COMPUTER GRAPHICS AT BOEING

By William A. Fetter

A graphic designer who works with computers on a daily basis, the author views them as an aid, not a threat, to creativity

William A. Fetter (right), supervisor of Computer Graphics at Boeing, reviews a storyboard for a new film with James Berry, a Computer Graphics designer. The storyboard, designed to convey an engineer's message in proper sequence to the intended audience, is the basis for all estimates, design, data transcription, computing, illustration, narration and sound effects required to make the film. Involved in all the Computer Graphics projects shown and described on these pages are Fetter and John Freyman, who supervises the computing support activity. For purposes of brevity, the others involved in the projects are listed in the appropriate captions by their last names only. The full names and specialties of those credited in the captions are as follows: James L. Berry, Robert H. Mellor (Computer Graphics design); Thomas F. Parker, F. Michael Welland (data transcription); Constantino Lazzaretti, Sally D. Lloyd, Charles Cretin, Gary Meeker, Charles Spurgeon (computer programming); Kenneth C. Frank (final illustration); and J. Craig Evans (motion picture specialist).

Editor's Note: William A. Fetter is supervisor of Computer Graphics at the Boeing Company in Seattle. A graduate of the University of Illinois, where he received a BA in Graphic Design, Mr. Fetter began his professional career at the University Press, Art Division. He subsequently became art director for a national magazine whose headquarters were in Chicago. While with the magazine he became interested in the possibilities of computer-aided magazine formating. His experiments convinced him of the enormous potential of the computer in that field.

In 1959, Mr. Fetter accepted a position as supervisor, advanced design graphics, at Boeing's Wichita facility. One aspect of his work was exploration of new graphics techniques which would lead to the development of true perspective drawings by computer. He has since managed a formal research program aimed at development of applications of Computer Graphics technology to Boeing programs. Applications have taken the form of still, stereo, and motion pictures.

The Computer Graphics Group, which Mr. Fetter presently supervises in Seattle, produces documents, brochures, films, and cathode ray tube displays through application of a combination of the skill of graphic designers, the know-how of programmers, and the speed of a computer. In these products, creative communication is combined with engineering accuracy for purposes of analysis, simulation, and mock-up.

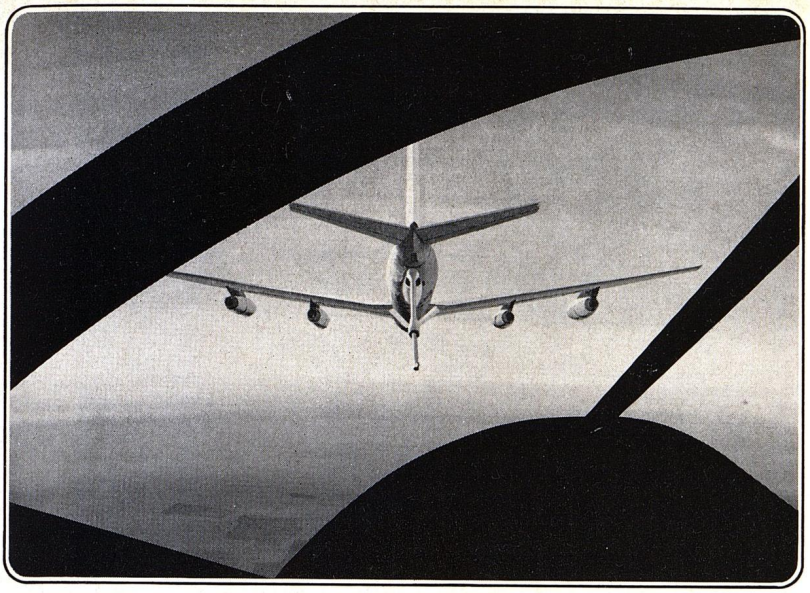
Mr. Fetter has received a number of awards for design and art direction and, in recent years, has lectured internationally and extensively on Computer Graphics technology. He is a member of the American Institute of Graphic Arts, Society of Typographic Arts, Aspen Design Conference, and the AIAA Subcommittee on Computers, and is the author of an NSF monograph, "Computer Graphics in Communication," which was published earlier this year by McGraw-Hill.

"But doesn't the computer invade the creative sphere of the designer?"

Questions such as this, posed at the "Computers in Design" conference held last spring at the University of Waterloo, reveal how deeply concerned designers and artists are about the possible impact on their work of the new Computer Graphics technology. You could sense the creative heels digging in from that first word "But . . ."

The response by conference speakers to these questions ranged from, "The computer simply elevates the level of possible creative work," to, "The computer can handle some elements of creativity now—by current definitions of creativity." A number of films have already been produced that are purely "creative," but even in the task of presenting largely technical information, creative ability is required. In short, the computer is a graphic tool employed to simplify the designer's task, thereby allowing him more time for purely creative pursuits.

As a designer, suppose for a moment that you have been asked to prepare a creative, logical sequence of pictorial and verbal information (let's say films) in which you are required to show precise, complex movements of an airplane maneuvering into position to be refueled in the air, as viewed from the pilot's seat of another aircraft that does not yet exist except on paper. Further, suppose you are required to prove the two airplanes are accurately related at all times during the refueling. Conventional animation techniques would go a long way toward explaining the technical concept and even significant details. Suppose, however, there is the need to move the eye point freely from place to place to better observe the actions, constantly showing the airplanes in accurate perspective. Suppose that it is also necessary to dolly in from an overall view to a close-up of a small detail inside an aircraft, such as a bolt, correct to a thousandth of an inch, while maintaining an accurate, constantly changing perspective view—all this to be accomplished on a budget about the size of



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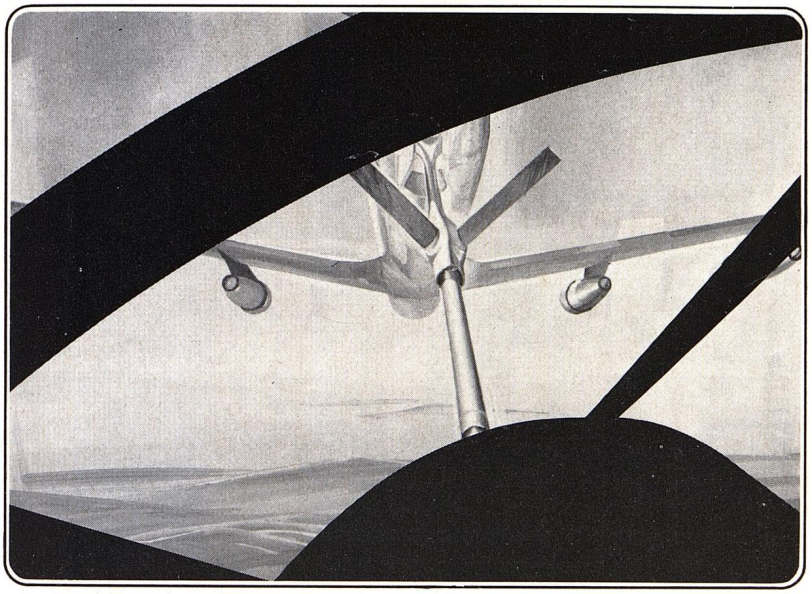

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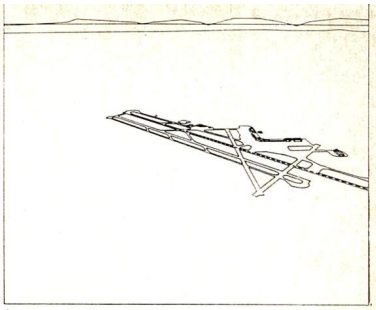

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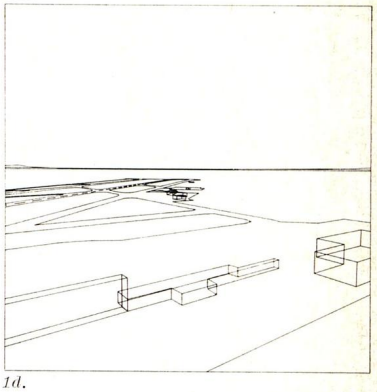

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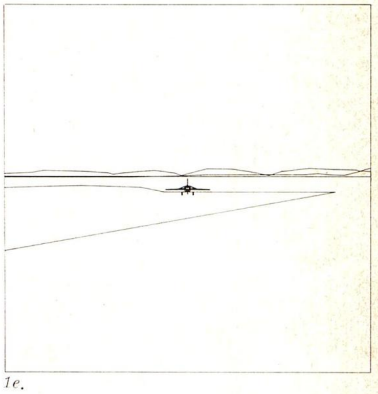

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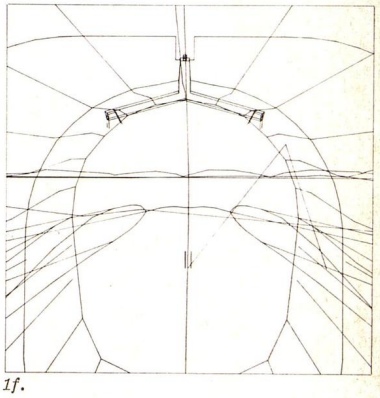
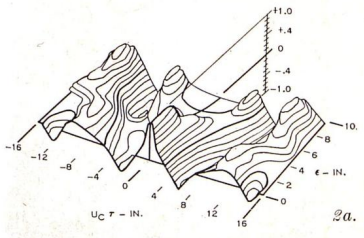


1f.

1. *Rendering based on computer plots for a Computer Graphics film which accurately shows cockpit visibility from an airplane yet to be built. Critical visibility is shown during refueling approach (a) and contact (b) with the tanker. Pictures (c) through (f) are selected computer plots of eye motion animation; they range from a point on an airport ramp miles away from the plane to a point inside the aircraft. Details in (f) are within a thousandth of an inch. This series demonstrates the ability to move freely and precisely within this numerically generated world. (Berry, Evans, Frank, Meeker, Parker, Welland.)*

2. *An acoustics study yielded significant information that could best be understood by viewing a three-dimensional graph with quantitative numerical values (a) and rotated to provide a qualitative view of the complete topology (b, c). (Berry Lazzaretti, Parker.)*



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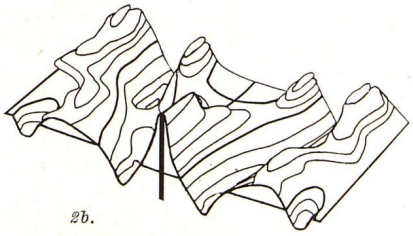

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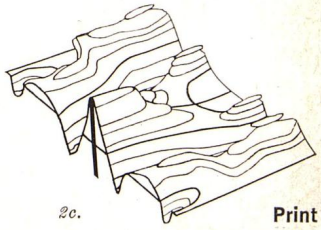
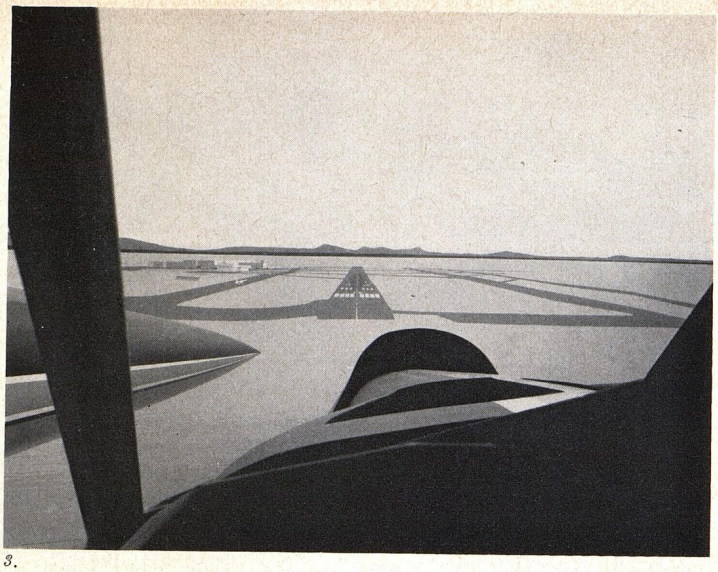


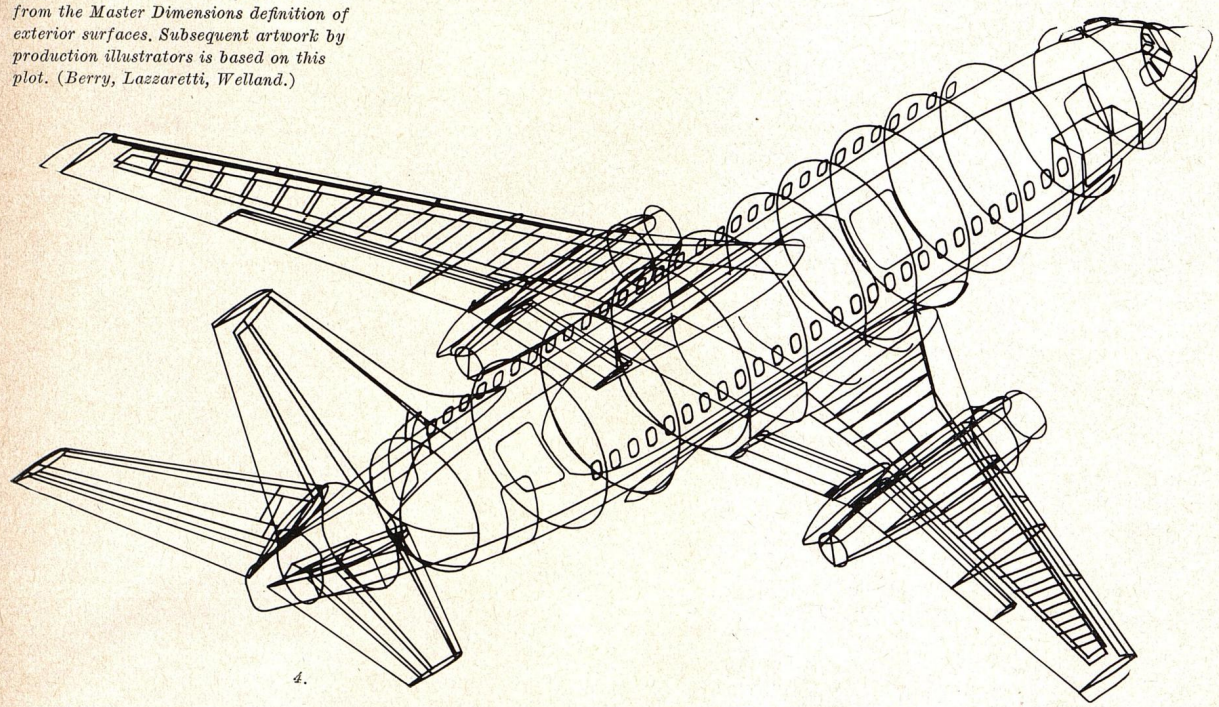
2c.

3. View of a 42-foot diorama scaled up and illustrated from a computer plot. It is positioned in front of a full-size cockpit mock-up, providing the pilot with an accurate view of a specific landing approach. (Frank, Lazzaretti, Mellor, Welland.)



3.

4. Isometric computer plots of the Boeing 737 were produced using numerical data transcribed by keypunched cards of known dimensions; by cards produced from engineering drawings by means of a Telereader machine; and by cards derived from the Master Dimensions definition of exterior surfaces. Subsequent artwork by production illustrators is based on this plot. (Berry, Lazzaretti, Welland.)



4.

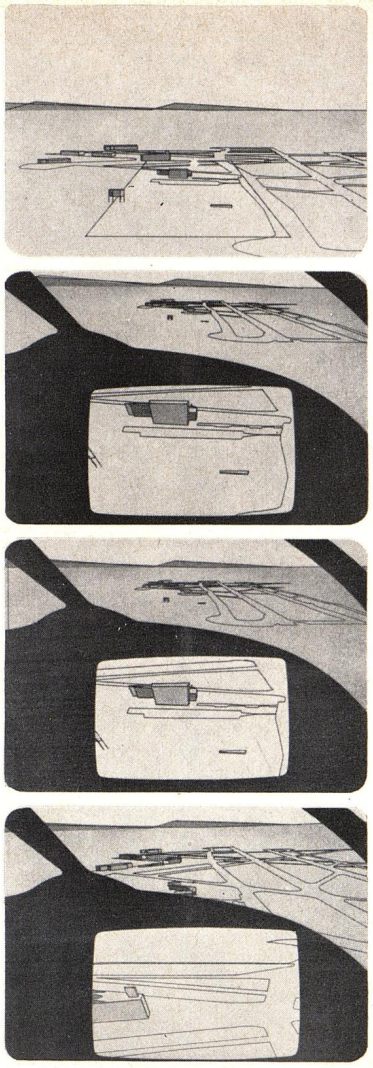
that of an underground movie!

Before you decide to get out of design and open a delicatessen, examine the sequence of pictures shown here from just such films (Fig. 1). These required the combined efforts of graphic designers, motion picture specialists, writers, draftsmen and artists—plus computer specialists—to meet all the above requirements.

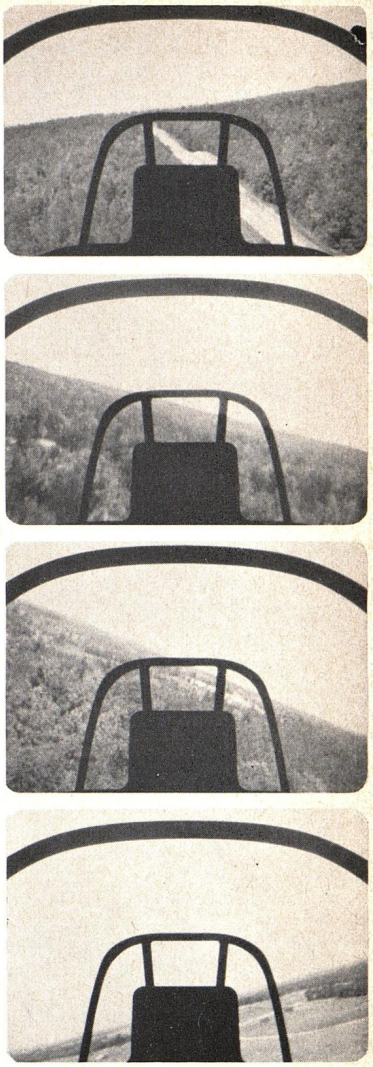
Since my own background is in graphic design, I believe I have some common ground on which to discuss the subject of Computer Graphics with others in my profession.

The need for a computer to simplify certain graphic procedures first became evident to me at the University of Illinois Press Art Division, when I had to design and render an illustrated title page for "Space Medicine." This was done from my own laborious construction drawings of the earth, moon, sun and a space station—a difficult task which even a new drawing projection approach didn't make much easier. Later, as art director for a Chicago-based magazine, when I found that frequent last-minute advertising changes that were dropped in my lap could upset the design of an entire issue, I started working with a computing manager to automatically make up magazine dummies and their innumerable changes.

Before completion of these computed design aids, I accepted an art director's position at Boeing, Wichita, where, incidentally, the need, the skills and the equipment existed for making a beginning in producing perspectives and motion pictures by computer. In 1960, when we at Boeing coined the term "Computer Graphics," we were considered optimistic about where we thought it would lead. Yet the overall technology has gone far beyond those early assertions. Today, since we have not yet converted our current capabilities to include routine use of the promising new cathode ray tube/light pen systems, I will omit discussion of our research effort in this area and discuss only day-to-day application of our Computer Graphics technology to urgent projects.

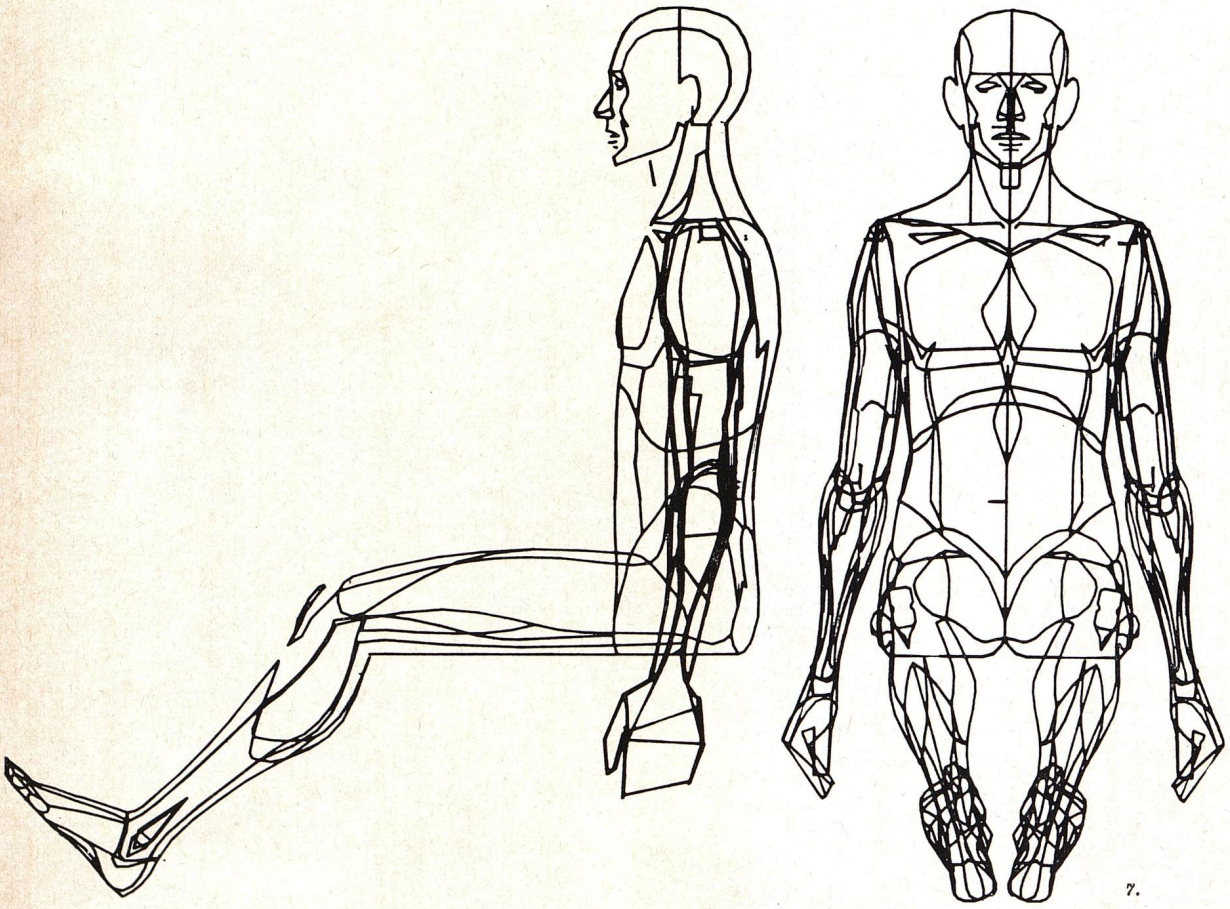


5. Sequence from a film showing a system in operation which is yet to be built. Picture at top shows a view of an airport (including a rectangle in perspective) which will be displayed on a screen in the cockpit during flight. The image of this area is transformed into another image that allows, as shown in the pictures below, objects on the ground to be located and observed at a faster rate than by direct observation through the window. (Berry, Parker, Spurgeon.)



6. Sequence from a film in which computer plots were converted into cockpit masks and combined with actual motion picture footage to achieve realism. (Berry, Evans, Lazzaretti, Parker.)

7. Views of an animated human figure showing front and side view. The measurements are the mean measurement of 50 per cent of Air Force pilots, according to anthropometric data supplied. The figure will be useful in many man-machine interaction studies. (Berry, Frank, Cretin, Parker.)



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To produce Computer Graphics in any system, three primary participants need to understand and appreciate each other's skills and problems. The first—the Communicator—has a message or an idea to communicate; sometimes he needs Computer Graphics to test the validity of his message. The second—the Communication Specialist—knows how to help him deliver it, graphically or verbally. The third—the Computer Specialist—knows how to assemble the right computing equipment and interpret the logic of the second specialist so that the equipment can act upon it. The last two specialist groups comprise the Computer Graphics team; obviously, the computing capability is put to use only when doing so makes this team more efficient than it would otherwise have been.

In Boeing Computer Graphics technology, the graphic designer not only retains his identity and creativity, but achieves greater freedom in many ways because of what he can do with the computing tool. He is called a Computer Graphics Designer because he has garnered a sufficient understanding of the current technology—much as he would augment his capacity by learning the techniques of handling a camera. A set of computing procedures, in fact, can be likened to a camera instruction manual.

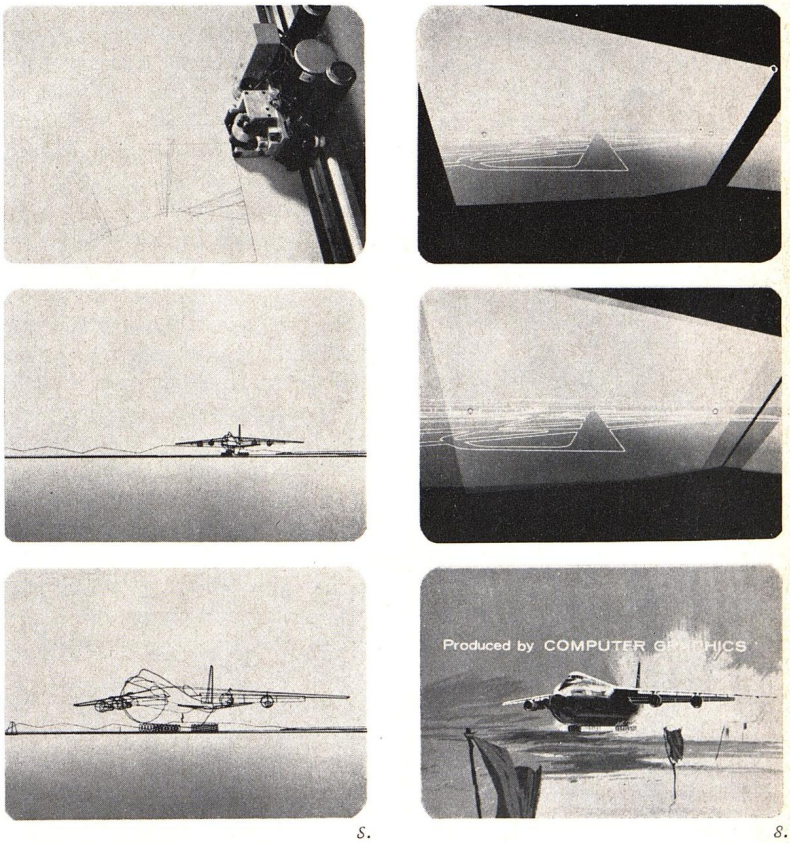
The Computer Graphics Group is a function of Corporate Headquarters, and supports all divisions in the company. The organization, skills and resources employed are very like those in any other creative studio, with the important support of the computing operation, the skills and equipment of which are organized much as any other scientific computing operation.

What typical recent projects (other than showing inflight refueling) have we been involved in? Here are some examples:

Rather straightforward three-dimensional graphs which show the scientific results of a complex acoustics study (Fig. 2).

A diorama plotted accurately and enlarged to a 42-foot curved surface,

8. These scenes from a proposal film, which briefly described the Computer Graphics process, verified the landing accuracy as viewed from the runway, then showed views from the pilot's seat. The final scene required graphic design and illustration, as did many other portions not shown here. (Berry, Evans, Lazzaretti, Parker.)



8.

which was used in front of the Supersonic Transport cockpit mock-up to demonstrate to pilot evaluators the exact visibility at a specific point in a landing approach (Fig. 3).

Very accurate isometric views of the new Boeing 737 which are now being used by the production illustrators to provide even greater accuracy in their drawings (Fig. 4).

Motion pictures of a pilot's view of a carrier landing with airplanes that are already operational have been confirmed by pilots who fly those airplanes —and then the same capability used to describe landing visibility of airplanes still on the drawing boards (not shown here).

A cockpit display system was simulated in operation before the system itself was constructed. The system gave an operator desired views of part of the ground ahead of the airplane by means of a TV screen in the cockpit. The TV image was not a true perspective view but a carefully transformed image which allowed human capabilities to more easily identify and then inspect objects on the ground at slower apparent motion than if observed directly by the unaided eye. The ability of the system to be trained on a given subject for closer scrutiny was also demonstrated (Fig. 5).

Low-level visibility from an airplane designed for high-speed, low-level flight presents special pilot and co-pilot visibility requirements. Here, realism was needed to the point of combining motion picture photography with the computed cockpit obstructions. To help the engineer examine each new cockpit design refinement during a design proposal (in as realistic a display as possible), the engineer's first configuration drawings were rapidly put into films for evaluation as one of several information sources that would influence redesign. An early cockpit design is shown here (Fig. 6).

Human factors studies require precise measurements for a number of body motions of a range of body sizes. A human figure which may be animated and altered in size has been prepared by Computer Graphics (Figs. 7, 9). [This human figure was drawn at Boeing from military data representing the 50th percentile. Its development is still in the early stages: plans are to include anthropometric data from the 5th to the 90th percentile. In a certain sense, the present drawings represent the first generation in a family tree, or "Adam." The ultimate goal is full animation for the figure.—Editor.]

The transport visibility study film, also shown here, is an example of a complete application as prepared for the technical film library portion of a proposal for a new airplane (Fig. 8).

From perspective computer plots of a new airplane design, full color renderings (not shown here) were produced by a staff illustrator who was able to confidently guarantee its accuracy to engineers.

Rather than altering the arrangement of entire documents because of the massive changes that must be made (far more extensive than magazine ad changes), a Computer Graphics documentation system is under development which does this and many other functions automatically. The changes necessarily occur during significant improvements in an airplane design proposal right up to the time of submittal.

My conviction about the possible change in some creative processes brought about by the computer is that speculation in this matter is valuable so long as it is coupled with a conscious effort to shape the technology toward meeting basic human goals—including human creativity. I feel it is not completely a question of what the computer will do to us, but a determination of what we will best have the computer do for us. Just as important is an assurance that a necessarily diverse group is in a position to make these basic decisions.

You may call this a "work and see" attitude, but in the meantime I find the efforts of designers who have become involved and productive in this exciting new field to constitute a very valid and pleasing form of creativity.

9. Another view of animated human figure.