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THE ROLE OF AUTOMATIC DIGITIZERS IN  
COMPUTER AIDED-DESIGN

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## Abstract

The incorporation of facilities for automatically digitizing documents can considerably enhance the power of computer graphics in computer-aided-design. A hardware-software process is described which rapidly and economically digitizes hard-copy drawings and translates them into computer data structures which faithfully represent both their geometry (including line widths) and their topology (line connectivities). These data structures may be directly interfaced to standard computer graphic manipulation software or they may serve as a source of information for analytic routines. The system thus allows drawings to serve as an immediate source of data for existing CAD processes. The result is that the tedium and inaccuracies associated with inputting graphic information has largely been removed so that the human may better concentrate his energies in the tasks of design and analysis.

Computing Reviews categories: 8.2

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## INTRODUCTION

Figures 1 and 2 are examples of the type of complex graphical data which should and can readily become accessible to computer aided design systems if automatic digitizers are included as standard hardware components. The easy introduction of drawings into computers is of prime importance to computer aided designers for the design process necessarily feeds upon such data. After all, the power of computer graphics in CAD is derived in large measure from the capability for interacting computationally with graphical information.

In spite of the fact that Figures 1 and 2 represent the rich type of data that designers need, their very complexity precludes their ready entry into computers by manual means. They do not lend themselves easily to simple geometric descriptions capable of being entered by keyboard or computer graphic menu selection. Neither can they rapidly be rendered by tracing methods employing manual digitizers, data tablets, or the like. Not only are such manual mechanisms inheritantly slow, but results must be laboriously checked for accuracy, and extensive care must be exercised to insure that pertinent information has not been lost. The cost of such operations may actually approach the cost of the preparation of the original document in spite of the fact that valid information has probably been distorted by the process.

## THE AUTOMATIC DIGITIZING PROCESS

Figures 1 and 2 are examples of what can be obtained through totally automatic means. The source documents were off-the-shelf hard-copy drawings, not specially prepared for the task. The figures are unedited digital replots of data obtained from an automatic digitizer and its related software. Lines were plotted double to indicate that line widths as well as locations have been captured by the three step process.

### 1. Digitization

The hard-copy document is placed on a drum scanner (Visicon AD-1 Automatic Digitizing System [1]) and digitized onto magnetic tape. The output from the digitizer is a set of appropriately coded triples (X, L, H) of coordinate values designating the location of black areas on the document. X is the abscissa, L is the minimum (low) ordinate, and H is the maximum (high) ordinate of black vertical rectangular bands 12.7 mm in width.

### 2. Graphical Collation

These points (X, L, H) are then sorted and restructured by graphic collation software [2] into ordered sets of points which represent the black areas (lines) on the drawing.

### 3. Graphical Lexical Analysis

The data derived from graphic collation is then processed into distinct line segments and replotted. The replots may portray the peripheries of black areas as in Figures 1 and 2, or they may be rendered into single lines through the center points of such peripheries. Concordant with this is the recording of line junctures and terminations.

The times required for these three steps are modest, especially when compared with those required by manual methods. The digitization step is accomplished in less than two minutes on the Visicon AD-1 system. The graphical collation and lexical analysis steps for Figure 1 were accomplished in less than four minutes on an IBM 370/158. This time includes the generation of digital plotter commands for the 38,749 straight line segments used in the replot which itself was accomplished in less than fifteen minutes.

The products of these steps are (1) a set of ordered coordinate values representing the geometry of the black areas (lines) on the drawing and

(2) a set of nodal points and paths which constitute a (graph theoretic) network representation of the interconnectivity of such lines. These two sets are basic components of computer graphic software systems and may easily be converted for their use. The geometric descriptions allow a regeneration of the image for human perception while the network description allows the image to be compartmentalized into discrete graphic data elements capable of individual manipulation on interactive graphic terminals. Both sets may serve as a source of data for pattern recognition or shape analysis software. What is lacking in this data base is identification information labeling the various graphical objects. Such information can be supplied by manual digitizers, through interactive graphic mechanisms, or perhaps by pattern recognition software.

The software is written in FORTRAN II and consequently is transportable between most computers. It currently requires roughly 170K bytes of IBM 370 storage but efforts are being made by the author to restructure the algorithms so that they will fit in moderate sized mini-computer memories.

#### SUMMARY

Automatic digitizers should become integral hardware components of CAD systems. They now have an established capability for rapidly and economically transducing drawings directly into computer data bases which can be converted to be compatible with existing interactive CAD software. No assumptions have been made concerning the use to which digitized drawings are to be put, and consequently the automatic procedures described in this paper are general enough to be applicable to as broad a range of CAD applications as are generalized computer graphics systems. In short, automatic digitizers can provide ready

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access to the complex drawings which are the data sources for economically feasible powerful computer aided design systems.

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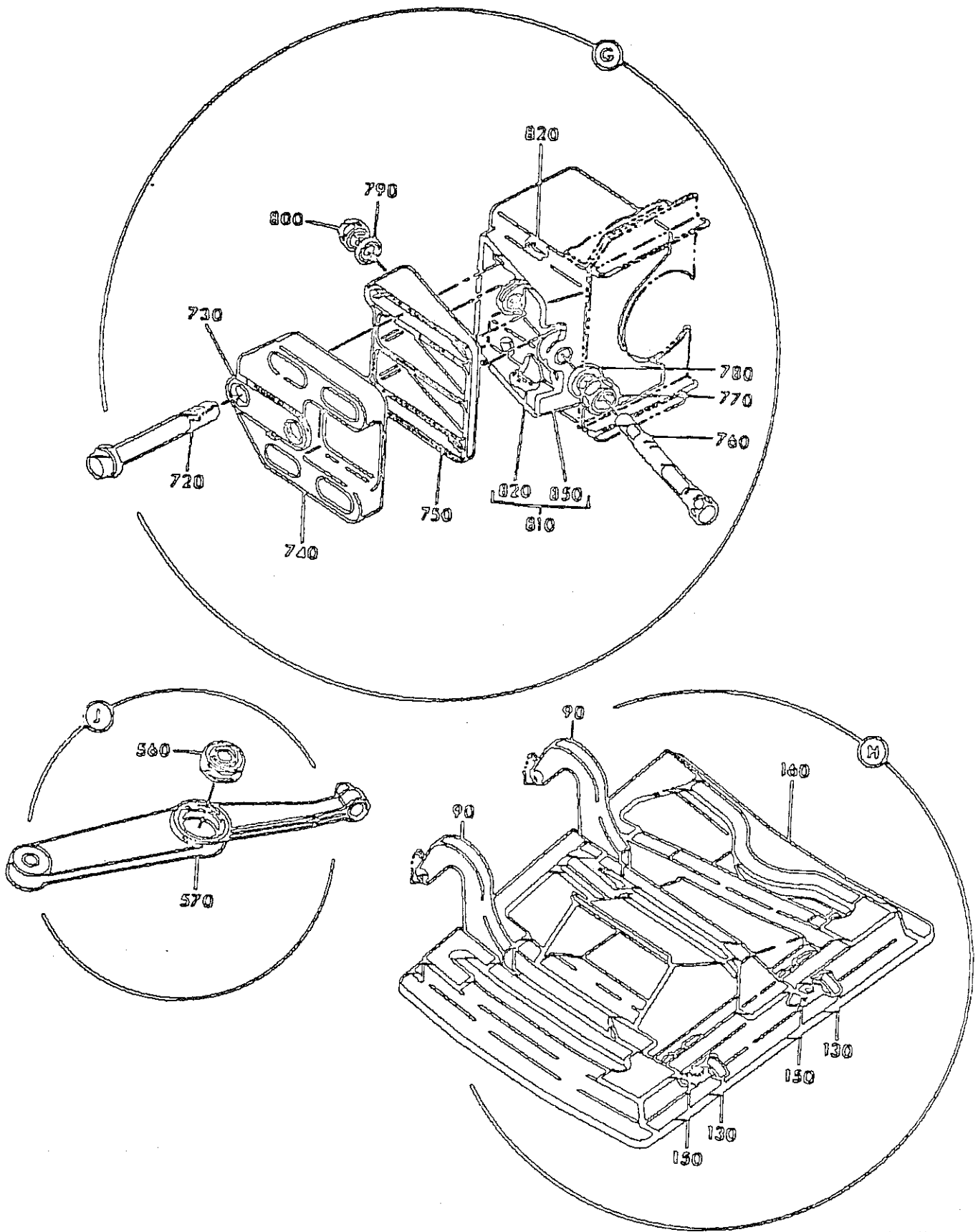
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CAPTIONS FOR ILLUSTRATIONS

Figure 1: Digital Replot of an Automatically Digitized Assembly Drawing.

Figure 2: Digital Replot of an Automatically Digitized Soil Map.



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DUCT ASSY-FIXED REVERSER AND FAN  
 FIGURE 1 (SHEET 3)

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