AN INTEGRATED PHOTOGRAMMETRY AND CAD SYSTEM APPLIED TO THE RESORATION OF A SEVENTEENTH CENTURY HOUSE

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ABSTRACT

Restoration of the important late seventeenth century mansion at Uppark, England, badly damaged by fire in August 1989, is being greatly assisted in an accurate, cost-effective, and efficient manner by the application of analytical photogrammetry, to capture in digital form the standing remains, and AutoCAD, to replicate the original design from salvaged fragments.

BACKGROUND

Photogrammetry has been used in connection with historic buildings for over fifty years. David Stevens* has recently re-emphasized the role of this technique for recording purposes and, with William McKay & Daryl Fowler**, he has introduced the idea of linking photogrammetry with CAD to help reconstruct buildings that have been damaged by fire.

The ability of photogrammetry to capture raw data in a digitised form at full scale, i.e.life size, provides the accuracy required by the architect and engineer dealing with major restoration projects as well as producing basic information required by the archaeologist and architectural historian to distinguish periods of construction and alteration. CAD allows the operator to handle and edit that information to the same degree of accuracy and the combination of the two techniques permits accurate, life-size reconstructions to be prepared in a digital form for use in a variety of ways. The integration of the two methods provides an ideal medium for the reconstruction of historic buildings for which information survives as a mixture of *in situ* remains, which can be captured by photogrammetry, and salvaged fragments which can be digitised, held in store on the computer, and slotted into place on drawings using CAD.

* Stevens,D.,1989. Photogrammetry for the Record. Transactions of the Association for Studies in the Conservation of Historic Buildings, 14:17-21.

** Stevens,D.,McKay,W.M.,&Fowler,D., The combined use of photogrammetry and CAD in the reconstruction of fire damaged buildings. International Archives of Photogrammetry (Zurich 1990) :77-84.

The system is being used throughout the U.K. by The Conservation Practice, a multi-disciplinary team of architects & specialist consultants dealing with the restoration of major historic buildings. This paper outlines how the system is being operated on one of these buildings.

THE PROJECT

Uppark House, West Sussex, England, is a late seventeenth century country mansion, extended and refurbished with a fine collection of furnishings acquired on Grand Tours undertaken by successive owners in 1749-51 & 1775-76. As a result of an unusual series of events the house was relatively unaltered from about 1815 until acquired by the National Trust and placed on show to the public in 1960.

The entire building was badly damaged by fire in August 1989. Whilst the former service rooms in the basement were relatively unscathed by the fire, though affected by water, and most of the ground level floor survived intact, above this there was a virtual total loss of roof, upper floors, wall finishes, and five highly decorated & extremely important ceilings. A salvage operation conducted during the fire led to the saving of most of the art treasures from the ground floor showrooms.

The decision to restore the house to its former glory, wherever possible preserving *in situ* fragments and re-using salvaged material, has led to a restoration project of major proportions and on an unprecedented scale in the United Kingdom. The brief and philosophy for the repairs is such that an exceptionally high level of salvage and recording was necessary, not only to enable fire-damaged areas to be accurately reinstated but also to understand the evolution of the house and provide a basis for the future management of the property.

Archaeological techniques were employed for the salvage operation during which every item was individually recorded and a massive sieving operation has been conducted through the ash which had been placed in more than 4,000 refuse bins. As a result, over 15,000 items, ranging from floorboards, pieces of wallpaper & panelling to metal fittings & plaster fragments, are available for re-use or use as models for replacements.

METHOD

The complete absence of any plans, elevation drawings, or detailed drawings of the house before the fire and the limited access available to the structure for long periods immediately highlighted the need for a comprehensive study of the standing remains. The decision was taken at a very early stage to initiate a comprehensive programme of photogrammetry which had to be carefully programmed to allow maximum photographic coverage before areas of the building were covered in scaffolding.

The photographs and survey control now provide not only a source for three-dimensional photogrammetric plotting but also a permanent record of the structure immediately after the fire. Photogrammetry, undertaken by Atkins AMC of Pewsey, commenced on the exterior and this was repeated some six months later after a temporary scaffolding roof had been torn off during gale force winds in January 1990. The two sets of external records are available for detailed three-dimensional comparison which may be required as evidence for insurance claims. In the interior the photogrammetry had an extended role for not only does the information provide basic data for the architect and engineer but it is also providing the detailed information which allows the project archaeologists to spend their time analyzing the structure rather than recording details by manual methods.

The total loss of both the first and second floors in all rooms and even the ground floor in two of the rooms made access difficult, and over half the photography was taken from four and eight metre towers, as well as from the top of the external scaffold looking inward. The site grid was extended into the eleven surviving internal spaces and in order to complete the internal survey a total of six hundred photographs (each 13cms.x 8cms.) were used to provide four hundred stereoscopic pairs. Approximately eight hundred hours were involved in plotting and editing detail on CAD.

The *external elevation drawings* were produced on CAD to a 1:50 compatible specification, i.e. if two lines merged at this scale then only one would be plotted, but the digitised information is used at scales of up to 1:5 for details of openings & mouldings. The specification was extended to record in greater detail areas where severe external damage had been caused by the collapse of a chimney stack and this included the plotting of individual brick courses & cracks, and a series of vertical profiles were prepared in order to measure the amount of distortion in the masonry fabric. The information provided in digital form on AutoCAD was layered according to the requirements of the architect and this provides a permanent record of the exterior of the building immediately after the fire. The drawings have subsequently been extended manually to include a few areas inaccessible to the camera and to complete the elevations as they would have looked before the fire on a separate set of layers. Additions are made using the best available information - measurements taken from the structure are fed directly into the system and salvaged items which are repeated around the building are stored as W-block files for insertion on any drawing in the system (Figs.1 & 2).

Plans of the building have been prepared from horizontal sections created from photogrammetric information and the project has been greatly helped by the ability of the system to produce this information at a time when access for manual measurement was not possible. The drawings can be used at a variety of scales, for the whole house or for a

single room, and for a variety of purposes, to record the positions of salvaged floorboards or to plan services & emergency fire exits.

The *internal elevation drawings* were produced on CAD to a 1:20 compatible specification but these are also capable of being produced to a much larger scale and this, again, has been beneficial in the handling of small details, such as plaster mouldings, which though destroyed can be mirrored or copied in from identical *in situ* fragments. Since all the floors and ceilings above ground floor level have been destroyed, elevation drawings include walls of at least three levels - ground, first & second or attic floor, and the information can be stored and used in this form to facilitate the recording of features which flow from one level to another. Where appropriate, adjoining rooms are stored alongside one another thus allowing complete elevations and sections through the building to be produced. The digitised information has been layered according to the type of building material, brick, stone, plaster etc., or by the form of detail, room corner, true edge of plaster or broken edge of plaster etc., and this allows for the information to be edited and presented in a variety of ways.

These photogrammetric plots, which often record only the masonry fabric of the walls on which the finished surfaces of plaster, wallpaper, or panelling will be mounted, have subsequently been upgraded using the best available information - plaster edges, scars, and marking-out lines, can be measured & fed onto CAD for storage at full scale. Details, such as cornices, dado rails, panel mouldings, architraves, and skirtings, are identified, classified, drawn, and stored full-size as W-blocks. Pre-fire photographs have been used for general layout & identification but difficulties have been encountered in using this material for photogrammetry because many have been taken with a plate camera and tilt-back lens which has eliminated the normal vertical distortion found in other cameras.

Over one hundred very detailed reconstruction drawings have already been produced in this way and others are being prepared. They are used at a range of scales and forms to facilitate the needs of the structural engineer, mechanical & electrical engineer, architect, & the historian (Figs.3-6).

TECHNICAL SUMMARY

A site grid was established to maintain a continuous three dimensional relationship for all the survey, architectural, & archaeological work undertaken. The photography was taken using a Zeiss UMK 1318 camera using Ilford FP4 film processed in Agfa Refinal. Photo-flood lighting was used to reduce shutter speeds due to the non-rigid nature of the scaffold towers. Control was installed using a combination of techniques and equipment, including intersection by theodolite and bearings & distance, mainly to targeted points but sometimes, due to lack of access, to photo-identified points.

All data was captured, by Atkins AMC, using two Galileo-Siscan Digicant 40 analytical instruments, with post-digital editing being carried out on AutoCAD Release 10.

CONCLUSION

The integrated system of photogrammetry with CAD, as used at Uppark and on other projects undertaken by The Conservation Practice in the UK, provides an ideal medium for the recording of historic buildings and the production of reconstruction drawings in an accurate, cost-effective and efficient manner.

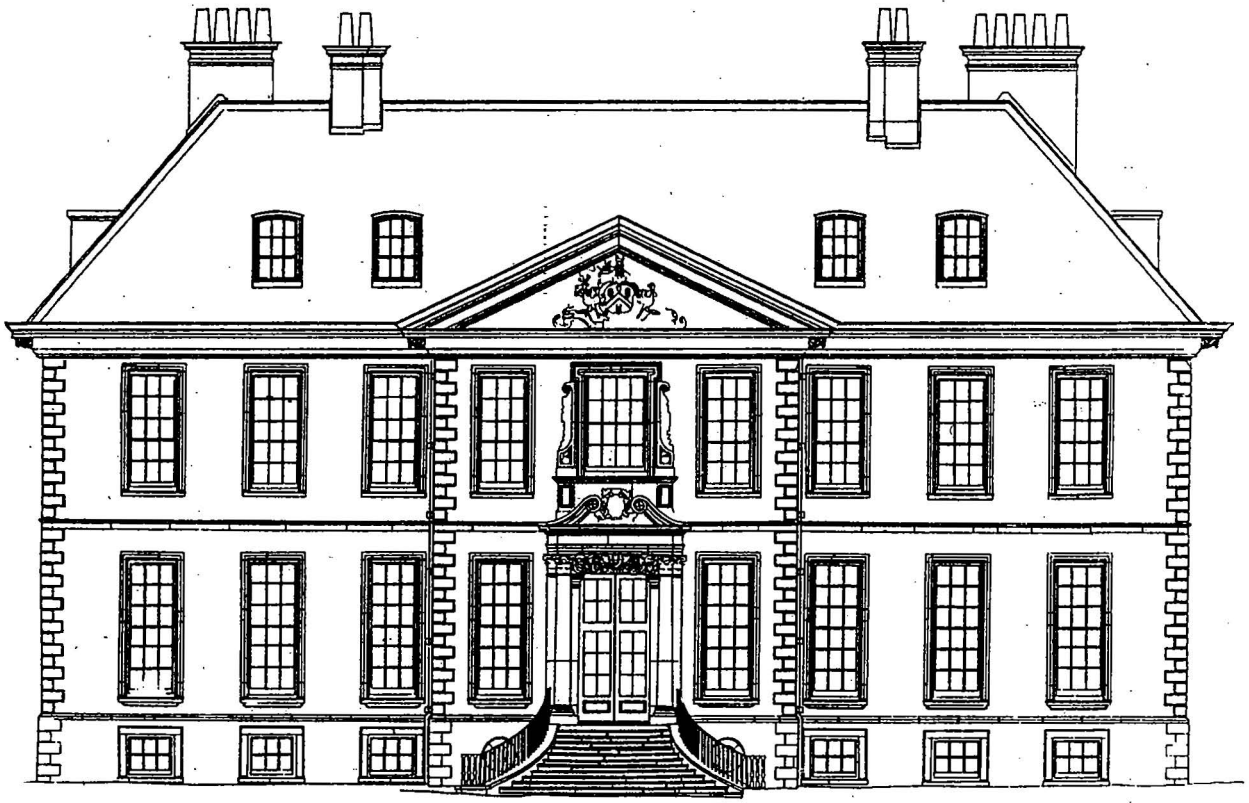

Fig.1 The south elevation of Uppark House, very much reduced from a digitised CAD drawing.

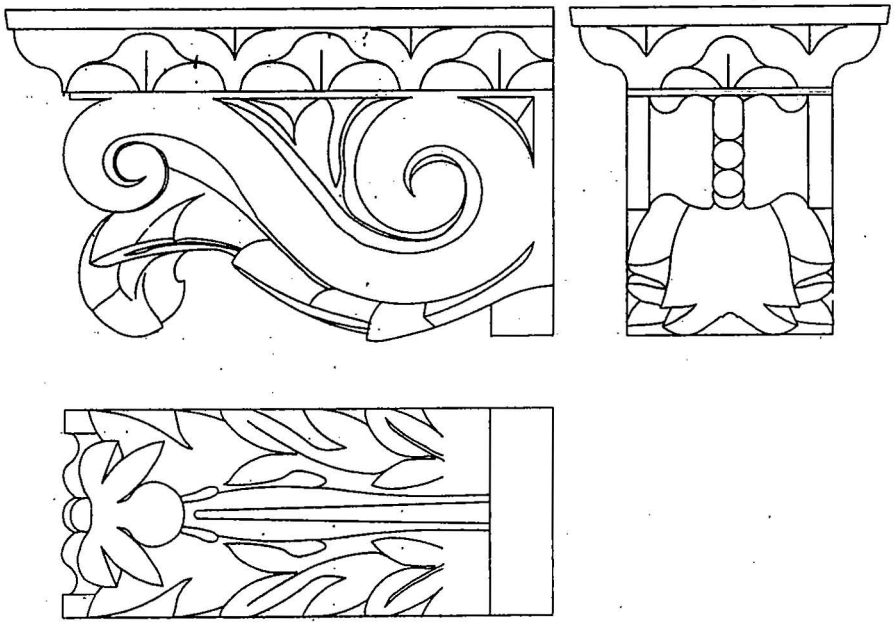

Fig.2 Three views of a modillion eaves bracket, stored at full size as a W-block on CAD. Over one hundred of these have been carved to replace those lost in the fire. The drawing, prepared from surviving fragments, is used at full scale for issue to the carpenter and in a reduced form many times on elevation drawings.

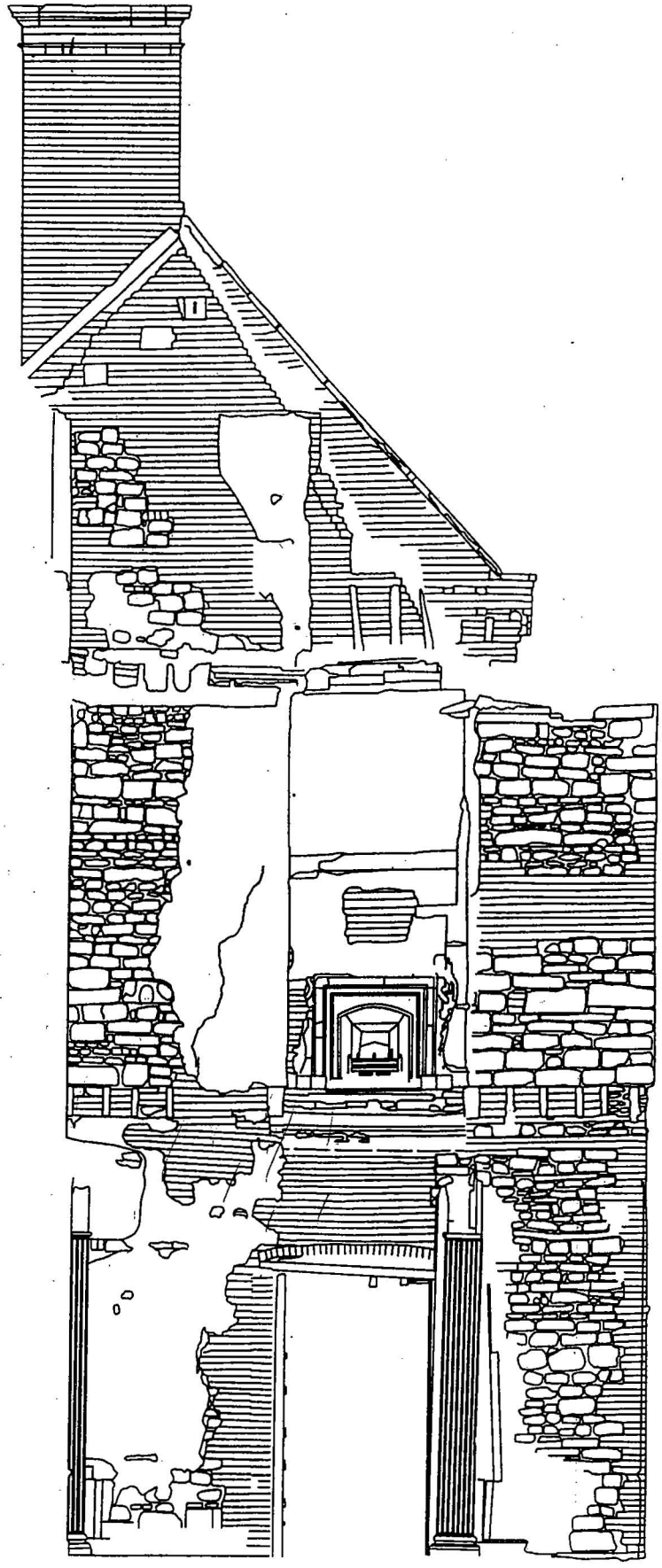

Fig.3 The north wall of the Dining Room and the rooms above as they survived after the fire and captured by photogrammetry.

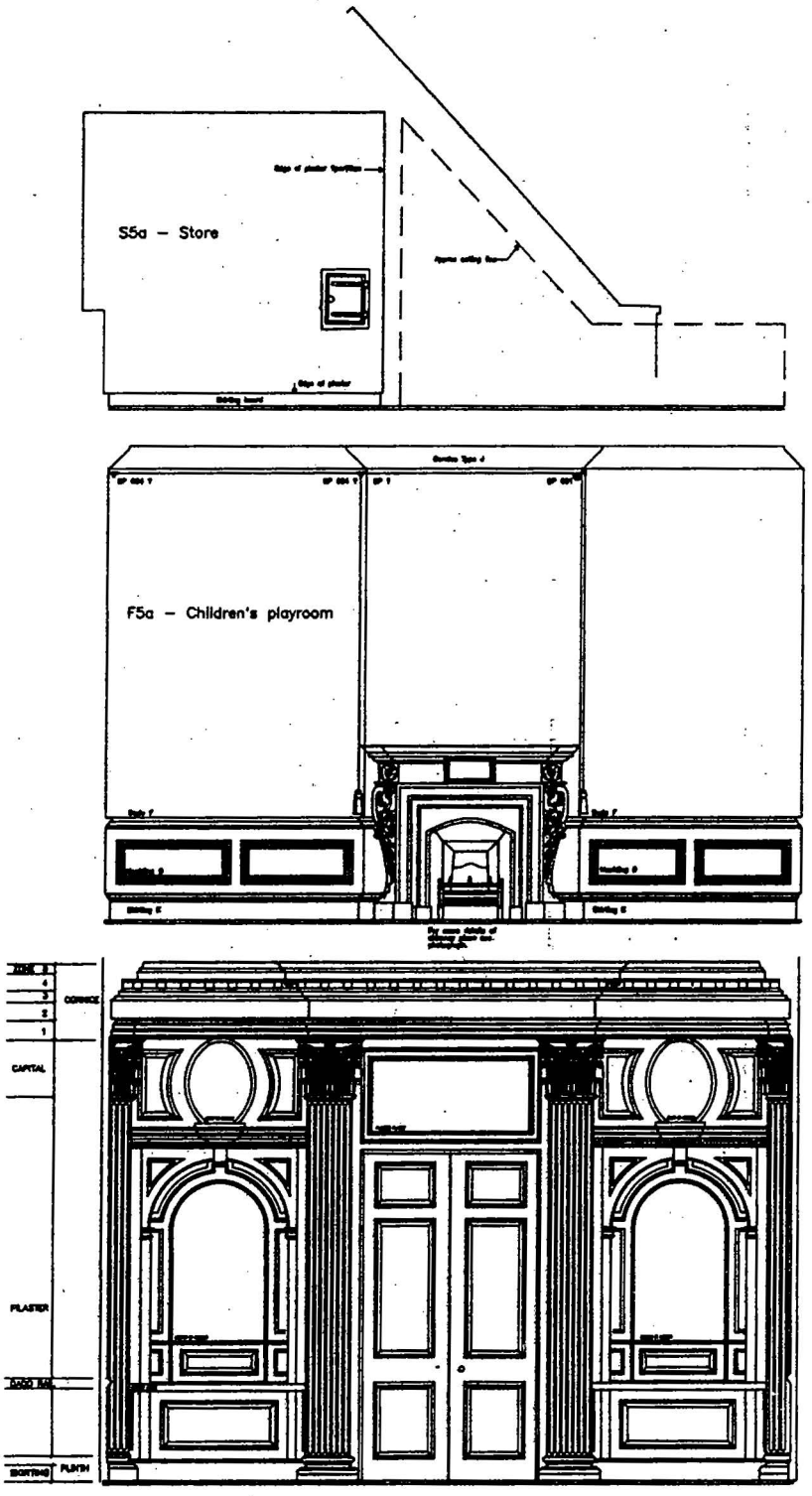

Fig.4 The north wall of the Dining Room and the rooms above as reconstructed on CAD using full scale information wherever possible.

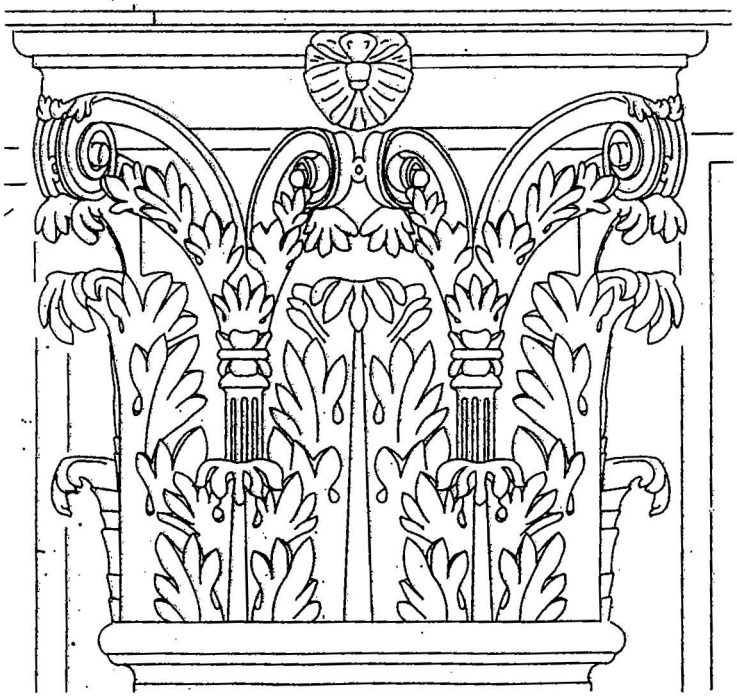

Fig.5 A drawing of a Corinthian capital from surviving fragments, held as a W-block on CAD for inclusion in elevation drawings of the Dining Room.

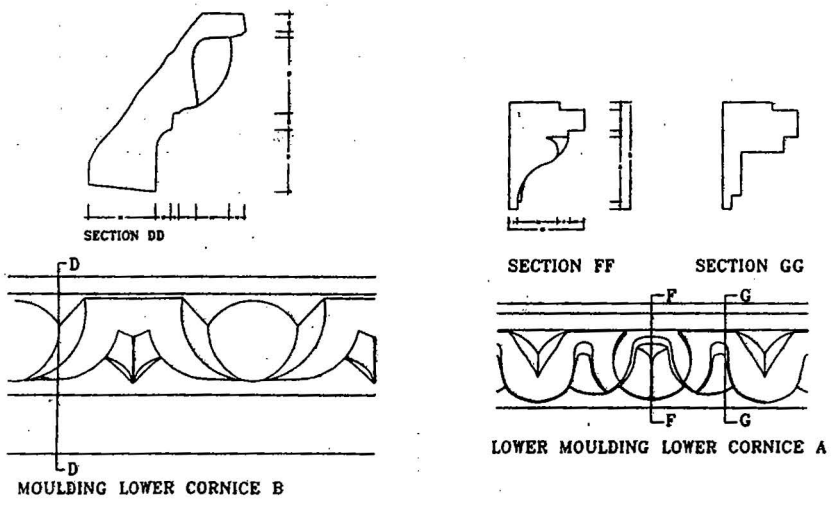

Fig.6 Drawings of carved details prepared from surviving fragments, held as W-blocks on CAD for inclusion in elevation drawings.