DÜRER-style Halftoning

- in work with Y. Pnueli we aimed to do halftoning by attempting to immitate the methods of ENGRAVERS.

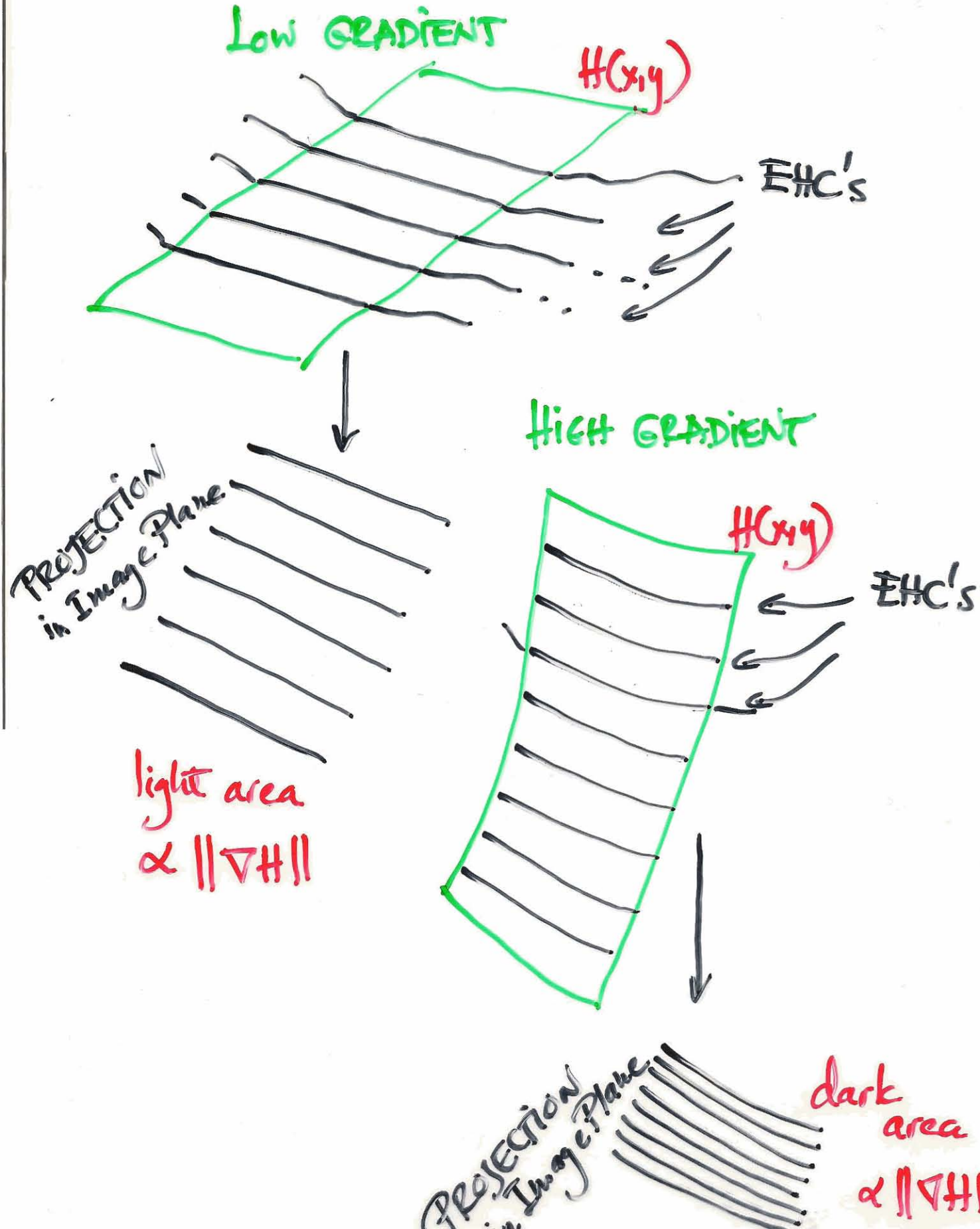
Halftoning by generating curves that have "local density" controlled by image gray level.

- Solve for the Equal Height Curves of $H(x,y)$ that obeys

$$\| \nabla H(x,y) \| = \sqrt{\left(\frac{\partial H}{\partial x}\right)^2 + \left(\frac{\partial H}{\partial y}\right)^2} = I(x,y)$$

H: a bivariate function whose EHC's are locally "parallel" & have density

I: input image


Low GRADIENT
H(x,y)
EHC's
High GRADIENT
H(x,y)
EHC's
PROJECTION in Image Plane
light area
$\propto \|\nabla H\|$
PROJECTION in Image Plane
dark area
$\propto \|\nabla H\|$

We need to solve for the ETC's of H where

$$\|\nabla H\| = I(x,y)$$

↑

The famous EIKONAL EQUATION

In Image Analysis this was done in solving the so-called SHAPE from SHADING problem

There are very efficient methods to do this based on advanced "Level Set Methods".

The ETC's of $H(x,y)$ are solved by Tracking Level Sets of another bivariate function.

SOME RESULTS

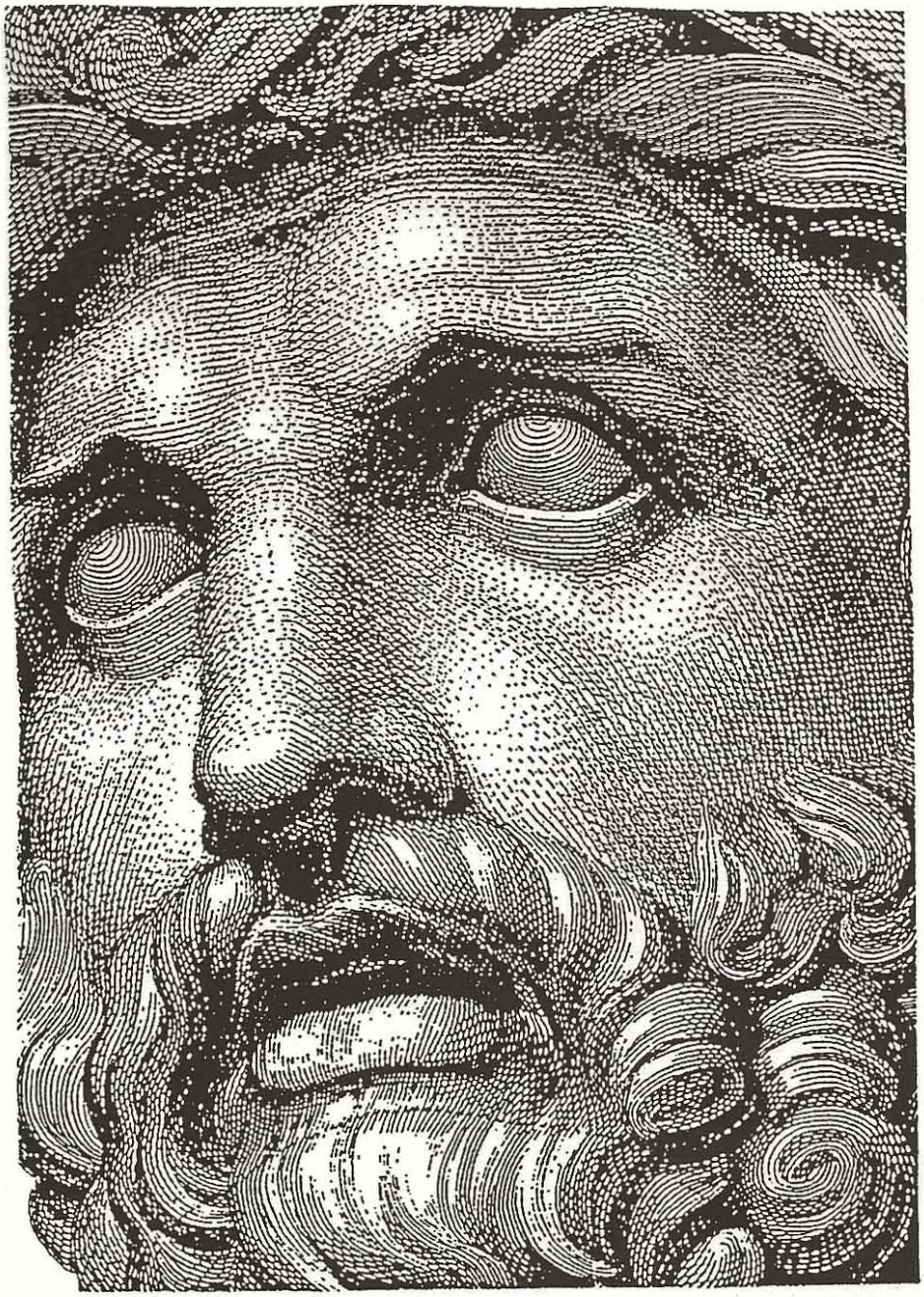


FIG. 6. A man-made halftone artwork [14].

example from
"Gridless Halftoning: A reincarnation of the Old Method"
by Pnueli & Bruckstein (1996).

Fig. 1 Traditional copperplate engravings: an enlargement of a modern post stamp (left) and an enlargement of a modern banknote (right).

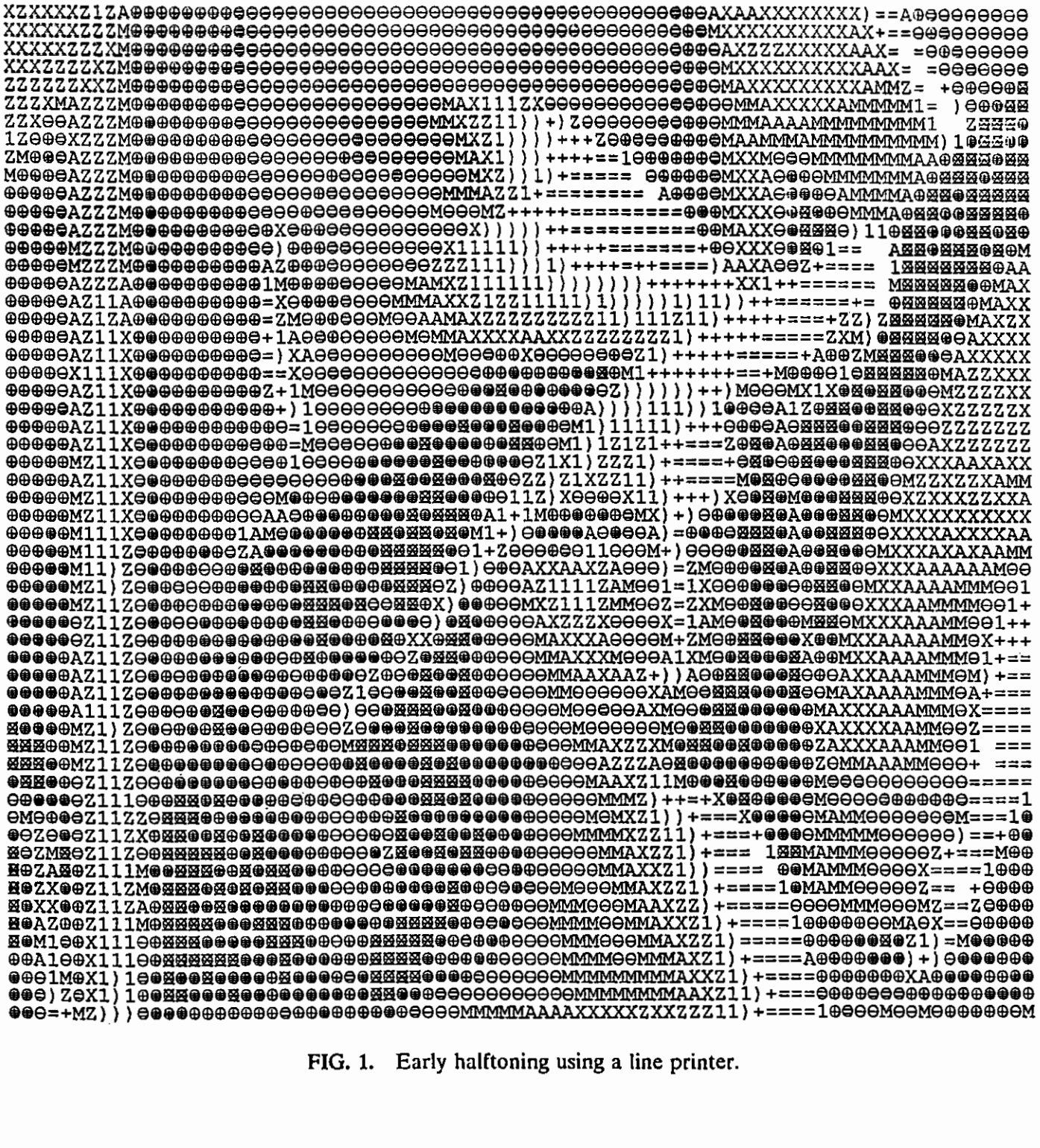


FIG. 1. Early halftoning using a line printer.

FIG. 2. Halftoning with clustered ordered dither.

FIG. 5. Neural network optimized halftoning [18].

FIG. 14. **Digi***Dürer* output utilizing edge/segmentation information.

FIG. 18. Gridless halftoning with dot elements.

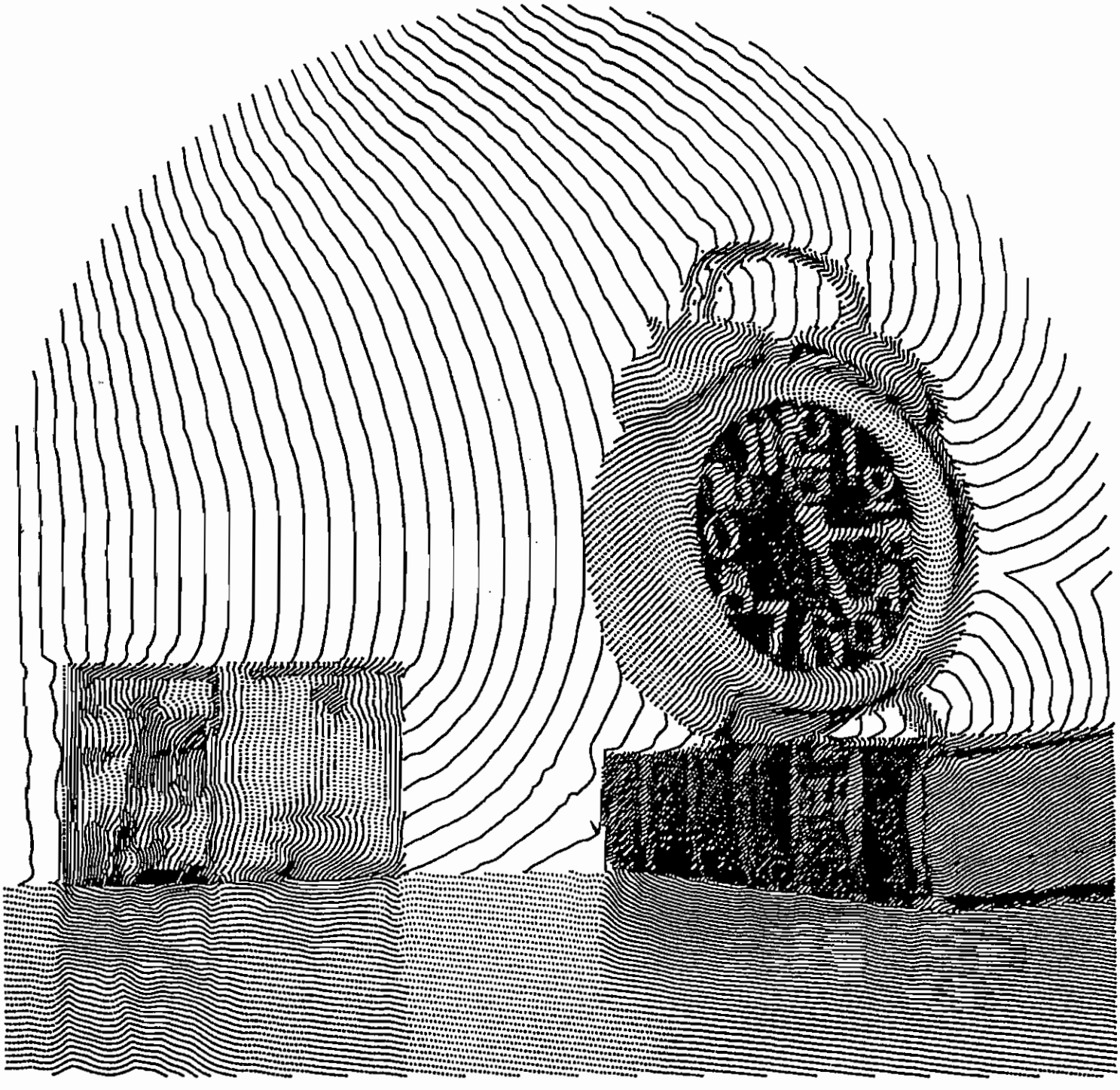
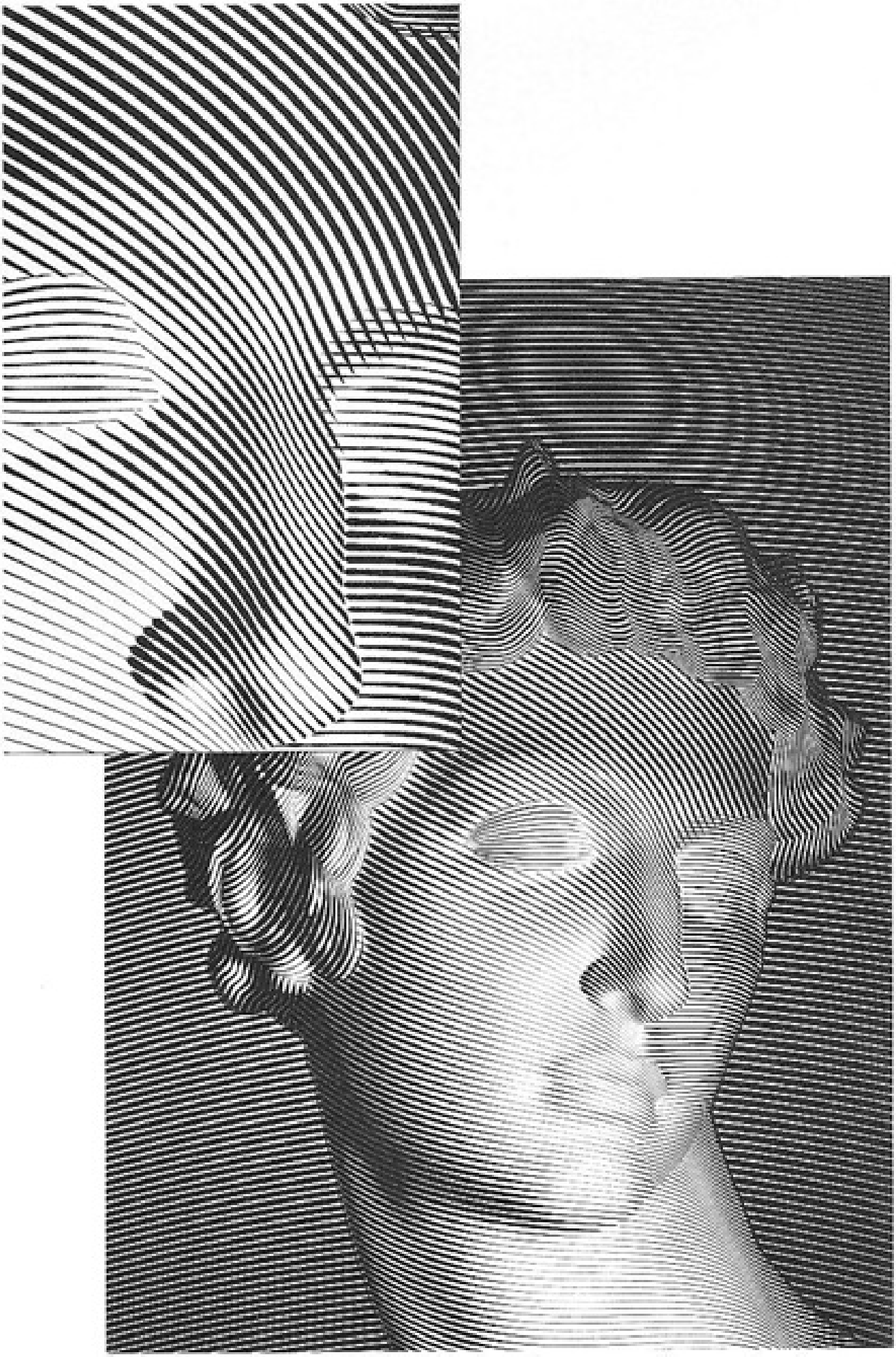


FIG. 15. **Digi***Dürer* output utilizing edge/segmentation information.

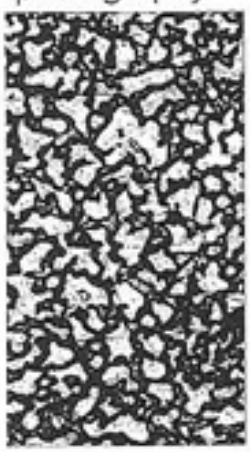
FIG. 16. **Digi***Dürer* output utilizing edge/segmentation information.

FIG. 25. (Art-Play-1) Image generated using a 3D equidistance curve evolution rule.

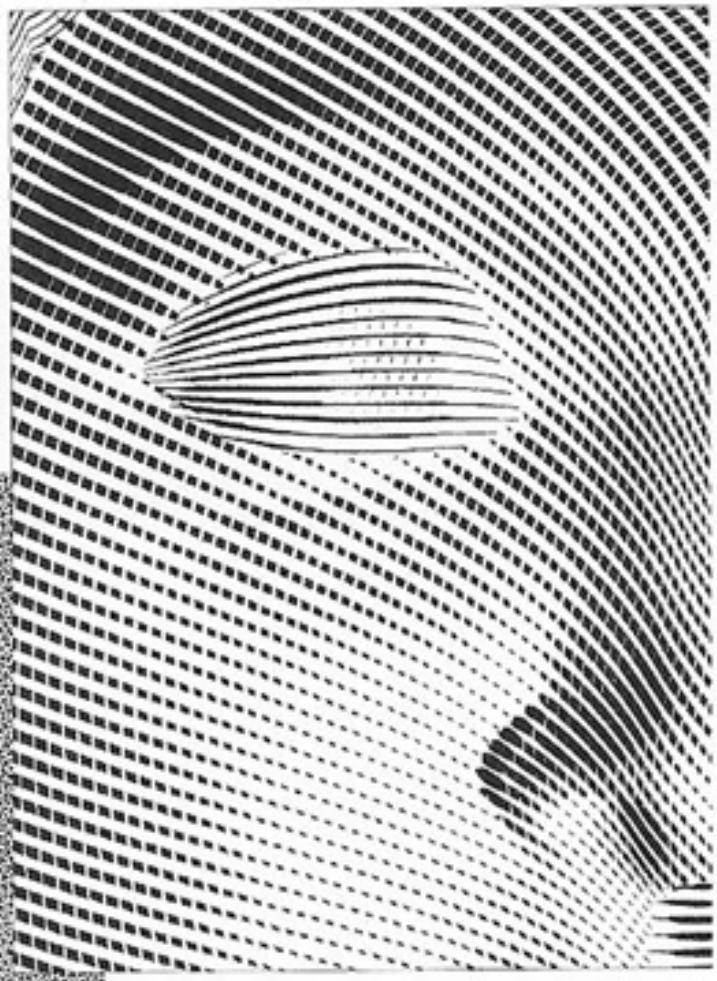
FIG. 26. (Art-Play-2) Image generated using a variable terrain 3D equidistance curve evolution rule.

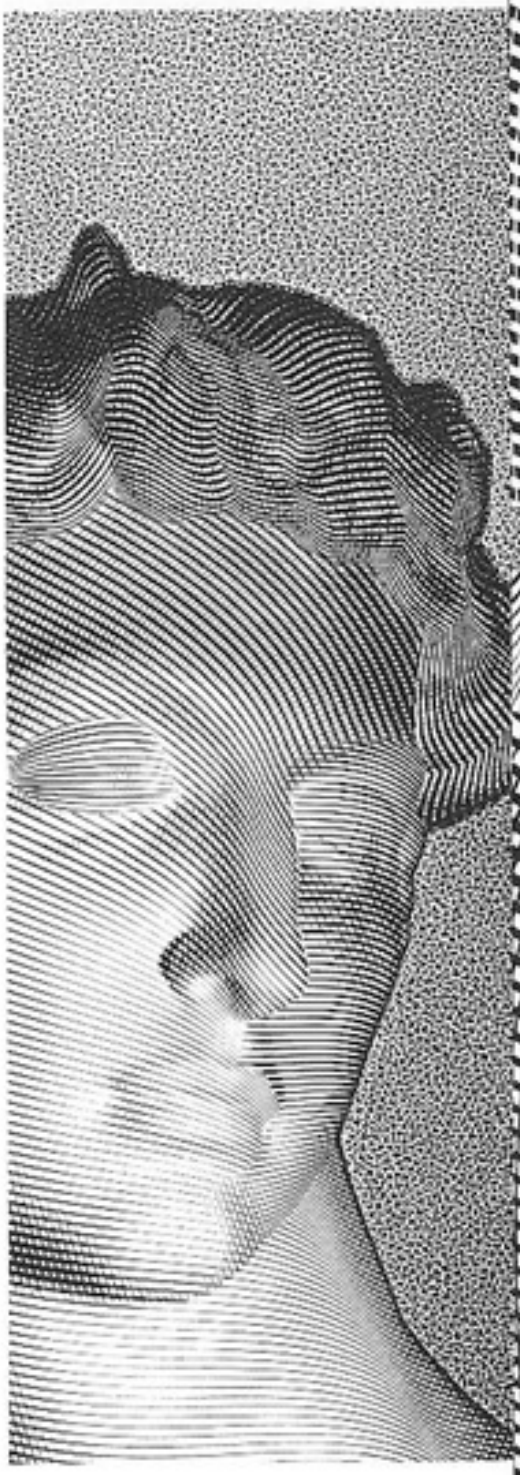


micro-
photography

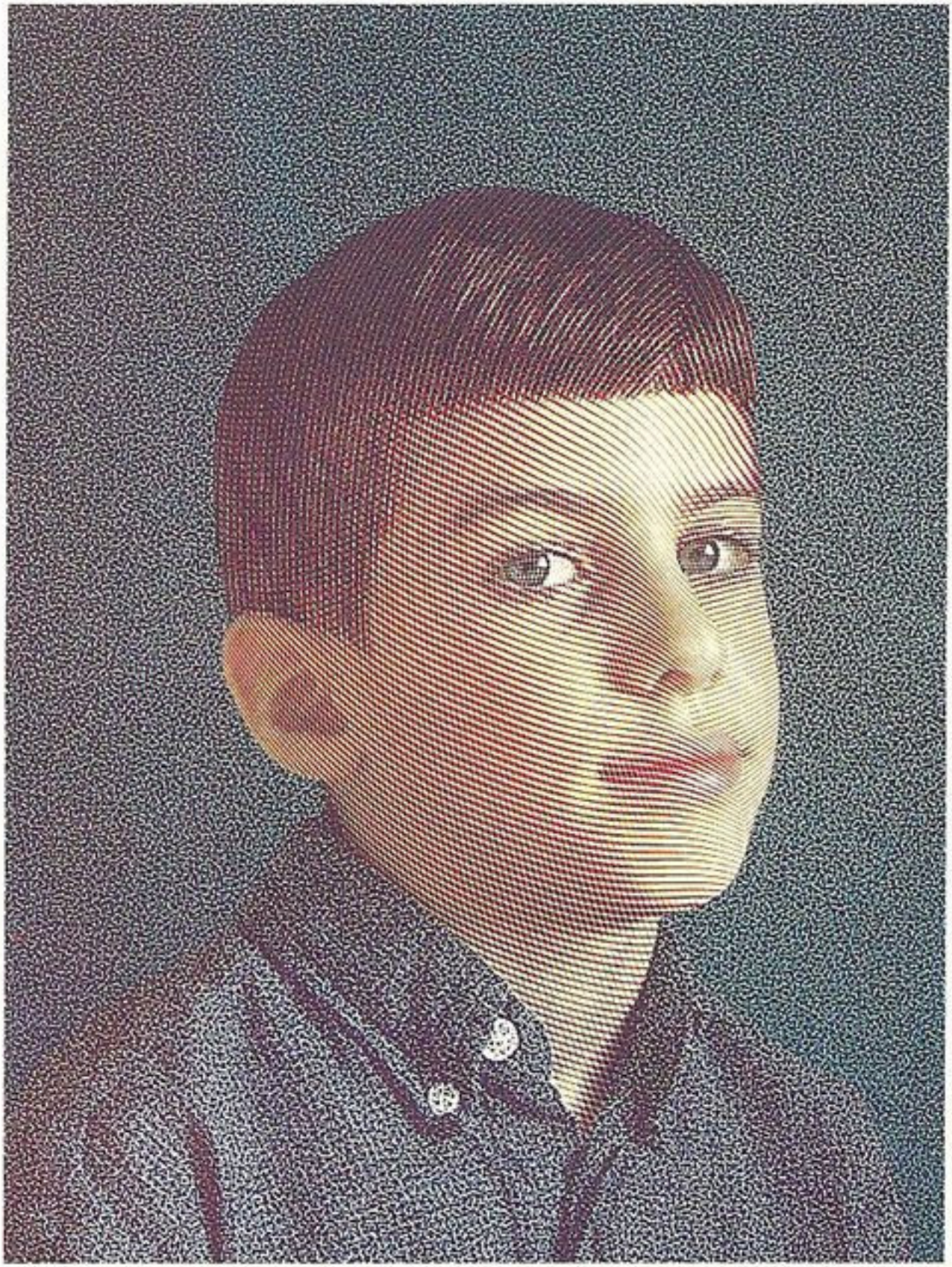


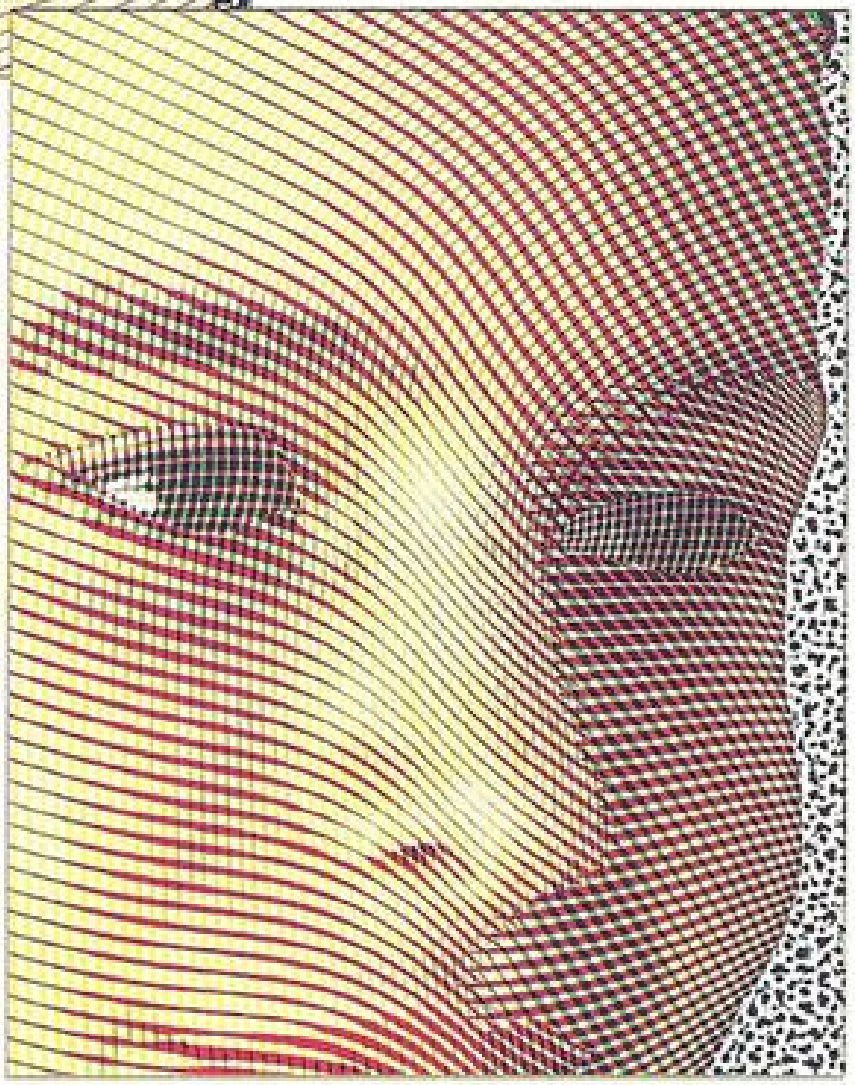
"bigger" and "smaller" rules

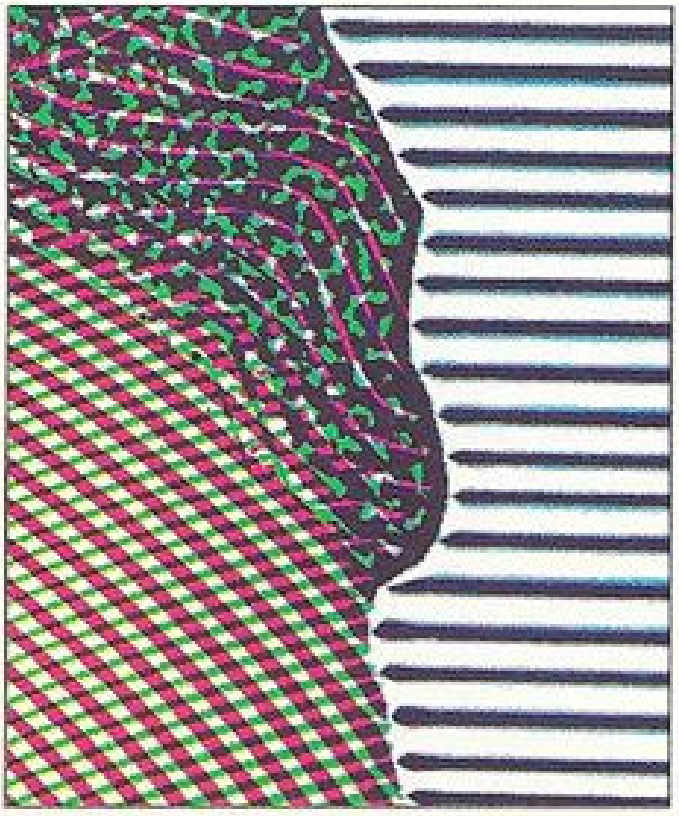




"smaller" rule







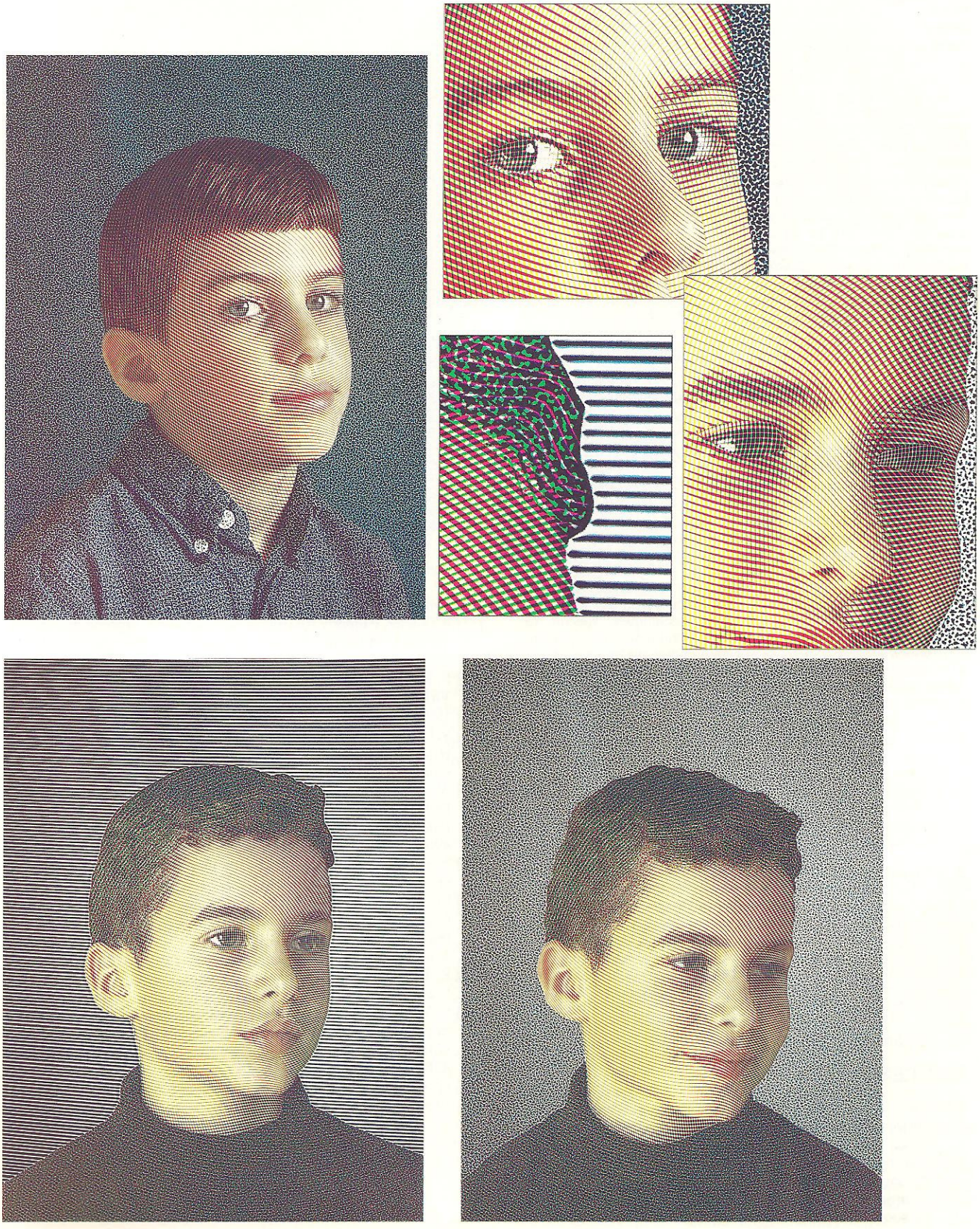


Fig. 9 Examples of color engraving.