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COMPUTER GRAPHICS IN ENGINEERING DESIGN AND ANALYSIS[1]

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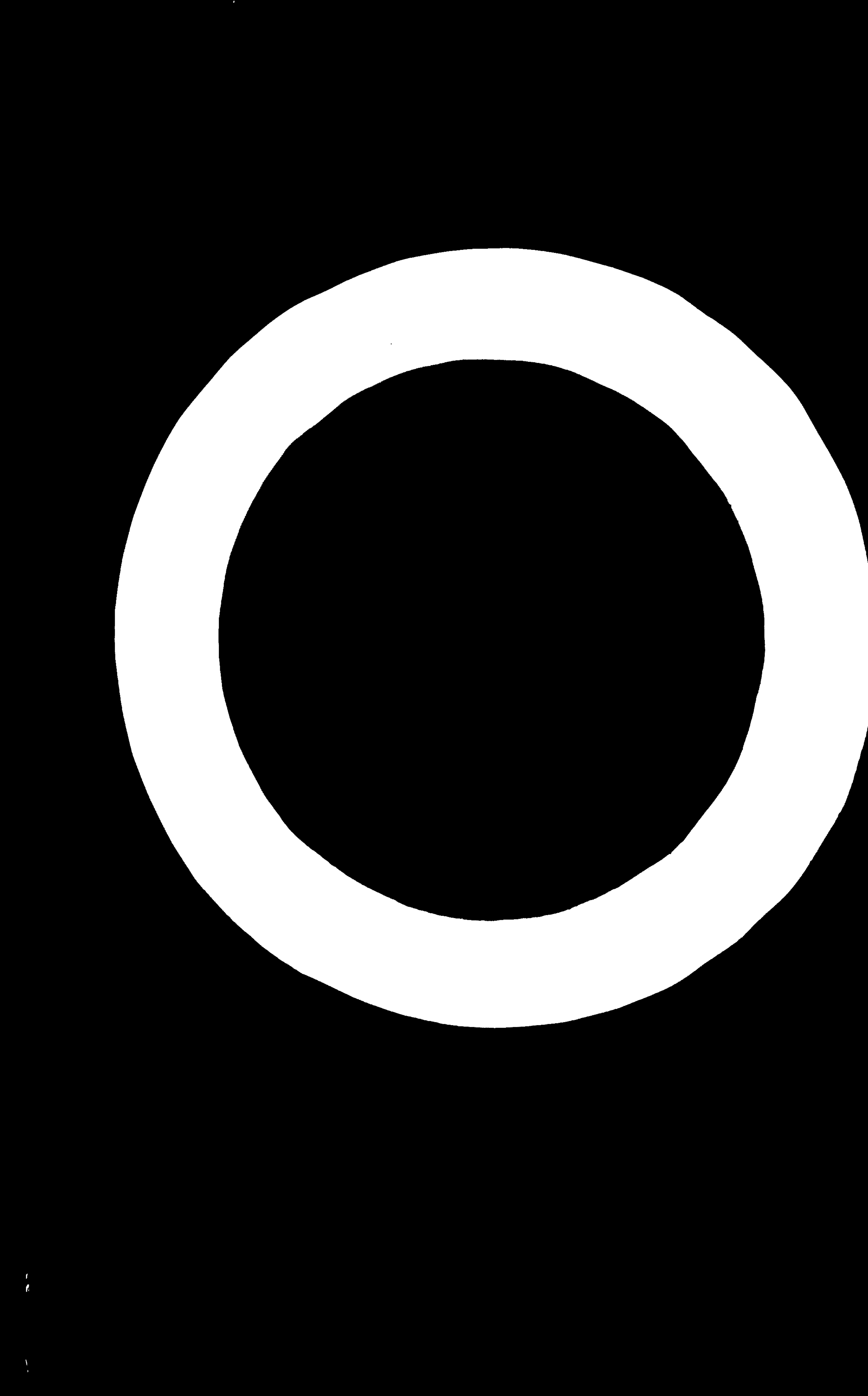


Introduction:

In order to understand the role that computer graphics is presently playing in the design cycle, we must first understand the process of engineering design and briefly look at the evolution of computer aids to design.

The Engineering Design Process:

Virtually every engineering design cycle evolves in an iterative or trial and error solution. The design problem is often, perhaps usually, ambiguous and open ended. The design process starts with the perception of a need and when the organization has adopted the fulfillment of that need as a goal. Considering an abstraction of the design process as outlined in exhibit 1, the designer's first job is to delineate the task in as specific and quantitative a fashion as is possible. These specifications serve as guidelines for activity to follow and a criteria for judging the degree of success that has been achieved when the final design is complete.

The designer must then generate a concept, usually in the form of a rough configuration. This is the creative phase of the design. The concept must then be evaluated by a process of analysis. Manufacturing considerations overlap the conceptual and analytical stages. The process being described does not generally occur in a simple sequential fashion. At each subsequent step it is possible that prior decisions may have to be changed and a new sequence started. Having carried out the design for a given concept or configuration, the designer may choose a different concept and repeat the above process. In any case, the total design process is highly iterative, involving "loops" within "loops" within "loops".

The designer's most important tasks are to establish the loop sequence and control the iteration process. Any part of the task which can be done practically and economically by computer should be done by computer. The engineer should expend his energies and talents only on these aspects of the problem which he is best equipped to handle, those involving concept generation, modeling, establishment of specifications and acceptability criteria. The particular attributes that the computer possesses include speed, memory and reliability. A computer performs computations and logical decisions at a rate that is difficult to comprehend. It is essential that the computer and the designer serve as partners in the design process, each doing the part of the job for which he is best suited. Thus, successful wide scale use of computers in the engineering design process implies a highly interactive man-machine configuration.

Evolution of Computer Aids to Design:

The flow of information between the man and machine must be rapid and the information must be accessible to both the man and the machine.

The engineer, however, has been confronted with two major obstacles in his usage of the machine. The first is the problem of communicating with the machine, the second is the availability of the computer with respect to time and physical location.

THE ENGINEERING DESIGN PROCESS

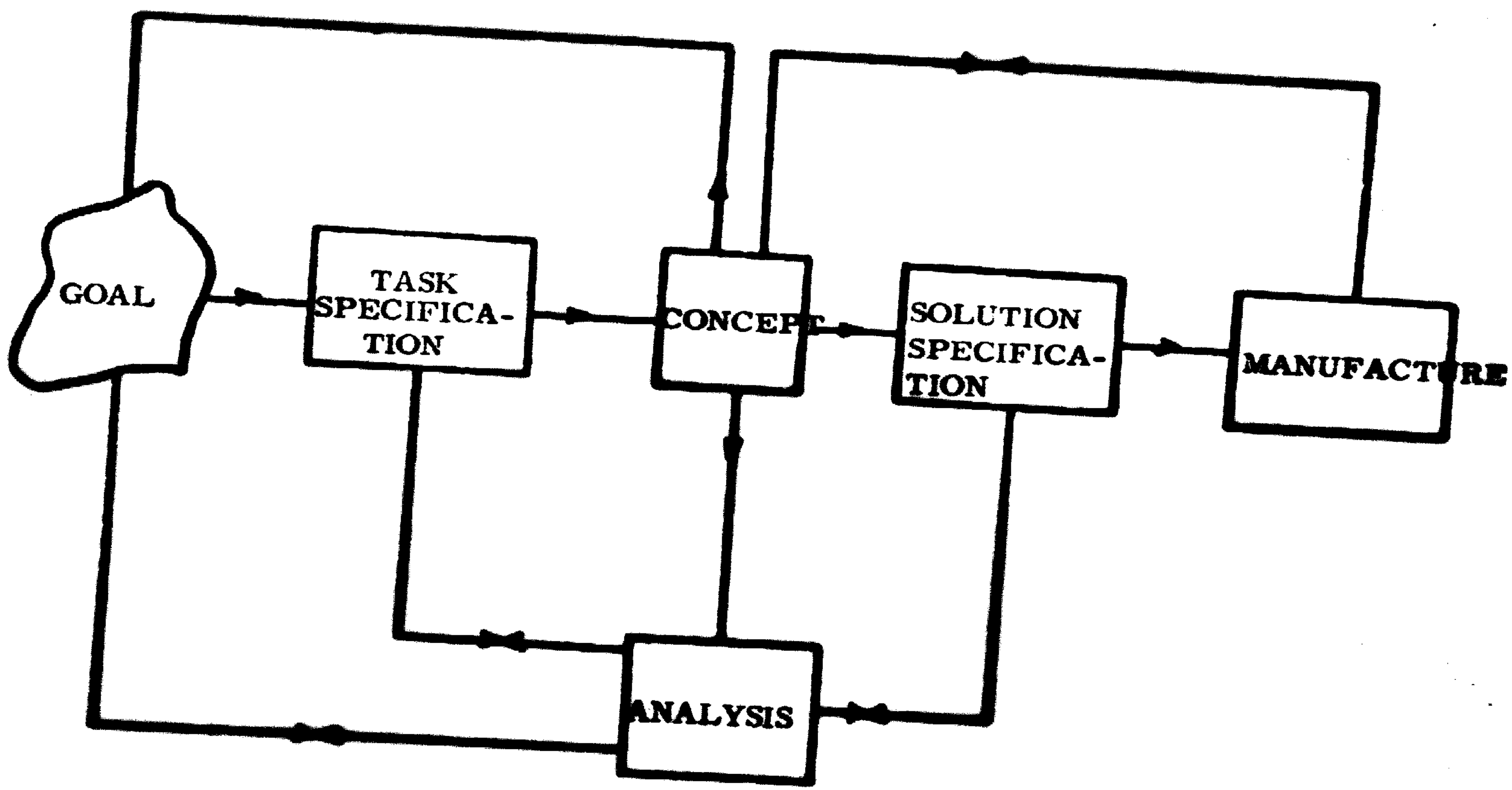


EXHIBIT 1

Prior to 1957, the engineer had to learn machine language to communicate with the machine. Algebraic compiler languages, such as FORTRAN, ALGOL, etc. represented a major step in easing the communication problem. Then came the problem oriented languages such as STRESS, COGO, and finally PLAN. All these represented a breakthrough in the process of man-machine configuration. They too suffer from shortcomings, however, because while they more nearly match the natural problem solving form of the engineer, they still fall short of a truly natural form.

Impact of Graphics:

The engineer works in graphical terms as well as in mathematical terms. When he has to translate his graphical expression (perhaps a drawing) into a linear stream of letters, numbers and special characters, he

(1) is using up time,

(2) is likely to make errors not always easily detected, and

(3) is not creative, at least not in a design sense.

Graphics is the language of design; and, if the engineer is to be relieved of the need to recast his thoughts into an unnatural form, graphics must be the part of the communication process.

The term "computer graphics" is very broad and includes numerous peripheral devices around the computer such as XY plotters, printers and drafting machines etc. These devices are used to convert computer output into graphic displays and are extremely useful because they give us pictorial information which is more natural to an engineer or a designer. However, even in such an environment, the engineer is no less isolated from the computer than he is when a typewriter prints out a solution in alphameric form.

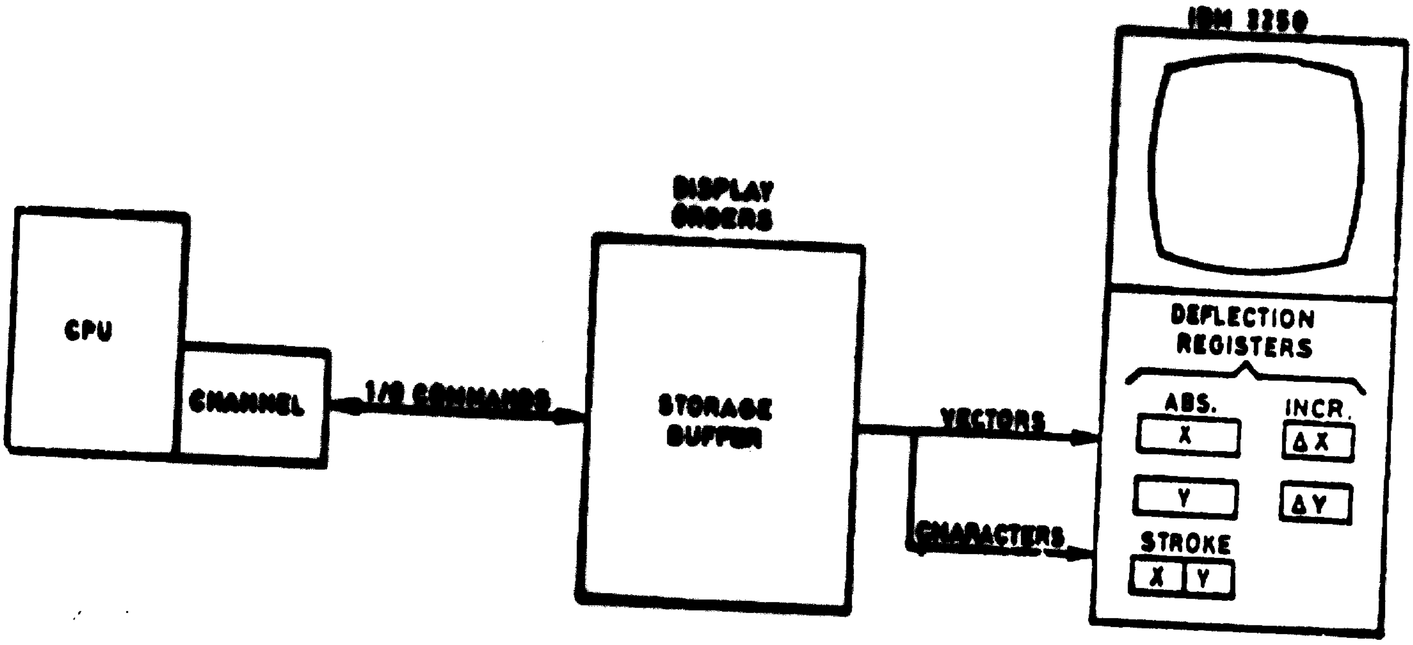
The graphic display screen, a cathode ray tube relieves the engineer's and designer's feeling of isolation and improves his productivity. He now sits in front of a CRT and with the aid of a light pen and keyboards he is given direct access to all the operating elements of a data processing system. He is now in an interactive mode with the computer communicating in his natural language.

Operation of the CRT and Accompanying Devices:

The operation of the CRT and accompanying devices is described here specifically in relation to the IBM 2250. The general principles however, will be applicable to other display tubes as well.

The 2250 has a 12 x 12 inch working area which in turn has an associated 1024 x 1024 grid or rastor. Two deflection yokes drive the electron beam from any one of the 1024 x 1024 points to any other point. One yoke is used for line segments. The second high speed yoke is used for short vectors and characters.

Generation of an image on the IBM 2250



<u>Exhibit 2</u>

Because the phosphor on the CRT face glows such a brief time after the electron beam has struck it, a display regeneration or "buffer" function is required (exhibit 2). The control unit (not shown separately) is the interface between the computer and the display, interpreting and executing orders that create the pictures, and interpreting and feeding back to the computer actions performed by the man at the console.

An image on the 2250 is initiated by I/O command from the CPU and regeneration continues under control of display orders accessed from buffer storage. The display orders form a stored program which is executed in a manner similar to CPU stored program.

The CRT in general is equipped with light pen, function keyboard, and console typewriter for man-machine interaction. (exhibit 3)

Exhibit 4 summarizes in graphic form the operation of the light pen, programmed function keyboard and alphanumeric keyboard. (The concepts would be explained in actual presentations)

Case Studies:

The movie "A Picture is Worth a Thousand Printouts" will be shown. In the movie, the following four case studies are discussed:

1. Complex Curve Plotting
2. Statistical Regression Modeling
3. Dynamic Engine Control Analysis
4. Turbine Blade Design

Pay-Off:

The major benefit of computer graphics is the possibility of substantial reduction in the time required for the design process. It is also possible to try out more solutions to any design problem than was previously possible. Thus, computer graphics presents a tool to shorten the design process, to try out more designs which in turn may mean better product. It is imperative that the developing nations with limited resources in terms of manpower and faced with the tecnology gap with the advanced nations give a good look to this new revolutionary tool.

A GENERAL COMPUTER GRAPHICS SYSTEM

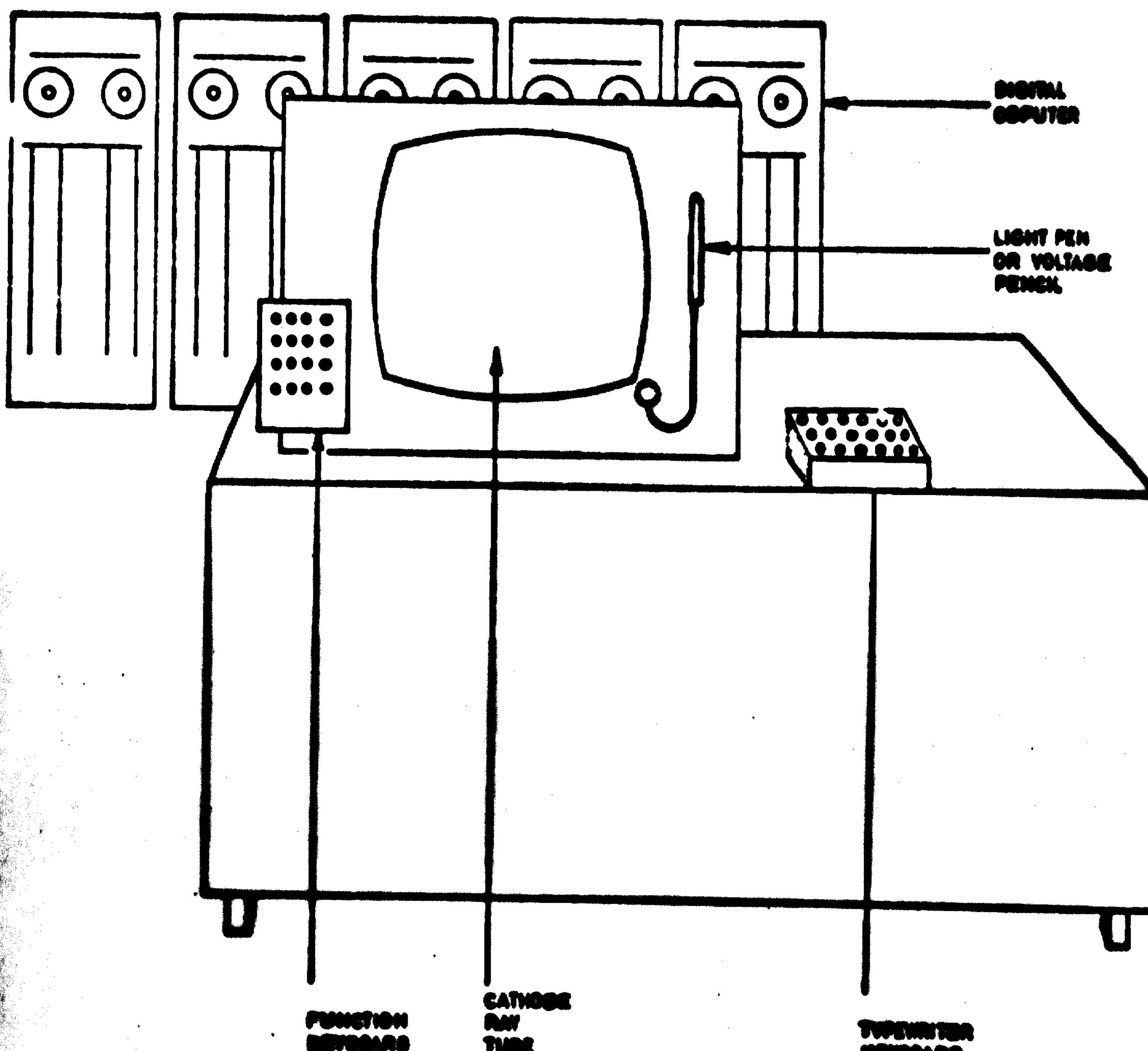
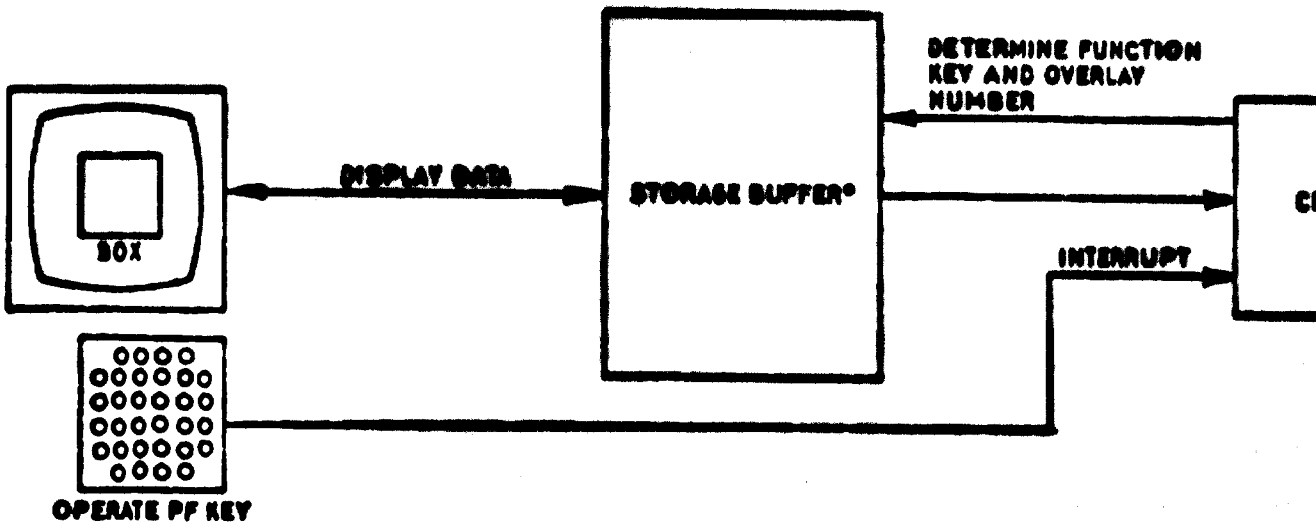


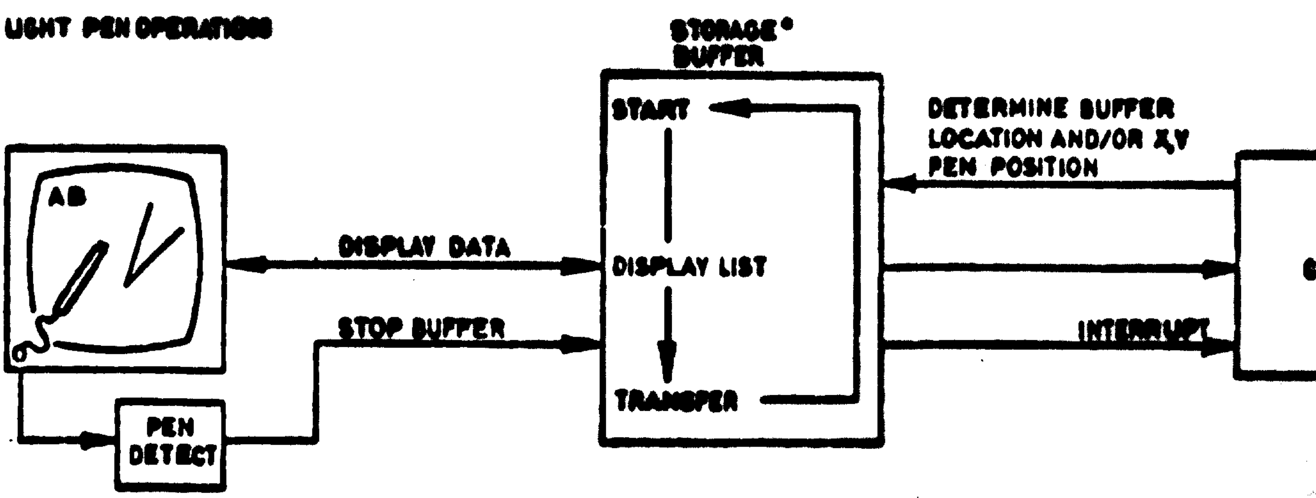
Exhibit 3

Basic functions of IBM 2250 input devices

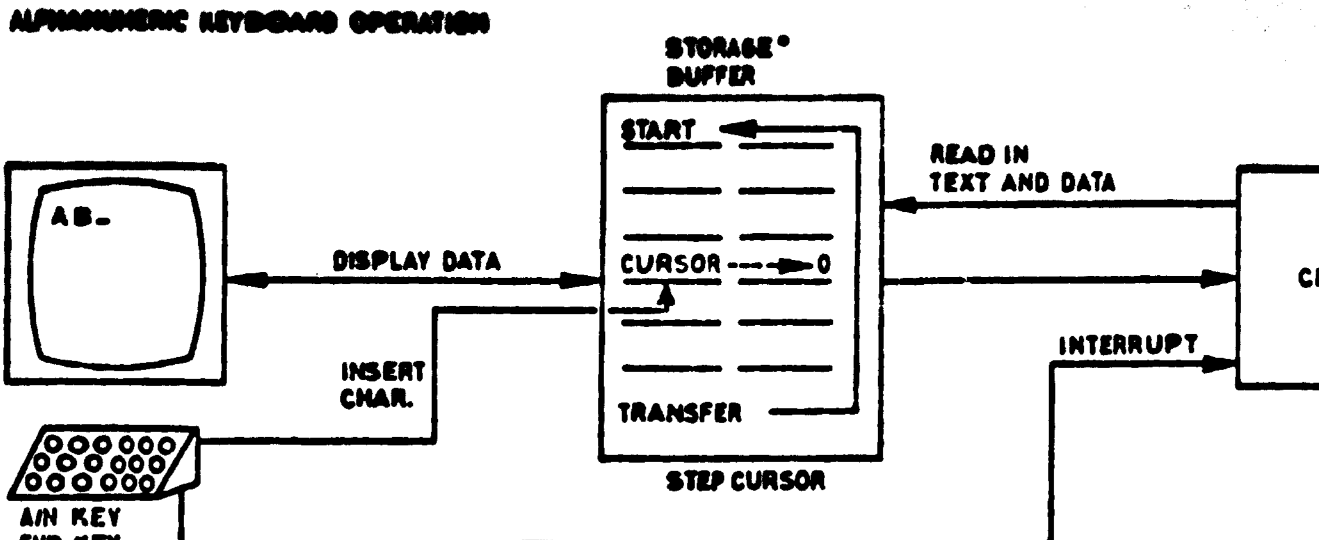
PROGRAMMED FUNCTION KEYBOARD OPERATION



LIGHT PEN OPERATIONS



ALPHANUMERIC KEYBOARD OPERATION



* STORAGE BUFFER IS PART OF 1130 STORAGE FOR 2250 MODEL 4

Exhibit 4

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