fig. 36). and plates of the late 1970s were or circular, often a flat form with a the centre.[10]

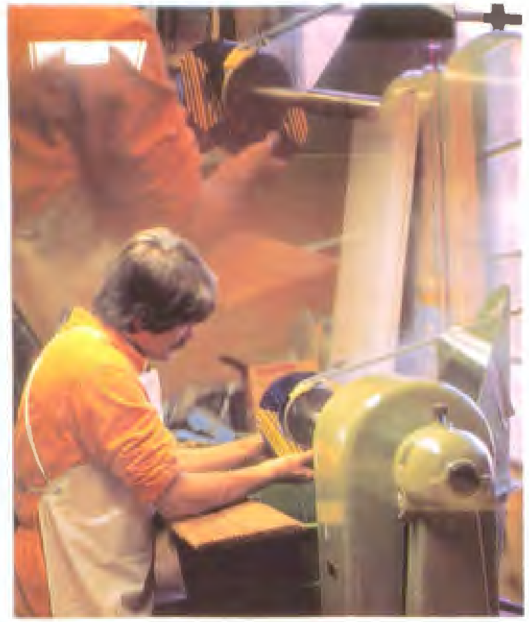

Fig. 36. Klaus Moje grinding inside curve of fused glass bowl using glass lathe and diamond cutting wheel.

Moje moved to Australia were he had been given a five year appointment to set up a and course at the Canberra Institute of the Arts. Before this move Moje's work rly subdued muted blues, greys and beiges. The striking effect of the southern light, nations, coral reef, colours and the unspoiled environment of Australia changed his is well as his way of working (figs. 37 37a). He says 'I found the end of a rainbow in the dscape' (Hollister 1984/5: 22). His colours became saturated, rich and vibrant and he technique of 'combing' in his works - pulling, dragging or combing a sharp instrument olten glass. This process destroys the formal geometry and gives a vibrancy and

Fig. 37. Klaus Moje, Mosaic bowl (Gold), 1980 (made in Germany) Fused glass rods, kilnformed, wheelcarved, semipolished, 7.1 x 32.4 x 24 8 cm

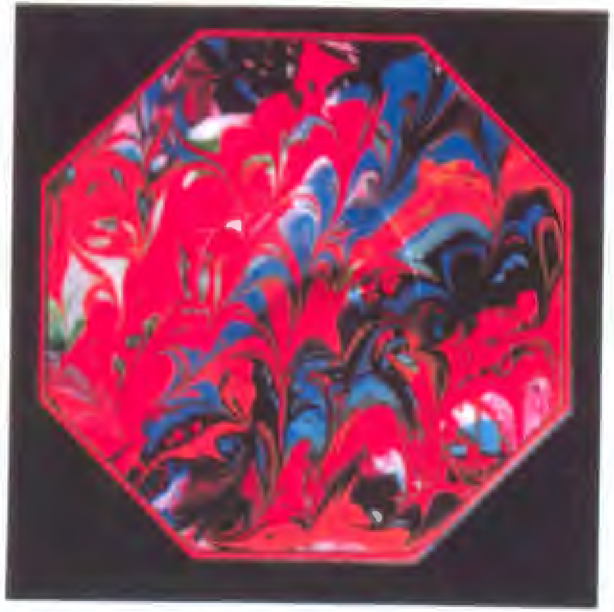

Fig. 37a Klaus Moje, Bowl (1990) Pieces of glass, glass canes slumped and fused, 53 x 53 x 7 cm

rhythmic excitement. In other pieces the overall pattern of small mosaic ribbon fields are replaced by pieces of patterned or plain richly coloured glass spaced at random. Moje moved from a strictly geometric approach to an expressionist approach, with gestural and painterly qualities - the glass surface becomes a canvas of luminous pulsating light (fig. 38). Technically, for these works, Moje builds up flat planes of fused, often patterned, Bullseye glass (see below) with no final design in mind. These pieces are cut into pieces again and reassembled and fused into a flat plate at 900°C. He then adds other glass pieces and the form is fired again and slumped in a silica and plaster mould at 700°C. Moje cuts off the rim and grinds and polishes the surface to remove any imperfections.

In the early 1980s Klaus Moje found that many of the German glasses which he used for his mosaic forms were incompatible, and that the glass either fractured or shattered in the kiln itself, or hours or days later. Extensive research followed a meeting with the owners of an American glass company - Bullseye Glass Company. Klaus Moje's problem challenged the Company to create glasses which could pass compatibility tests and insure that the art objects would survive once the glass had been fired and cooled. In the last sixteen years the company has grown from three young glassblowers - Daniel Schwoerer, Boyce Lundstrom and Ray Ahlgren who started to make their own flat glass in 1974 - to over fifty workers, and a product line which has increased from thirteen original glasses to approximately two hundred separate kinds of glass. Bullseye Glass Company has produced over a hundred thousand square metres of compatibility tested art glass which is used by glass artists all over the world. Artists, glassmakers, chemists and glass technologists work together to produce glass products which keep up with the demands of an ever-growing glass art industry. Bullseye produce the most extensive range of art glasses in the world today. These include cathedral glass,

Fig. 38. Klaus Moje, Untitled (detail). (1989). Mosaic glass, kilnformed, wheel-cut, 38,6 x 38,6 x 4,3 cm.

opalescent glass, fractured and streamer glass, and iridescent glass. Although they were designed for the warm glass artist, stained glass artists use Bullseye glass because of the very large range of colours, textures and patterns. To fuse the Bullseye glass, Moje uses two different kinds of kilns; one is a fibre kiln where the bottom rolls out so that he can assemble his pieces of glass on the kiln shelf and the second is a front-loading kiln which has heating elements all around the sides, top and floor. Moje stresses that more important than the type of kiln used is the ability to control the firing cycle accurately. He feels that computerized controllers are critical to the success of his pieces.

Accurate firing cycles are also critical to the vessels made by American artist, Mary Ann Toots Zynsky[11] (born 1951). If the firing cycle is not accurate the whole effect she wishes to obtain is lost. If too hot the vessel form collapses or the threads melt together. Zynsky has also updated and redefined the ancient process of fusing and slumping glass. She does not use the mosaic technique practiced by Klaus Moje, but uses literally hundreds of very thin canes of often brightly coloured glass (figs. 39 39a). Originally Zynsky heated globs of glass until they were of a treacly nature and pulled them into thin glass threads - a lengthy and time-consuming process. A meeting with the Dutch designer and inventor, Maathijs Teunissen van Manen, changed her way of working in glass. He invented two things for her; a bell furnace which can be assembled and dismantled in two hours and a machine for making glass threads, inspired by fibre optics technology. She lays coloured strands, or stringers, in up to twenty colours, on rice paper. These are then fired in a double metal mould. Her vessels have a painterly quality, with the threads forming brushmarks on the surface of the vessels. Strong colour contrasts, texture and the influence of the beaded baskets and the tribal costumes she saw in Africa are all visible in her vessels. It is interesting to visually compare the ancient forms of vessels created thousands of years ago to those created by Klaus Moje and Mary Ann Toots Zynsky (figs. 40-43).

Fig. 39. Mary Ann Toots Zynsky, Bowl. (1987). Fused glass fibres 18 x 18 x 30 cm.

Fig. 39a Mary Ann Toots Zynsky, Bowl. (detail)

Fig. 40. Murrhine vessel made by arranging fragments of coloured glass side by side and fused together. 1st century AD.

Fig. 41. Klaus Moje, Untitled. (1990) Mosaic glass, fused, kilnformed, wheel-cut, 33 x 33 x 5 cm.

Fig. 42. Millefiori bowl. *(1st century AD). Mould pressed with added rim. 6,5 cm.*

Fig. 43. Mary Ann Toots Zynsky, Bowl. *(1987). Fused glass fibres. 17,5 x 17,5 x 30 cm.*

All the ancient glassmakers worked with colour. They must have known that by adding certain substances to the raw material, coloured glass could be produced, and that by varying the furnace conditions many additional colours could be obtained from basic substances. Without a deeper scientific knowledge, they were unable to control the colour with the same accuracy as today's chemists. Iron oxide was used to make green glass, manganese compounds produced purple Egyptian glass while antimony created white glass and was used for the outer casing of the Portland vase. The brilliantly glowing opaque yellow obtained by the Egyptians has rarely been surpassed even by artists such as Tiffany. The most likely source was antimoniate of lead which would have been imported from Assyria. Cobalt was used for all blue colouring. Copper produced turquoise, pale blue, green, ruby red or dark red depending on the furnace temperatures.

Today, chemists know the theoretical principles governing the development of colours and can achieve consistent and varied colours. Two basic factors affect the colouring power of substances; firstly the nature of the atoms and secondly the action of chemical and electrical forces. In glass colourants only inorganic substances are affected, thus the nature of the atom is the more important factor. The various materials which give colour can themselves be colourless or intensely coloured depending on how many links are available for combining them with other atoms (their state of valency). Thus a clear demarcation line between colouring and colourless substances cannot be made. Certain compounds which contain an element with more than one valency give more intensive colours when this element is in its lower state of valency, while other elements can give the opposite result. Dominick Labino, who in the early 1960s invented the studio furnace, was fascinated by the chemistry of colour, and worked systematically for years on the development of colour formulae for the glass artist. As sources for premixed glass batches and colourants became unobtainable in the late 1970s, and glass objects made from poorly formulated glass mixtures began to deteriorate Labino - with his vast chemical knowledge - was able to give valuable help to experimenting glass artists.

In the last few decades there have been technological advances in the development and production of coloured tubes and rods of varying richness and tones. Initially rods and tubes were made from a clear borosilicate glass which was used to make scientific apparatus. These tubes and rods are used by artists today when working with oxy-propane torches, using a process which is known as lampworking or flameworking. Objects are produced by softening and fusing glass tubes or canes in the direct heat of a flame. Lampworking is a term which comes from the early use of a lamp fuelled with oil. The heat of the lamp was increased by air which was pumped through a pointed tube connected to a bellows operated by a foot treadle. Many early objects and beads show evidence of lampworking. Fine details were achieved by the intense localised heating of glass with the lamp which was quite separate from the furnace. During the Industrial Revolution lampworkers made objects called whimsies or friggers. These were often full-rigged ships, musical instruments or birds on perches with spunglass tailfeathers. Between 1886 and 1936 glass flowers, botanically accurate in every detail, made using the lampwork process, were created by Leopold Blaschka and his son Rudolf for the Botanical Museum of Harvard University. Equally accurate and incredibly delicate are the enlarged glass models of primitive microscopic protozoa made in 1915 by Herman O. Mueller and his father for the American Museum of Natural History.

In 1845 the Venetian artists created the paperweight when they discovered that if they flattened the base of a glass ball it would rest without rolling. Millefiori or lampworked objects were added to the interior. The French factories of Baccarat, Saint-Louis and Clichy made paperweights famous between 1845 and 1858 (fig. 44). The most common style contained short sections of millefiori

Fig. 44. French paperweights from the Saint-Louis, Baccarat and Clichy factories. (1845-1858). Flameworked glass.

canes arranged in various patterns and set in glass, an idea which originated with the mosaic glass of pre-Roman times. The magnifying dome enhanced the kaleidoscopic effect.

Paul J. Stankard (born 1943) makes paperweights using the lampworking process.[12] For five years he experimented with making paperweights which contained softly coloured American wild flowers. Stankard works with oxy-propane torches, an annealing oven and a heating furnace. His materials consist of coloured glass rods and tubes in various lengths and diameters. He approaches his lampworking techniques as a painter, aware of the details but also aware of what to eliminate and what to emphasize to suggest the overall character of the flower and plant. During 1977 he produced a series of limited edition paperweights for the Smithsonian Institution and another for the Art Institute of Chicago. After research and experiment he developed a new technique. The internal forms of the paperweight had always been viewed from above. Stankard placed the whole plant in its environment including the roots and the earth in which they grow (figs. 45 45a). He studied illustrations in medieval books on herbs and added 'root people' to his paperweights. To accommodate these forms Stankard changed the shape of the traditionally round paperweight to a thin elongated form. His paperweights give a full-length, vertical view of a plant encased in a column of clear, sometimes deeply coloured glass. His is a difficult process which involves laminating three pieces of glass together which contain the lampworked flowers. In 1986 Stankard broke another lampworking tradition by holding a paperweight demonstration and workshop for forty students and artists at the Penland School of Crafts. In this audience were two makers of traditional paperweights who had refused to reveal the secrets of their techniques to Stankard but Stankard demonstrated every stage of his process of laminating glass to form paperweights.

Fig. 45. Paul Stankard, flameworked glass, detail of process.

Fig. 45a. Paul Stankard, Indian pipe flower and spirits. (1987). Encased flamework, height 19 cm.

Fusing, slumping or laminating glass are processes of working with 'warm glass', while the processes of lampworking/flameworking and blowing glass from a furnace are known as working with 'hot' glass. ' Hot' glass is also used in the work of Bertil Vallien when objects are sandcast, using molten glass from the furnace. A 'cold' method of working with glass is stained glass. Its history goes back almost as far as the making of glass itself. Thousands of years ago small fragments of glass in various colours were used to build pictures or designs. As architecture developed, patterns or designs were used for the rooms in which people lived and the objects they used. During the Byzantine period glass mosaic work became a dominating feature used to inspire the faithful. Later the stained glass window of Gothic architecture became as significant a part of the interior decoration as mosaic had been in the Byzantine church. Light flooded into the interior of the cathedrals through richly coloured stained glass windows, creating an atmosphere of spirituality which heightened the ethereal effect caused by the immense height and apparently weightless hovering vault. To the medieval mind light had the power to transform the soul. Abbe Suger, who had the abbey church of Saint-Denis rebuilt to his instructions, said that stained glass possessed the ability to transform 'that which is material to that which is immaterial' (Panofsky 1970:62). Gothic architects refined the system of thrust and counter-thrust and concentrated upon internal supports only at isolated points, reducing internal structures to the minimum to achieve even higher and more delicate buildings - 'to risk all to create the first and greatest architecture of glass' (Swaan 1969:48).

The process used for making stained glass has remained much the same for centuries. The materials and tools are for the most part developments of those used by medieval glaziers. According to the medieval monk, Theophilus, glass making was a secret art with closely guarded secrets in his time (c 1055-1100). However he gives accurate details of the techniques practiced in the twelfth century. He describes how glass was cast and other ingredients added at crucial moments, and discussed metallic compounds which were added during fusion to give the required colours.[13] Lead, in section like the letter H, was used to hold the glass together. Originally the sections were made by pouring molten lead over reeds laid in a container with tiny gaps between them. Each reed provided a hole through the lead sheet for a half section; later the leads were cast until in the seventeenth century the lead vise was introduced.

As flat glass became more widely used for window glazing, new methods of production were invented to meet the growing demand. Since 1900 the making of flat glass has undergone two major changes, resulting first from the invention of the drawing and rolling processes, and later of float glass. Drawing takes advantage of the treacly nature of glass at about 800°C - by drawing a ribbon of glass vertically from the melt, letting it cool and cutting it up into sheets. Rolling glass is a process whereby glass is flattened in between two rollers when it is in a treacly state. Rolling and drawing glass allowed patterns and textures to be pressed onto the glass during its manufacture. The invention of the float-glass process in the 1950s made all other methods of producing flat glass obsolete. In this technique the liquid glass is floated on a bed of molten tin, producing a polished flat underside almost as fine as the top surface.

There was a resurgence of interest in stained glass during the 1950s with advances in stained glass technology in Germany, France, England and the United States. Today, stained glass has moved away from religious traditions and is more often used in public and private buildings. Stained glass windows in churches are often one of the last architectural considerations - almost an afterthought.

Ecclesiastical stained glass commissions, therefore, are few and far between, and with few exceptions, are for 'safe', traditionally designed church windows.

Today many artists using stained glass do not come from a traditional glass working background but from a fine art background and use stained glass as an art form neither bound by the convention of materials or expression nor limited to the fenestration of a building. This has resulted in a very different approach to stained glass, indicating a new freedom and vitality. Artists are willing to use any additional materials to create rich and complex images. Glass tubing, neon, lasers, epoxy for the surrounds, three-dimensional objects, x-rays, photographs, silk-screen prints - are all used in the search for new expressions and concepts. In addition there is the exciting potential of holography in stained glass. Other processes and treatments of the glass are used, for example, slab glass, which is an inch thick is cut into approximate shapes using a tungsten steel-tipped hammer. The edges are faceted like a diamond to make them sparkle. These pieces are held together with concrete or resin-reinforced stone to form structures of considerable beauty and strength. Windows made this way let in a great deal of light.

The introduction of new colour effects and surface treatments in glass, including the coating of lead cames with colour or metals, air-brushing colour onto glass, the use of bevelling and mirrors, the ability to laminate stained glass allowing much larger areas to be free of intrusive supports, are all new and exciting processes which are available to the stained glass artist.

Today we are bombarded with new technologies, signs, advertisements, images, reproductions, flashing lights, noise and confusion. Artists of the 1960s investigated properties of light and space, using plate glass and mirrors (Larry Bell, Robert Morris), or in conjunction with the new technology of video, the glass screen of the television set (Nam June Paik), and neon. Neon lighting is one of the existing technical products which has been used as a raw material for art. It has been taken out of context as a sign and advertising medium and placed in an art gallery, challenging the viewer to see glass in another way. Dan Flavin makes neon-tube sculptures using either white or coloured standard tubes in a Minimalist form, showing a parody of reductivist aims not unlike Duchamp's readymades.

The actual technique of neon is based on the principle that electricity flows through inert, or rare, gases (such as neon or argon) at a low pressure, causing them to glow.[14] Neon tubing can be heated and worked over a flame, adding light and colour to sculptural forms. Neon has a red to orange range and argon is a whitish blue. The addition of mercury increases the intensity of these basic colours. Brighter colours can be obtained by adding fluorescent powder to the neon and argon, and the glass tubing can also be coloured so that hues of green, purple and navy blue are obtained.

Early in his career Dale Chihuly worked with neon. At this stage he could only blow clear glass and colour was obtained by spraying the objects with lacquer paint or by filling the glass with electrified neon. Chihuly's interest in neon 'stemmed from a desire to animate the glass, to move from solid, sculptural statements to more energised environments that invited human participation and response' (Nordon 1992:26) The use of neon and argon increased the range and intensity of colours he could use, adding greatly to the expressive potential of his work. In 1971 Chihuly and James Carpenter combined neon and ice to form *20,000 Pounds of Ice*[15] (fig. 46). To make this installation they placed U-shaped neon tubes in about sixty moulds filled with water with electrodes above the tops of the moulds. The water expanded and froze into 140kg blocks of ice. This work was initially installed at an ice manufacturer close to where Chihuly and Carpenter had a studio, and was re-created as a

Fig. 46. Dale Chihuly and James Carpenter, 20,000 Pounds of ice. *(1971). Neon and ice, 56 m^2.*

corridor of ice at the entrance of the Rhode Island School of Design Art Gallery, and later at the opening of the Seattle Art Museum's 1992 exhibition.

In 1968 the Toledo Museum of Art began an annual survey of contemporary art glass. In 1970 when Chihuly and Carpenter were invited to exhibit works, they submitted large 'botanical' pieces, which combined glass, neon and argon (fig. 46a). These works were the first pieces of glass art to combine technical and creative issues; the pieces were very large, and used neon as an art form. They placed Chihuly and Carpenter in the forefront of the studio glass movement and gave glass validity as an art medium in the fine art world by shifting glass from functional object to sculpture.

Peter Freeman (s.a.) of Britain uses a wide diameter glass tube which spreads the light over a wider area and creates a soft effect. He bends the tubing over a flame into curved sculptural shapes. Delicate multicoloured internal patterns are achieved by painting a liquid binder to the inside of the tube and then pouring fluorescent powders through the tube so that they adhere to the binder. The effect is quite different from the harsh advertising slogans that make up our normal consciousness of neon. Paul Seide (born 1949) uses the neon tube as a three-dimensional sculptural drawing (fig. 47), using blown neon forms activated by radio waves. These artists use the internal light of the neon tube as a colour source and focus primarily on harnessing the aesthetic potential of modern glass technology.

'Hot', 'warm' or 'cold' processes are all used by glass artists today to make sculptural images and forms. All the ancient methods of forming glass as well as modern technologies are explored, exploited and adapted by artists using glass for their sculptural forms to fulfil their conceptual and

Fig. 46a. Dale Chihuly and James Carpenter, Installation view, Toledo Glass National III. (1970). Glass, neon and argon, 76 cm.

Fig. 47. Paul Seide, Frosted radio light from the spiral series. *(1986). Blown, manipulated; charged with neon and mercury vapour from a transmitted radio field, 48,4 x 53,5 cm.*

technical concerns. After the Toledo workshops and the invention of the studio furnace, the 1960s were years of immense energy, growth, discovery, exploration and experimentation. Stylistically, the output of this time was closely related to contemporary ceramics. Technical knowledge, glassworking courses (largely still unavailable in South Africa) became readily available overseas. Different types of mould material became available, new silicone adhesives allowed glass components to be bonded in different ways, and equipment to cut, polish, grind, sandblast and sandcast was available. Premixed concentrated colourants and various qualities of pâte de verre glass could be readily obtained. Armed with all this equipment and skill, the exploration of ways to form glass continued, but less out of a sense of curiosity than in a search for specific visual effects. There was an increased awareness of the expressive potential of glass which attracted a new group of artists from other media looking for different ways to manifest their ideas. Sculpture began to reflect the role of glass as just one of the many media available to artists.

In America Peter Voulkos (born 1924) had experimented with the idea of the nonfunctional clay vessel as a starting point for sculptural forms. He and Erwin Eisch in Germany made a similar move possible in glass. The influence of Pop Art and its ceramic offshoot Funk Art, plus a similarity between Op art patterning and the intricacy of the Italian millefiori paperweight technique is seen in the work of Richard Marquis (s.a.). With skills acquired when he studied glass techniques at the Venini factory in Venice, Marquis produces eccentrically shaped and decorated vessels. These objects show the confluence of Funk sensibility and the craftsman's ethic. Though much Funk art is deliberately crude, much of it maintains an astonishing degree of technical proficiency even when it mocks the serious tone of most conventional art and craft. Process is not an end in itself, but rather a means of demonstrating the Funk artist's responsiveness to materials and their expressive potential. Marquis's non-functional vessels indicate that he is a master of the latticino, ritorte, reticello and murrini techniques while simultaneously subverting these techniques to the Funk sensibility. Blown, cast, slumped and lampworked glass is combined with found objects (figs. 48 48a). Toy cars, cheap mementos, electronic vacuum tubes - the flotsam of kitsch at which Modernism would take offence - are added to the surface of his vessels. A sense of tension is created between the beauty of the glass and the comical tackiness of the found objects. Although Marquis feels that this bizarre combination is one way of questioning the inherent beauty of the glass and a way of getting rid of the preciousness of the traditional techniques and of the material, the glass is never anonymous, and can never be treated as though it could be any other material.

In the sculptures of Dan Dailey (born 1947), the choice of glass seems to have hampered rather than aided his creativity. His early blown glass forms reflected his interest in glass and the influence of Dale Chihuly, but his more recent work of humorous caricatures in ever increasing sizes and thematic variations depicting everyday scenes of contemporary life with a 'campy' sense of humour could have been made of any material and make no use of the intrinsic properties of glass in establishing their identities. Many of these works are life size, and are comprised of pieces of coloured flat glass, metals and other materials executed in variations of stained glass techniques. *The Slip*[16] (fig. 49) which is nearly life size (91x183 cm), with its flat colour and crisp dispassionate images could just as effectively been made of plastic. These works remind one that self-conscious art-historical modernism is not absent from the glass world.

Christopher Wilmarth (born 1943) uses glass for specific effects. Wilmarth combines glass and steel in abstract geometric forms. He has devised a process of etching and painting the glass with

Fig. 48. Richard Marquis, Grey rock. (1986). Blown glass, millefiore decoration and mixed media, diam. 58 cm.

Fig. 48a. Richard Marquis, Wizards. (1985). Blown glass, murrhine (or murrine) technique, height 66 cm.

Fig. 49. Dan Dailey, The slip. (1982). Wall relief panel, plate glass, vitrolite glass, brass, aluminium frame, 91 x 183 cm.

hydrofluoric acid which brings out its inherent turquoise/sea green colour, enriches the surface quality and also gives him a control over the degree of transparency of the glass. The combination of the rugged solid surface of the steel and the translucent, softly coloured glass gives the effect of light and shadow. Steel plates are placed at an angle to the glass which intensifies the colour of the glass.[17] By adjusting the angle he is able to regulate the passage of light through the glass to achieve the degree of translucency he desires. In many ways his images refer to Rothko's floating rectangles particularly when the painterly etched glass is placed directly in front of the steel forms, and in this way the hard edges of the works are blurred (fig. 50). His works evoke the land and the sea and the light on water - misty and diffused. Wilmarth has stated that he does not use glass for its own sake but for its ability to generate different light experiences

> ... Glass is only a vehicle, the medium is light. If I could use another material to come to the images and feelings I want to express, I would, because glass is not an easy material to deal with. I use glass because it got me closest to those qualities and characteristics of light that I felt evoked what I wanted to say (Wilmarth 1985:73).

Wilmarth's sculptures concern themselves neither with glass as such, nor with the glassmaking process. Instead, glass forms one component immersed in a larger whole.

Howard Ben Tré (born 1949) uses ordinary window glass to cast his sculptures, and has proved that glass is a suitable material for monumental work as well as for the smallest sculptures. His sculptures also show that glass is as viable and varied a material as bronze or other materials which have been tried and tested for much longer (fig. 51). His large works are sandcast in a factory in Brooklyn, in America. Initially the form is made out of a flexible plastic similar to Styrofoam. A chemically treated sand compound which hardens after one or two hours is packed around this form. When the sand compound has hardened, the Styrofoam is removed using special tools, leaving the sand mould, which could weigh between 180 and 230 kg. Molten glass is ladled into the mould and placed in an annealing oven which uses computer technology to gradually lower the temperature of the glass to normal room temperature. Six weeks later the glass is ready to be removed from the mould which gradually disintegrates. Sandblasting removes any remaining sand. The piece is then ground and polished. The size of his pieces vary from table top size to monumental forms and garden furniture. He has made highly unusual benches based on classical Etruscan forms and made of solid glass (fig. 51a), cast much like bronze sculpture. Each bench consists of three pieces; a seating slab and two side supports, joined and supported structurally by a copper frame. While the benches appear thick and massive, the image is softened by light which penetrates but does not pass through the glass, making the benches glow with a rich blue-green light. Danny Lane (s.a.) produces furniture made from layers of stacked sheet glass (fig. 52). His furniture uses the emotive quality and the danger inherent in broken glass. Chairs and tables look jagged and dangerous, but are in fact polished smooth. His sculptural furniture is decorative, practical and evocative.

In the early stages of the studio glass movement, glassblowing was the process which fulfilled the sense of urgency, immediacy and excitement of a 'new' artistic medium. Today glassblowing is just one of the many processes available to artists. Blown, laminated, fused and glued glass and combined with photosensitive glass, neon and other mixed media are combined for different conceptual effects, indicating that glassmaking processes can enjoy the same conceptual freedom as other artistic materials and that the wider the technical base, the richer the range of expression.

Fig. 50. Christopher Wilmarth, Clearing I. *(1973). Etched glass and steel, height 203 cm.*

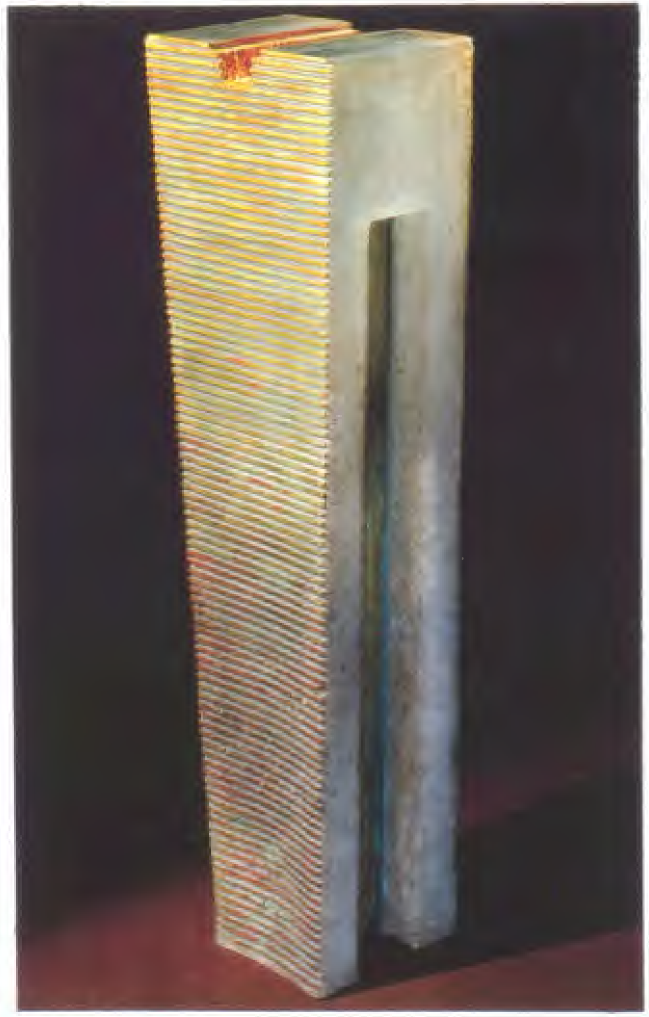

Fig. 51. Howard Ben Tré, Dedicant #8. *(1987). Glass form cast in sand mould, sandblasted, cut, ground, guilded lead and brass details, 35,5 cm.*

Fig. 51a. Howard Ben Tré, Garden benches *(c 1985). Cast glass and copper.*

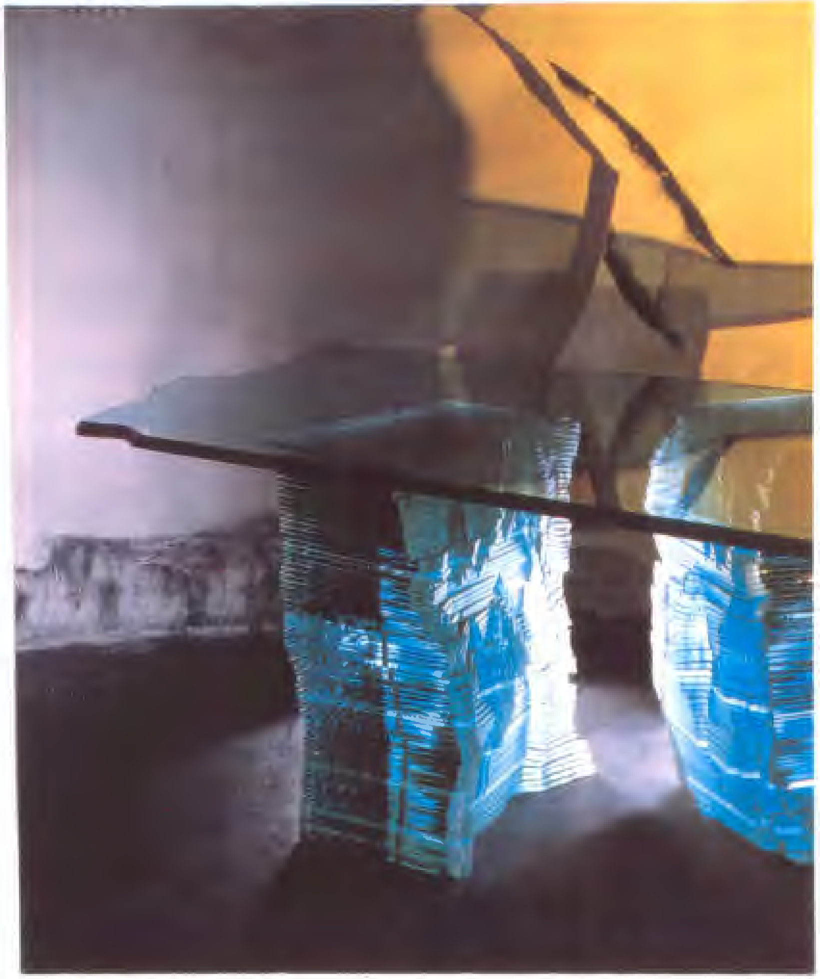

Fig. 52. Danny Lane, Stacked table. *(1985). 70 sheets of 10 mm of laminated and glued float glass.*

NOTES

1 Born in Tacoma, Washington, Dale Chihuly attended Harvey Littleton's pioneer graduate glass programme at the University of Wisconsin and graduated from the Rhode Island School of Design with a deep interest in architecture and glass. He was influenced by Minimalism, site-specific sculpture and process art.

2 Pilchuck is situated fifty miles north of Seattle, in the foothills of the Cascade Mountains. It is, today, the most important glass forming school in the world, with a 1992 budget of $1,2 million, and a summer school involving 250 students, 50 teaching assistants, 30 faculty members, 10 artists in residence, and 10 master glassblowers. Pilchuck has highly sophisticated technical resources and offers a large variety of glass making techniques including glassblowing, painting, sandcasting, engraving etc. Instruction continues on a round-the-clock basis, when students can watch the work of international artists or attend workshops; make or blow glass using any of the techniques available; take part in discussions or watch films or videos showing the work of other glass artists.

3 Born in Stockholm, Sweden in 1938, Bertil Vallien studied glass design and ceramics at the National College of Art and Design in Stockholm from 1957 to 1961. On graduating he was awarded the Royal Stipend, established by King Gustav Adolf VI, which enabled him to travel and to study in Mexico and the United States. In America he was exposed to the influence of Voulkos and Funk art. Vallien, whose Swedish training had been both formal and traditional was strongly affected by the sheer bravado, sense of rebellion and free spirit of the American glass artists.

4 Doreen Hemp, *Whisper Wreck*. (1995). Sandmould, 44cm. Collection: the artist

5 The Factory Inspection Control in Germany forbade women to work at the glass furnace. This so-called safety law was passed during the Nazi regime and was only revoked in 1976.

6 From the beginning of the studio glass movement, some of the most powerful artists have been women. They have been involved in this movement since the early 1950s, when women numbered seven out of the eighteen students at the Toledo workshops.

7 It is interesting to note that at the turn of the century women worked in glass factories doing a variety of jobs requiring both dexterity and physical strength. For example women in Belgium were used as cylinder carriers (*porteuses de canons*). They carried very large glass cylinders using a cord tied to their waists, around the cylinder and tied around their wrists.

8 Concentrated research by Daum Cristallerie in Nancy, France, has resulted in a secret process of making pâte de verre which enables exact copies of the artists original work to be

reproduced. Jacques Daum recalls: 'Since 1968 we have been using a new process for the manufacture of pâte de verre, a modern process to replace the former, [which was too unpredictable in its results]. We wanted to create contemporary sculpture through the lost art of wax moulds. We had to convince one of the greatest artists of our time ... Dali. Pâte de verre is a Dalinien substance. Therefore I have used it to create these works of art. I am delighted with this new substance which has the molecular elasticity of a snail and, at the same time solidity of the Gare de Perpignan' (Daum 1992:32).

9 Doreen Hemp, *Silent Wreck.* (1995). Laminated window/soda glass with copper wire, 7 x 44 x11 cm. Collection: the artist.

10 'The mosaic process was attractive to me because of the exactness I was able to produce. When you look at the blown glass of the 1970s, 60% of the results were produced by the artist and 40% happened by chance. With mosaic glass, you eliminate the chance. Also, the glassblowing process usually involves other people; it's a collaborative way of working. When you do mosaic work or any kilnforming techniques, you are on your own. It's a question of temperament. I'm not a team worker when it comes to artwork' (McGregor 1992:5).

11 Mary Ann Toots Zynsky comes from a fine art background. She graduated from the Rhode Island School of Art, where she was influenced by Dale Chihuly. During 1971 and 1973 she collaborated with Dale Chihuly to establish Pilchuck. She completed a research project with the Ghanaian Ministry of Culture and the Institute of African Studies in 1984-5. She is a former director of the hot glass programme at the New York Experimental Glass Workshop, and a recipient of two National Endowment for the Arts Fellowships and a research grant from the Stichting Klankshap Foundation in the Netherlands.

12 Paul J. Stankard had a rigorous training as a glassblower and then worked for several companies producing optical glass, laboratory glass and scientific instruments.

13 A cartoon for the glass design was drawn up and marked to indicate the various shapes to be used. The glass was then cut, using a tool known as a 'grozing iron', which was a flat piece of iron with a notch at one end, rather like a modern spanner. The grozing iron was used until about 1500 when the modern method of diamond cutting was introduced. Details were then painted onto the pieces of glass. At first the use of paint for these details was confined to an opaque brown (grisaille) and used not as colour but as a means of outlining the design or giving fine details to the glass. Pigment consisted of powdered glass mixed with iron oxide and gum to make the mixture adhere to the surface of the glass. If highlights were required, the whole surface was covered with a wash of oxide and lines were scratched through with a pointed stick. The glass was then fired in a kiln.

Stained glass windows are still made and coloured in the same way they have been for centuries. The glass is coloured by adding different metallic oxides to the basic mixture;

the pieces of coloured glass are then joined with lead cames, or rods, and soldered together. Flat glass was first made by casting a piece of glass in a flat mould. With the invention of the blowing iron, a bubble of glass was transferred to a solid iron rod and reheated and rotated at a high speed to create a large flat disc in which concentric circles were formed. The flat plate was then cracked off the iron leaving a thick whirl of glass in the centre. This centre knob was thought to be inferior in quality to the remainder of the glass.

14 Fluorescent lamps have been commercially available for over 50 years. The method of construction makes it very adaptable to mass production techniques and consequently is relatively cheap. Its performance in terms of its high conversion of electrical power to light, its flexibility in size, its colour rendering properties, together with its low surface brightness have made it a useful and important light source.

15 Dale Chihuly and James Carpenter, *20,000 Pounds of Ice*. (1971). Neon and ice, 56 m^2. Rhode Island School of Design. (Sims 1992:39).

16 Dan Dailey, *The Slip*. (1982). Wall relief panel, plate glass, vitrolite glass, brass, aluminium frame, 91 x 183 cm. (Gardner 1983:186).

17 Poirier states: 'Coupled with the coldness and impenetrable surface feeling of the steel, the glass resonates with an almost magical presence reminiscent of the most compelling medieval stained glass windows. The dialogue in which the two materials engage - steel with its ruggedness and permanence, glass with its transparency and vulnerability - transforms their individual voices into a single, unique metaphorical language' (1985:68).

CHAPTER 4

MY WORK: SOME TECHNICAL AND CONCEPTUAL ISSUES

> There is nothing more certain than that we live within a round game of images. Between the word and the echo, the look and the looking-glass, subconscious and conscience [sic], between our appeals and the responses, the involuntary and the intentional, we advance through a maze in which we devour ourselves... By this I mean that in it we wear out time. Prisoners in a glassed-in passage, in which the walls evaporate and the windows break, we think ourselves free, only to find ourselves alone, captives of a desert (Seghers 1972:185).

Glass and photography have provided technical and creative challenges for me over the past two decades. I have been particularly influenced by the Namibian desert mirages[1] (fig. 53); the rusty, slowly-disintegrating wrecks[2] which lie on the wind-swept desolate beaches of the Skeleton Coast[3] (fig. 54); the deserted sand-filled ghost houses of Elizabeth Bay and Kolmanskop[4] (fig 55), and archaeology, in particular an ancient cedar boat discovered at the base of the Great Pyramid at Giza.[5] (fig. 56). From these images I have taken the boat and house forms that constitute my glass sculptures, and through these forms I have created images which tell of the frailty and ephemerality of life.

Initially the emphasis of my research was on the historical use of glass and on discovering how to manipulate the different glass processes to give me the forms, concepts, images and effects I needed. Although the rigid classification of the 1950s had largely broken down and the key characteristics delimiting craft namely, female, utilitarian, medium-specific, hand-worked, and decorative no longer described a particular body of work, working with glass - previously designated

Fig. 53. Black granite inselbergs float in the shimmering glimmer of a mirage.

Fig. 54. Wreck on Namibian Skeleton Coast .

Fig. 55. Kolmanskop.

Fig. 56. The boat that journeyed through time ... reconstructed ancient cedar boat.

as a craft material - in a post structural, post-modern, untraditional, fine art context I found that I was challenging many of the paradigms. I defined boundaries with the creation and use of two fairly simple forms - the house and the boat: both possess rich references and allusions, some of which became clearer as I worked with them and found a language to release meanings. I worked entirely on my own in my studio. Although the technical problems of working with glass were, and often still are, formidable and have placed limitations on me which were different from any other material I had ever used, glass presented challenges which continue to intrigue and fascinate me. Glass has its own life, its own reality and its own set of rules which I needed to address. There has been a slow maturation process in the objects I create and the processes used to create them. In many respects these are similar to the archaeologists' slow and meticulous methods of unearthing vestiges of the past.

Initially, I reacted to the lure of the unknown, suggested in the brittleness and transparency of glass, but ultimately hidden meanings have asserted themselves from the depths of my subconscious, and as my research progressed I became more and more aware of the appropriateness of the combination of the chosen forms, photographic image and glass. Material, image and forms began to speak the same metaphorical language, and in many ways I worked in the space between two realities and two civilizations - my own and the past. Muffin Stevens wrote in a review, 'It is interesting to see, in the glass sculptures of Doreen Hemp, how the material, coinciding with the image it represents, can become meaningful. Her *Shipwreck*[8] depicts the bare bones of a boat, tilted as if lying long on the sand, while the grainy, crystalline quality of the glass suggests that the wreck itself had, over time, turned to salt' (Stevens 1995:3) (fig. 57a). The boat and house images became vehicles for dualities, ambiguities and seeming paradoxes because of their ancient lineage and simultaneous multiple associations they have had across civilizations through the millenia. Both

Fig. 57a. Doreen Hemp, Shipwreck. (1993). Sandcast glass, 42 cm.

forms seem to represent superficially a secure, comfortable, isolated, self contained world but from these single images there are a whole range of human complexities and contradictions.

The inherent qualities of glass - brittleness, fragility, transparency - are used in my sculptures to portray wreckage and survival, loss and preservation, impermanence and sustenance, the ephemerality and strength of nature, society and culture. Glass also speaks of transparency/opacity, inside/outside, conscious/unconscious, actuality/illusion. A transparent glass boat alludes to water - is it part of the sea, what is sea and what is boat, is the boat there at all, is the house filled with water, are the forms trapped or protected inside? This elusive quality seen in a transparent boat form is found in the mirages of the Namibian desert, where shimmering sheets of water in the dry arid desert are 'real' enough to be photographed, but retain an elusive distance from the viewer, only to recede and disappear altogether as one gets closer. Glass is transparent and at times does not exist visually, there is nothing for the eye to hold or focus on, and the colour and inclusions become illusive, floating in a non-visible material. In addition glass is a liquid - an ambiguous reminder that things aren't what they appear to be.

The ark or boat is a symbol of safety, sacredness and salvation. The boat is perceived as a universal symbol of transition, a container of safety which passes imperceptibly from the mundane to the elevated, but is exposed to risks and uncertainties at every turn, from violent weather to danger, sinking and drowning. Boats take on the significance of mythic artifacts - the Egyptians believed that the sun is the radiant persona of the god Ra, who rides in a solar boat through the heavens and beneath the earth at night. The soul passes from this world to the next in a boat. The image of the sunken ship and the skeletal remains are symbols of destiny and mortality; the sunken ship as the antithesis of a sailing floating ship; the boat as a vehicle for transcending existence metaphorically. Brittle, fragile glass boats tell of rites of passage through life and death. For me, no other material could have so adequately expressed the fragility of life, isolation, loneliness and alienation; concepts which are made visible in small broken minimalist forms exhibited in a large unlit space.

In using the sandcasting process I have roughened and encrusted the glass surface, imparting the patina of age, and associations are made to mythology, history and alchemy. I have embedded various forms into the glass which create a visual stratum that alludes to the archaeologic. Glass is easily broken and expendable, and yet it has for centuries mirrored the societies that made it; glass objects which have survived for centuries have given archaeologists their greatest clues to civilizations long vanished.

The house, in real and philosophical terms, represents a symbolic container for body and soul; the outside walls are protection for the treasures inside. The house is a container that speaks of power, possession, of being imprisoned/protected, nurtured/suffocated, trapped/safe. Its significance moves between polarities. The photograph as well as the house and boat forms have shifting realities, and like glass itself, are full of ambiguities, ambivalences and contradictions, can carry many simultaneous messages, and have undertones of illusiveness. They have no fixed meaning but are invested with meanings by the viewer who interprets them from different perspectives. The possibility of multiple meanings is potentially a stimulus to creative thought and increased understanding. Glowen (1991:15) states, 'Glass - as product, element, form and phenomenon - is a fundamental vehicle for signification and meaning in contemporary art and life. The house of art is made from glass.'

The ambiguity and fluidity of the symbolism in both the forms and the material, as well as the lack of fixed signification between signifier and signified place them in a post-structural framework. This framework embraces ambiguity and illusiveness and in transcending or subverting conventional definitions indicates the potential of enhanced perception and greater insight. Implicit in this consciousness is a reflexive awareness that meaning is constructed subjectively, and that the process of constructing meaning adds another dimension to the interpreted object. Hodder (1990;50) says, 'Style is really process masquerading as thing. The creation of style may attempt to 'fix' meanings in space and time. But in the interpretive process there is a necessary ambiguity'.

Light is a transformative device in glass as well as in photography - in dim light my objects look dead - like the back of stained glass windows. In ambient light there is a rainbow quality in glass shards, when spotlighted the total form becomes emphatic and dramatic. It became obvious to me that glass sculpture embodies the concept of change, depending as it does on the source of light. This can be controlled or left to chance in the installation. The boat form, when suspended and lit from above floats in space on an invisible sea and casts reflected light and shapes onto the surface below, extending and enriching the space. Lifted by light yet anchored by weight, the form silently speaks of wreckage and survival, contemplative ritual function, and as a metaphor of time. *Shipwreck* (fig. 57b) is lit from behind and above. The form of the tilted, wrecked boat is mirrored in the shiny glass base and the weathered, eroded surface of the boat is reflected as the surface of wet translucence left on sand by retreating waves, while the sharp irregular edge of the boat forms a pattern of waves. *House of Darkness*[7] (fig. 58a) is lit only from below which increases the sense of darkness and mystery. (This work is illustrated but not exhibited as it was accepted and sent for final judging and exhibition in Japan at The International Exhibition of Glass, Kanazawa '95). In all of these works, the sandcast process and the sandblasted surface permit only a limited view of the core, which

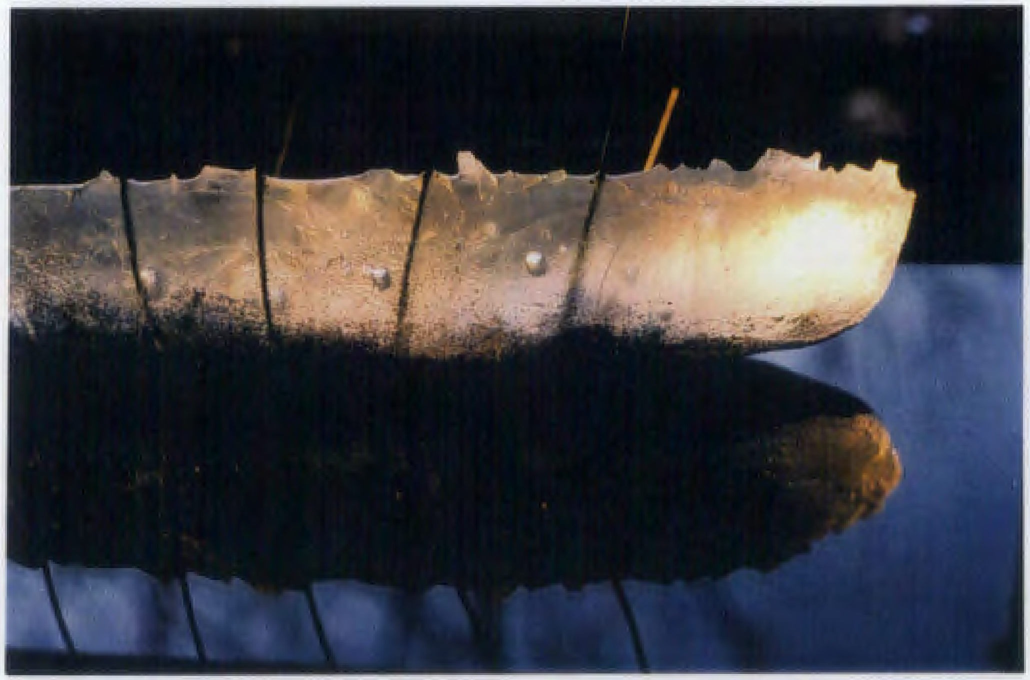

Fig. 57b. Doreen Hemp, Shipwreck. *(1993). Sandcast glass, 42 cm.*

Fig. 58a. Doreen Hemp, House of darkness. (1995). Sandcast and mould-cast glass forms, mixed media, 42 x 28 x 29 cm.

Fig. 58b. Doreen Hemp, House of darkness (detail). (1995). Sandcast and mould-cast glass forms, mixed media, 42 x 28 x 29 cm.

symbolically indicates the depth and the spiritual centre of the object, or serves as an analogy for the mind as a place of peace in the tumult of the physical world.

For the last two decades I have conducted numerous experiments with various types of glass. Initially my experiments were conducted to discover how to achieve effects, create textures, control the glass and to learn about the characteristics and qualities of glass. I laminated and fused many different types of glass together, placed anything and everything I could think of between them - steel wool, Vim, rusty pieces of metal, salt, aluminium foil, silver foil, boracic powder, chalk, ash, oxides, mica, copper sulphate, shells, bicarbonate of soda, leaves, sea weed, bones, graphite, glass beads, marbles, fibreglass strands, wire etc; - and fused them together in my small ceramic kiln, firing them at different temperatures, ranging from 500°C to 1000°C. Not all combinations of glasses or objects were successful.

Some substances, when laminated between the pieces of glass, caused the glass to blow up and burst (bicarbonate of soda and chrome oxide) other objects simply disappeared (leaves and aluminium foil) while chalk, oil and mica produced bubbles in the glass; lead from wine bottles turned a chrome yellow when laminated and cleared the surrounding glass; copper foil with a sprinkling of copper chromate bled a turquoise-pink into the surrounding glass. Temperatures of between 400°C and 600°C were tried for the annealing of different glasses of varying thicknesses. An approximate temperature of 540°C is now used with time periods varying between two hours and a week for annealing objects, depending on the thickness of the glass. To get a specific surface on the glass, such as the surface which showed the wet translucence left on sand by retreating waves, I did many experiments into the process of pâte de verre followed by experiments and research into the use of cast glass. I used sand in the moulds, or sandcast the glass which gave it the dull, sandy, rough quality which I wanted. Sandblasting the glass in specific areas gave me another surface quality. I still experiment continuously and although many pieces fail, I have lost any feelings of 'preciousness' towards objects which I make. The memory of one successful piece dulls the pain of the disasters, breakages and shattered pieces. When pieces fail I, like Diana Hobson and every other artist who works with glass, look for yet another reason why, but when the glass works it is the most rewarding material with which I have ever been involved. The many experiments have proved to be invaluable as my ideas and concepts of the actual sculptural objects have become clearer. When I work with glass, I work with heat, gravity, danger and taking risks.

Although the scale of the glass objects is limited by the size of my equipment, I find the small intimate forms conceptually acceptable as this restricted physical scale compels close intense viewing.

Various processes have been used in forming my boat and house images. Different types of glass have been used in the casting of the boat and house forms. These glasses include optical glass in the form of reject lenses. This is a very pure, clear glass - the deep green glass is from the lenses used for Ray-ban sunglasses. The pale turquoise glass and light green glass are both soda glass from Italian wine bottles, and were used when absolute clarity was not needed. In *SS Namaqua*[8] (fig. 59) layers of clear window or soda glass were cut into shapes and laminated together with copper wire between the layers. When stacked together the layers form a single image with defined edges layered and fitted with distressed glass fragments. In *Hollow, broken boat*[9] (fig. 60) two pieces of shaped, flat glass with different glass colours and copper wire added between the layers, were fused over a mould. Fractured and joined, slumped and disfigured, the forms are braced and pinned by

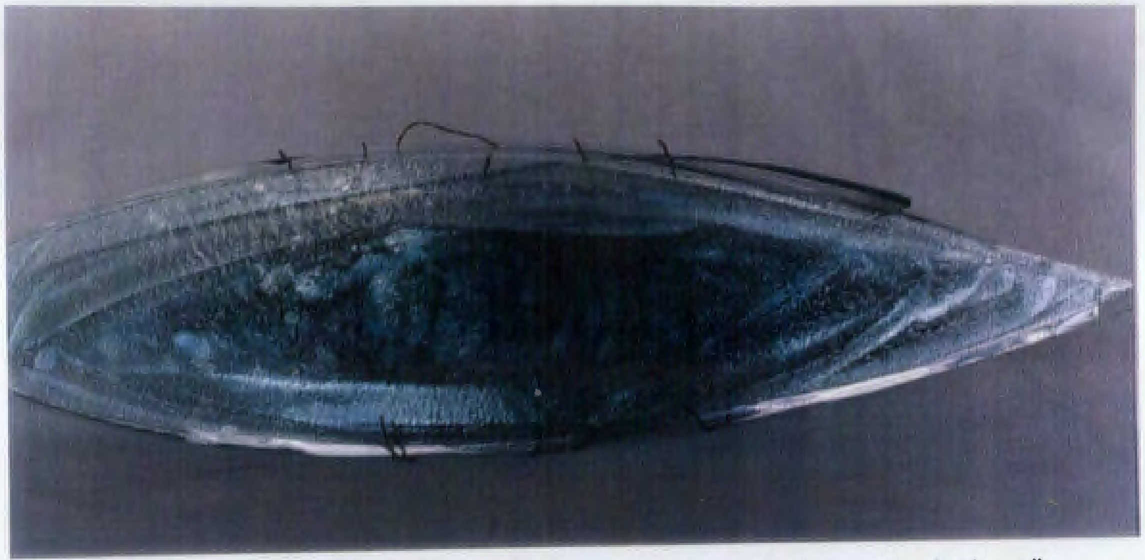

Fig. 59. Doreen Hemp, SS Namaqua. (1995). Laminated soda glass and mixed media, 41 cm.

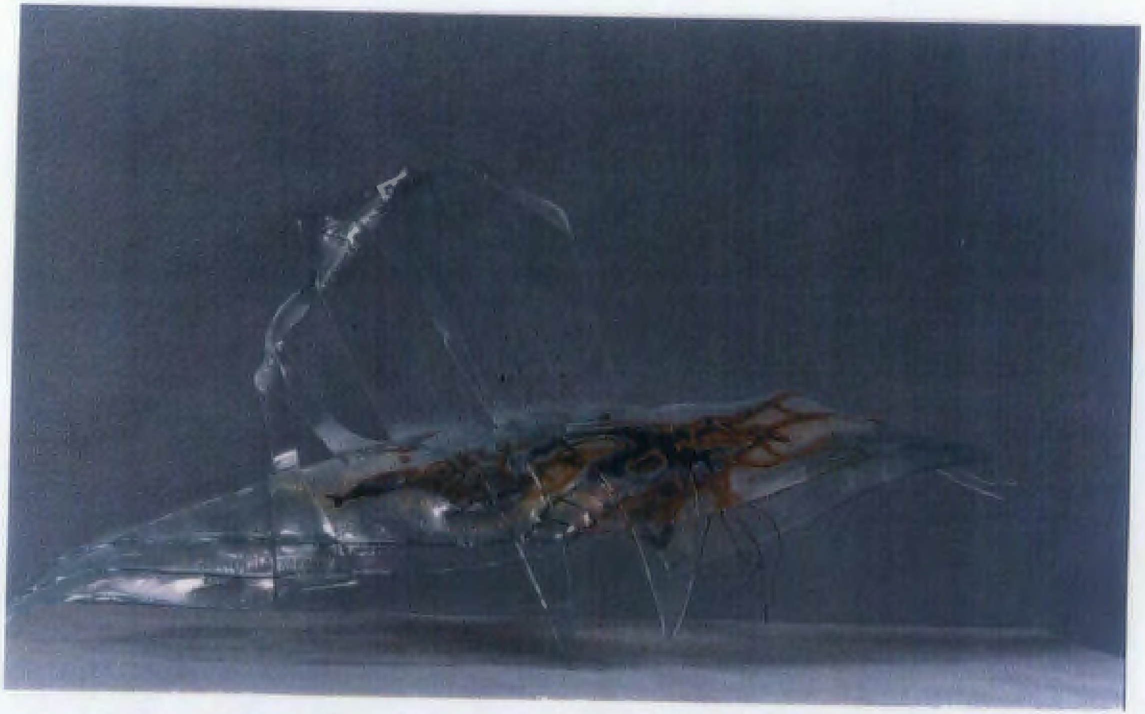

Fig. 60. Doreen Hemp, Hollow, broken boat. (1995). Slumped glass form, mixed media, 41,7 cm.

metal components. The figures in the forms were cut from copper or brass foil with copper sulphate which bled a coral colour into the glass. All of my sculptures include mixed-media; found objects, mainly rusty pieces of metal, copper wire, lead foil and clay.

In *Shipwreck*, I made a mould in the shape of a simple boat, and pressed rods of nichrome wire, in the form of ribs, into the form. The mould form was allowed to dry out completely, and fired to 920°C in a ceramic kiln in my studio. While still hot, I brushed the surface with a mould release and sprinkled a combination of river sand, fairly fine mica flakes and compatible glass powder onto certain parts of the surface, and allowed the form to cool. Clear optical glass of varying sizes was placed in the boat form; in the sections where I wanted bubbles I broke the glass into fairly small pieces and where I wanted clear glass, I used large pieces of glass. In this work only a few pieces of rusty metal were placed inbetween the pieces of glass, in other boat forms many more pieces of metal, wire, copper foil and additional found objects were used. The form containing the glass was placed in the centre of the kiln and slowly fired to 900°C. The kiln was then turned off and wearing didyium glasses and gloves, I opened the kiln door to check the quality of the red-hot glass. As the surface was rough, and not smooth enough, the kiln door was closed and the glass heated to a higher temperature. When satisfied with the surface of the glass, I turned the kiln off and allowed the temperature to drop to 600°C. The control was turned to 'ON', a setting which was sufficient to maintain a constant temperature, and the work was annealed for 48 hours. The kiln was then turned off and allowed to cool to room temperature. After several hours, during which time the glass cools, the mould was broken and the glass form removed, polished and sandblasted.

Each stage of the process incorporates some degree of chance, and working with glass acknowledges chaos and control. The concepts and processes are carried out and the limits are set, then one has to let go while heat and fire take over. Treating the surface and choosing lighting and space restores the control. I need to control the glass processes to achieve certain effects but in others the chaos and faults are utilized and prized. Often pieces shatter during the process and even the ones that survive the fire and the kiln emerge with scars, needle points, cracks and fissures that then become part of the sculptures. *Broken Spine*[10] (fig. 61), which is a broken, fractured boat form held together with a strip of metal, relates to the fragility of our own spine and allows the viewer to see inside the boat form in a way which would not otherwise be possible. This work speaks more clearly of wreckage and brittleness than any controlled work I could possibly create. The jagged splinters of glass symbolize my personal experiences of pain and death.

Gallé said:

> All [my] calculations can be, and often are, disrupted by unforeseen causes; but the very hazards of a craft in which fire collaborates, violently and brutally, often serve me in the most fortuitous way.... to become for a moment a slave to matter in order to force it to express an idea, and to make nature play her game so that the final work may seem the result of a preconceived agreement between chance and genius: this is the kind of work that solicits all the spirit of invention, all the resources and all the skill of an artist. This, is indeed a seductive art! (Warmus 1984:1887).

Glasses have different coefficients of expansion and even glasses made by the same manufacturer, but of different colours, are not compatible, which results in the glass shattering or fracturing, sometimes hours or days after coming out of the kiln. I have used this unique phenomena of glass in the process of making the sculpture *Belleisle*[11] (fig. 62). In this sculpture I deliberately used glasses which are incompatible, so that I could achieve a shattered, broken and

Fig. 6l. Doreen Hemp, Broken spine. (1993). Cast glass, 31,6 cm.

Fig. 62. Doreen Hemp, Belleisle. (1995). Cast incompatible glass, 42.1 cm.

transitory boat form. In *Wrecked Journey*[12] (fig. 63), I exploited the same phenomenon, but instead of using glasses which were incompatible, I placed a bisque clay figure in the glass form; the clay and glass are not compatible and have different coefficients of expansion, and this form also shattered. While working with, and photographing glass in this way, I have discovered the beauty of the fragment - a shard of glass, a fragment of rusty metal, a piece of torn photograph, an isolated rib of a slowly disintegrating wreck, a single, fleeting recorded moment in time, the photograph of a microscopic section of a huge overwhelming desert landscape or a single bleached bone.

In the work *The Glassblower*[13] (fig. 64) I have negated the 'glassy' quality of the glass in most of the house and base forms and have left the bubble of blown glass as a contrast to the matt painted surface of the forms. The fragile blown bubble also contrasts with the solid pieces of glass held by the glassblower's assistant and the pieces of glass surrounding the glassblowers. *Oceanos*[14] (fig. 65), *Batavia*[15] (figs. 66 66a 66b), *Belleisle* (fig. 62) and *SS Namaqua* (fig. 59) all relate to actual wrecks or sunken ships. *Oceanos* has within the glass form indications of the debris which floats to the surface of the sea after the ship has sunk. Many of the works are exhibited on sand - the glass emerging out of the sand and disintegrating back to sand, the basic component of glass.

Initially my photographs were merely records to document the works. The fragility of the glass, the large number of failures and the tenuity of my compositions made these photographic records the most satisfactory and permanent manifestation of the early pieces, many of which no longer exist.

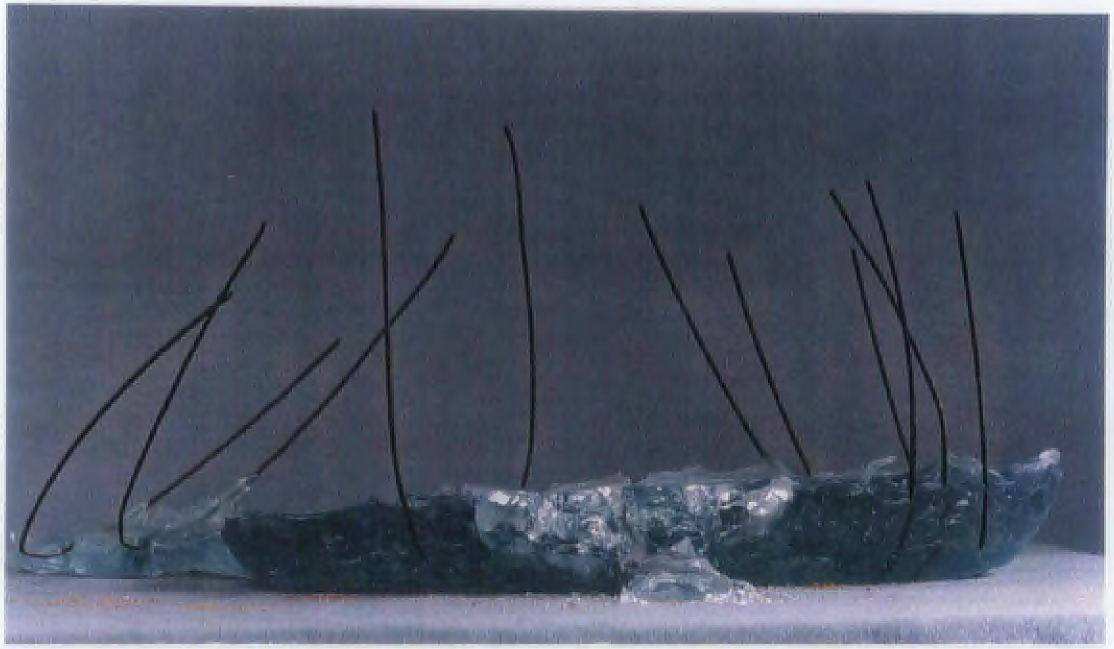

Fig. 63. Doreen Hemp, Wrecked journey. (1995). Cast glass with ceramic form, 42 cm.

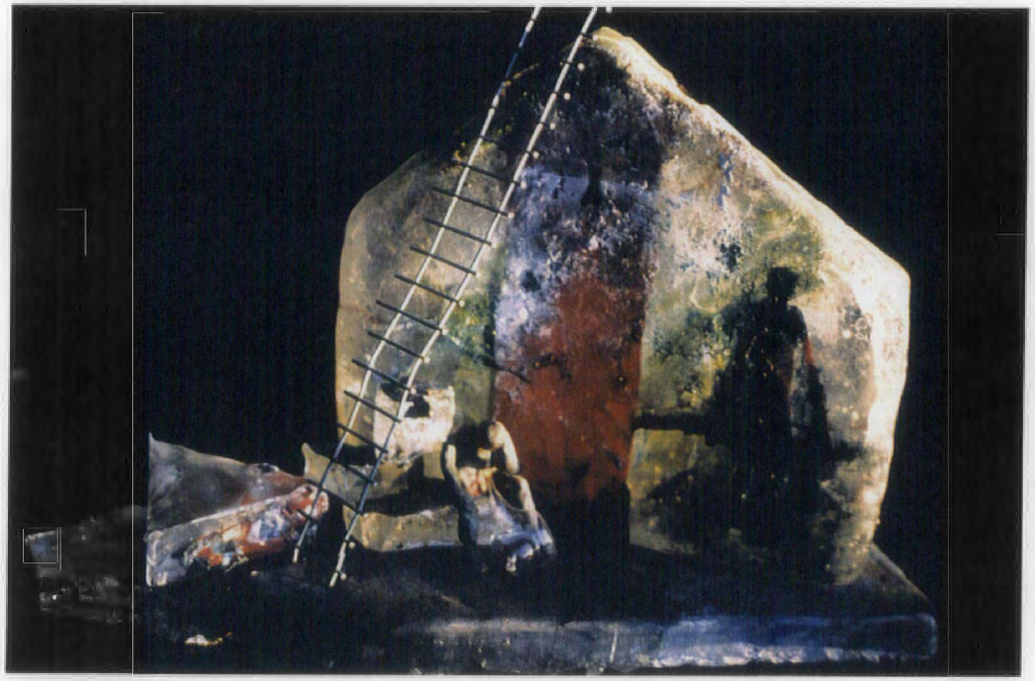

Fig. 64. Doreen Hemp, The glass blower. (1995). Cast glass, blown glass, paint, ceramic form, metal inclusions, 40 x 30 x 35 cm.

Fig. 65. Doreen Hemp, Oceanos (two views). (1993). Cast glass, mixed media, 30 cm.

Fig. 66. Doreen Hemp, Batavia. (1995). Laminated glass, copper foil, copper sulphate, 30 cm.

Fig. 67. Doreen Hemp, Step wreck. (1992). Cast glass, mixed media, 20 x 32 x 18 cm. This work is not referred to in the text.

I now use photographs not only to document the work but as an art form, and in many works they form an integral part of my work, extending and enriching conceptual issues. Photographic processes are explored and adapted to suit my specific needs; I can tone up or tone down emotion, increase or decrease light, I can blur the image, do multiple exposures or alter the surface of the prints by manipulating the surface. Photographs tend to flatten the world which the human eye sees as three dimensional, as a result space and scale become ambiguous. In some of the images it is not possible to tell whether one is looking at huge or very small rocks and in the photographs of the wreck in *Shipwreck* (fig.57b), the form is reflected in the shiny glass base and one is not sure which is reflection and which is boat or sea.

My interest in photography as an art form developed gradually as my technical knowledge increased and my ideas became clearer. Photography itself has developed gradually and evolved with the evolution of the medium itself[16] and has from the very beginning been linked to painting and drawing, as artists searched for ways to improve their drawing ability. Modern photography began in the years 1910 - 1920, and since then has been linked to the concepts of modern art. With the introduction of the small camera in the 1920s photographers were able to capture an image in a fraction of a second, and photography developed in a way that was related, both in form and content, to mainstream art and the movements that developed into Modernism. Photographers such as Paul Strand, Rodchenko, Alfred Stieglitz, Laszlo Moholy-Nagy and Man Ray, used photographs as another means by which to express their artistic concepts, and their photography was shaped by the same issues that guided their explorations into other media. Their work opened the door to new artistic uses of photography, which cannot be explained without reference to the other visual arts, just as contemporary art itself cannot be fully understood without reference to the photographic image and its cultural content. Works of art, to the vast majority of viewers, are only known through the photographic image, and contemporary art is disseminated through publications which rely solely on the photograph.

> The museum is the camera, the camera is the museum, the art is the photograph, and the photograph is the art. And the phenomenon of the artist as photographer is just one special aspect of a blood relationship between art and photography now so intimate that the bonds are indissoluble (Vaisey 1982:169).

Over the past three decades many contemporary artists have recognised that photography is a viable artistic medium which goes far beyond the dictates of lenticular representation. As Paul Rosenfeld said

> Life appears always fully present along the epidermis of his [universal man] body: vitality ready to be squeezed forth entire in fixing the instant, in recording a brief weary smile, a twitch of the hand, the fugitive pour of sun through clouds. And not a tool, save the camera, is capable of registering such complex ephemeral responses, and expressing the full majesty of the moment. No hand can express it, for the reason that the mind cannot retain the unmutated truth of a moment sufficiently long to permit the slow fingers to notate large masses of related detail (Sontag 1986:207).

The primary aesthetic concerns in photography are linked to the mainstreams of modern art - formalism in photography, as in art, grew out of Cubism and Constructivism; dream imagery from Surrealism; Expressionism, and the pluralistic directions taken by artists - Body Art, Conceptual art, Modernism, post Modernism are all seen in photography. In the 1960s an approach, which emphasized the sanctity of the single image, shaped and influenced by painting, became the dominant trend in photography. During the 1970s with the influence of film and the grid forms of Pop Art there was an interest in sequential imagery. In these works the essential issue became the individual photograph in an extended body of work in which its interrelationship with other images was crucial to the creation of its formal and iconographical significance. Each element reinforces the other, to create an integrated progression that is not necessarily narrative.

I have used multiple and sequential imagery in *Series I* and *Series II* (photographic images which are on exhibition but not illustrated in this text), where the single image or individual photograph could not adequately describe the information I wanted to communicate. The sequenced images are sometimes about the flow of time, and in others are a mosaic of fixed moments, that together create a sense of suspended time. Time continually overtakes the interpretive event and is therefore the source of an inherent ambiguity. However, a distinction must be made between conceptualising time as a succession of states, each momentarily fixed, and time as duration, and the continuous time of lived experience, for this implies that time can be arrested and meaning be fixed and could convey an impression of stasis. By sequencing together photographs of related, similar images, the viewer is forced to ferret out the similarities and differences among the multiple views, and compare one thing with another; implying that seeing is an active process and that art is an open-ended form of investigation.

In *Series I*, I have in some images used a technique accidently discovered by Man Ray in the early 1920s. In this process, known as a rayograph or photogram, images are created without a camera, by placing objects on photosensitive paper and momentarily exposing them to a white light. The exposed parts of the paper turn black when placed in the developer while the parts covered by the objects yield vestiges of the forms that were placed on the paper. Real objects are the source of the forms created, but the images produced are only vaguely related to everyday reality. It was this transformation of the familiar into the unknown, ambiguity and dislocation which interested the

Dadaists and later the Surrealists. I use the rayograph, because of its ability to extend beyond the visible. It expands the range of significance of simple objects which are transformed into something mysterious and ambiguous. Both the imprint of the object and its shadow remain on the paper; the combination of blacks, white and grey reveal the presence of light and space. As there is no negative, the result is a fixed non-renewable moment in time.

I find there is an interesting contrast working with glass which is a long, time-consuming process, and making photographs, where I am able in a very short time to create an image, or realize a concept. The concept of time and timelessness in photography interests me - a painter or sculptor may delay or postpone, but when the subject matter is in place or the light right, the photographer must take the photograph, if not, there may never be another chance to get that particular image again. The photographer 'stops the world' for a second and holds a fleeting moment in time. The resulting image is a moment frozen in time.

When exhibited in a gallery space, the photographs and sculptural forms are mediated by the manner of presentation; lighting, or lack of lighting, the confines of spatial arrangement, installation, mood, and sound, all contribute directly and indirectly to the impact of the works, which evoke and create a range of personal and very different associations and meanings from the viewer. Meaning itself exists in relation to a wider field of associations, which continually changes with time. Ideally the interaction between the viewer and the works on exhibition stimulates both the senses and the intellect, appeals to the imagination, and the work is given new and meaningful interpretations, but these reactions are ambiguous, as Davidson states

> The "necessary ambiguity" ... results from a recognition that interpretation always takes place in lived time and is, therefore, superseded the moment after it has occurred. [The object] only has an existence relative to an interpretation, and is therefore open to continual

re-interpretation. Creative viewing is thus a process of making meaning anew (Davidson 1991:18).

NOTES

1 A mirage is an atmospheric optical illusion in which the observer sees non-existent bodies of water, inverted images and various other distortions. This is caused by the refraction of light as it passes through layers of atmosphere of varying density. An increase in density of the air decreases the velocity of light passing through; thus as the light goes through a layer, or stratum, of marked density change, its wave front is refracted and a displaced image is likely to appear. In this way the atmosphere acts as a huge lens, bending the incoming light rays.

Several early maps of the Skeleton Coast show non-existent bays, for example Viktoria Augusta Harbour, a bay 'discovered' by Dr Esser, which has never been located and it appears that it was nothing more than a mirage. In addition several of the sailing ships which ran aground could have done so as a result of approaching the land towards such a 'bay', and, realising too late that the inlet had been a mirage, were driven onto the beach or rocks by the strong currents and winds. Survivors and castaways would also have struggled to get to ever-receding and elusive stretches of water.

2 It is not known when the first ships were wrecked on the southern coast of Africa, as no recorded proof exists, but according to the Greek historian Herodotus, the ancient Phoenicians, who were excellent mariners, had undertaken voyages of exploration as early as 1000 BC with the aim of rounding the southern tip of Africa, certainly going beyond the Pillars of Heracles (the Straits of Gibraltar). Herodotus records that the voyage took three years to complete and told of how the rising sun which had been on their left on their voyage down the east coast had later been on their right, indicating that the Phoenicians did indeed round the southern tip of Africa (Turner 1988:11). By the 10th and 11th centuries Arab and Persian traders had established a trade route to India, and probably sailed round the southern tip of Africa from east to west. There is evidence in the form of glass beads and Chinese ceramics excavated at the Iron Age settlement of Mapungubwe in the northern Transvaal that these traders penetrated far inland in search of gold, ivory and slaves, possibly at the beginning of the 15th century. There is no doubt that many ships were wrecked on the coast of Africa at this time, but no record exists as any remains of the early wooden ships and old galleons would have disintegrated quite quickly in the pounding surf.

The first documented wreck on the coast of southern Africa is a wreck known only as the 'Soares Wreck' which took place in 1505 - seven years after Vasco da Gama opened up the sea route to the East. An illustration from an early Portuguese document records the loss of four vessels from the fleet of Pedro Cabral during a storm off the Cape of Good Hope. Bartolomeu Dias, who captained one of these vessels drowned on this voyage.

Few of the world's coasts are as desolate and bleakly inhospitable as that of Namibia's southern coastline. Over the centuries this coast has claimed hundreds of ships and many thousands of lives; hence the name 'Skeleton Coast'. The changing size, position and shape of the underwater sand-bars, the fog, the often turbulent Atlantic Ocean, the jagged submarine diamondiferous gravel deposits and unpredictable currents all combine to make this coast a mariner's nightmare. Wrecks lie in the sea with only rusty remains visible at low tide, while the ribs and spars of others can be seen beached up on the drifting sands of the central Namib shoreline. Anyone visiting the Skeleton Coast today can but wonder how there were any survivors from these wrecks. In 1949 an old slate was found with a message which had been written in 1860 - 'I am proceeding to a river sixty miles north, and should anyone find this and follow me, God will help him' (Schoeman 1984:131). Human skulls, as well as thousands of seal skulls lie on the beaches - a mute testimony of man's brief presence in this timeless place.

3 'The skeletons on the coast are not only those of men. The bleached bones of countless whales, exploited in the heyday of the whaling fleets; the sand and wind-blasted remains of tugs, liners, coasters, galleons, clippers, gunboats and trawlers, and their pitiful flotsam and jetsam, lie strewn untidily on endless miles of desolate beach, while at the river mouths in tangled heaps are the skeletons of a myriad trees...' (Schoeman 1984:131).

4 'The old settlements (Kolmanskop, Pomona, Elizabeth Bay and Alexander Bay) their treasure reaped, became ghost towns in a forbidden area which no one was permitted to enter. Ravaged by wind and sand, the walls crumbled and collapsed and the machinery rusted away into grotesque monuments of engineering. Only Daliesque scenes of skeleton houses and wind-battered graveyards in a setting of utter isolation are left to remind us of those glamorous old days'(Coulson 1991:207).

It had been suspected as early as 1863 that large diamond deposits existed along Namibia's barren coastline. Prospectors from all over the world converged on the area, and within a very short time thousands of hectares had been pegged for diamonds. Kolmanskop was the site of the first find and was soon a thriving town where elegant homes, a bakery, furniture factory, four skittle alleys, a swimming pool, community centre, well-equipped hospital, theatre, general dealer and a soda-water and lemonade plant, were built to accommodate the mining executives and their families. When the diamond deposits were depleted in the surrounding areas, people moved away, and the towns were abandoned, gradually buried by the desert sands, and became ghost towns - forlorn legacies of the early diamond rushes.

5 In 1954 workmen uncovered a row of 81 huge limestone blocks which covered two pits. 'A few days later, Mallakh [the Egyptian archaeologist Kamal el Mallakh] opened a small hole in one of the six-foot-thick slabs. After clearing away the fragments, he peered through the hole. Because of the darkness he saw nothing. "Like a cat, I closed my eyes, and then with my eyes closed, I smelled incense, a very holy, holy, holy smell. I smelt time. I smelt centuries. I smelt history." Peering down into the cavity with the aid of sunlight reflected off his shaving mirror he made out the pointed tip of an oar and realised that I had indeed come upon an astounding historical relic". Only a few feet beneath him lay the disassembled pieces of an entire cedar boat - part of the funeral trove for Khufu, builder of the Great Pyramid, who died nearly 4500 years before' (Papanek 1992:61). Archaeologists have taken 16 years to remove and rebuild the boat which consisted of more than 1200 pieces.

6 Doreen Hemp, *Shipwreck*. (1993). sandcast glass, 42 cm. Collection: the artist.

7 Doreen Hemp. *House of darkness*. (1995). Sandcast and mould-cast glass forms, mixed media, 42 x 28 x 29 cm. Collection: the artist.

8 Doreen Hemp, *SS Namaqua*. (1995). Laminated soda glass and mixed media, 41 cm. Collection: the artist.

SS Namaqua 1 - Iron screw coaster of 352 tons, wrecked at Island Point, south of Hondeklip Bay on 29th March 1876 carrying copper ore. C.C. *3/7/2/2/*. (Turner 1988:140).

9 Doreen Hemp, *Hollow broken boat*. (1995). Slumped glass form, mixed media, 41,7 cm. Collection: the artist.

10 Doreen Hemp, *Broken spine*. (1993). Cast glass, 31,6 cm. Collection: the artist.

11 Doreen Hemp, *Belleisle*. (1995). Cast incompatible glass, 42,1 cm. Collection: the artist.

Belleisle - British wooden brigantine of 135 tons wrecked on rocks of St Sebastian Bay on 15th July 1849 at night during a south-east gale while on a voyage from Table Bay to Port Beaufort with a cargo of 724 bars and 64 bundles of iron, 200 bags of sugar, 158 bags of coffee, 158 bags of rice, 22 casks of fish, wine, beer, gin, cheese, cotton, tea, medicine, timber, hats, furniture, 8 casks of hardware, 15 boxes of tin plates and 10 kg of horse-shoes. No lives were lost. Cape Archives, C.C. 2/17. (Turner 1988:176).

12 Doreen Hemp, *Wrecked journey*. (1995). Cast glass with ceramic form, 42 cm. Collection: the artist.

13 Doreen Hemp, *The glassblower*. (1995). Cast glass, blown glass, paint, ceramic form, metal inclusions, 40 x 30 x 35 cm. Collection: Dr Ingram Anderson.

14 Doreen Hemp, *Oceanos*. (1993). Cast glass, mixed media, 32 cm. Collection: the artist.

The luxury liner *Oceanos* sunk off the Transkei coast in August 1991.

15 Doreen Hemp, *Batavia*. (1995). Laminated glass, copper inclusions, mica, 30 cm. Collection: the artist.

The Batavia, flagship of the Dutch East India Company's fleet, was wrecked on a reef off the Abrolhas islands in 1679, laden with treasure including ten chests of silver, gold, silver plate, the Caspar Boudin Cameo (315 AD) and the Rubens Vase (c 400 AD). The Caspar Boudin Cameo is one of the largest surviving cameos (22 x 30cm) and depicts a triumphant chariot drawn by centaurs.

16 Photograph, a combination of two Greek words, *photos*, meaning 'light' and *graphikos*, meaning 'drawing', first used by the astronomer and scientist Sir John Herschel. Herschel related the process to 'drawing with light', he was also the first person to use the terms 'positive' and 'negative'. These positive and negative images were to form the basis for all photographic images until the introduction of electronic technologies.

From the very beginning, photography has been related to painting and drawing, as artists searched for ways to improve their drawing abilities. There is evidence that Renaissance artists, who did a great deal of work on perspective were influenced by the camera. It is not known exactly when the camera obscura - an early camera that was able to project images onto flat surfaces - was first invented, but it was certainly used by artists, such as Jan Vermeer, in the sixteenth century.

CONCLUSION

> Ancient and modern, fragile and strong, opaque and transparent, hot and cold, precious and mundane, liquid and solid, the fabric of modern sky-scrapers and jewels of ancient Egypt; glass has sustained its mysteries and attractions for two thousand years. The evocative qualities of glass and its often-cited contradictions have provided endless enticement for curious artists .... (Ruffner 1991:8)

Glass has a long and diverse history which began with the making of tools from obsidian. Man-made glass includes ritual and decorative objects which were, for centuries, made in glass workshops by glass craftsmen within a factory tradition. During the nineteenth century, with the industrial revolution, the glass craftsman was replaced by the factory worker and artists became designers. The glass objects of artists such as Gallé, Lalique, Tiffany, Cros, and Marinot form an important part of the history and development of the art glass movement. They functioned as designers at a time when working glass in its molten state outside the factory tradition was virtually non-existent.

With the invention of a small portable furnace by Dominick Labino and Harvey Littleton in America glassblowing became possible for the individual artist in a home studio. This invention marked the beginning of the studio glass movement, the rise of which was related to developments in other crafts. The Littleton/Labino invention was probably as significant as the invention of the blowing iron was centuries ago, and it parallels Peter Voulkos's iconoclastic work with clay in revolutionizing functionality.

The 1960s were years of technical and conceptual discovery, exploration and experimentation. Learning came almost entirely from trial and error with lecturers and students experimenting and working together at the many universities and institutions which came into being after the Toledo workshops. To build a furnace, make glass, melt it, colour it, work with it and anneal it, took an enormous amount of enthusiasm, perseverance, patience and staying power. The past thirty years have been marked by many technological advances in studio glassmaking and increased skill on the part of artists as well as a number of developments in many diverse methods of glassmaking - fusing, pâte de verre, lampworking, casting, stained glass and mixed media.

From the very beginning of the studio glass movement there were two different attitudes to glass. The sculptor in search of form was willing to forgo technical virtuosity to push glass over technical boundaries to emphasize concept and content; the craftsperson strove to create a perfectly executed functional object from new processes with the finest glass available. A great deal of work being done today succumbs to the basic seduction of glass; these works have become problematic as they are made from glass and are about glass - material and skill are equated with content. The natural beauty and sheer attractiveness of the material can be so alluring that viewers accept any object regardless of its quality of form, technique or meaning. The aesthetic limitations of glass and the superficiality that results when artists are simply content to manipulate the formal aspects of the glass - colour/transparency/mass etc. - without giving sufficient attention to history, meaning, content or idea, result in works which are visually interesting for a limited period and in limited quantities, but initiate no further mental engagement. While there is undeniably something special about glass as a medium - its purity, fragility, transparency, translucency and ability to enrich its surface with colour or texture - these characteristics alone do not necessarily make a good work of art.

Glass is an extremely versatile substance and its uses are prodigious. When accessing the prospects of glass as a creative medium it is not the material which is restricting; what matters is the purpose towards which proficiency and skill are directed. The medium is an intrinsic factor, the means by which an artist communicates, not the message itself, and for Post-modem sculptors this is an extremely important issue.

Although I have not dealt with the art/craft debate, the problem needs to be briefly discussed at this point in terms of the acceptance of contemporary glass into mainstream art. Despite the constant questioning, challenging and redefining of the notion of art, the subordination of the crafts within the hierarchical structure of art still persists, and although the main characteristics delimiting craft - female, utilitarian, medium specific, handmade, domestic, decoration, etc. - have in many instances been removed, the debate as to whether objects made out of materials such as clay, glass and fibre, are art or craft is still not resolved. The word 'craft' has become a word of powerful signification but it defies simple definition; it is a word that carries important economic and marketing consequences, but has no significant value. As soon as glass/ceramic/fibre objects are put on exhibition or put up for sale one is drawn into the whole hackneyed debate. It would appear that the art/craft debate is still perpetuated by powerful marketing forces, crafts councils, galleries and museums with medium-specific exhibitions, dealers and critics, and that the art/craft debate floats among alternative marketing strategies, political and economic issues, aesthetic choices and a desire to made sense of and create some continuity with the traditional past and the celebration of uniqueness. Good glass pieces are good because they are made by artists who have strong convictions about what they have to say and they say it well. Their work would be impressive in whatever context it was shown, whether it is a vessel or a piece of sculpture.

Artists such as Bertil Vallien have found ways of combining the visual properties and the objectiveness of glass expressively, of transcending the literal and of suggesting something about existence. His works exist as real objects with a history, a concept, a character and an identity. His objects do not suggest emotions but engage the viewer's imagination and intellect by referring to something other than themselves.

Several glass artists avoid references to craft in their work. One of the first prerequisites for attaining the status of 'art' and escaping what has became the 'stigma of craft' is to be rid of functionalism. This is manifested in the creation of works that refer to utilitarian objects, particularly vessels but which are not functional. This anti-utilitarian or anti-functional attitude manifests itself most obviously and predominantly in the works of Dale Chihuly with his large groups of non-functional works of art modelled on functional vessels. However, this anti-functional movement has also resulted in works which could be labelled as decorative formalist objects and has shown that there is a very fine line between 'works of art' and objets d'art. The monumental sculptural works of Howard Ben Tré and sculptures which include other materials as in the work of Mary Shaffer, Nancy Mee and Christopher Wilmarth, where glass is employed as just one among many materials, have become acceptable as works of art. It is interesting to note that the distinctions between art, craft, applied art, decorative art or design do not apply to work done by artists such as Marcel Duchamp, Salvador Dali, Joseph Cornell, Meret Oppenheim, Alexander Calder and Robert Smithson (no matter what the quality/content of the work). They managed to avoid the stigma of craft, having already achieved recognition as artists.

In glass, as in all art forms, process is the basic handwriting of the artist and the true test of artistry is what can be said once the handwriting is formed. The glass 'handwriting' of artists varies a great deal today - there are artists who exploit the material to the full and produce works which could not be made of any other material and artists who use glass but the glass could be replaced by another material; these artists seem hampered rather than aided by this chosen medium. Yet another group of artists use glass as a vehicle to achieve certain specific effects in a total concept. This multiple approach to glass sculpture has raised the issue of questioning the necessity, relevancy and effectiveness of having exhibitions where the emphasis is solely on the material used. However, no matter how glass art is formed or shown, instead of making art within an external shared language of form as in the past, everything depends on the individual's own effort and not on the security of traditional status. We can no longer expect a style within glass making. Whether the glass is blown, fused or cast, made in a studio with the artist working alone, or with a team, the glass object is created after individual choices have been made.

Developments, skills and advances in studio glassmaking in the last thirty years have resulted in a large number of glass objects formed from many different processes. In the long history of glassmaking, individually made art glass objects have only a short history. A paucity of critical and scholarly writing on glass art compared to other media such as painting and sculpture has prevented a healthy discourse from taking place and has made an assessment of the quality and importance of contemporary glass problematic. Time will tell whether contemporary glass objects are 'good art' or good 'for' glass art, and whether glass objects made in this period are significant or insignificant art. Only when critics can look back with hindsight will contemporary art glass be more fully and exactly evaluated.

Today the central artistic issues in contemporary glass are shifting from concerns of process - how an object is made and perceived, or what defines its style - to considering the concepts of why art is made and experienced, and what a work means or signifies beyond its formal, stylistic, and material ingredients. Contemporary art glass is at a critical point in its history - a critical point with problems and questions about glass and its place in the larger continuum of mainstream art. Glass now has an identity crisis. No sooner had the artist/viewer/critic grown accustomed to the idea of glass being an acceptable art form which could be admired for its own sake then one was asked to think again and to perceive/produce it in another way. There is always reluctance in accepting new developments until comfortable points of reference with the past are established but the way forwards demands a degree of courage - from all concerned - artist, critic and viewer.

Contemporary glass reflects the ambiguities, ambivalences and contradictions that concern artists today. Whether making monumental glass sculptures or fragile pâte de verre vessels, emotive glass furniture, sandcasting musical instruments, boats or garden furniture, blown glass forming heads or stomachs, glass artists are, with sweat, toil and consummate skill, creatively using this paradoxically transparent, opaque, ancient, modern, solid, brittle, liquid to make art forms which speak of life, material, impermanence and sustenance, the strength and fragility of nature and society, in a volatile transitional and insecure world permeated in disbelief and doubts. New glass technology is here to be exploited and extended. For the artist with imagination, concepts, strength and enthusiasm there is an almost limitless potential for the use of glass as an art form.

APPENDIX

GLOSSARY OF GLASS-WORKING TERMS AND PROCESSES

ACID ETCHING A glass finishing process which can alter the surface of the glass object either uniformly overall or in selected areas. Glass is highly resistant to most acids except hydrofluoric acid which attacks it vigorously, the degree of attack varying with the type of glass used; the silicates are broken down and a gas, silicon fluoride is given off. Lead crystal glass is more easily dissolved than harder potash glasses. The surfaces can acquire a brilliant smooth polished effect, be satin etched or have a frosted translucent effect.

All acids can cause serious burns. When working with them one should adopt the attitude that anything which is wet is acid, not water. Gloves made from industrial rubber must be used and be carefully checked for pin holes. In addition, acid fumes are noxious and can cause considerable discomfort and extremely harmful effects to the lungs. Safety glasses and a mask or respirator should be used at all times. Always prepare acid solutions by slowly adding acid to water as heat is produced and local boiling and splattering of acid can take place if water is added to acid.

1. The object must first be cleaned in a bath of 100 parts water, 12 parts concentrated sulphuric acid and 1 part hydrochloric acid. Place the object in a wire or plastic container. Dip four times taking twenty seconds for each dip. Wash the object well using long-sleeved industrial rubber gloves in an acid free room.
2. The object is then dipped in a polishing bath which is contained in a lead-lined steel tank, a

rubber-lined steel tank or a polyethylene or unplasticized polyvinyl tank. The polishing bath is made up as follows:

	soda lime glass	lead glass
Strong hydrofluoric acid (70 - 80%)	6	3
Strong sulphuric acid (92-98%)	7	2
Water	3-4	1

In a small workshop work at room temperature - the mixture is preferably kept at 50°C. Dip the object in the solution for thirty seconds - if no etching is visible, dip for a longer period, if there is still no etching, a higher proportion of hydrofluoric acid is required. If the etching is too matt, add more water. The silica fluoride salts from the lead, lime or potash are deposited on the surface and have to be cleaned constantly or the glass will have a matt look. If only certain areas are to be etched, other areas can be masked with an acid-resistant resist such as a mixture of beeswax and turpentine. The design is scratched through the resist to expose the underlying glass surface. It may be necessary to retouch the resist several times to prevent undercutting during deep etching. When disposing of acids the addition of lime will result in an effluent containing the lowest amount of soluble fluorides.

ACID POLISHING A process of polishing the surface of glass forms by dipping into a mixture of 3,5 concentrated hydrofluoric acid, 6,5 concentrated sulphuric acid and warm water until the desired polish is obtained.

AGATE AND MARBLEIZED GLASS A glass made by Tiffany using a process thought to have been first used by the Romans in about the 1st Century BC and revived by the Venetians in the late 15th century. It was produced by putting a number of variously coloured opaque glasses into the same melting pot and carefully heating them together. Sometimes reactive glass was also added to give a laminated effect. Great care had to be taken in the melting process for if the glass became too hot it would fuse into a colourless mass. When the glass had cooled it was polished or carved to reveal the different colours and laminated patterns. One variation Tiffany made with Agate ware was Marbleized glass in which he sought to imitate the coloured striations and veinings found in natural marble (Potter 1988:46).

ALUMINA Used both as a component of glass and in mould making. In most glass batches the amount of alumina added is not more than one per cent; in glass fibre batches there is fourteen per cent alumina. Alumina occurs in several crystal forms. These may have the same chemical formula but differ in the way they respond to heat. Hydrated alumina is used with kaolin clay as a shelf primer. In mesh sizes of over 325 mesh it is used for dense cast, open-faced moulds intended for multiple piece reproductions. Hydrated alumina and alumina silicate can be bonded with colloidal silica which can be used for very strong moulds with low thermal expansion and excellent surface reproduction.

ANNEALING The process of maintaining the temperature at a suitable level for a sufficient period to allow internal stresses to be relieved, prior to cooling. No kiln heats evenly throughout and since most glass is a poor conductor of heat, when the temperature rises in the kiln, warm, hot and cool areas of the glass expand unevenly, causing uneven stresses to form throughout the glass. If the kiln is turned off, and left off immediately after firing the cooling glass will shrink unevenly as it becomes more viscous. This creates internal stresses in the glass which will cause the glass to shatter in the kiln or when removed from the kiln. Annealing stabilises the glass and relieves the internal stresses; the soaking heat spreads the heat evenly throughout the glass until the molecules can realign themselves. The temperature is kept at the annealing point for varying periods of time depending on the thickness and type of glass to be annealed.

ANNEALING SOAK The process of soaking (or holding the heat of the kiln) at a controlled temperature for a pre-determined length of time, to allow annealing to take place.

AQUAMARINE GLASS Glass produced by a process in which aquatic plants or marine life such as fish, seaweed and sea urchins were embedded into an inner layer of glass and were then enclosed within an outer layer of green glass to give the illusion of sea water. This process demanded a high degree of glass-making skill as the three ingredients - the marine forms, the inner and the outer vessels had different fusing points. Derived from Tiffany's Paperweight style, Aquamarine glass was produced mainly around 1913, and was among the most difficult processes achieved by Tiffany craftsmen. Consequently very few were made, and these were very expensive, as even in 1913 pieces sold for up to $250 (Potter 1988:46).

ARSENIC Very few colourless glasses used today for tableware do not contain arsenic, which is usually introduced into glass as white oxide of arsenic. It is a valuable constituent as the colour, transparency and brilliancy of glass are all enhanced by the presence of arsenic. During the melting process some arsenic vapour is lost, but a large proportion of the arsenic remains dissolved in the glass. White oxide of arsenic is manufactured from minerals containing the metal. White oxide of arsenic is given off as a vapour which is carried into flues where it condenses into a white powder very much like flour. The amount of arsenic used in glass is comparatively small, usually one part to one thousand parts silica.

BAFFLE WALL A low wall made from pieces of refractory material, used to diffuse heat in the kiln and prevent hot areas.

BALLONTINI Small bead-like balls of glass which are used in the sandblasting industry. Ballontini of various sizes can be used instead of crushed glass in pâte de verre work.

BARILLA A plant, grown in the salt marshes in areas of the Mediterranean and Spain, which was burned to make a special kind of soda ash used to make soda glass. It was used as an alternative to potash. After the advent of lead glass barilla was hardly used and today chemical soda is used.

BATCH A mixture of various raw materials which are melted in the furnace to form glass. A batch usually includes a proportion of broken glass known as cullet.

BEADS Glass beads can be made in several ways

a) beads can be drawn; a lump of melted glass is blown until a hole is formed, it is then pulled until it becomes a tube which is cut into beads of the desired size;
b) A filament of molten glass is wound around a rotating wire, or
c) Powdered glass is pressed into moulds with a wooden stick in the middle, and then fired, the stick burns out leaving a hole in the centre of the bead.

BEVELLING Grinding and polishing the edge of a glass surface to create a sloping border.

BISQUE Clay which has been fired to a state where it has bonded but remains open and porous. Bisqueware is often used to make moulds for sagging and slumping.

BLISTER A bubble on the surface of overfired glass.

BLOWING The process of forming an object by inflating a glob of soft glass gathered on the end of a hollow tube called a blow pipe.

BLOWPIPE A hollow tapered metal tube used to blow glass.

BORAX Used extensively in glass making and was originally used for its fluxing properties or ability to dissolve other glass-making materials. It becomes a mobile fluid at about 840°C and under certain conditions exerts a greater fluxing action than either soda or potash. It enables glass to resist shock such as sharp blows or sudden changes in temperature. Boracic acid also helps to increase the chemical durability of glass and for this reason is used in the production of laboratory equipment.

BOROSILICATE GLASS Glass which contains boracic oxide. It has a low rate of thermal expansion and contraction and is highly resistant to thermal shock. The ingredients of borosilicate glass are -

Sand 80,3%
Alumina 2,5%
Borax 12,5%
Soda 4,7%

BUBBLES Formed in laminated glass by placing mica flakes on the interface. Mica flakes puff up during the firing and eventually disappear leaving bubbles. It is relatively easy to produce a regular pattern of bubbles in laminated glass by mixing finely powdered clear glass with a little flux applied to an oiled pattern on the glass surface.

Bubbles can also be produced by placing tiny dots of fresh baking soda on the glass. A general bubble effect can be achieved if a pinch of baking soda is mixed with a metallic oxide and sifted over the glass. To avoid getting bubbles sift an extra layer of glass flux in the centre of the form. The centre fuses first, forcing air to the outside edge where it escapes.

CAME A thin strip or channel of lead used to hold pieces of glass in stained glass objects or windows.

CAMEO GLASS Produced by a process in which two or more layers of glass are carved with fine scraping tools or grinding wheels. Cutting through a layer of glass produces a raised design in low or high relief similar to cameo-carved stones. With lathe cutting grooves and facets could be produced to create designs in cameo relief and was the reverse process of intaglio. Known to the Egyptians and Romans, this technique was also used by Emile Gallé. The *Portland Vase* is the most famous example of cameo glass.

CANE Glass rods of varying thicknesses. Today glass canes are sometimes called stringers.

CARTOON A term used to describe a full-size drawing, usually on tracing paper, for the planning and layout of the individual pieces of glass which will be translated into a mosaic or stained glass object.

CASING Process where glass of one colour is fused onto the inner surface of glass of a different colour. By repeating this process a multicoloured layered glass can be produced. This process was used in the nineteenth century for making cameo-glass blanks.

CASTING A process in which moulds, either open or closed, are filled with glass. Molten glass can be poured into an open mould, or the mould may be pressed onto the molten glass on the marver. Centuries ago mummiform figures called shawabtis, statuettes of people, heads of members of royalty, heads of horses as well as body parts were all cast. By 7 BC hemispherical bowls of almost transparent clear glass were being made by some type of casting method. A huge piece of cast glass measuring 3,35m by 1,98m and estimated to weigh almost 9 tons, was excavated at Beth She'arim, near modern Haifa in Israel. It is thought that this piece of glass was made during the fourth century, and although the methods of casting the glass are not known, it must have been cast in a huge furnace.

CASTING WITH MOULDS A technique used from the Bronze Age until late Roman times. Glass casting techniques were probably developed from early metal, ceramic and faience methods of casting, and consisted of various processes. Molten glass could have been poured into an open mould to form simple objects including beads. More complex casting methods probably included the use of two or more interlocking moulds, or casting using the lost wax technique. Glass could also have been forced (in a manner still not fully understood) into the hollow space between two moulds. The process of fusing glass discs or mosaics between an inner and outer mould was another method of casting with moulds. Decorations, handles, rims and base rings were either cast as part of the vessel or added later. All of these casting methods are used by contemporary glass artists.

CATHEDRAL GLASS Transparent coloured sheet glass.

CERAMIC FIBRE INSULATION A light-weight insulation material composed of alumina silicate fibres, used in the manufacture of kilns. It is very lightweight and absorbs less heat during the period the kiln takes to heat up than does insulating firebrick, making the kiln operation for fusing more economical. It can also be used as a mould for forming glass.

CERIC OXIDE (CeO_2) A pale, yellowish-white powder used to polish glass.

CHAIR The name given to a glassblower's bench, where he sits and with one hand rolls the blow-pipe or pontil back and forth on the flat extended arms of the chair while working the molten glass with tools held in his other hand. The chair as we know it today probably dates from the seventeenth century. In the sixteenth century the Italian practice was to strap boards to the glassblower's thighs; this method may have originated from the Roman practice.

CHALK The addition of chalk to the batch causes an evolution of gas which results in a film of tiny

silvery bubbles. This process was used in Stourbridge to make ovoid-shaped 'bottle green paperweights with chalk bubbles' as well as doorstops which could weigh anything up to 2,7 kg. Some of these doorstops had bubbles in a pyriform shape with silvery threads at the narrow end. These bubbles were formed by denting the soft glass with a sharp tool such as a large nail, to which a thin piece of wire was attached. The tool with its attachment was plunged into the glass and sharply withdrawn. The layer of glass subsequently closed around the indentation and caused a pear shaped bubble to form which tapered down to a fine thread. A number of these bubbles in a door stop gave the effect of floating balloons.
French chalk or talc is used sieved or suspended in water as a fine separator to prevent glass from sticking to metal or ceramic supports.

CHAMPLEVÉ An enamelling process of separating colours. Instead of creating wire barriers, as in cloisonné, depressions are etched out of the glass surface (or metal in enamelling processes) and then filled with enamel or glass colours. The end result is not as precise as cloisonné separation. A resist is painted on those surfaces which are not to be etched, and the form is immersed in acid until the required depth of etching is achieved. This area is then filled with enamel or glass colours and fired.

CHEMICAL DURABILITY The ability to withstand decay resulting from exposure to corrosive materials. Chemical durability in glass is determined by its chemical composition; glasses which have a high boron content exhibit excellent chemical durability, soda lime glasses with calcium oxide contents above 9% are also chemically durable.

CHROMIUM Chromium gives a green or greenish-yellow colour to glass and can be used instead of iron to produce green tints in the glass. The use of chromium in the production of dark green glass dates to the nineteenth century as the element itself was not discovered until 1795. Before this time, iron oxide was used for producing green glass. Chromium can be introduced into glass either in the form of chromic oxide or potassium dichromate.

Potassium chromate is yellow, and to produce emerald green glass in which the yellowish tinge is eliminated, arsenic or tin oxide is added to the batch. In chromium aventurine glass glistening metallic flakes are caused by large amounts of chromium being used, forming fairly large plates of chromic oxide which crystallise out from the melt. During the blowing process these crystals of chromic oxide separate from the glass and orient themselves nearly parallel to the glass surface where their reflections give an aventurine effect. The best results are obtained in heavy lead glasses. Although chromium is associated mainly with green glass, colours from yellow to bluish-red, red to dark green and even black can be produced if chromium is combined with other oxides. If chromium oxide and aluminium oxide are combined and the furnace is controlled so that either oxidising or reducing occurs, the following results can be obtained: with a crystal mixture of 5% chromic oxide and 95% aluminium oxide, under oxidising conditions red is produced, and under reducing conditions a reddish-blue is produced; with a mixture of 30% chromic oxide and 70% aluminium oxide under oxidising conditions a purple colour would be obtained and under reducing conditions a green colour. If over 50% chromic oxide is used in any mix the colour would be green irrespective of oxidising or reducing conditions.

CIRE-PERDUE (See LOST-WAX-CASTING)

CLAMP A tool used in the place of the pontil, to hold a blown glass object or vessel at its closed end while being finished. The use of a clamp avoids the pontil mark.

CLAY Provides strength, rigidity and durability to moulds. Used on its own it cracks and can stick to the glass. It is not recommended for moulds which will be fired to above 975°C as it breaks down and calcifies at temperatures over 1000°C.

CLOISONNÉ An enamelling technique using thin metal wires of nichrome, copper, gold or silver shaped into a design on a glass or metal base, forming areas which are then filled with finely ground enamels and fired to maturity. The cloisonné process permits precise and dramatic colour contrasts by separating different colours with wire barriers.

COATING CEMENT A material consisting of colloidal silica and a fine-particle clay commonly used to coat fibre moulds and kiln floors. Coating cement is used in place of kiln wash or shelf primer in fibre-insulated kilns to protect the kiln floor. It hardens the surface, making it resistant to deterioration caused by glass melting onto the floor.

COBALT Cobalt added to glass mixtures produces a deep blue colour and is the most powerful agent used in glass colouring. Cobalt can give shades of pink in a borosilicate glass and green with iodides. When used in any quantity very little light penetrates the glass. Cobalt used with manganese produces black glass. It is not known when cobalt was first used as a colourant but it was well known to the ancient Persian and Syrian glassmakers. It was used in stained glass windows in the twelfth century and was also used for producing blue ceramic glazes. Vessels from the Ming Dynasty (1368-1644), Chinese porcelain and the ceramics of the Tang Dynasty (616-906) were decorated with cobalt blue glazes.

COEFFICIENT OF EXPANSION A measure of the expansion of glass with temperature. If two thin strips of glass of different compositions are heated together, when cool one will contract more rapidly than the other and the strip will bend and fracture.

COLLOIDAL DISPERSION This occurs when minute particles of material are distributed in a liquid in such a way that they are not properly dissolved and therefore do not become a solution but are merely in suspension. The particles never settle out on standing and can only be filtered off with the finest of meshes. When light passes through a colloidal dispersion the particles scatter the light rays; some are stopped while others pass through, and since some of the colours of the spectrum are subtracted, the light which is observed appears coloured. The materials which are generally included in glass to give this effect are the metals gold, silver and copper, and the non-metals selenium and sulphur. (See STAINING WITH METALLIC OXIDES).

COLLOIDAL SILICA A suspension of fine silica particles in a liquid used as a bonding agent in cements.

COLOUR IN GLASS There are two main ways of imparting colour to glass:

a) Colloidal dispersion
b) Staining with metallic oxides

COMBING This decorative technique was used in ancient Egypt when threads of glass were superimposed horizontally on the surface of the glass vessel. These threads were combed vertically into zigzag shaped bands using a pointed metal rod. An example of this technique dates

from approximately 1450 BC and examples can be seen in the Munich Agyptische Staatssammlung.
The process consists of placing different layers of coloured glasses on a compatible glass base or kiln shelf and heating them to 965°C, or until the surface is liquid enough to be combed with a metal instrument. The kiln must be switched off at this point. To make the act of combing easier, the curved pointed metal rod can be attached to a wooden handle. The glass gives way slowly but consistently, and great volume control can be achieved. Design techniques may vary from symmetrical to abstract. As the glass cools, combing becomes more difficult; at this point the kiln should be closed, turned back on, and the glass reheated.
Avoid using an all-metal device for combing and make sure that the kiln is switched off before combing the glass.

COMPATIBILITY Glasses that have the same coefficient of expansion are compatible.

CONE A small pyramid-shaped piece of unfired clay designed to soften and bend at a specific temperature. The cone is identified by a number that is indicative of the temperature at which bending occurs.

COPPER A powerful and versatile colouring agent, used to colour glass since ancient times. A deep blue glass which was used by the Egyptians and was also popular in the Roman Empire derived its colour from a copper compound. The Egyptians seem to have used a combination of copper and iron to produce this blue. Copper-coloured glass was also found at Tel-el-Amarna. Copper oxide produces a blue, green or ruby colour in glass according to conditions and temperatures used in the firing or melting. Copper blues and greens are not difficult to produce but the art of using copper for ruby glass reaches far back into ancient times. Ruby glass is the most difficult of all coloured glasses to make successfully as it is produced by the colloidal dispersion of metallic copper.

CORE FORMING A process for making vessels by building glass around a central removable core. The core, usually animal dung, sand and clay, is packed around a metal rod and modelled to the interior shape of the vessel. The core is covered with hot glass, either by dipping it into a crucible or by repeatedly trailing glass over it. The vessel form is then rolled on a flat surface to make it smooth. The metal rod can then be removed and the core scraped out, leaving a rough, pitted, sandy interior. Handles and details are applied separately. Many glass fragments with rough inner faces which must have been formed in this manner were found in the burial chamber of Amenophis II; glasses were manufactured in this way in Egypt, Syria and Palestine until the invention of glass blowing.

CRAZING A fine network of cracks in the surface of glass.

CRISTALLO Italian soda glass, developed around the fourteenth century was made with the soda ash from the barilla plant. Cristallo glass was a pale yellow or clear glass and was extremely ductile.

CRUCIBLE A container made of refractory material in which glass can be melted. Crucibles are not difficult to make and can be thrown on a potters wheel, made by hand or slip cast using the following recipe from Bruce Lundstrom (Camp Colton)

Calcined alumina (alumina oxide)	28%
Kaolin	8%
420 grog	25%
Ball clay	10%
Fire clay	28%
Bentonite	1,5%

Mix dry ingredients and add water. Wedge until an even consistency is achieved. The walls of the crucible must be at least 1.3 cm to 1.9 cm thick. Crucibles with sloping sides and a large flat bottom are easiest to handle. Dry, and then fire to cone 10. These ingredients can all be bought at pottery shops. Stoneware clay fired to 920°C bisque can also be used to make crucibles but can only be used for two or three firings.

CRUCIBLE CASTING A process of melting glass in a crucible in a kiln. This process enables the artist to work with molten glass without having a furnace. Molten glass made in a crucible can be used for sandcasting, casting in moulds, free forming rods, stringers, lines and shapes on the marver.

Crushed glass, approximately 10% borax and enough water to dampen the glass, are placed in the crucible and mixed well. A crucible filled with cullet will only be one-half to two-thirds full when melted. This must be taken into account when designing glass objects which are to be cast in a crucible. The temperatures necessary to melt the glass vary depending on the glass used and the processes which are to be used. Temperatures of between 850°C and 900°C are needed to enable the glass to be poured from the crucible into a sand mould.

The cast glass form, and the crucible must both be annealed. Crucibles will suffer thermal shock if not returned to the kiln while still red hot.

CRUCIBLE FURNACE A kiln or furnace that contains one or more crucibles which are used for melting glass. Most ceramic kilns can be used for melting glass in crucibles, but there are limitations. Small crucibles which contain less than 2,5 kg of glass work well in a ceramic kiln but larger amounts take longer periods of time. Although many ceramic kilns can reach temperatures of 1300°C they are not meant to remain at these temperatures for long periods of time and it is therefore difficult to maintain the temperatures needed to melt glass. In addition fluxes in the glass become volatile at high temperatures. These vapours attack the kiln elements causing them to burn out. The elements need replacing after six to eight firings.
A crucible furnace can be built fairly easily and has many advantages over a ceramic kiln, or a tank furnace. Scrap stained glass, window glass or bottles can be melted in four or five hours in a crucible. It is important to remember to turn off the kiln when removing the crucibles and to wear gloves, a long sleeved shirt (obviously not made of synthetic material) and safety glasses.

CULLET The name used in the glass trade to refer to broken glass of all descriptions. Some glass always breaks during manufacture. Cullet is collected, cleaned and used again as an ingredient of the batch. Cullet is a valuable material because it saves fuel charges as it melts more easily than batch. Cullet is not usually used for coloured glass because of possible imperfections. The term was first used in Britain in the eighteenth century when it became an important consideration of the glass maker as Parliament had passed legislation imposing a tax of one penny per pound on all the materials used in the making of glass. This act became known as the Glass Excise Act and proved a great burden to English glass makers for a century. The Act, however, allowed the glass maker a certain amount of broken used glass free of duty which he could then re-melt. Poor families collected waste used glass for which they were paid up to one third of its original price by weight.

CUTTING GLASS From very early times glass was cut using gem cutting lapidary techniques in imitation of precious stones. Just as gem stones with two or more strata of contrasting colour were cut to reveal the contrast, glassmakers, as early as the Roman period experimented with glass composed of two fused layers of contrasting colours, specifically made to imitate the layers found in natural stones such as onyx. The Alexandrian workshops were known for their fine workmanship in stone, glass and gem cutting. During the Roman Empire shallow wheel cutting was widely used, grooves and hollows constituting patterns in the glass. Tools similar to those used in cameo work were used by artists to create vessels of great beauty, with skills which amaze and intrigue contemporary glass artists.

The most renowned example of the cameo carving technique of cutting glass is the *Portland Vase*, housed in the British Museum in London. This blown glass amphora, probably made in the First Century BC/AD was possibly a funerary urn of Alexander Severus. It is formed in dark blue glass overlaid in white glass which has been cut away in cameo relief.

Glass cutting is one of the few 'cold' glass decorating techniques. Cold working in antiquity achieved exceptional results in vessels such as the *Portland Vase* and in Roman vessels called *vasa diatreta*. The *Lycurgus Cup* is a masterpiece of complex cutting and belongs to this group of vessels. It is the culmination of Roman achievement in glass carving. The figures illustrate the story of Lycurgus, King of Thrace. The glass was thickly blown in one layer and instead of cutting away just enough of the background to leave the design in relief, the design was almost completely cut away from the background, leaving only a few bridges of glass to hold the 'cage' to the base vessel. The cutting and carving is detailed and complex. The colour of the *Lycurgus Cup* is important, lit from the front it is an olive green colour and resembles jade but when lit from behind it glows with a translucent amber light. It is thought that this change of colour occurs owing to a small quantity of gold in the glass.

The invention of lead glass by George Ravenscroft in the seventeenth century led to further developments in glass cutting techniques. Lead glass is particularly heavy and lends itself to cutting techniques yielding great refracting and reflecting qualities. These qualities have been exploited by the cut glass industry and by contemporary glass artists.

Some South African glass cutting and decorating factories such as TransNatal Glass do not have a factory, but buy their blanks from suppliers of lead glass and lead crystal glass and then cut the glass.

When cutting flat glass it is important to break the glass immediately after scribing the glass, as glass gets 'stale' and the cut reseals itself.

CYPRIOTE GLASS This has a finely pitted, nacreous surface, a process used to imitate ancient Greek, Roman and Hebraic glass objects with patinaed, corroded surfaces decayed with time. Tiffany made Cypriote ware by rolling a gather of transparent yellow glass over a marver covered with crumbs of the same glass. The surface was heavily lustred but otherwise only minimal decoration was used (Potter 1988:38).

DECOLOURISERS Small quantities of metal oxides are added to the glass batch in order to improve its clarity. The principle of decolourising glass was known to Roman glass makers; Pliny (Natural History, Book XXXVI) stated that 'magnes lapis' was added to the glass. This was most probably manganese; Manganese dioxide is the main decolouriser for lead glass today. Decolourisation may be carried out by a physical process in which an oxide is added to the glass which is complementary to the natural colour of the glass (two colours are said to be complementary when, between them, they absorb to an equal extent the rays making up white light). Thus when adding a complementary colour to the natural colour of the glass the glass appears 'clear'. Purple manganese is added to a batch to 'balance' the greenish tinge of the iron. Manganese dioxide also acts as an oxidising agent in the conversion of ferrous iron oxide to the paler yellow ferric state. The addition of manganese dioxide must be very carefully controlled otherwise instead of taking away colour, colour will be added to the glass.

DEVITRIFICATION Crystallization in glass, which takes place when glass is held at high temperatures.

DIATRETA The process of creating a design by carving from a thick blank. Figures, flowers leaves etc. are carved in relief and then cut away, and are only attached to the background by small bridges of uncut glass. The Lycurgus Cup is decorated by this process (see CUTTING GLASS). After its use during Roman times the process of diatreta was not used again until the nineteenth century.

DICHROIC GLASS A material which exhibits two colours in the same piece. It is a glass which transmits light of one colour when viewed straight-on and another colour when viewed at an angle. It was originally manufactured for colour separation photographic processes by a method called vacuum deposition. Colour separation coatings are only one of many types of vacuum coatings which consist of a thin film of dielectric material such as silicon, titanium or magnesium. The materials are evaporated and vacuum deposited onto glass to such a fine degree of thickness that certain wavelengths of light will pass through and others will be reflected. The reason glass changes colour when viewed from different angles has to do with the laws of refraction and deals with differences in refractive indexes between air, glass, and the coating materials used. Dichroic glass is very expensive to produce because as many as 25 layers of coatings, evacuations and vapourizations are needed to produce the dichroic glass.

Several colours of Dichroic glass can be obtained from Allen H. Graef-Dichroic Glass, 3823 E. Anaheim Street, Long Beach, CA 90804. (They will also supply a single free sample of the glass, or a colour sample kit consisting of a 2,5 x 2,5 cm piece of each colour, at a cost of $25.00, if required.) These colours are:

Magenta which has a shift colour of yellow and a silver-blue reflective colour

Blue - shift colour of magenta and a gold reflective colour

Cyan - shift colour of turquoise and an orange reflective colour

Yellow - shift colour of clear glass and a blue-purple reflective colour

Red - shift colour of orange and a silver-blue reflective colour

Orange - shift colour of yellow-orange and a blue reflective colour

Green - shift colour of blue and a deep pink reflective colour

Dichroic glasses are fusible as long as the base glasses are compatible. The coated surface can be fired face up and does not need to be fused in-between two layers of glass. The result will be a reticulated surface that is still dichroic. Dichroic coatings should not be fused face to face as they will stick together.

ELECTROPLATING ON GLASS A process in which a glass object is covered in a thin metal conductive substance which is painted on the areas to be plated. An adherent film of metal can also be used. The piece is placed in a copper sulphate solution and an electric current causes the copper to build up on the surface of the glass.

ENAMELLING A decorative process known to the Romans, in which finely powdered coloured glass suspended in a liquid or oil-based medium is applied to the glass surface and fired until the two are fused together. There are three main suspending mediums or vehicles for glass colour - water, water and denatured alcohol with some glycerine added, and turpentine. Water and alcohol (3-4 parts water to 1 part alcohol), is used for white enamels so that the decomposing oils will not discolour the white colour during firing. Turpentine is used as it evaporates rapidly and can be applied without crawling, and is applied to objects that are slightly oily or dirty after handling. If water is used gum arabic or gum tragacanth can be used to get the colours to set hard when dry. It is important to note that the enamel must be fused at a lower temperature than the softening point of the article itself; for this reason a muffle furnace is usually used when decorating objects with enamel powders. The enamel must also have the same coefficient of expansion as the glass body otherwise it will crack off. Glass enamels fire at between 560°C and 580°C.

The highest artistic attainment in enamelling in the past is that of Islamic craftsmen of the thirteenth and fourteenth centuries when they enamelled hanging lamps used for lighting mosques. Early Islamic glass shows the continuation of late Roman decorative motifs, but is further enriched by the discovery of gold lustre painting; mosque lamps are masterpieces of the glass painters art. Some two hundred mosque lamps have survived the centuries and examples can be seen in the Victoria and Albert Museum, London.

ENGRAVING Engraved glass was produced in ancient times using lapidary tools. With the development of Venetian cristallo glass, engraving was no longer practiced as the surface was too fragile for any deep incisions, and any engraving needed was done using a diamond point to scratch designs lightly onto the surface.

FAIENCE Small objects such as beads, scarabs and armlets, covered in a vitreous blue and green glaze, and dating from about 3000 BC were discovered. These objects were in stone, pottery and faience. Faience consists of a glass-like substance and was produced by grinding quartz and fusing it with an alkali when it was fired. Faience is also a name used to describe tin-glazed ware from Faenza. It is now often used to describe any glazed and decorated earthenware.

FIRE POLISHING Re-heating a finished piece of glass to remove tool marks or a dull surface in order to regain a smooth glassy appearance.

FIRING SCHEDULE A predetermined selection of temperatures, times and rates of raising or lowering the temperature of a kiln.

FLAMEWORK Working glass in the direct flame of an oxy-propane torch. The heat is applied to the glass in a strictly localised manner.

FLASHING A thin coating of different coloured glass fused onto the outer surface of the glass. This is done by taking a gather of the inner colour and dipping it into a crucible containing molten glass of another colour. A much thinner layer of glass is achieved than when using the process of casing or that which is achieved in an overlay.

FLINT This has some of the properties of investrite and can be used as a substitute for it.

FLINT GLASS A process of making glass where flint stones are used for their silica content to form colourless glass. Sand is not used. The flint stones are burnt and then ground to a fine powder.

FLOAT PROCESS A process by which all commercial window glass is produced. Molten glass is floated over the surface of a bath of molten tin where it spreads out to a sheet of uniform thickness, producing an excellent, fire-polished surface on both surfaces.

FLUX A substance added to the basic ingredients to stabilise the batch. The best fluxes are soda, potash, wood ash and lead oxide. The addition of flux to enamels causes them to melt and fuse at a lower temperature, before the object itself melts. Most enamels and enamel paints are already fluxed when sold. An additional flux is needed if a test sample shows that enamel powder or paint fails to flow and mix with the glass.

FORMING Placing glass in a mould and heating it to form the shape of the mould.

FRIGGER A traditional term for any small glass object made by the craftsperson for his or her own use, as a decoration or gift.

FRIT Small pieces of crushed or broken glass. Also a calcine mixture of sand and fluxes which is melted to form glass.

FURNACE Equipment used for forming molten glass for blowing.

FUSE The process of melting two or more pieces of glass together.

GAFFER The master blower or head of the blowing team.

GADGET A special rod with a spring clip on the end which grips the foot of the glass while the worker finishes off the blown object. It was developed to take the place of the pontil to avoid leaving a 'pontil' mark on the foot of blown objects.

GATHER The glob of molten glass attached to the end of the blowing iron, pontil or gathering iron, prior to the making of the glass object. The glob is formed by dipping and swirling the pipe in the furnace until covered with glass.

GILDING The process of using gold on glass in one of the following ways

a) Mixing gold powder or foil and a fixative, painted or brushed on the glass and then fired and burnished.
b) The design is painted on the glass with a fixative, gold leaf is then placed on the fixative and dried.
c) Gold leaf is enclosed between two layers of clear glass.

GLASS CERAMICS A process discovered by accident in 1957 when a sample of photo sensitive glass was irradiated and then heated far above its usual developing temperature because of a fault in the furnace. Instead of melting, as would have been expected, the glass turned into an opaque high silica glass of great strength which could withstand very severe heat-shocks. It is used for nose cones of missiles, windows and antenna shields for space vehicles. This material is known as a glass ceramic and is also used in domestic cooking for objects which can be taken straight from the refrigerator and placed on the top of a red hot stove. Glass ceramic tiles form protective layers for space shuttles, composed of 7% solids and 93% air, they are excellent thermal insulators. Seconds after coming out from a kiln, a glass ceramic cube can be safely held by its corners while the interior glows at 1200°C.

GLASS FIBRE In spite of its many recent industrial applications, glass fibre is not a new product. It was made 2000 years ago in ancient Egypt and Rome. (see SPUN GLASS). Ingredients for glass fibre are:

Sand	56%
Alumina	14%
Soda	0,5%
Lime	21%
Borax	8,5%

GLORY HOLE A small opening on the side of a furnace, used for reheating cooled objects without melting or destroying their shape.

GOLD Minute quantities of gold powder added to the batch produce rich ruby red tints in glass. Because of the obvious expense and the intensity of the colour of the glass, it is usual to use glass containing gold as a thin layer over a colourless glass (see CASING; FLASHING). Another method of producing ruby-red glass is to add selenium and copper to the batch.

GOLD FOIL Gold foil was first used to decorate glass by the Alexandrian Greeks in the First Century BC. Examples taken from the tombs of Canosa can be seen in the British Museum in London. They are forms decorated in gold foil with a design of acanthus, plants and tendrils. Gold foil (and silver foil) is fixed to the glass with linseed oil.

GRAPHITE Graphite mixed with water or alcohol is a good separator for low temperature slumping. At temperatures above 600°C the graphite burns away.
Two or three layers of a graphite paste such as Zebo, which is still sometimes used to polish cast iron stoves, can be applied to the mould, drying each layer before adding the next. This works for higher temperature firings. Graphite powder, used for lubricating locks and bought at hardware shops, can either be sprinkled on a sand mould, applied to the sand surface using an acetylene torch, or applied to wax and leather-hard clay models to keep the damp sand from sticking to them.

GRINDING GLASS Glass often needs to be ground to get rid of needle points or rough surfaces. A PUMA 1/4" Mini Die Grinder with various textured tungsten carbide burrs is an inexpensive and easily-used tool for grinding glass. A grinding wheel may also be used. Several different qualities of abrasive can be used - silicon carbide for rough grinding, aluminium oxide for finer grinding and tin oxide and cerium oxides for polishing. Water is used as a suspension medium for the abrasives and also as a coolant.
Between grindings the wheel must be scrupulously cleaned of the coarser abrasive or the piece will show scratch marks which become very difficult to remove. Silicon carbide waterproof papers can be used for finer grinding and polishing. Gradings from 200 (roughest) to 1200 (finest) can be used.

GROUND The decorative background to a paperweight design. Traditionally paperweights are domed and have a ground of clear, opaque or translucent glass.

GUM ARABIC A binding agent which is added to crushed glass and enamel powders, which if dry would not adhere to the glass surface. To use, mix the gum arabic and water to a creamy consistency and add to crushed glass or enamel powder.

HIGH TEMPERATURE AGGREGATE High alumina refractory ranging in size from dust to 6 mm aggregate. It is inert at high temperatures. It must be kept from surface contact with forming glass as it will stick and contaminate the surface. It is used as a support in a mould where cracking and glass seepage is likely, and is used as a dust or as a heavier aggregate determined by the requirements of the mould.

HISTORY OF GLASS Although shrouded in mystery, over the centuries there have been books written which describe some glass-making processes. These are *Pliny the Elder's books on natural history*, (23-79 AD); *The Various Arts* by Theophilus Rugerus. 1110-1140. (Translated by C.R. Dodwell, Thomas Nelson and Sons. 1961); Agricola, *De Re Metallica*. 1556. (Translated by H.C.Hoover. Dover Publications 1912.) and *The Art of Glass* by Antonio Neri. 1612. (Translated by Christopher Merret, 1662).

HYDROFLUORIC ACID The only known acid which will actively attack glass. A mixture of hydrofluoric acid and sulphuric acid produces a gloss on lead crystal glass unequalled by any other polishing method. The addition of a neutralising agent such as ammonia to the hydrofluoric acid produces a frosted effect. Hydrofluoric acid can be used in conjunction with acids such as sodium fluoride. Ammonium bifluoride and sodium bifluoride can also be used. In an aqueous solution the bifluorides release hydrofluoric acid so they have a similar effect to the hydrofluoric acid (See ACID ETCHING).

ICE GLASS A process in which the surface of the glass is made to look like cracked ice by plunging a paraison of soft glass into cold water early in the blowing process. After a gentle reheating (to avoid smoothing the surface), the final blowing enlarges the web of cracks and produces a shattered effect. A similar effect can be achieved by rolling the soft glass on splintered glass on the marver.

INCANDESCENCE The emission of visible light by a hot object.

INTAGLIO Decorative engraving or wheel-cut designs below the surface - the reverse of cameo design. The design itself is cut away from the outer layer leaving motifs of one colour set into the ground of another.

INVESTRITE (Crystobolite) A castable product produced for jewellery casting. It provides, softness, counters the tendency of plaster to crack and is easily removed from glass after forming.

IRIDIZED GLASS A process of spraying a metallic salt dissolved in a dilute hydrochloric acid solution onto the surface of very hot glass to produce a lustrous, iridescent finish. Stannous chloride is the most successful chemical used for the iridizing process but other metal salts may be added to stannous chloride to provide other iridescent finishes, depending upon the colour and type of glass as well as how thickly the chemical is applied. This is a dangerous process, it is therefore important that a mask is worn and that the work is carried out in a well ventilated area.

Stannous chloride Iridizing solution: (taken from Lundstrom. Glass Fusing Book 1)

By volume:

1 part stannous (tin) chloride crystal

1 part swimming pool acid (hydrochloric acid)

2 parts water

Tetraisopropyltytanate is a non-toxic, organic solution commonly used as an iridizing solution. However, it burns off in the fusing process.

IRON is generally present as an impurity in sand (or silica). Iron oxide may be present as either ferrous oxide (FeO) or ferric oxide (Fe_2O_3). Ferrous oxide gives a blue-green cast to glass, while ferric oxide gives a yellow-green cast. Oxidising agents such as arsenous oxide, potassium nitrate (saltpetre) or sodium nitrate can be added to the batch. They release oxygen into the melt which keeps any iron oxide present in a pale or ferric condition. The process of changing colour by oxidation is known as chemical decolourisation. Decolourisation may be carried out by the addition of a stain which is complementary to the natural colour of the glass. Manganese oxide which has a purplish colour can be added to the batch to balance the greenish tinge of the iron. (see DECOLOURISERS)

In its reduced condition, iron, in combination with chromium, is used for the manufacture of wine bottles. When combined with sulphur, iron sulphides form, giving a dark amber colour. However if sulphur and iron by themselves do not give the required deep amber colour, a reducing agent in the form of carbon powder is added to the batch. Beer bottles are coloured in this way.

KAOLIN ($Al_2O_3.2SiO_2.2H_2O$) Commonly known as china clay it is used as an ingredient of shelf primer and a component of glass melting crucibles.

KILN FIRING TEMPERATURES

20°C	Ambient (room temperature)
100°C-400°C	Glass is a frozen liquid and cannot be formed.
500°C-560°C	Annealing range. The only processes within this range are enamelling and lustreing. These are surface processes, i.e. the introduction of colouring agents onto glass forms which already exist. Moulds are not necessary, but whatever supports the glass in the kiln must be coated with a separator.
600°C-700°C	Unsupported glass begins to bend under its own weight and take up the mould form. Moulds for bending are the simplest ones: a. Plaster/sand 50/50 b. Plaster/investrite 50/50 c. Plaster/flint 50/50 These are measured by volume, mixed together when dry and then added to water (use 20% less water than when mixing plaster alone - 850 ml water to 1,1 kg plaster). Moulds made from these mixes can be used many times if they remain undisturbed on the kiln batt. If moved, they disintegrate rapidly. At the upper end of this temperature range, glass will stretch and become sticky and pick up the texture of the mould. Metal and ceramic forms can be used almost

indefinitely to bend glass in this temperature range, providing separators are used.

700°C-800°C Glass can be fused and complex textures can be imparted to the glass. The main mould mix for this temperature range is:

1/3 clay or potters plaster

1/3 investrite

1/3 high temperature aggregate (80 mesh)

By volume, mix dry, add to water, using 20% less water than when mixing plaster alone. When used this way the fine high temperature aggregate becomes coated with plaster and investrite and does not come into contact with the glass. This mix is suitable for pâte de verre.

800°C-975°C Glass is at its most liquid (still turgid and 100 times more resistant to pouring than water). All forming between these temperatures counts as casting, and the mould is completely responsible for shaping the glass. Moulds to be used at this temperature range are made from the following mix:

40% potters plaster

40% high temperature aggregate

20% investrite

or

1/3 potters plaster

1/3 high temperature aggregate

1/3 investrite

This information concerning temperatures for kiln forming was taken from notes from the Wolverhampton Glass Summer School.

KILN WASH Powdered refractory material mixed with water and applied to kilns, shelves and moulds to act as a release agent.

KNOP The bulge in the stem of a glass, either hollow or solid of many different designs.

LAMINATE Bonding two or more layers of glass together, with either heat or adhesives. Many decorative effects can be used when laminating glass. Coloured designs or patterns can be made using metal oxides, glass enamels or crushed glass. Bubbles can be obtained by placing mica flakes, oil or chalk between the layers of glass. Thin wire structures, even wire mesh can be cut to shape and laminated - these wires can be extended beyond the edge of the glass and used for suspension. Tin, lead, and copper foil can also be used to obtain interesting effects. Sand, particularly the finer grades, produces an iridescent effect. Glass rods and fibre glass strands on their own or dipped into an underglaze make interesting textures in the laminated glass.

LAMINATING TEMPERATURES

Below 550°C: Heat kiln fairly slowly particularly for the first hour.

550°C - 700°C: The surface of glass becomes more glossy, painted surfaces become semi-glass and most metallic lustres mature by 650°C. There is no visible change in the glass form. Bubbling between layers to be laminated can occur if the kiln temperature rises too rapidly between 600°C and 700°C. Unfortunately bubbling only becomes visible at a much higher temperature of about 800°C.

The kiln door may be slightly opened from this point, but the kiln must be turned off and the door must only remain open for a very short period.

700°C - 720°C: Glass begins to change colour and if left at a constant temperature, begins to sag, depending on the type of glass. The glass is still brittle and the edges are sharp.

730°C - 780°C: Glass begins to slump and edges soften losing their sharpness. Pieces of glass will start to stick together if touching, and the glass has a red colour.

785°C - 820°C: All glass will have slumped by this stage and lamination will have taken place. The laminating process is visible at this stage. The kiln should be turned off and the door opened fairly wide to see the glass more easily. If lamination is as required, open the door fully and allow the kiln to cool rapidly to the annealing temperature, which will depend on the number of layers of glass and the type of glass.

LAMPWORK The process of making glass objects or fine details using a small flame, like a Bunsen burner. Miniatures of all kinds, which would be too small to be manipulated at the furnace, are made by the lampwork process using rods or thin canes. Paperweight patterns are assembled on a mould from prepared chips and cane slices before being enclosed in glass from the furnace.

LATTICINO Venetian name for a process first used by the Romans to decorate rims of bowls. The process consists of making a lacy-looking glass using very, very fine opaque white or coloured glass threads which are entwined and twisted through the mass of colourless glass.

LAVA GLASS A glass surface used by Tiffany to imitate the effects of volcanic forces on glass. It was made by adding basalt or talc to molten glass to produce a black or dark coloured surface with a rough texture, and then covering the surface with gold lustre.

LEAD Lead oxide has been known since ancient times. Egyptians used lead for water conduits as far back as 3000 BC. Lead is mined in the form of galena - a lead sulphide which is found extensively in America. Lead crystal glass which is produced from the fusion of sand, red lead and potash, was discovered by George Ravenscroft during the seventeenth century in Britain. Red lead (Pb_3O_4) is formed when air is blown over the surface of molten lead causing a substance called litharge (PbO) to be formed. Red lead is produced by further oxidation.

As lead is a heavy substance the density of the glass is considerably increased, enhancing its power to refract and disperse the light transmitted through it. This property of density and the corresponding power to disperse light gives lead crystal glass its unrivalled sparkle and brilliance. Lead crystal glass has a clear bell-like note when struck. Special optical lenses are made from lead glass because of its superior refractive power.

Lead glasses have to be melted in a way that differs from other glasses. The furnace conditions must be of an oxidising nature to prevent the reduction of the lead compounds to a metallic condition. The presence of metallic lead will cause not only discolouration of glass but can result in damage to furnaces, moulds or crucibles.

LEAD CRYSTAL GLASS BATCH The mixture of raw materials for making lead crystal glass is as follows

Sand	1000 parts
Red lead	660 parts
Potash	330 parts
Saltpetre	40 parts
Borax	30 parts

Arsenic 3 parts
Decolouriser small quantity

LATTIMO Opaque white glass.

LEADLIGHT Separate pieces of glass joined together with strips of lead soldered at the joints. Another word for stained glass.

LEHR A type of annealing oven, sometimes with a moving base, which travels slowly through a controlled temperature zone until the annealed objects are removed at the other end. The speed can be adjusted to the type of glass to be annealed. A lehr can also be used for firing enamels and lustre painting onto glass objects at low temperatures. Cold objects needing further decorations or additions at the furnace are first returned to the lehr for gentle reheating. A lehr can be built as an auxiliary part of the furnace and in this way draws heat from the furnace.

LIGHT BULBS Soda lime glass transmits light rays and is able to withstand the temperatures resulting when electricity passes through the filament. For this reason soda lime glass is used to produce light bulbs. When the temperatures are not suitable for soda lime glass (outdoor fittings for example) heat resisting borosilicate glasses are used. The invention of the Corning ribbon machine, in the beginning of the twentieth century, has revolutionized the manufacture of the light bulb, as just under 70000 can be produced in an hour by a single machine. A narrow ribbon of molten glass travels over a moving steel belt, the glass sags through holes in this belt into moulds below and puffs of compressed air shape the glass into light bulbs.

LIME A powerful flux which reacts with silica at very low temperatures to form calcium silicate, the essential stabiliser for glass. Lime also increases the viscosity of glass leading to more rapid stiffening when glass cools. Without lime glass is more difficult to work. Lime occurs in marble, limestone or chalk. The quality of lime used in the manufacture of glass has to be good and the iron content low, as in sand. Limestone is crushed to a granulated powder form. Lime added to glass also gives increased stability and adds to the weathering qualities of glass. It is an ingredient used for everyday glass - bottles, window glass, electric light bulbs etc.

LOST-WAX CASTING (CIRE PERDUE) A method of casting in which a wax or wax-coated form is embedded in clay and then steamed, baked or heated so that the wax melts, and is 'lost' leaving a mould into which the glass can be poured. The mould then has to be broken to retrieve the object.

LUSTRE A process of decorating glass using metal oxides, especially silver and copper. When the painted object is fired in the furnace, the compounds of silver and copper change colour because the oxygen is reduced. The amber or reddish-brown film which remains has a lustrous sheen.

MANGANESE compounds have been used to colour glass for centuries. Purple Egyptian glass, produced around 1400 BC has been discovered at Tel-el-Amama. Manganese has been used since the time of Pliny to de-colour glass - in its low state of oxidation manganese is colourless, but at the same time it is a strong oxidizing agent and is used for decolourizing purposes to oxidize iron impurities in silica. In modem glassmaking manganese has been replaced to a large extent by sodium nitrate and selenium for decolourising glass. Manganese produces an amethyst colour which is almost complementary to the naturally green colour produced by iron in the glass. Manganese produces a deep purple glass. This is obtained by the trivalent manganese, but its divalent state, which cannot be completely eliminated, imparts a weak yellow or brown tint resulting in the greenish or orange fluorescence in manganese coloured glasses.

MARVER A metal or stone surface on which molten glass is rolled or pressed to form shapes or to pick up surface embellishments, such as gold leaf, oxides or small pieces of coloured glass. The marver is also used when forming the 'blob' of glass for a paperweight.

MERESE A small disc of glass usually placed between the bowl and stem or stem and foot of a wine glass or goblet. It is partially ornamental, but also has a practical function of giving greater strength to the object.

METAL A term traditionally used to refer to molten or cold glass.

METALLIC OVERGLAZE A material which contains very fine particles of metal such as gold, silver, copper, or palladium. When these materials are fired onto glass the result is a shiny, metallic surface which is sometimes referred to as a metallic lustre.

MILLEFIORI Literally 'a thousand flowers'. A process in which many slices of coloured glass canes are embedded in clear glass, in multicoloured chevron, floral or other patterns, in alternating concentric bands.

MILLEFIORI CANES A process in which moulded shapes, and forms of figures, animals and birds, are placed in concentric layers of differently coloured glass. These canes are originally quite thick, however when the design is completed they are heated again, and drawn into long thin threads.

When these are cooled and hardened they are sliced very thinly into hundreds of pieces.

MILLEFIORI BOWLS Keith Cummings, in a paper presented at the Working with Hot Glass Conference at the Royal College of Art, London, 1976, said: 'The conventional explanation of the transformation of milleflore pieces into bowls was that sections of these canes were used to line ceramic moulds, and the moulds fired to produce a fusion. Our first experiments found that this was simply not an adequate process. Our successful version was to fuse the canes into a thick disc (the thickness was necessary to facilitate the subsequent cutting and polishing, which finished all of these forms) and then to deform the disc into a mould or through an aperture in a free gravity drop. This latter method produced fire-polished forms which were not mould marked and therefore did not require polishing. We found that it was better to combine fusion of the disc and sagging in one operation. This we did by fusing the cane sections on a flat metal plate at about 750°C. Once fusion occurred, we dropped the temperature to 600°C, transferred the now frozen disc to either a sand and plaster mould (75% plaster 25% sand) or to a sheet of mild steel 0,3 cm thick with an aperture cut in it. The temperature was raised again until sagging was achieved'.

MODEL FOR REFRACTORY MOULD FOR KILN-FIRING GLASS It is necessary when using a refractory mould for kiln-firing glass to make a model from a non-rigid material. Soft clay or silicone rubbers are suitable, the reason being that the plaster constituent is so diluted by other refractory materials that it remains soft. Even on flexible models, a release agent is required and great care must be taken not to damage the mould face. Soft clay provides an adequate model, but there is always a chance that the clay piece may be damaged when being removed from the mould. Important works should therefore be transferred into silicone rubber so that, if necessary, several impressions can be made. Most of the synthetic resin manufacturers such as Dow-Corning, ICI or CIBA make synthetic rubber castables, and these, although expensive, produce excellent models for this process.

Preparation of the model for mould making:

1) The model is set up, on a base within a retaining wall. An adequate margin of approximately 50 mm should be allowed around the model for mould walls.
2) A release agent such as paraffin is thinly brushed on. Immediately before casting, a fine mist of wetting agent (detergent in water) is sprayed on. The minimum wetting agent should be applied or the mould surface may deteriorate.

MOIL The waste glass left on a blow-pipe or pontil, which is used for cullet. Moil is knocked off after every making into a collecting bin.

MOULD (see KILN FIRING TEMPERATURES) Form made of a variety of substances including ceramic materials, plaster, sand or metal, and used to form glass. A mould has to be stable, be able to withstand temperatures of between 400°C and 1000°C, and be resistant to cracking and distortion at these temperatures. It is also very important that the glass can be easily removed from the mould after firing. There are a large number of different refractory mould mixtures which include the following ingredients:

1) Binders which bind the high temperature refractory materials together - fire clay/plaster of paris/ciment fondu
2) Refractories which are materials that will withstand high temperatures without deforming - sand/silica/alumina/zirconia

3) Modifiers are added to mould formulas to increase porosity and to absorb expansion or contraction of the other mould materials - vermiculite/grog/sawdust/paper/kaolin

Good quality, heavy stainless steel, mild steel, cast iron and cast brass can all be used to form glass. Metal moulds are excellent to use for slumping glass as they absorb and give out heat at a rate similar to glass. Aluminium is never used as it has a very low melting temperature.

Sand moulds are only suitable to form fairly simple objects as the sand would not hold undercuts. Bertil Vallien formulated a mixture of clay, sand, charcoal and water which produces an ideal mould for casting. The quantity of water used in the mix is crucial to the success of the casting - the sand mixture must be firm when held fairly tightly. If too dry the mould will collapse, and if too wet bubbles will form in the glass. The surface of the sand mould is sprinkled with graphite to prevent the sand from sticking to the glass. Molten glass of 1100°C is poured into the mould. The glass is formed in fifteen to twenty minutes, removed from the sand mould, and annealed.

Depending on the size of the kiln, glass objects can be sand-moulded in a kiln. A container with sand and a model is placed in the kiln and fired to between 700°C and 900°C depending on the size of the piece.

Moulds for sagging glass can be made from 75% fine casting powder and 25% silver sand (or fine high temperature aggregate). This mould recipe should only be used for temperatures up to 700°C. For moulds where the temperature will go up to 800°C; 60% plaster, 20% silver sand and 20% grog (or previously fired mould material crushed to a powder form) is used.

For sagging glass at temperatures over 800°C the following recipe can be used :

45%	Plaster
45%	Investment powder
10%	Previously fired mould material crushed to a powder-like consistency.

(These mould recipes are taken from The Technique of Glass Forming by Keith Cummings.)

The following refractory mould recipe was developed by Frederick Carder and is still employed by Corning Glass Company for casting one-off specials. It is suitable for temperatures of around 900°C and the mould material is soft which allows for movement of the glass and makes it easy to wash away after firing. It is possibly the most successful mould recipe and for this reason is repeated in this glossary under 'REFRACTORY MOULD FOR KILN-FIRED GLASS'. The following ingredients are mixed with 170 ml of water:

100g	Plaster
100g	Quartz
20g	China Clay
2g	Alumina fibre
2g	Any heavy paper (cartridge)

The following mould mixture was developed by Gabriel Argy-Rousseau to cast onto rigid models made from plaster. This mixture is too soft to be used for lost wax casting.

28%	Plaster
22%	Pre-fired fine calcined kaolin
3%	80-100 mesh unfired kaolin
10%	Ground sand
37%	Grain sand

MUFFLE KILN Low temperature kiln used for re-firing glass to fix enamelling or gilding. Also a construction which can be placed within the furnace for heating materials without direct exposure to the fire.

MURRHINE BOWLS (vasa murrhine or millefiori) The term 'vasa murrhine' was scientifically controversial for a long time. It was initially thought that these bowls were made of semi precious stones because of the glass's close resemblance to jasper, agate and lapis lazuli. The production of these bowls demanded a great deal of skill. A number of glass rods were placed together to form a pattern and melted together. The resulting cane was cut into fine slices which were then placed side by side in a mould and fused together. The bowls were then ground and polished.
Murrhine bowls were famous in the ancient world; Cleopatra is said to have possessed a collection of over 3000 vessels. This legendary collection was auctioned in Rome by Augustus. Records show that at that time murrhine vessels were highly valued, in his Book of Natural History, Vol. XXXVII, Pliny reports that Pompey brought 2000 murrhine bowls to Rome after his victory over the Persian king Mithradates, and dedicated them to Jupiter.

NEEDLE POINTS Needle-like edges on glass due to overfiring. These can be ground off using a Mini Die Grinder.

NICHROME WIRE Wire used in the heating elements of kilns. As nichrome wire does not deform or melt at high temperatures, it can be used for various designs in laminating and casting glass.

NICKEL The addition of nickel to the batch gives two different colours to the glass depending on the conditions. If used with glass containing lead or potash a very deep violet is obtained, whereas in soda lime glass a dirty yellow colour is produced. Nickel is not an important colouring agent.

OPALESCENT GLASS Translucent glass which shows a milky iridescence like that of an opal. The image of the incandescent light filament, transmitted through an opalescent glass, appears as a red outline.

OPAQUE Glass which is neither transparent nor translucent and which light is not able to penetrate.

OVERGLAZE Finely ground glass of a specific composition which is applied to the surface of glass before it is fused to prevent devitrification and to produce a very glassy surface. It is generally applied as a powder or suspended in a spray medium.

OVERLAY The outer edge of cased glass. Double overlay glass consists of two outer layers of different colours.

OXIDE The compound formed by an element combined with oxygen. Glass is made by combining powdered oxides and melting or fusing them by the application of heat. The most important oxides used in glass manufacture are silicon dioxide, sodium oxide, potassium oxide, calcium oxide and lead oxide.

PAPERWEIGHT VASES Rare vases made by Tiffany by encasing a thick layer of decorated glass within a smooth outer layer - in effect trapping the decoration between two layers of glass. The internal glass or decoration itself gave each piece its descriptive title, so that Red Paperweight has an inner layer of opaque red glass, Reactive Paperweight has an inner layer of reactive glass (which changes colour by chemical reaction when heated) and Millefiori Paperweight incorporated a layer of Millefiori glass (Potter 1988:44).

PARISON (PARAISON) Balloon of molten glass, formed at the end of the blow-pipe.

PÂTE DE VERRE Literally means glass paste. It is made by placing granulated, crushed or broken glass, oxides, water and a binder into a mould and firing to achieve an object of translucent or almost clear quality.

The following method of making objects from pate de verre is a technique used by Diana Hobson which she sent to me some years ago. This is just one method of using pate de verre. It is not a casting process but is a method of building up layers of glass paste inside a refractory mould to achieve a hollow form up to 200 mm in height. This form is then fired to 700°C.

Make a clay model which is wider at the top than the base for easy access to the inside of the mould. A refractory mould is then made directly from the clay model unless more than one copy is required. In this case a silicone rubber model is made.

Glass is crushed, put through a 60 mesh sieve to remove any large grains, and washed by placing it in a bath of water. The water is poured off when the glass has settled in order to wash away any very fine grains as well as surface impurities. Iron and other metal impurities can be removed with nitric acid.

The mould should be completely saturated with water and kept as wet as possible all through the process by wrapping it in wet rags or plastic.

Mix enamels with the finer glass and layer them in the mould with a brush or spatula, compacting them to the sides of the mould. Use spoons to compact the glass as the more compact the glass is the better it is. Next, add a thicker layer of about 2-3 mm in thickness and compact again. Continue to build layers until the work is the desired thickness.

Paint two layers of gum arabic on the layered glass. It is possible to mix the gum arabic with the glass but this can cause air bubbles.

Compact the whole surface and leave to dry out until completely dry. The piece is then fired. Firing temperatures will differ depending on the size of the piece, the thickness of the mould and the type of kiln. Generally, however, the piece is placed in the kiln, without the bung and fired very slowly until the temperature reaches 500°C. (about five hours). Close the vents and take approximately 45 minutes to reach 700°C. The door of the kiln can be opened at this point to check on the glass and mould. The temperature can drop quickly at this point until it reaches the annealing temperature of 510°C. Leave to soak for three hours. Lower the temperature to 460°C, soak for two hours; lower the temperature again down to 410°C, soak for one hour; and finally lower the temperature to 360°C, and soak for one hour. Turn off the kiln and let it cool down to room temperature.

PATINAS The patinas found on most ancient glass are the result of weathering and devitrification and were never intentional. The iridescent gold, silver and rainbow-like effect occurs when thin layers of alkali in the glass are attacked by moisture and chemical agents in the soil or in the atmosphere. Eventually the surface of the glass becomes pitted, gradually corrodes and disintegrates. Only objects and vessels which have been preserved in very dry climates such as that of Egypt survive.

Achieving this iridescent effect on the glass surface is most successful in a fuming chamber. Stannous chloride in a heated ladle is placed at the base of the heated kiln. Fumes will flow upwards over the piece of glass and then pass out through the eye hole. The stannous chloride fumes attack the hot glass and the surface layer of the glass undergoes chemical changes allowing it to absorb some of the rays of the spectrum. Iridescence is caused by variations in the thickness of the attacked glass layer and often shows up best on dark glasses.

PHOTOCHROMATIC GLASS The addition of silver halide crystals to the melt causes the glass to darken when exposed to light and to lighten when the light level is reduced.

PHOTOGRAM (see RAYOGRAPH) A process of making photographic images without the use of a camera.

PHOTOGRAPH The combination of two Greek words, photos, meaning "light" and graphikos, meaning "drawing", thus "drawing with light". A word first used by the astronomer and scientist Sir John Herschel. According to the Modem Greek and English English/Greek Dictionary, 1979, New York: Divry Publishing Inc. the word `graphikos' means `writing', and the Greek work `ignographia' means `drawing'.

PHOTO-SENSITIVE GLASS A type of glass where the development of images is dependent upon exposure to ultraviolet radiations, and later, to heat treatment. The selective development of images is controlled by placing a mask or photographic film in contact with the glass before exposing it to ultraviolet radiations. In this way photographs can be reproduced within the glass.

PLATE GLASS Window glass which exceeds 5 mm in thickness. Most plate glass is produced using the float process.

PONTIL (PUNTY) A metal rod used during hot manufacturing processes which enables the glass-worker to take an object off the blowing iron and to hold and manipulate it to allow the top to be finished. As it cools, the glass solidifies and it is knocked off the pontil leaving the 'pontil mark'.

century it has been ground flat. The absence of any pontil mark may also mean that the vessel was opened by cracking off or that a clamp was used to hold the object during its final shaping.

POT Another word for a crucible made of fire clay in which the batch of glass ingredients is heated before being transferred to the furnace.

POT RING A ring made from fire-clay which floats on the surface of a pot. Although the molten glass may move because of the heat, the ring keeps the glass comparatively still enabling the glassblower to be sure that the glass is free of bubbles and impurities before he blows it.

POTASH Used as a substitute for soda in glasses such as crystal glass where the cost of raw materials is of secondary importance; the resulting glass is less subject to discolouration during melting than glass containing soda as the fluxing agent. In lead glass where clarity is essential, such as optical glass and the best tableware, potash and lead are used in the batch.
Potash is found naturally in Germany and South America. A solution of potassium chloride is carbonated which results in potassium carbonate. Carbonate of potash used to be produced from the ashes of wood from the bark of oak or lime trees. This ash contains six to seven per cent of carbonate of potash.

POTASH GLASS Although this glass is still used today, historically it was used in Germany and Bavaria. Harder and more brilliant than soda glass, it can be engraved and cut on the wheel.

PRESSED GLASS A process in which molten glass is pressed into a mould. Flat plates and bowls are formed in a base mould and a top section is brought down to mould the top surface. Mould marks are ground and polished off by hand to produce objects very similar to cut glass.

PRINCE RUPERT DROPS A tadpole shaped piece of tempered glass, named after a seventeenth century Bavarian prince, which is made by dripping molten glass into a bath of water or oil, cooling the exterior faster than the interior. This creates a surface compression which makes the drops both tough and fragile; if hit with a hammer they won't break but if a mere scratch is made on the surface, or if the very end of the 'tail' is snipped off, there is an explosive chain reaction of fractures which shatters the glass into hundreds of lethal shards.

PYREX is a borosilicate glass and was originally manufactured by Coming Glass Works. Pyrex has a low coefficient of expansion (0,0000059 to 0,0000065 per deg C) and can resist thermal shock such as when exposed to a direct flame.

PYROMETER A high temperature thermometer which indicates the temperature inside the kiln. It generally consists of three parts: a thermocouple, a temperature indicator, and a connecting lead wire. The indicator may be one of two types: galvanometric or potentiometric. A galvanometric indicator is composed of a needle that rotates on a small shaft, indicating the temperature on a calibrated scale. The length of the lead wire between the thermocouple and the indicator will affect the accuracy of the reading. A potentiometric device indicates the temperature on a digital display and is more accurate, but it requires electrical power to operate and is more expensive than the galvanometric indicator.

RADIANT HEAT The heat from the elements and the heated walls of the kiln that is transferred to the kiln contents by radiation.

RAYOGRAPH A photographic process of making cameraless images, discovered accidentally in the early 1920s by Man Ray. Objects are placed on photosensitive paper and exposed to a white light. When placed in the developer the parts of the paper exposed to the light turn black, while the parts covered by the object yield vestiges of the forms that have been placed on the paper. Execution is automatic and instantaneous.

REACTIVE GLASS Certain kinds of glass change colour in the furnace. Tiffany used this phenomenon in many of his objects. Rainbow glass is a type of reactive glass made from a uranium-impregnated batch; flashed, while Pastel Tiffany glass is made by coating reactive glass with a non-reactive coloured glass then reheating the resulting object to make it opalescent.

REFRACTORY MATERIAL A material such as alumina, silica or zirconia which does not deform or change chemically at high temperatures.

REFRACTORY MOULD FOR KILN-FIRING GLASS This mould material, suitable for kiln sagging and pate de verre techniques, is designed to operate in the 750°C to 1000°C temperature range. It was developed by Martin Hunt of the Royal College of Art, London, from a mixture developed by Frederick Carder used by the Corning Glass Company for casting their one-off specials.

100g	plaster
100g	quartz
20g	china clay
2g	alumina fibre
2g	heavy paper (cartridge, paper towel)

170 ml water

1) Liquidize the paper and alumina with water in a domestic blender. Pour the pulp through a 40 mesh sieve, to remove excess paper size and drain.
2) Add the other ingredients, sprinkle onto the measured water and when absorbed, add the pulp. Stir slightly.
3) Mix together vigorously with a paint stirrer fitted to a power drill, for about 20 seconds. The mix sets quicker than normal plaster so care must be taken over the timing at this stage. A considerable amount of air is trapped in the plaster by this high speed stirring. The mix should be moved around or the bucket tapped with a wooden spoon to get rid of the bubbles.
4) Spray on the wetting agent (detergent in water).
5) Pour the mix slowly, allowing it to creep across the surface of the model. The wetting agent flows in front of the plaster carrying it into every crevice. Move the mould around again immediately after pouring to lift any bubbles away from the mould face.

Casting the glass in the mould.

1) Dry the mould and fire in a kiln to approximately 800°C.
2) Place crushed or broken glass or molten glass from the furnace in the mould. Take care as the mould is very soft, for this reason it is better to place the mould on the kiln shelf and then to fill it with the glass. Refire the glass and mould to approximately 750°C or until it can be seen that the glass has flowed level and filled the whole mould.
3) After annealing, and once the kiln is cool, remove the mould from the kiln and break away leaving a finished glass piece.

RESISTS A sandblast-resistant material used for making designs or patterns when sandblasting. They are produced in a variety of thicknesses and consist of either a resistant film or an adhesive tape.

RETICELLO (VETRO A RETICELLO) Literally glass with a small network. A material composed of single white threads or canes creating a very fine mesh. Tiny air bubbles are trapped in the small cavities between the mesh.

RETICULATED The process of manipulating trails of glass to achieve an open network or loosely woven effect. Originally a sixteenth to eighteenth century Venetian technique, it was also used for friggers and other novelties. Tiffany used reticulated glass for lamp bases, candlesticks and inkstands, and used a different process which was to blow coloured glass at high pressure into a cast metal or twisted wire framework so that the glass bulged out through openings in the frame. It is one of the rarest of all Tiffany's art glass (and is very rare.)

RODS A solid stick of glass. A group of rods makes up a cane decoration.

ROD FORMING (see CORE-FORMING) Rod forming techniques were first developed in the Bronze Age. Vessels were formed with a metal rod covered with clay, sand and dung. Pendants and other small decorative sculptural forms were made by the rod forming technique where a core was not used. The object was formed directly on a metal rod which was probably covered with a thin layer of some material which would have acted as a separator to prevent the glass from sticking to the metal rod.

ROUGE A reddish powder, mainly ferric oxide, used to polish glass.

SAND or silica is the base of all common glasses. It is found on the earth in great abundance. Although sand is so abundant, the supplies for the making of colourless glass are limited owing to contamination by small quantities of iron. All sands contain this impurity, and their suitability for the making of colourless glass is determined by the amount of iron present. As little as one part of iron oxide in five thousand parts of sand is sufficient to impart a pale sea-green tint to the finished object.

Sand for glass-making is specially selected to have as low an iron content as possible, to have grains as uniform as possible and also to be free of other impurities such as carbonaceous matter which would also discolour the glass.

To achieve these conditions, sand is well washed, heated to a dull red heat and then pressed through screens to remove coarse grains and lumps.

In the 17th and 18th centuries the source of silica for glass making was not always sand but flint stones, burnt and then ground to a fine powder to make 'flint glass', a term still used today to describe a colourless glass.

Builders sand can be used in loose form to bend glass on, also sieved to achieve a soft surface texture. It can also be used to prevent precast elements from moving while casting.

SANDBLASTING is a process invented by a Philadelphian chemist, Benjamin Tilghman, in 1870. It has only been adapted to decorative techniques in the past few decades. The process consists of using a high pressure air jet to direct fine grains of sand against the glass surface. By altering the size of the nozzle of the gun, the air pressure and the quality of the sand, varying grades of finish can be obtained. The effect of the sandblasting can be superficial or by continuing the attack with a coarser grain of sand, a degree of depth can be obtained. A slight relief effect is increased by the natural refractive properties of the glass.

Portions of the design not to be sandblasted are masked with specially treated adhesive paper or adhesive film impervious to the action of the impinging sand particles. As these resists are not readily available in South Africa masks can be made of a thin sheet of zinc which is easily formed around contours and easily cut with a Stanley knife. Masking tape can be used as well as proprietary latex-based materials which can be painted on the surface; when their solvents evaporate a rubbery skin remains which can be cut with a stencil knife.

A variety of textures are possible due to different types of grit, air pressure and length of time of the sandblasting. If the glass is then heated in a kiln to above 650°C the glass will clear and have a textured surface.

A suitable sandblasting gun for small-scale glass work requires an air pressure of about 600 kPa, and a free air flow rate of about 3 l/s. A suitable compressor would require a 1,1 kW motor.

SEEDS Small bubbles in the glass causing an imperfection in the glass usually as a result of impurities in the batch. Seeds can also be caused by insufficient heat or time in the furnace during the melting and refining process.

SELENIUM When used alone produces a pink colour in soda lime glass and is often used in glass to neutralise the green tint caused by iron impurities. With lead glass selenium gives a clear amber colour. The combination of selenium and cadmium sulphide gives a rich sealing-wax red colour. Selenium is a colloidal colourant and will often strike when reheated.

SHAWABTIS Mummiform figures which were cast and were made to represent servants in the next world.

SILK-SCREENING ON GLASS A method of making a stencil which is used to impose a design on a screen made of silk or other fine fabric; the blank areas are coated with an impermeable substance and a printing medium is forced through cloth onto the printing surface - a process which is the same for glass as for fabrics, posters and ceramics. In glass an acid paste consisting of sulphuric or liquid hydrofluoric acid is used, and a 43T screen; the silk is blocked out except where the colourant will print on the glass. The open areas of the silk become the design. Opaque powdered glass may be sifted on top of the printed design to change the original colour while it is still wet. If the piece is not to be laminated, sift a light dusting of transparent clear glass or a clear flux over the powder.

SILICA Sand, flint, sandstone, cristobalite are all forms of silica. Silica, found all over the earth in great abundance, is the main ingredient of all common glasses.

SILICA GLASS Silica glass is made from pure silica and has a melting point of over 1700°C. Special furnaces are needed to form silica glass. It has great heat resistant qualities.

SILICONE SEALANT A transparent, opaque or coloured adhesive which is used to glue glass.

SLUMPING The process of heating glass until gravity forces it to conform to the shape of the form on which it has been placed.

SODA (Sodium carbonate) Considerably lowers the melting temperature at which glass forms. It acts as a good flux, but has the disadvantage of decreasing the durability of the glass. Silica and soda fused together in roughly equal proportions produce a glass which is readily soluble in water (water glass), and hence glass only contains from twelve to fifteen per cent soda.

The everyday compound of sodium used for household purposes is common salt. This also forms the basis for the manufacture of the soda compound used by glass makers - soda-ash or sodium carbonate. In the manufacture of soda ash, common salt (sodium chloride) is converted into crystalline soda-ash by carbonating it in a solution of brine. The crystalline product is then heated to drive off the water of crystallisation, leaving the anhydrous soda ash which is used by the glass maker. Other materials containing soda which are used in glass-making are saltpetre and borax.

In glass where the cost of the raw material is of secondary importance (such as crystal glass) potash is used in preference to soda.

SODA GLASS Glass which contains soda as the alkali rather than potash.

SODA LIME GLASS Basic glass which is made from a mixture of soda, lime and silica. The basic ingredients for soda lime glass are:

Sand (SiO_2)	65%
Soda Ash (Na_2CO_3)	20%
Limestone ($CaCO_3$)	15%

This batch is fired to over 1500°C. A percentage of cullet is usually added to the basic ingredients to lower the initial firing temperature.

SODIUM SILICATE (Na_2SiO_3) Water glass is water soluble and occurs as a white powder or a liquid. It is used as a binder in refractory mould mixes and as a low-temperature flux.

SOFTENING TEMPERATURE The softening temperature for common glass is between 400°C and 800°C. Boracic oxide, lead oxide, potash and phosphoric oxide all lower the softening temperature of glass.

SPUN GLASS Spun glass or glass fibre was first made 2000 years ago. In the British Museum in London, there is a small ancient sculptural head with strands of hair hanging over the forehead. The individual strands are no thicker than a horse hair, and under magnification each hair has been found to consist of nine alternate layers of transparent and opaque glass. After Egyptian and Roman times, glass fibres were made by Arabs, Syrians, Venetians and Germans. Spun glass was made wherever glass was made, and in the 19th century it was used as a familiar curiosity in friggers.

Spun glass is made by heating a glass rod under a flame. A thread is continuously drawn from the soft glass and wound around a large wooden wheel. With great skill, and by carefully synchronising the speed of the wheel and the movement of the glass into the flame, it is possible to draw a thread of even thickness.

STAINING WITH METALLIC OXIDES Metallic oxides can be added to the batch so that the glass is self coloured but, as the glass is highly viscous, it is not easy to distribute the metallic oxide powders in the batch if an even colour is required. It is usual therefore to disperse the powder thoroughly in a small batch which is then added to the main batch.

Metallic oxides are essential colouring agents for glass. A few are volatile and will evaporate while some, because they are unstable at high temperatures, are likely to change colour as they change their chemical state.

The most stable form of iron oxide, and a common colouring agent, is red iron oxide (Fe_2O_3) which may turn to the green form (FeO) in the furnace. In this case one oxygen atom has been taken up by the hydrocarbons in the fuel to support combustion. Known as a reduction process, this is initiated by starving the furnace of oxygen. The reverse process, oxidation, can be achieved in an oxidising flame where the metallic oxide changes colour because it has gained oxygen.

Metallic oxides are also greatly affected by the fluxes present in the mix, particularly if they are lead or alkaline based. Many such colours depend upon a reaction with the basic glass material.

Red Most red-coloured oxides are unstable at high temperatures and cannot be used for staining. Rich ruby coloured glasses are made by colloidal dispersions. Gold chloride, obtained by dissolving the gold in hydrochloric and nitric acids, when added to the batch in the smallest of quantities (0.001%) produces a rich ruby colour. When the glass is first worked, a yellowy-straw colour is obtained; the glass must be reheated to a dull red heat to develop the true ruby colour. Overheating produces a purple or brown colour.

Precipitates of cadmium, selenium and sulphur act in a similar way.

Copper colloids also produce a rich red.

Yellow When iron oxide and manganese dioxide are added to the batch in the right proportions an amber tint results. The manganese dioxide, being a strong oxidising agent, reacts with the iron to produce a ferric yellow. By varying the proportions and increasing quantities, a range of colours from bright yellow to orange and yellow-green can be obtained. Cadmium sulphide produces a bright yellow. In the fourteenth century a yellow stain was produced for colouring stained glass windows and consisted of a thin film of silver nitrate laid onto the glass surface which was fixed by firing. The result was a brilliant colour which could be varied from pale yellow to a dark ochre. Silver chloride is still used to obtain yellow, and in a similar way is used to stain the surface of an object after forming has been completed. Pure sulphur makes a good yellow colour except in lead glasses when it reacts with the lead to form lead sulphide. Carbon compounds can assist in the formation of yellow tones.

Blue Cobalt oxides have been used for centuries to stain glass blue. The technique was well known to the ancient Persian and Syrian glass makers. Early glassmakers used to burn raw cobalt ores to obtain a crude oxide which they called zaffre. Cobalt oxide is extremely potent; 0.001% produces a strong, bright blue colour. On its own, cobalt produces a harsh blue-black and so it is usually used combined with iron or manganese oxides.

Green A yellow-green is produced by adding chromic oxides to the batch. Chromic oxides can withstand high temperatures. Cupric salts or copper oxides give glass a bluish-green tint. Nickel oxides are sometimes used but there are disadvantages and the colours obtained vary a great deal depending on the composition of the glass. In glass containing potash a purple is produced while in soda glass a blue-brown is produced and in lead glass a red colour.

Violet A combination of nickel and manganese oxides produces a violet colour in glass.

Purple Manganese dioxide produces a purple stain but in excess quantities produces a brown. With lime/potash glass manganese produces a turquoise colour and in lead/lime/soda glass a purple-red colour.

Black glass is produced by adding large quantities of manganese tempered with the addition of copper, cobalt or iron.

Opals Opal glass is not easy to produce, and to produce controlled opal colours involves complicated technology. Glass is a non-crystalline, super-cooled liquid and crystallization or devitrification causes it to lose its transparency. It should therefore be possible to induce a controlled amount of crystallization to make glass opaque or opal. If glass is slowly cooled from its low viscosity state, and not super-cooled, crystallization takes place without the help of opalizing agents. However, if fluorides are added they form nuclei for crystal formation even with a normal cooling cycle. By varying the amounts of sodium or potassium fluoride added to the batch varying degrees of opacity can be obtained. Opalescence is produced in glasses which contain two phases having different refractive indices. There are two main types - emulsion opal (phosphate) and crystalline opal (fluoride).

STRESS The two main types of stress existing in glass are compressive and tensile stress: tension results from stretching and compression results from squeezing.

STRIATIONS Linear marks on the surface of the glass due to uneven furnace temperature.

STRIKING Reheating glass after cooling to develop colour or opacity when glass contains colloidal particles. This reheating causes very small particles in the glass matrix to grow larger or to migrate together.

STRINGER A very fine glass rod or thread. Stringers can be a by-product of glass casting, made by dipping a punty into molten glass and whipping it from side to side or be made from flat glass scraps by using a torch and a pair of pliers.

SUSPENSION A coarse, non-colloidal dispersion of solid particles in a liquid.

SWIRL The internal design in a paperweight where rods of two or more colours radiate spirally downwards from a top central cane.

TALC Used sieved or suspended in water as a fine separator to prevent glass from sticking to metal or ceramic supports.

TEARDROP A name used to describe a teardrop shaped bubble of air deliberately trapped in the glass for purposes of decoration when forming the stem of a wine glass or goblet.

TEL EL AMARNA GLASS A name used by Tiffany for vessels which were inspired by ancient Egyptian vessels from archaeological sites which he visited in 1878. He generally used deep turquoise opaque glass to make these large bold symmetrical vessels with a matt lustre. Decoration was non-existent or minimal, confined to simple patterns such as palm leaves at the base or neck. These vessels are also known as Egyptian Decorated.

TEMPERING GLASS A process to produce internal stress in red hot glass by sudden cooling with a blast of air for 1-2 minutes. In this process the surface hardens rapidly and becomes rigid. As the cooling continues, the inner part of the glass continues to shrink, causing the outer surface to be in compression which makes the glass very strong and able withstand pressures up to 150 MPa. Tempered glass cannot be cut and attempting to do so will cause the glass to shatter. Tempered glass is used in eyeglasses, oven cookware, and car windows which shatter instead of breaking into lethal shards. (See PRINCE RUPERT DROPS).

TESSERA Small, usually square, piece of flat glass used to build a mosaic design or pattern.

THERMAL SHOCK Shock caused by rapid changes in temperature. Thermal cracking occurs in glass as a result of too-rapid heating or cooling below the strain point temperature of the glass.

THERMOCOUPLE The part of the pyrometer which is inserted into the kiln to measure the temperature accurately. There are many types of thermocouples, the most commonly used for measuring temperatures in the fusing range is type "K" which is composed of two metal alloys known as chromel and alumel. The junction is welded together and ceramic spacers are used to insulate the two wires from each other.

TRAILING The process of applying threads or strands of glass in decorative patterns onto the surface of the object. The trailed glass can then be pulled into other shapes to form different patterns.

TUNGSTEN CARBIDE An extremely hard material used in tools, dies, machine parts and abrasives. Tungsten carbide is used for rough grinding.

URANIUM The use of uranium to colour glass produces a prominent yellow. In a glass with 71% lead oxide it produces a deep red colour.

VENT An opening in the kiln to allow fumes from organic material, smoke and air to escape during the early stages of heating the kiln, and to allow excess heat to escape after reaching fusing temperatures.

VISCOSITY The internal forces in glass that resist the tendency to flow. As the viscosity increases, the liquid becomes stiffer. Viscosity is measured in centipoises. In glass, viscosity increases as the temperature decreases, therefore, glass becomes stiffer and stiffer as it cools until the temperature is below the strain point, at which time it acts as a solid.

VITREOUS Resembling or having the nature of glass.

VOLATILE The tendency to evaporate rapidly.

WARP A bend or twist in a straight, or flat glass form. Warping in fused glass occurs due to improper annealing or the use of incompatible glasses.

WHITING Powdered calcium carbonate. It is sometimes used for low-fire kiln wash or for texturing glass.

WINDOW GLASS (Soda Lime Glass) The ingredients for a soda lime glass batch are:

Sand	73,0%
Alumina	1,0%
Soda	12,0%
Potash	0,3%
Lime	10,0%
Magnesia	3,3%
Iron oxide	0,1%
Sulphur trioxide	0,3%

WIRE MESH Used to strengthen high temperature moulds. It is incorporated in the mould walls.

BIBLIOGRAPHY

Anderson, H. 1971
Kiln-fired glass. London: Pitman.

Anderson, N. 1989.
Epoch-making glass. *Craft Arts* 16: 45-48.

Anderson, N. 1989.
Pranks and prunts. *Craft Arts* 17: 50-54.

Arwas, V. 1987.
Glass: Art nouveau to art deco. London: Academy Editions.

Ashton, D. 1984.
Christopher Wilmarth; Layers. *Cimaise* 31 March-April: 69-72.

Baines, J., Málek, J. 1992.
Atlas of Ancient Egypt. Amsterdam: Time-Life Books.

Beard, G.W. 1976.
International modern glass. New York: Scribners.

Benjamin, W. 1982.
Illuminations. London: Fontana/Collins.

Berger, J. 1980.
About looking. London: Winters and Readers.

Brooks, J.A. [S.a.]
Glass: 100 masterpieces of crystal and colour. London: Camden House Books.

Burnham, J. 1973.
Structure of Art. New York: Braziller.

Burton, J. 1967.
Glass: Handblown, sculptured, coloured. Philosophy and method. London: Pitman.

Carroll, B.H., Higgins, G.C., James, T.H. 1980.
Introduction of photographic theory: The silver halide process. New York. John Wiley and sons.

Chihuly, D. 1988.
Persians. New York: Dia Art Foundation

Coke, van D. 1986.
Photography: A facet of modernism. Photographs from the San Francisco Museum of Modern Art. New York: Hudson Hills Press.

Collins, M. 1987.
Towards post-modernism: Design since 1851. London: British Museum.

Coulson, D. 1991.
Namib. London: Sidgwick & Jackson.

Cousins, M. 1989.
Twentieth century glass. London: Quintet.

Cowen, P. 1979.
Rose windows. London: Thames and Hudson.

Crawford, W. 1979.
The keepers of light: A history and working guide to early photographic processes. New York: Morgan and Morgan.

Cubitt, G. Joyce, P. 1992.
This is Namibia. Cape Town: Struik.

Cummings, K. 1980.
The technique of glass forming. London: B.T. Batsford.

Daum, N., Bacri, C., Petry, C., 1993.
Daum: Masters of French decorative glass. New York: Rizzoli.

Davis, F. 1973.
Antique glass and glass collecting. London: Hamlyn.

Dietrich, R.V., Wicander, E.R. 1983.
Minerals, rocks and fossils. Toronto: John Wiley.

Dixon, J.E., Cann, J.R. Renfew, C. 1968.
Obsidian and the origins of trade. *Scientific American* 218 (3) 38-46.

Douglas, D. 1988.
Speakeasy. *New Art Examiner.* (September) 13-14.

Edmondson, L. 1979.
Etching. New York: Van Nostrand Reinhold.

Edwards, G. 1990.
Like an oriental calzedonio: Neues glas von Klaus Moje. *Neues Glas* 3/90, 202-209.

Edwards, G. 1995.
A sea-change into something rich and strange. *Craft Arts* 34/1995, 47-51.

Eliscu, F. 1964.
Sculpture, techniques in clay, wax and slate. Toronto: Chilton.

Elliot, P., Lyle-Smythe, S. 1965.
Glass: Modern industries series. London: Pilkington.

Ellis, W.S. 1993.
Glass: Capturing the dance of light. *National Geographic* 184 December: 37-69.

Feininger, A. 1975.
The creative photographer. New Jersey: Prentice-Hall.

Frantz, S.K. 1989.
Contemporary glass: A world survey from the Corning Museum of Glass. New York: Harry N. Abrams.

Frost, A. 1986.
Fragments against ruin. *Crafts* 79 March/April 1986: 31-33.

Gardner, P.V. 1983.
Glass creations by Dan Dailey. *Neues Glas* 4/83: 182-189.

Garner, P. 1979.
Glass 1900. London: Thames and Hudson.

Gick, T.L. 1980.
Sandblasting, etching and other glass treatments - including bevelling, glue chipping, etching and engraving. California: Gick Publishing.

Giedion, S. 1967.
Space, time and architecture. Massachusetts: Harvard University Press.

Glowen, R. 1986.
Metaphorical cargo. *American Craft* June/July: 35-41.

Glowen, R. 1991.
Looking for meaning: Glass in twentieth century art. Seattle: University of Washington Press. (Catalogue published in conjunction with an exhibition organized by Tacoma Art Museum, Tacoma, Washington, 2 November 1991 to 26 January 1992.)

Graham, B. 1982.
Engraving glass. New York: Van Nostrand Reinhold.

Grundberg, A., Gauss, K. 1987.
Photography and art: Interactions since 1946. New York: Abbeville Press. (Catalogue for an exhibition held at Los Angeles County Museum of Art, Los Angeles, California, 4th June to 30th August 1987.)

Hall, A.J. 1977.
Dazzling legacy of an ancient quest: world's oldest known ship. *National Geographic* 151 March: 293-311.

Hammesfahr, J., Strong, C.L. [S.a].
Creative glass blowing: Scientific and ornamental. San Francisco: W. H. Freeman.

Haynes, D.E.L. 1975.
The Portland vase. London: British Museum.

Heller, D. 1951.
In search of OVC glass. Cape Town: Standard Press.

Herman, L.E. 1992.
Clearly art: Pilchuck's glass legacy. Washington: Whatcom Museum of History and Art.

Hodder, I. and Conkey, M.W. & Hastorf, C.A.(eds). 1990.
The uses of style in archaeology. Cambridge: Cambridge University Press.

Hollister, P. 1984/5.
Klaus Moje. *American Craft* 44 November-December; 18-22.

Hollister, P. 1988.
Pâte de verre: The French connection. *American Craft* 48 August-September: 40-47.

Holt, Rinehart, Winston. 1980.
Architecture for people. New York: Holt, Rinehart and Winston.

Janis, S. 1995.
Christopher Wilmarth. *Art News* 94(6) Summer:123.

Johannesburg Art Gallery. 1991.
Art and ambiguity: Perspectives on the Brenthurst collection of Southern African art. Johannesburg:

Penrose Press. (Catalogue published for an exhibition held by the Johannesburg Art Gallery, Johannesburg, 4 December 1991 to 29 March 1992.)

Kampfer, F., Beyer, K.G. 1966.
Glass: A World history. London: Studio Vista.

Kavolis, V. 1968.
Artistic expression: A sociological analysis. New York: Cornell University Press.

Kayser, A. 1981.
Artists' portraits. New York: Harry N. Abrams.

Kehlmann, R. 1987.
Glass of the 80s. *American Craft*, April/May: 32-38.

Kemp, J., Perron, R. 1990.
Architectural ornamentalism: Detailing in the craft tradition. New York: Whitney Library of Design. Guptill Publications.

Klein, D. 1989.
Glass: A contemporary art. London: William Collins.

Klein, D., Lloyd, W. 1984.
The history of glass. London: Orbis Publishing.

Kruse, Dr. J., Maedebach, Dr. M., Netzer, Dr. S. 1985.
Zweiter Coburger glaspreis fur moderne glasgestaltung in Europa. Coburg: Druckhaus Neue Presse Coburg. (Catalogue for an exhibition held in Coburg - Kunstsammlungen der Veste Coburg, 14th July to 13th October, 1985).

Langford, M.J. 1980.
Advanced photography. London: Focal Press.

Lierke, R. 1983.
Glas-weiblich. *Neues Glas* 1/1983: 19-23.

Lindqvist, G. 1994.
Bertil Vallien. Stockholm: Carlsson Bokforlag.

Lippard, L.R. 1983.
Overlay: Contemporary art and the art of prehistory. New York: Pantheon Books.

Lucie-Smith, E. 1987.
Sculpture since 1945. Oxford: Phaidon.

Lundstrom, B., Schwoerer. 1983.
Glass fusing. Book one. Camp Colton: Vitreous Publications.

Lundstrom, B. 1989.
Advanced fusing techniques: Glass fusing book two. Camp Colton: Vitreous Publications.

Lundstrom, B. 1989.
Glass casting and moldmaking: Glass fusing book three. Camp Colton: Vitreous Publications.

Lynggaard, F. 1987.
Young glass. Ebeltoft: Skive Offset aps. (Catalogue for an international competition held at the Glass Museum, Ebeltoft, Denmark, 5th July to 13th September, 1987).

Maloney, T.F.J. 1967.
Glass in the modern world: A study in materials development. Science and technology series. London: Aldus Books.

Penrose Press. (Catalogue published for an exhibition held by the Johannesburg Art Gallery, Johannesburg, 4 December 1991 to 29 March 1992.)

Kampfer, F., Beyer, K.G. 1966.
Glass: A World history. London: Studio Vista.

Kavolis, V. 1968.
Artistic expression: A sociological analysis. New York: Cornell University Press.

Kayser, A. 1981.
Artists' portraits. New York: Harry N. Abrams.

Kehlmann, R. 1987.
Glass of the 80s. *American Craft*, April/May: 32-38.

Kemp, J., Perron, R. 1990.
Architectural ornamentalism: Detailing in the craft tradition. New York: Whitney Library of Design. Guptill Publications.

Klein, D. 1989.
Glass: A contemporary art. London: William Collins.

Klein, D., Lloyd, W. 1984.
The history of glass. London: Orbis Publishing.

Kruse, Dr. J., Maedebach, Dr. M., Netzer, Dr. S. 1985.
Zweiter Coburger glaspreis fur moderne glasgestaltung in Europa. Coburg: Druckhaus Neue Presse Coburg. (Catalogue for an exhibition held in Coburg - Kunstsammlungen der Veste Coburg, 14th July to 13th October, 1985).

Langford, M.J. 1980.
Advanced photography. London: Focal Press.

Lierke, R. 1983.
Glas-weiblich. *Neues Glas* 1/1983: 19-23.

Lindqvist, G. 1994.
Bertil Vallien. Stockholm: Carlsson Bokforlag.

Lippard, L.R. 1983.
Overlay: Contemporary art and the art of prehistory. New York: Pantheon Books.

Lucie-Smith, E. 1987.
Sculpture since 1945. Oxford: Phaidon.

Lundstrom, B., Schwoerer. 1983.
Glass fusing. Book one. Camp Colton: Vitreous Publications.

Lundstrom, B. 1989.
Advanced fusing techniques: Glass fusing book two. Camp Colton: Vitreous Publications.

Lundstrom, B. 1989.
Glass casting and moldmaking: Glass fusing book three. Camp Colton: Vitreous Publications.

Lynggaard, F. 1987.
Young glass. Ebeltoft: Skive Offset aps. (Catalogue for an international competition held at the Glass Museum, Ebeltoft, Denmark, 5th July to 13th September, 1987).

Maloney, T.F.J. 1967.
Glass in the modern world: A study in materials development. Science and technology series. London: Aldus Books.

Plagens, P. 1986.
I just dropped in to see what condition my condition was in ... *Artscribe* 56 February/March: 22-29.

Poirier, M. 1985.
Christopher Wilmarth: The medium is light. *Art News* 84 December: 68-75.

Polak, S. 1978.
An afternoon with Marinot. *Crafts* 34 September/October: 33-37.

Potter, N., Jackson, D. 1988.
Tiffany. London: Octopus.

Preble, D., Preble, S. 1985.
Artforms. New York: Harper and Row.

Prior, M. 1987.
The magic of glass: A short introduction to the Consol glass collection at the Talana Museum, Dundee, Natal. Germiston: The Consol Glass Collection Trust.

Redman, C.L. 1978.
The rise of civilization: From early farmers to urban society in the ancient Near East. San Francisco: W.H. Freeman.

Reeve, C., Sward, M. 1983.
The new photography. New Jersey: Prentice-Hall.

Ricke, H. 1983.
Neues glas in Deutschland: New glass in Germany. Dusseldorf: Kunst & handwerk/Verlagsanstalt Handwerk.

Roberts, C. 1980.
Commitment and creativity in the twentieth century. [S.I.] Hunter Publishing.

Rothenberg, P. 1974.
Complete book of creative glass art. New York: Crown Publishers.

Ruffner, G. (ed.) 1991.
Glass: Material in the service of meaning. Tacoma: Tacoma Art Museum. (Catalogue for an exhibition curated by G. Ruffner held at the Tacoma Art Museum, November 2, 1991 to January 26, 1992).

Sarup, M. 1988.
An introductory guide to post-structuralism and postmodernism. University of London. Hertfordshire, Great Britain: Harvester Wheatsheaf.

Savage, G. 1972.
Glass. London: Octopus Books.

Scarfe, H. 1973.
Introducing resin craft. London: B.T. Batsford.

Schoeman, A. 1984.
The Skeleton Coast. Johannesburg: Southern Book Publishers.

Schuler, F., Schuler, L. 1971.
Glassforming: Glassmaking for the craftsman. London: Pitman.

Seghers, P. 1972.
Clave. Barcelona: Ediciones Poligrafa.

Selden, R. 1989.
A Readers' guide to contemporary literary theory. Reprint. Sussex: The Harvester Press Limited.

Sharer, R.J., Ashmore,W. 1979.
Fundamentals of archaeology. California: Benjamin/Cummings.

Silberman, R. 1985.
Decorative arts: "Americans in glass": A requiem? *Art in America* March: 47-53.

Sims, P. 1992.
Dale Chihuly: Installations 1964-1992. Seattle Art Museum.

Sinz, D. 1987.
Toots Zynsky: Glas fur glas - Color for color. *Neues Glas* 4/87: 276-279.

Sontag, S. 1977.
On photography. Middlesex: Penguin Books.

Stennett-Wilson, R. 1975.
Modern glass. London: MacMillan.

Stevens, M. 1995.
Beautiful glass well worth seeing. *The Pretoria News.* 10 May: 3.

Swaan, W. 1969.
The Gothic cathedral. London: John Gifford.

Tait, H. (ed.) 1991.
Five thousand years of glass. British Museum Press.

Tejera, V. 1965.
Art and human intelligence. London: Vision Press Limited.

Theophilus, J. 1991.
Sources of inspiration. *Crafts* 113 November/December: 44-47.

Turner, M. 1988.
Shipwrecks and salvage in South Africa: 1505 to the present. Cape Town: Struik.

Vaizey, M. 1982.
The artist as photographer. London: Sidgwick & Jackson.

Vose, R.H. 1975.
Glass. London: *The Connoisseur.* Chestergate House.

Wade, K.E. 1978.
Alternative photographic processes. New York: Morgan and Morgan.

Warmus, W. 1984.
Emile Gallé: Dreams into glass. New York: Corning Museum of Glass.

Waugh, S. 1947.
The making of fine glass. New York: Crown Publishers.

Wills, Geoffrey. 1971.
Antique glass for pleasure and investment. London: John Gifford.

Wright, G.A. [S.a.]
Obsidian: Analysis and prehistoric Near Eastern trade 7,500 BC - 3,500 BC University of Michigan. Anthropological Papers. No. 37.

Wright, G.A., Gordus, A.A. [S.a.]
Obsidian: Distribution and utilization of obsidian from Lake Van Sources between 7500 and 3500 B.C. *American Journal of Archaeology* 73: 75-77.

Zelanski, P., Fisher, M.P.
Design, principles and problems. New York: Holt, Rinehart and Wilson.