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INTEGRATED INFORMATION SUPPORT SYSTEM (IISS)
Volume VIII - User Interface Subsystem
Part 10 - Graph Support System Unit Test Plan

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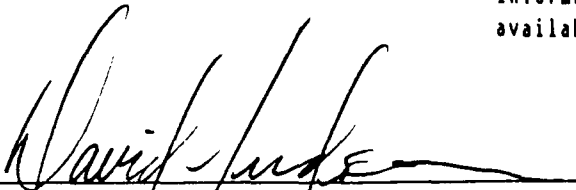
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FOREWORD

This technical report covers work performed under Air Force Contract F33600-87-C-0464, DAPro Project. This contract is sponsored by the Manufacturing Technology Directorate, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio. It was administered under the technical direction of Mr. Bruce A. Rasmussen, Branch Chief, Integration Technology Division, Manufacturing Technology Directorate, through Mr. David L. Judson, Project Manager. The Prime Contractor was Integration Technology Services, Software Programs Division, of the Control Data Corporation, Dayton, Ohio, under the direction of Mr. W. A. Osborne. The DAPro Project Manager for Control Data Corporation was Mr. Jimmy P. Maxwell.

The DAPro project was created to continue the development, test, and demonstration of the Integrated Information Support System (IISS). The IISS technology work comprises enhancements to IISS software and the establishment and operation of IISS test bed hardware and communications for developers and users.

The following list names the Control Data Corporation subcontractors and their contributing activities:

<u>SUBCONTRACTOR</u>	<u>ROLE</u>
Control Data Corporation	Responsible for the overall Common Data Model design development and implementation, IISS integration and test, and technology transfer of IISS.
D. Appleton Company	Responsible for providing software information services for the Common Data Model and IDEF1X integration methodology.
ONTEK	Responsible for defining and testing a representative integrated system base in Artificial Intelligence techniques to establish fitness for use.
Simpact Corporation	Responsible for Communication development.
Structural Dynamics Research Corporation	Responsible for User Interfaces, Virtual Terminal Interface, and Network Transaction Manager design, development, implementation, and support.
Arizona State University	Responsible for test bed operations and support.

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DTIC TAB	☐
Unannounced	☐
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normalized projection coordinates (NPC): the hypothetical cartesian coordinate system defined within the unit cube (X, Y, and Z coordinates lie between or equal to zero and one). This allows a device independent method for defining a view area.

Page: instance of forms in windows that are created whenever a form is added to a window.

Programmer's Hierarchical Interactive Graphics System (PHIGS): A 2 and 3-dimensional graphics draft standard which is defined independently of any programming language or system.

polyline: a graphics primitive consisting of one or more sequential line segments.

polymarker: a graphics primitive consisting of one or more markers, all of which use the same marker type.

post: to identify a PHIGS structure for display on an open workstation (to display the structure).

redraw all structures: to clear the display surface and then redisplay all previously shown graphics.

structure: a series of elements, transformation definitions, and/or aspects of primitives which define an output image when traversed in a forward direction.

structure network: a set of one or more related structures which combine to form an output display image. Posting of the root structure will display the entire image. The individual structures can not be related in a recursive manor.

transformation: a mathematical conversion which controls the position and orientation of points in space.

text: a geometric primitive consisting of one or more characters. This primitive has the aspects of character height and character color index.

unpost: To remove a structure network from a particular workstation, thereby removing the image from the specified display surface.

update workstation: to display all graphical information which is awaiting display on the display surface of a given workstation.

Window: dynamic area of a terminal screen on which predefined forms may be placed at run time.

workstation: an abstract graphical workstation which provides the logical interface to the applications program. It is analogous to a form in a window.

workstation window: The region in normalized projection coordinates for which graphical output is allowed.

workstation viewport: the true region on the display surface to which the normalized projection coordinates are mapped. The units used for this definition are device specific.

SECTION 2

DEVELOPMENT ACTIVITY

2.1 Statement of Pretest Activity

During system development, the computer programs were tested progressively. Functionality was incrementally tested to verify correct operation of the code. Any bugs which were discovered during this process were corrected as found.

Each form used in the UTP for the Graphics Support System was tested individually. This was conducted by the developer in a manual mode, entering data and then observing the results.

2.2 Pretest Activity Results

Each Graphics Support System callable routine was tested individually. The test program ARTEST was modified to accommodate the calling of the PHIGS C binding routines. This test program allowed the developer to type in the commands and then to immediately observe the results for verification. With this test, all Form Processor calls may be executed. ARTEST is the major testing tool for the Unit Test Plan of the Graphics Support System.

SECTION 3

SYSTEM DESCRIPTION

3.1 System Description

The Graphics Support System is a direct application program interface which allows the generation and manipulation of 3-dimensional graphics information. The system follows the PHIGS standard as closely as possible.

3.2 Testing Schedule

The execution of the Graphic Support System (GSS) is dependent upon the Form Processor, which is in turn dependent upon the NTM subsystem of IISS when it is not configured stand-alone. Testing of the Graphics Support System must be done only after the NTM and Form Processor have been successfully tested. In this unit test plan, the Graphic Support System is dependent upon (and an integral part of) the Form Processor (FP), which is dependent on the Application Interface (AI) and the Virtual Terminal (VT).

3.3 First Location Testing

The tests of the Graphics Support System require the following:

Equipment: Air Force Testbed, Tektronix 4100 series computer terminal.

Support Software: Integrated Information Support System.

Personnel: One integrator familiar with the IISS.

Training: The FP User Manual has been previously provided with the current release.

Deliverables: Current release of the User Interface System

Test Materials: This test may be run interactively by input of the appropriate data and observing the output as outlined in this test plan. A script file has been created to run this unit test plan and save the resulting output.

Security Considerations: None.

3.4 Subsequent Location Testing

The requirements as listed above need to be met; however, in subsequent testing it is advantageous to create a script file of the outlined tests and run this, saving the output of the test for future comparisons.

SECTION 4

TEST SPECIFICATIONS AND EVALUATIONS

4.1 Test Specifications

The Unit Test Plan is designed to cover specific functionality of the Graphic Support system, as outlined in the Form Processor development specification. The divisions of the functional requirements test follow, each of which contains the list of steps during the test (described in Section 5) in which each is used.

A. Controlling the Graphic Support System

- | | |
|---------------------------------|--------------|
| 1. open PHIGS | (2) |
| 2. close PHIGS | (114) |
| 3. open workstation | (3, 6) |
| 4. close workstation | (112, 113) |
| 5. set workstation window 2-D | (4) |
| 6. set workstation window 3-D | (85) |
| 7. set workstation viewport 2-D | (5) |
| 8. set workstation viewport 3-D | (86) |

B. Transformation Utilities

- | | |
|---------------------------------------|----------------|
| 9. scale 2-D | (69) |
| 10. scale 3-D | (79) |
| 11. translate 2-D | (66) |
| 12. translate 3-D | (76) |
| 13. rotate about X axis | (54) |
| 14. rotate about Y axis | (60) |
| 15. rotate about Z axis | (77) |
| 16. rotate 2-D | (67) |
| 17. compose matrix 2-D | (68, 70) |
| 18. compose matrix 3-D | (78, 80) |
| 19. transform point 2-D | (71, 72, 75) |
| 20. transform point 3-D | (81, 84) |
| 21. build transformation matrix 2-D | (73) |
| 22. build transformation matrix 3-D | (82) |
| 23. compose transformation matrix 2-D | (74) |
| 24. compose transformation matrix 3-D | (83) |

C. Displaying Messages

- | | |
|-------------------|---------|
| 25. message | (103) |
| 26. error handler | (110) |
| 27. error log | (111) |

D. Controlling Graphic Display

- | | |
|---------------------------|---------------------------------|
| 28. redraw all structures | (101) |
| 29. update workstation | (50, 51, 53, 102) |
| 30. post structure | (47, 48, 59, 65, 91, 96, 100) |
| 31. unpost structure | (52) |
| 32. unpost all structures | (92) |

E. Adding or Removing PHIGS Structures

- 33. open structure (6, 14, 21, 29, 33, 41, 55, 61, 87, 93, 97)
- 34. close structure (13, 20, 28, 32, 40, 46, 58, 64, 90, 95, 99)
- 35. delete structures (49)
- 36. delete structure network (104)
- 37. delete all structures (105)

F. Adding Data to PHIGS Structure

- 38. polyline 2-D (10, 27)
- 39. polyline 3-D (11)
- 40. polymarker 2-D (36)
- 41. polymarker 3-D (39)
- 42. text 2-D (17, 18)
- 43. text 3-D (19)
- 44. fill area 2-D (31)
- 45. fill area 3-D (24)
- 46. set local transform 2-D (88)
- 47. set local transform 3-D (56, 62)
- 48. set global transform 2-D (94)
- 49. set global transform 3-D (98)
- 50. execute structure (12, 42, 43, 44, 45, 57, 63, 89)

G. Changing Characteristics of Graphic Primitives

- 51. set line type (9, 26)
- 52. set line color index (8, 25)
- 53. set marker type (35, 38)
- 54. set marker color index (34, 37)
- 55. set character height (16)
- 56. set text color index (15)
- 57. set interior style (23)
- 58. set interior color index (22, 30)

H. Transferring Data Between GSS and Applications

- 59. inquire list of available workstation (106)
- 60. inquire workstation connection and type (107)
- 61. inquire display space size 2-D (109)
- 62. inquire display space size 3-D (108)

4.2 Test Methods and constraints

The tests as outlined in section 5 must be followed. The required input is stated for each test. This test procedure uses the normal operation of the functions, and does not exercise all the possible error combinations.

4.3 Test Progression

The progression of testing is fully outlined in section 5 of this unit test plan. These steps should be followed exactly to insure successful testing of the IISS configuration item.

4.4 Test Evaluation

The test results are evaluated by comparing the information returned on the various output screens to that specified as successful for the given test. As outlined in section 5, each test of the Graphic Support System functionality will provide an input screen with the required data entry specified and the resulting output for a successful test.

SECTION 5

TEST PROCEDURES

5.1 Test Description

A general description of this test was supplied in Section 3 of this manual.

5.2 Test Control

As outlined, this unit test may be done manually or run automatically using a supplied script file. To manually perform this unit test would require the tester to be logged into the IISS system and enter SDARTESTZZ on the IISS function screen.

5.3 Test Procedures

This unit test uses the ARTEST program and its associated forms. The specific forms (before and after each test step) are supplied after the listing of test steps (pages 5-6 through 5-233). They allow one to fully interrogate the 2 and 3-dimensional graphics abilities of the system.

The commands which have been made available are those routines which are described in the Form Processor Development Specification (ref. [3]). A complete description of these commands is supplied in Appendix A.

The test steps will proceed as follows:

- 1) set up graphics screens: graphics
- 2) Open PHIGS: popph
- 3) Open workstation: popwk 1 .screen.gfl.w1
- 4) set workstation window: pswkw 1 0 1 0 .50908675
- 5) set workstation viewport: pswkv 1 0 65535 0 33363
- 6) open workstation 2: popwk 2 w2
- make structure #1 with X-Y-Z space triad
 - 7) open structure: popst 1
 - 8) make lines RED: psplci RED
 - 9) make solid lines: psln SOLID
 - 10) add X->O->Y polyline: ppl 3 .8 .2 .2 .2 .2 .8
 - 11) add O->Z polyline: ppl3 2 .2 .2 0 .2 .2 .8
 - 12) display labels: pexst 2
 - 13) close the structure: pclst
- make structure #2 with labels for triad

```

14) open structure:      popst 2
15) make characters blue: pstxci BLUE
16) set height=small:   pschh .1
17) add X text:         ptx .8 .2 X
18) add Y label:        ptx .2 .8 Y
19) add Z label:        ptx3 .2 .2 .8 0 0 1 0 0 1 Z
20) close structure:    pclst

-- place a green triangle fill offset by Z=1.

21) open structure:      popst 3
22) fill color green:    psici GREEN
23) set interior style:  psis SOLID
24) fill area:          pfa3 3 0 0 1 1 0 1 0 1 1

-- make structure #3 as 2-D wire frame square box

25) make white lines:    psplici WHITE
26) make lines dashed:   psln DASH
27) make box:           ppl 5 0 0 1 0 1 1 0 1 0 0
28) close structure:    pclst

-- make structure #4 as yellow filled diamond inside #3

29) open structure:      popst 4
30) fill color yellow:    psici YELLOW
31) add region:          pfa 4 .5 0 1 .5 .5 1 0 .5
32) close structure:    pclst

-- make structure #5 as red stars at vertices of #4

33) open:               popst 5
34) marker color red:    pspmci RED
35) marker type to star: psmk STAR
36) position:           ppm 4 .5 0 1 .5 .5 1 0 .5

-- place MAGENTA circles at vertices of fill in #3

37) marker color magenta: pspmci MAGENTA
38) marker type=circle:  psmk CIRCLE
39) 3-D positions:       ppm3 3 0 0 1 1 0 1 0 1 1
40) close structure     pclst

-- make structure displaying above definitions

41) open:               popst 6
42) yellow fill in box:  pexst 4
43) box w/ fill area:    pexst 3
44) markers in structures: pexst 5
45) display triad:       pexst 1
46) close structure     pclst

47) display from 2-D view: ppost 1 6 1
48) post in smaller window: ppost 2 6 1

49) delete labels from triad: pdst 2

```

```
50) update display in #1:      puwk 1 PERFORM
51) update display on #2:      puwk 2 PERFORM

52) remove graphic display:    pupost 1 6
53) update empty workstation:  puwk 1 PERFORM

-- rotate picture 45 degrees about X axis

54) make rotation matrix:      prox 45 A3
55) open new structure:        popst 7
56) add local matrix:          pslmt3 A3 POST
57) bring in displays:         pexst 6
58) close                      pclst
59) display rotated figure:     ppost 1 7 1

-- overlay this with rotate 45 degrees about Y axis

60) make rotation matrix:      proy 45 B3
61) make new structure:        popst 8
62) add local matrix:          pslmt3 B3 POST
63) bring in displays:         pexst 7
64) close                      pclst
65) display rotated figure:     ppost 1 8 1

-- test 2 dimensional transformation utilities

66) translate 2-D:             ptr 10 10 C2
67) rotate in 2-D:             pro 180 B2
68) compose 2-D:               pcom C2 B2 A2
69) scale 2-D:                 psc 10 100 B2
70) add to matrix:             pcom A2 B2 C2
71) transform point 2D:        ptp 1 0 C2
72) transform point 2D:        ptp 0 1 C2

73) trans. matrix 2D:          pbltm 10 20 -10 -20 2 4 180 A2
74) mult w/ previous:          pcotm A2 -10 -20 10 20
                                   .5 .25 180 B2
75) verify back to identity:    ptp 1 1 B2

-- test 3-D transformation utilities

76) translate:                 ptr3 10 10 10 C3
77) rotate about Z:            proz 45 B3
78) compose 3D:                pcom3 C3 B3 A3
79) scale 3-D:                 psc3 10 100 1000 B3
80) add to matrix:             pcom3 A3 B3 C3
81) transform point:           ptp3 1 1 1 C3

82) make transf. matrix:        pbltm3 10 20 30 1 2 3 2 4 8
                                   180 0 0 A3
83) compose transform:          pcotm3 A3 -10 -20 -30 -1 -2 -3
                                   -180 0 0 .5 .25 .125 B3
84) verify identity:           ptp3 1 1 1 B3

-- check misc. items

85) set workstation window:     pswkw3 1 0 1 0 .69999237 0 1
```

86) set workstation viewport: pswkv3 1 0 65535 0 33363
0 65535

-- check usage of 2-D local/global matrices

87) open new structure #9: popst 9
88) set local 2D transform: pslmt A2 POST
89) reference other: pexst 8
90) close structure: pclst
91) display w/ transform: ppost 1 9 1
92) unpost all structures: pupast 1 9

93) append global transform: popst 9
94) set global 3-D matrix: psgmt B2
95) close structure: pclst
96) display (no change): ppost 1 9 1

97) append global transform: popst 9
98) identity 3-D: psgmt3 B3
99) close structure: pclst
100) display (same display): ppost 1 9 1

101) redraw structures: prst 1 ALWAYS

102) update workstation: puwk 1 PERFORM

103) send message: pmsg "GSS UTP output is completed"

104) delete structure network: pdsn 6 DELETE

105) delete all structures: pdas

106) inquire available workstations: pqewk

107) inquire workstation conn. and type: pqwkc 1

108) inquire display space size 3-D: pqdsp3 w1

109) inquire display space size 2-D: pqdsp w1

110) error handler: perhnd 0 0

110a) examine message queue results

111) error log: perlog 0 0

111a) examine message queue results

112) close workstation 1: pclwk 1

113) close workstation 2: pclwk 2

111) close PHIGS: pclph

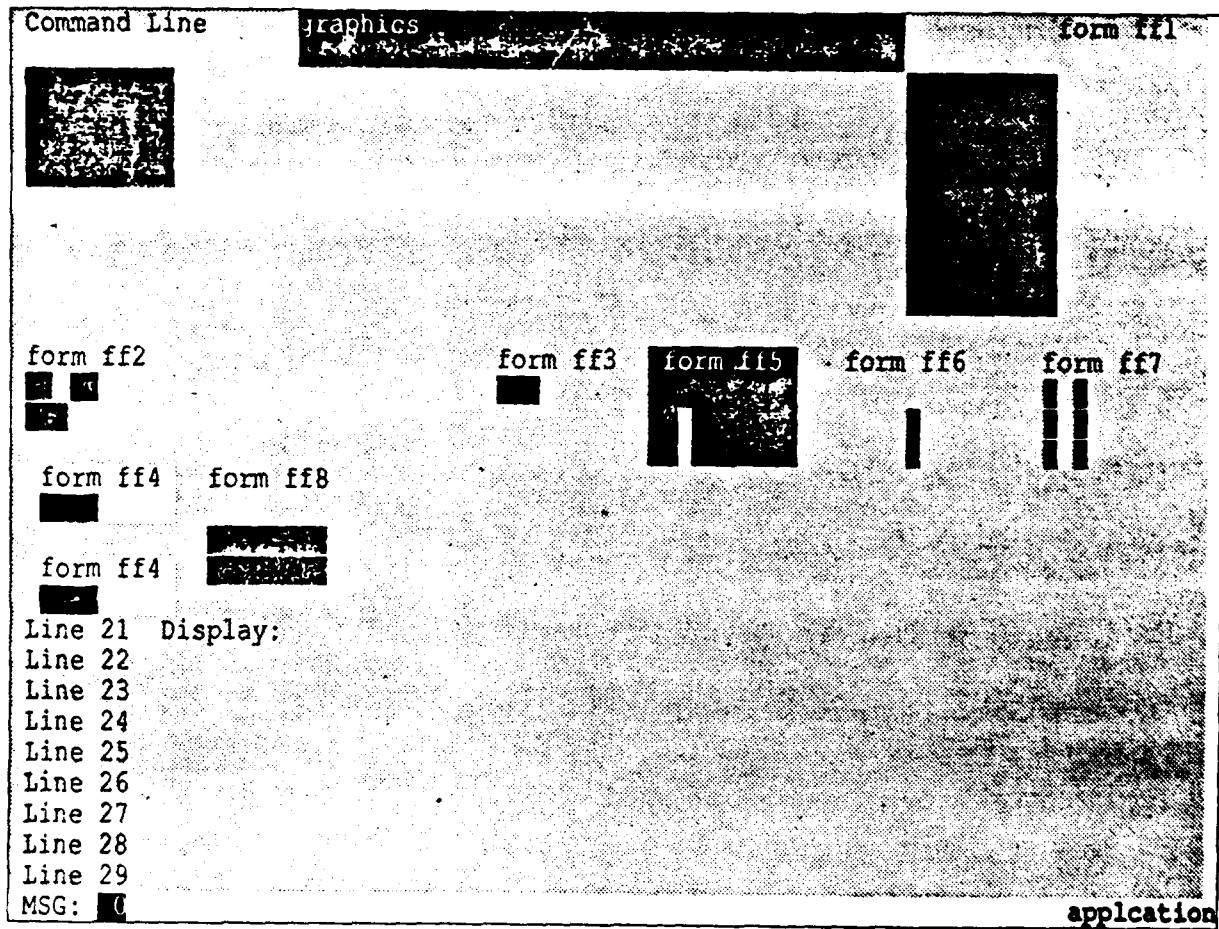


Figure 5-1a (BEFORE)

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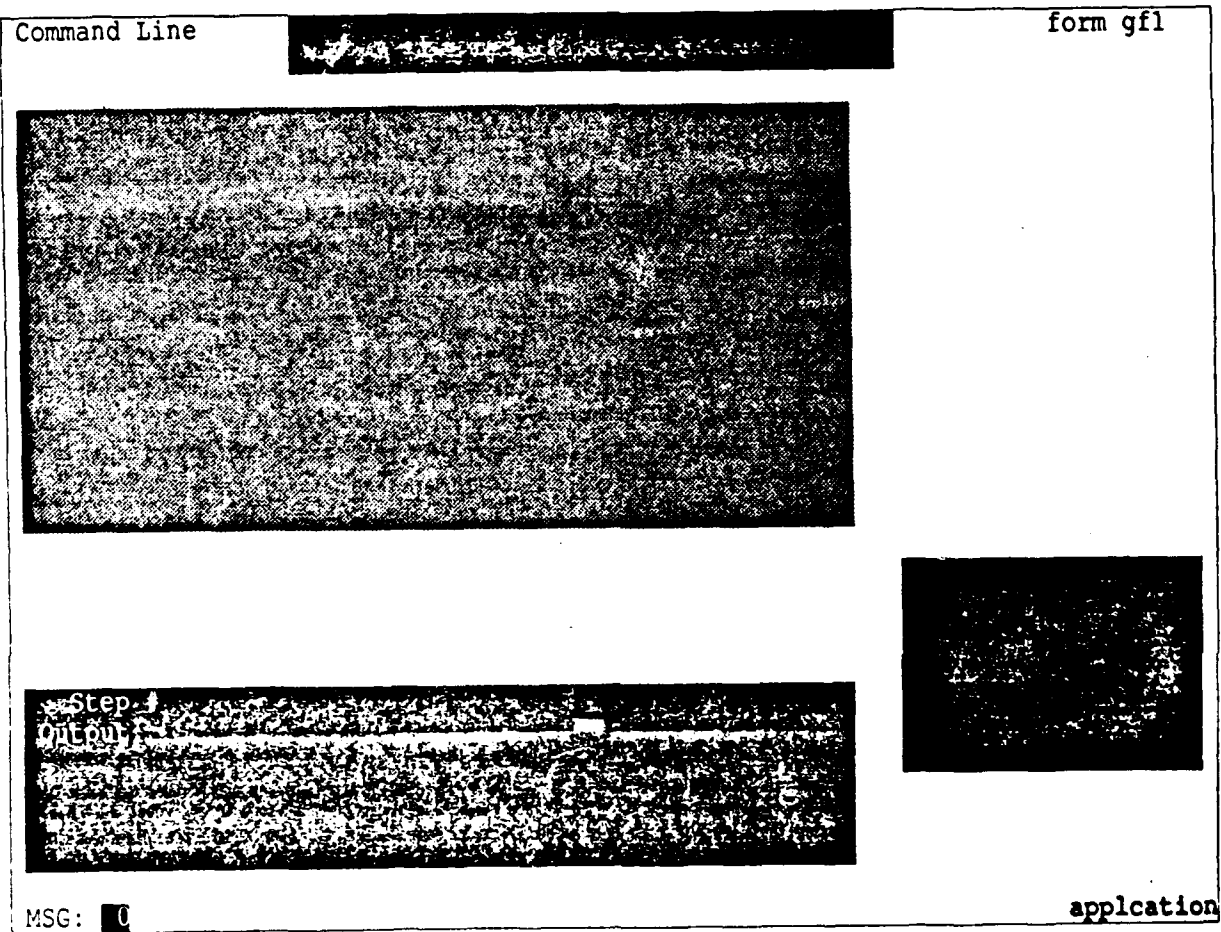


Figure 5-1b (AFTER)

UTP 620344220
30 September 1990

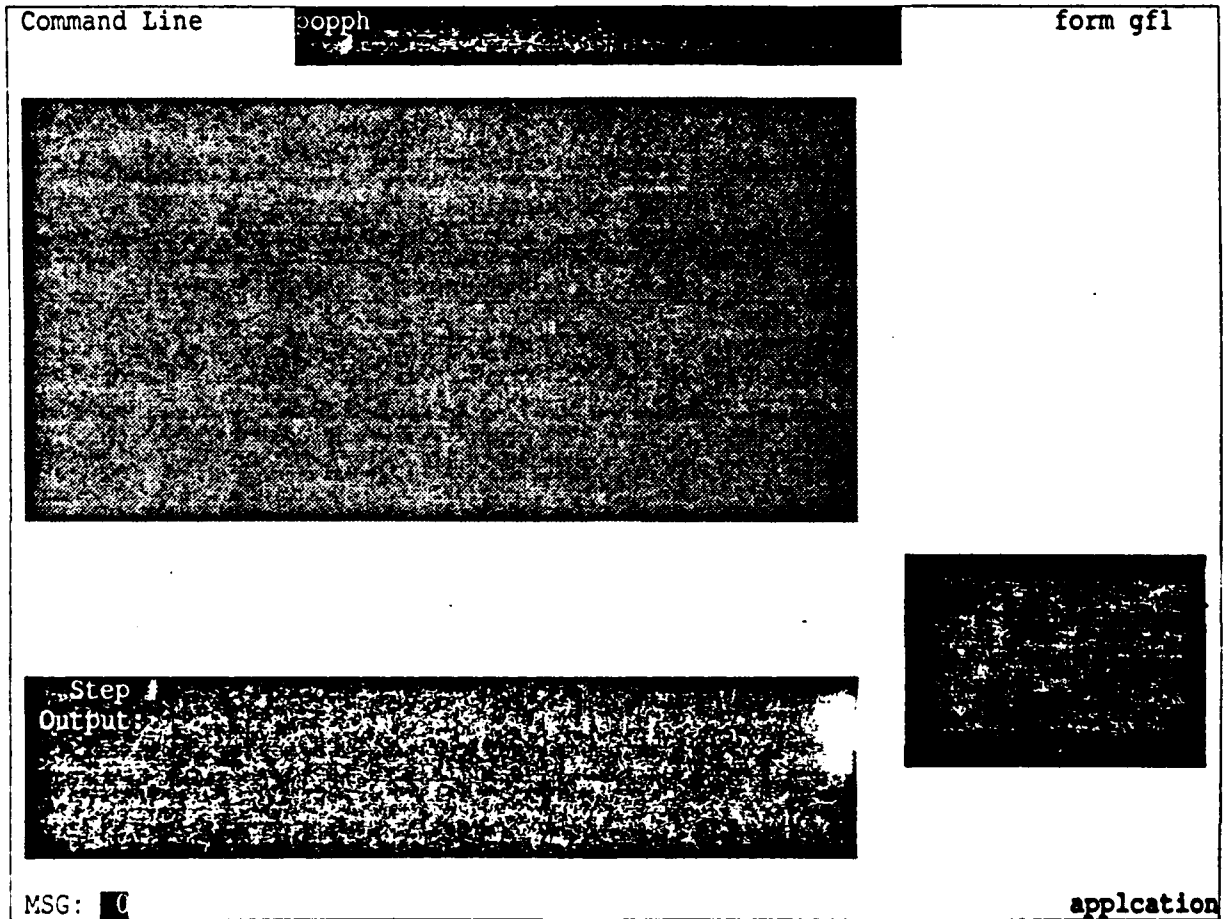


Figure 5-2a (BEFORE)

UTP 620344220
30 September 1990

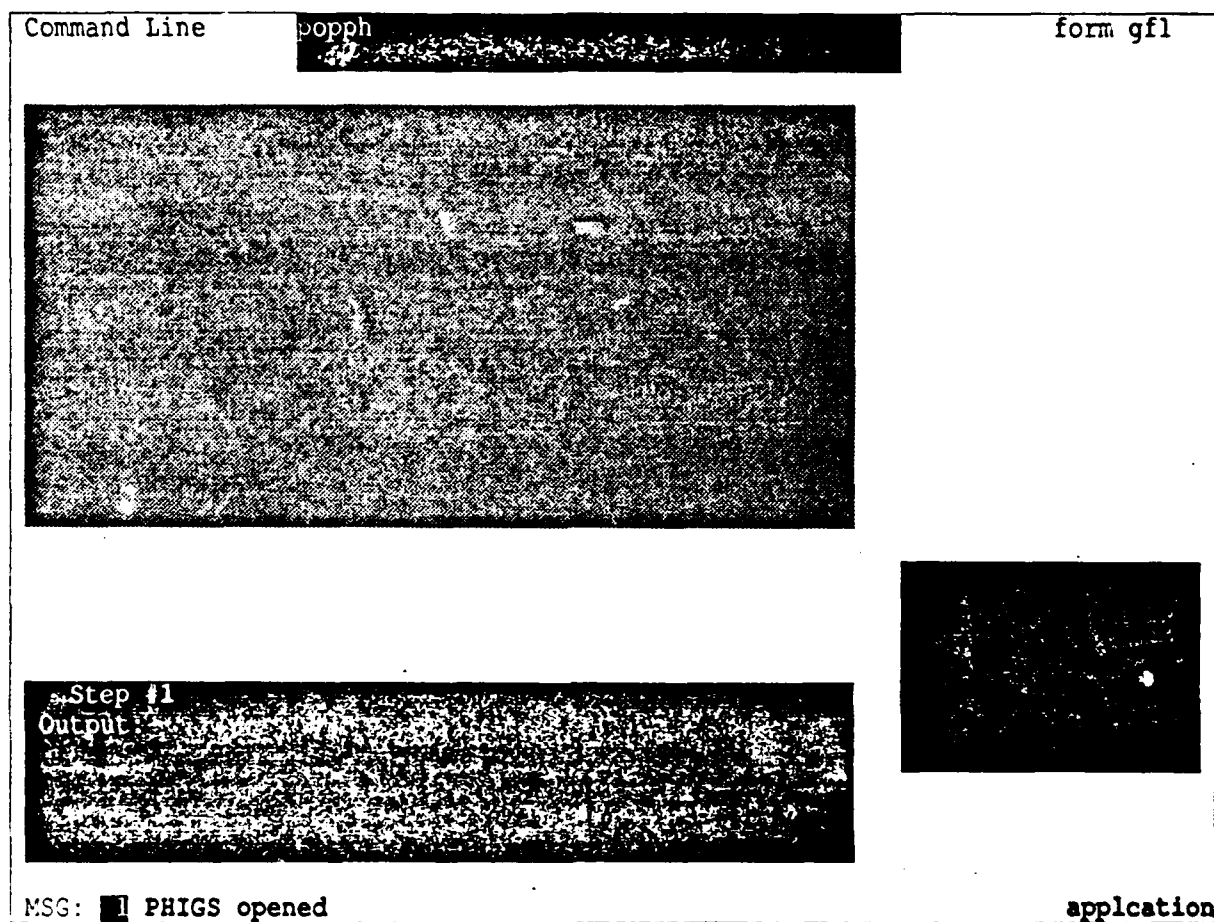


Figure 5-2b (AFTER)

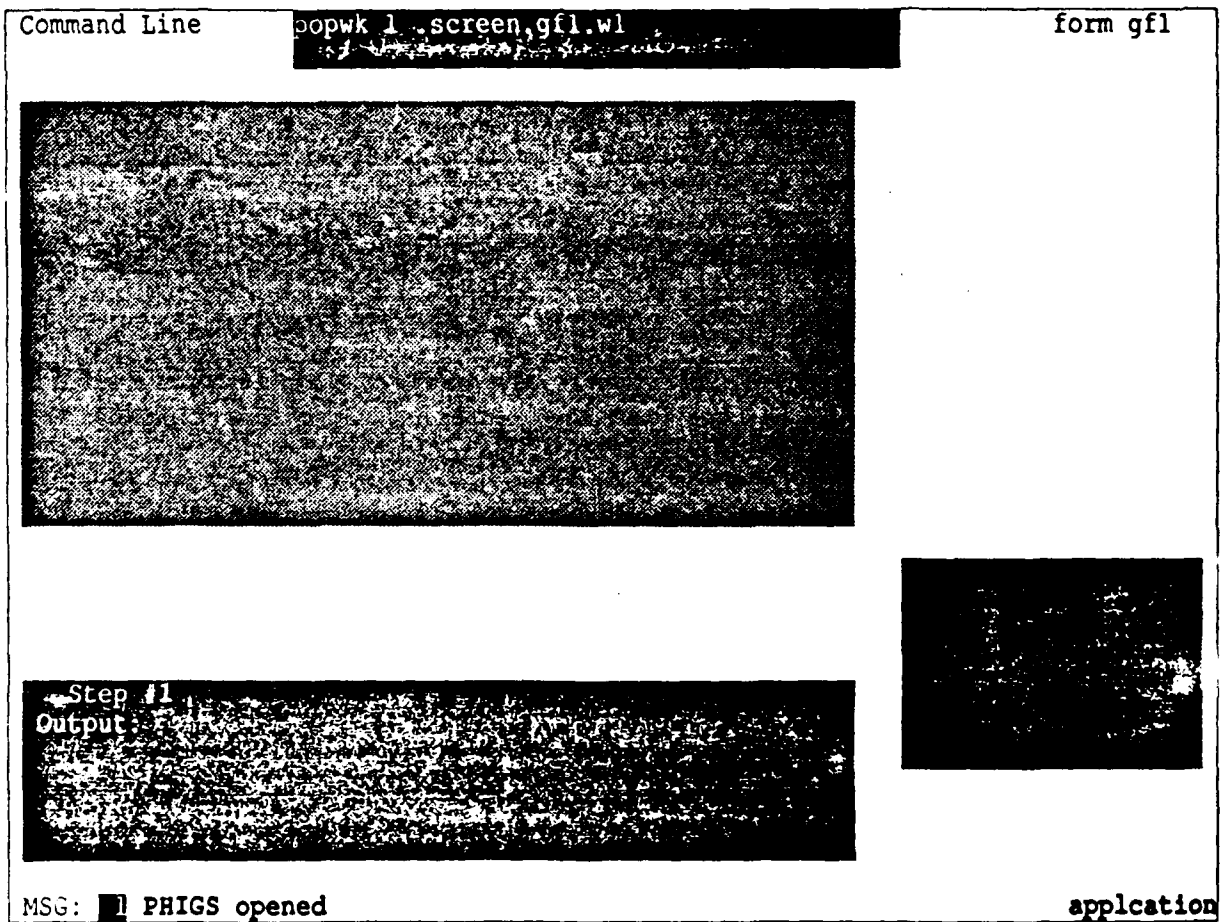


Figure 5-3a (BEFORE)

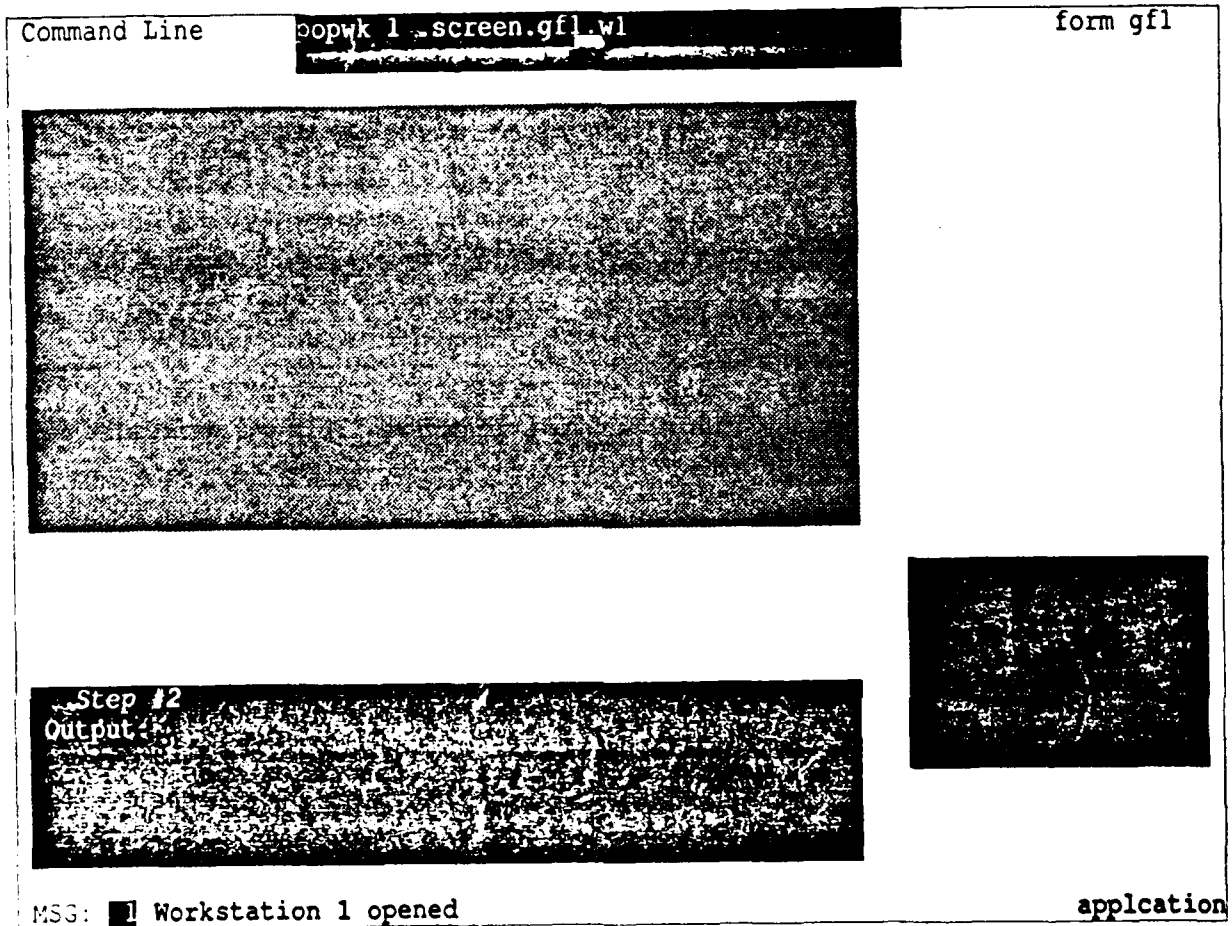


Figure 5-3b (AFTER)

UTP 620344220
30 September 1990

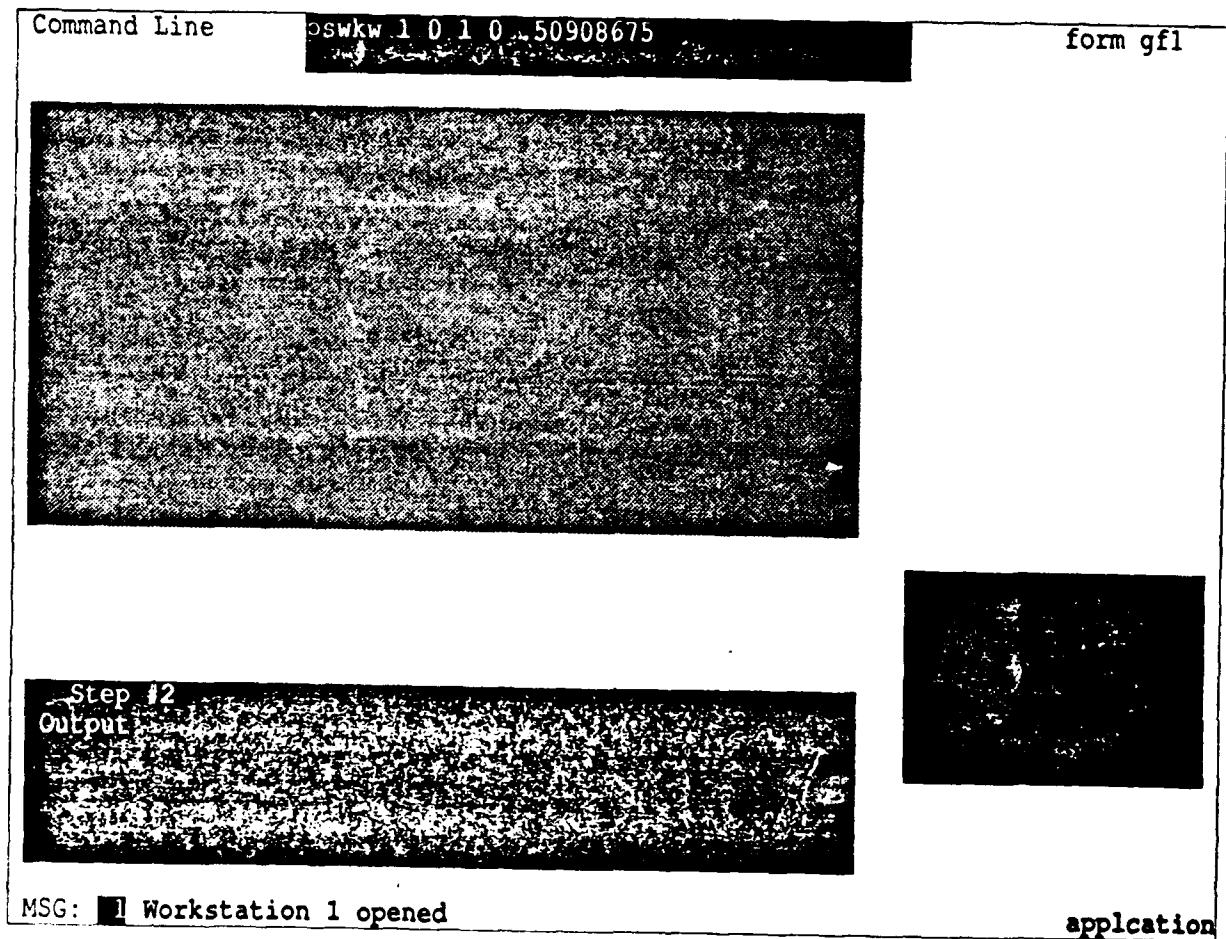


Figure 5-4a (BEFORE)

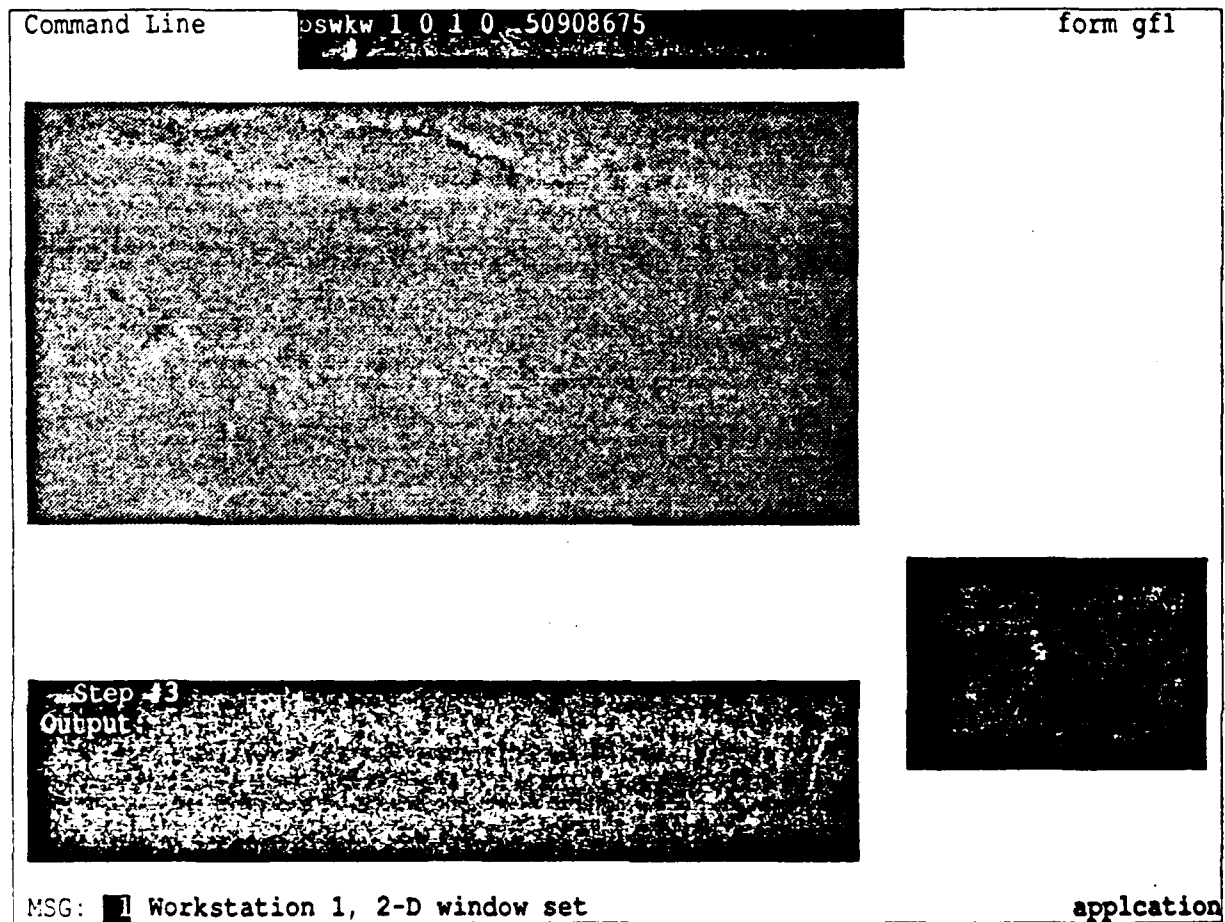


Figure 5-4b (AFTER)

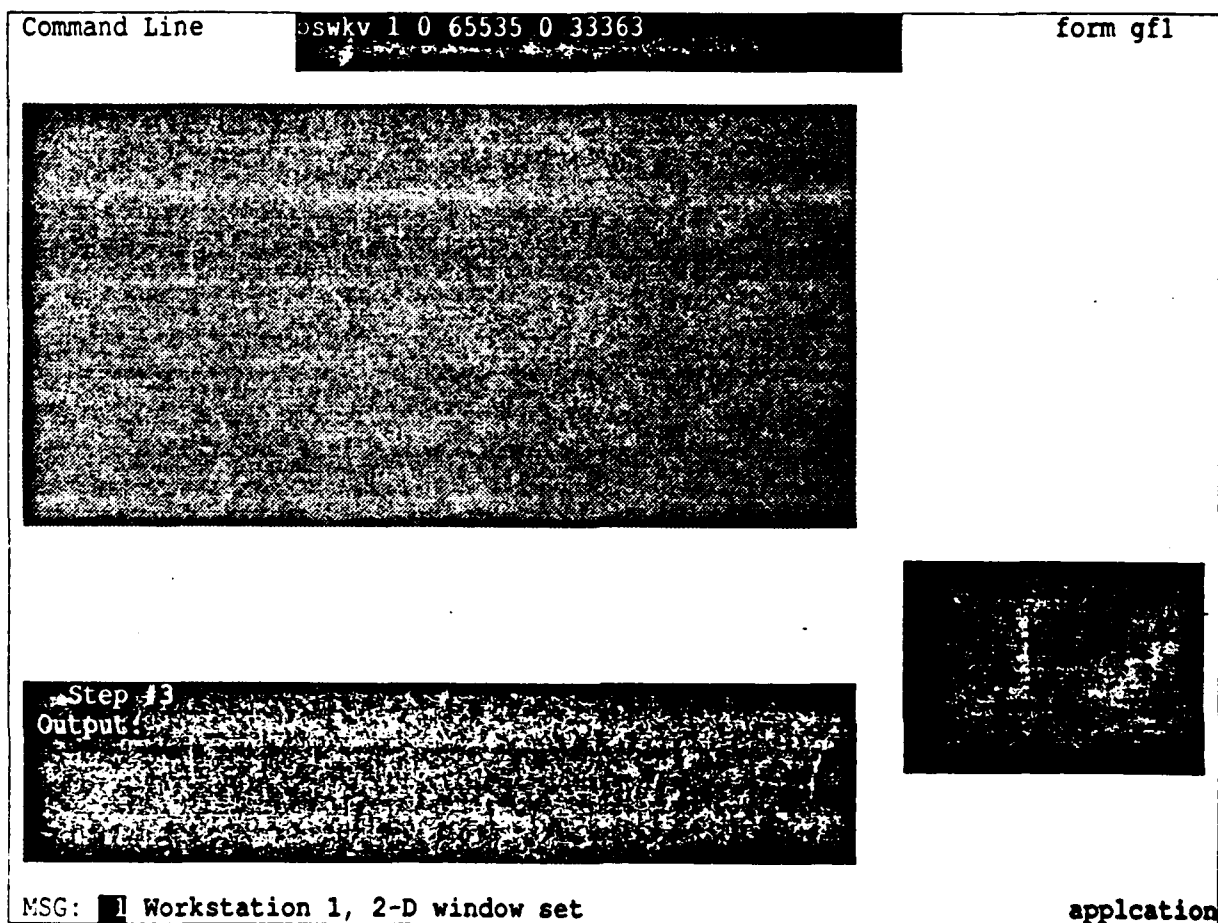


Figure 5-5a (BEFORE)

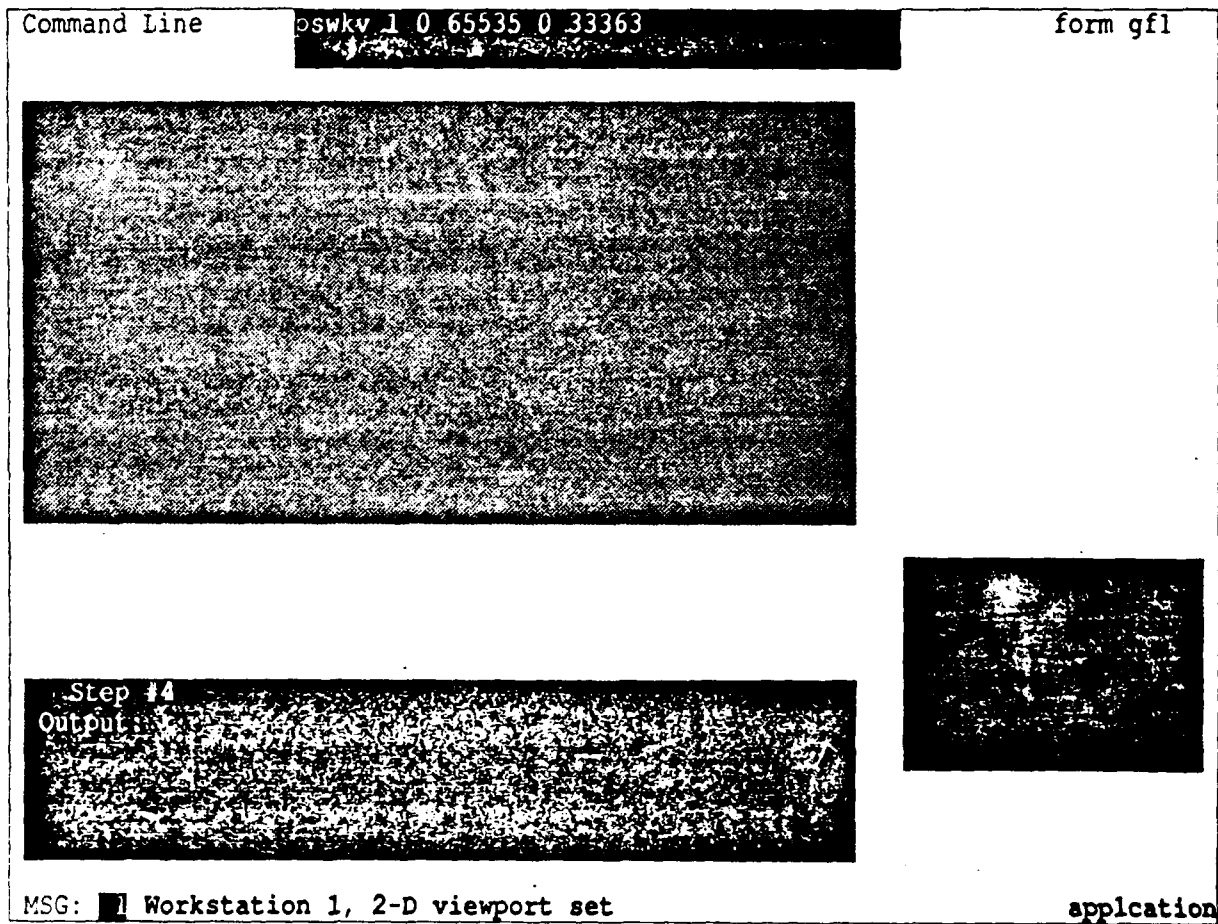


Figure 5-5b (AFTER)

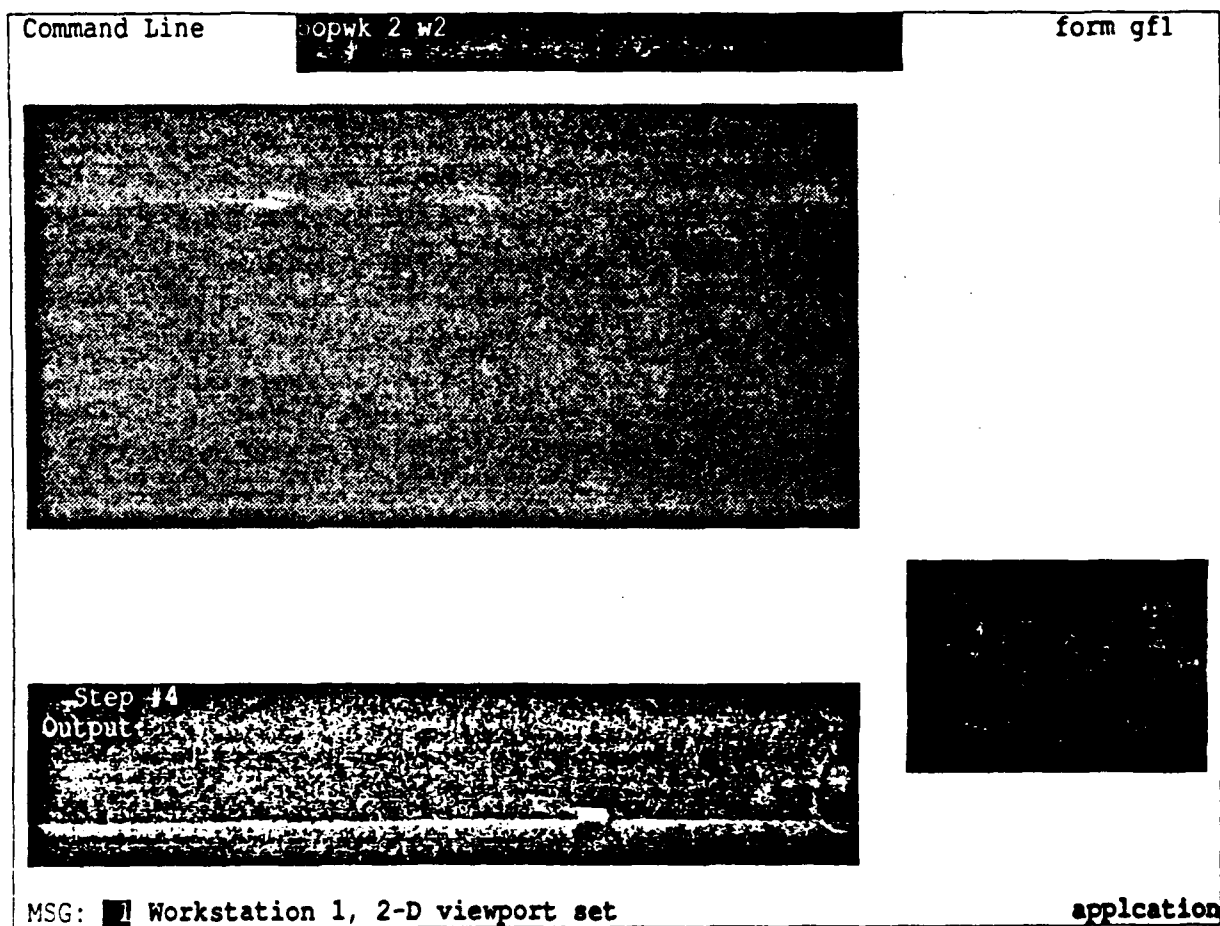


Figure 5-6a (BEFORE)

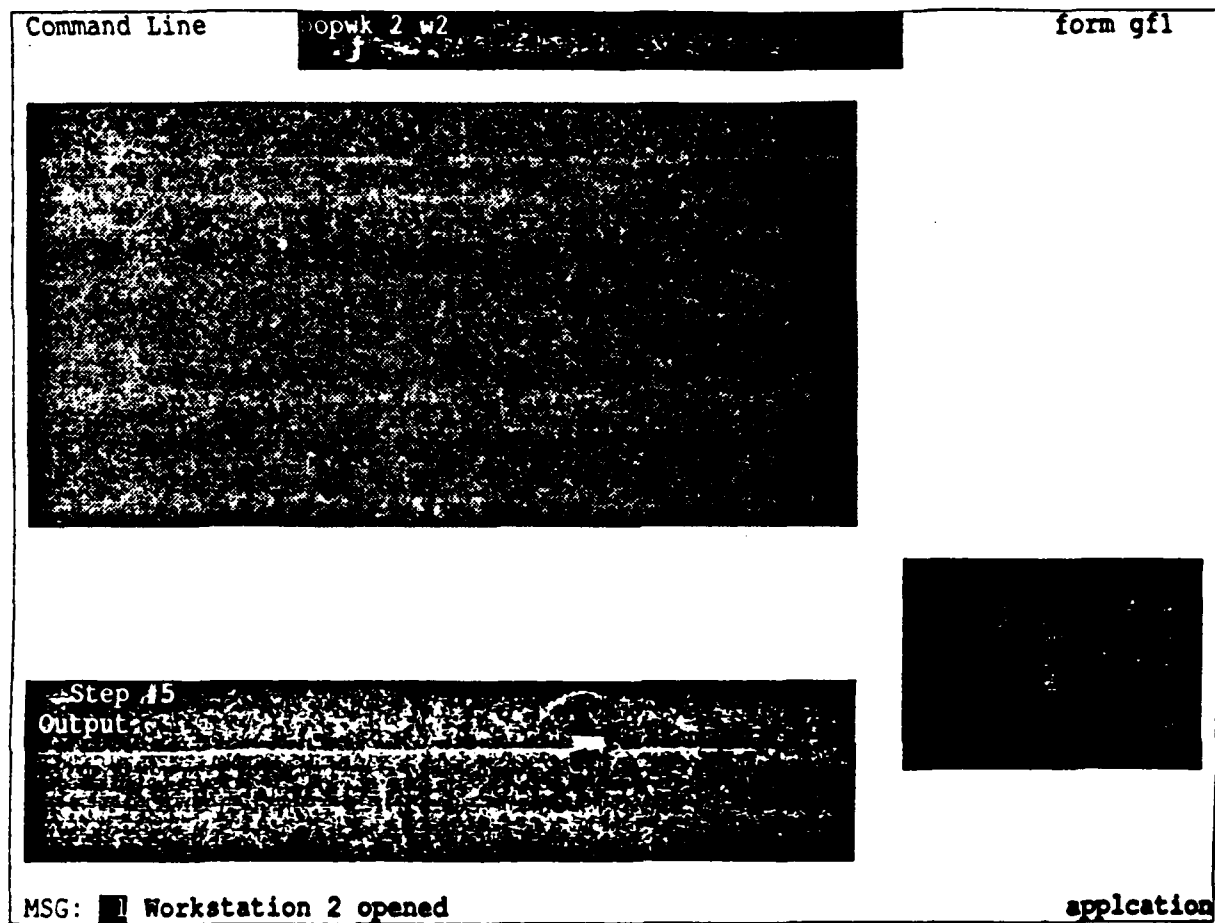


Figure 5-6b (AFTER)

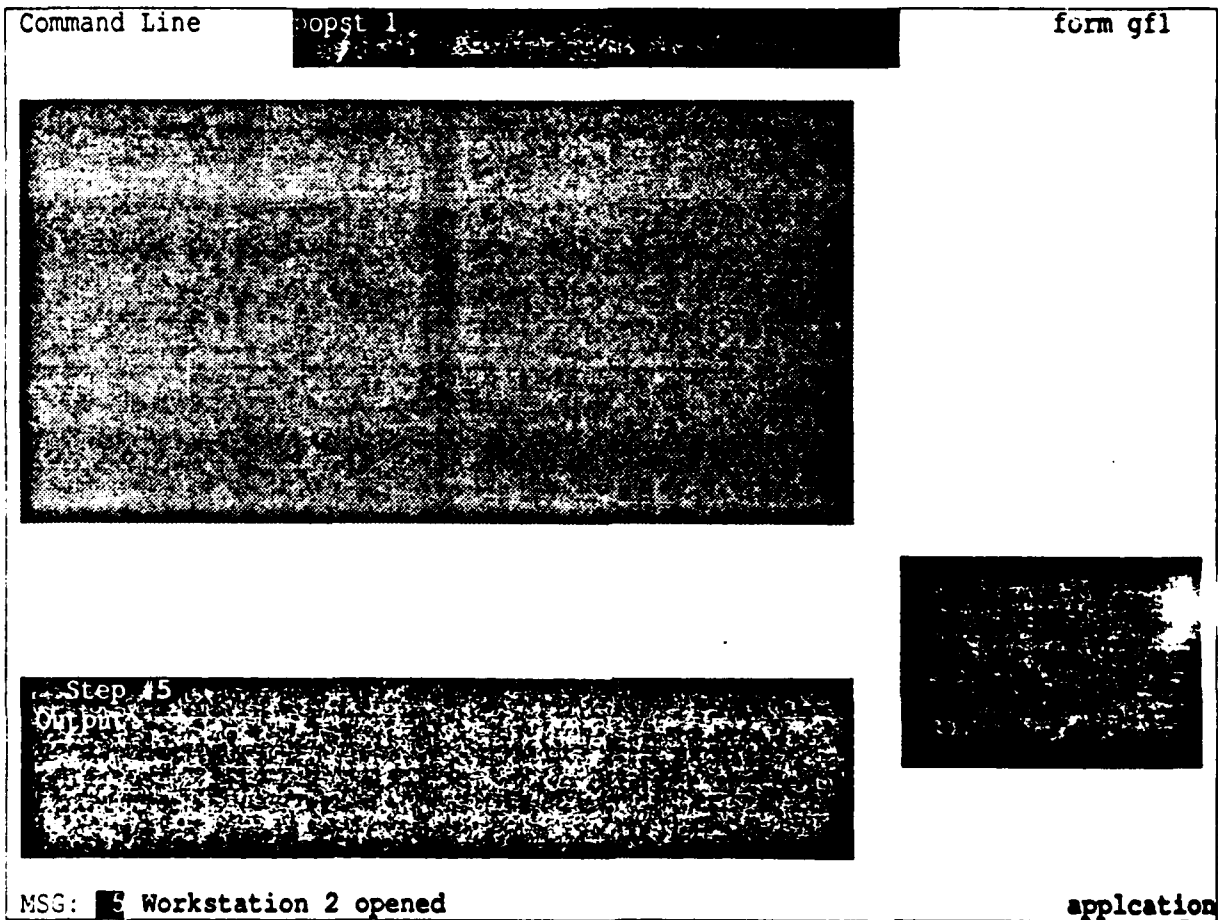


Figure 5-7a (BEFORE)

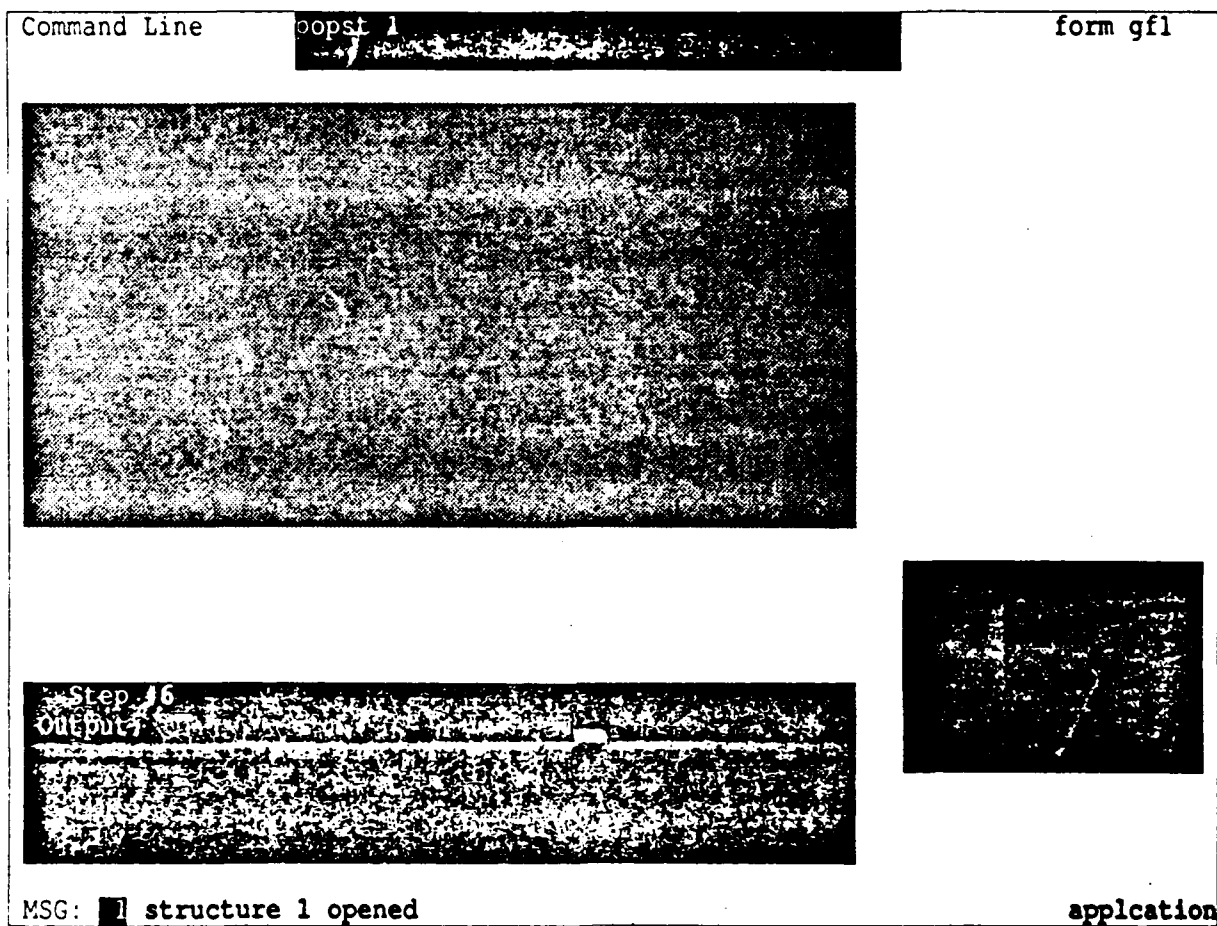


Figure 5-7b (AFTER)

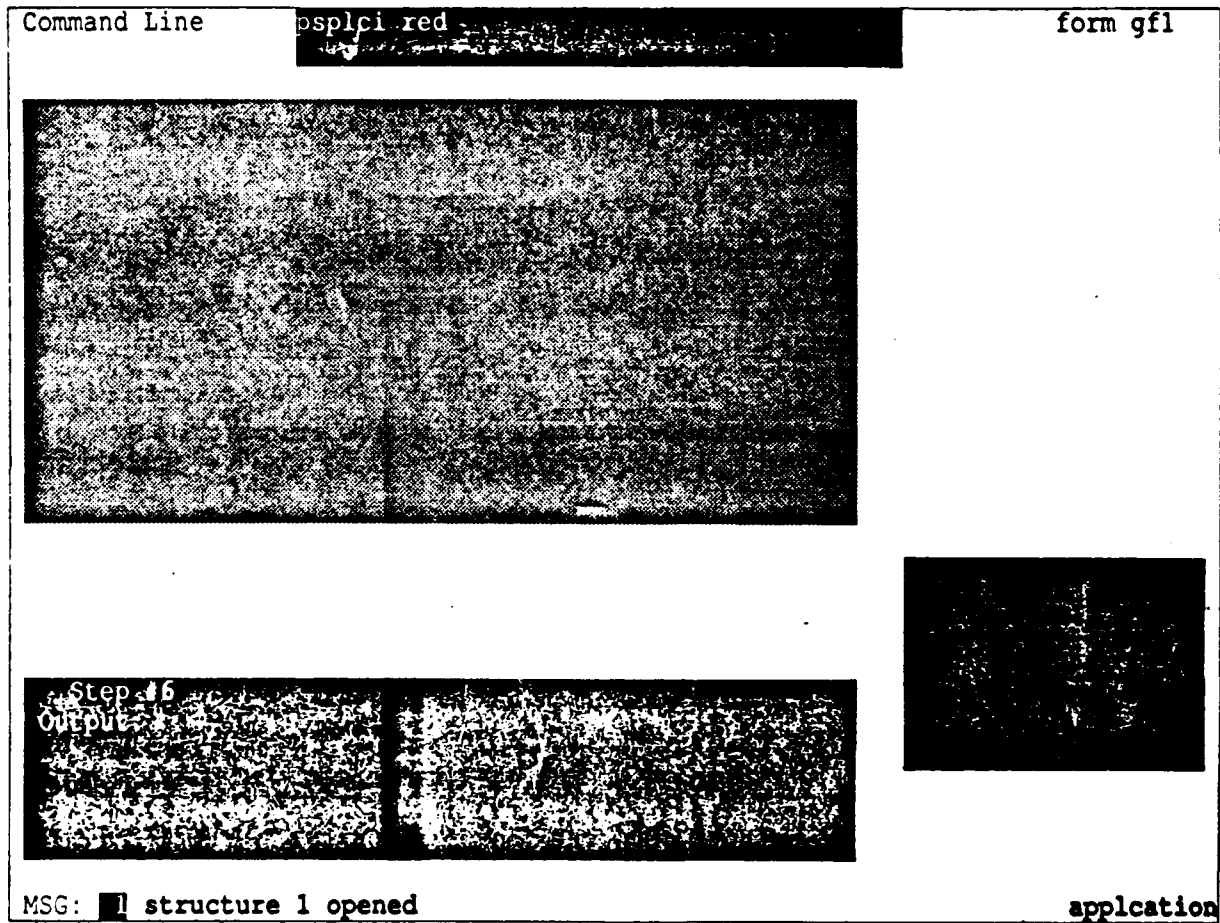


Figure 5-8a (BEFORE)

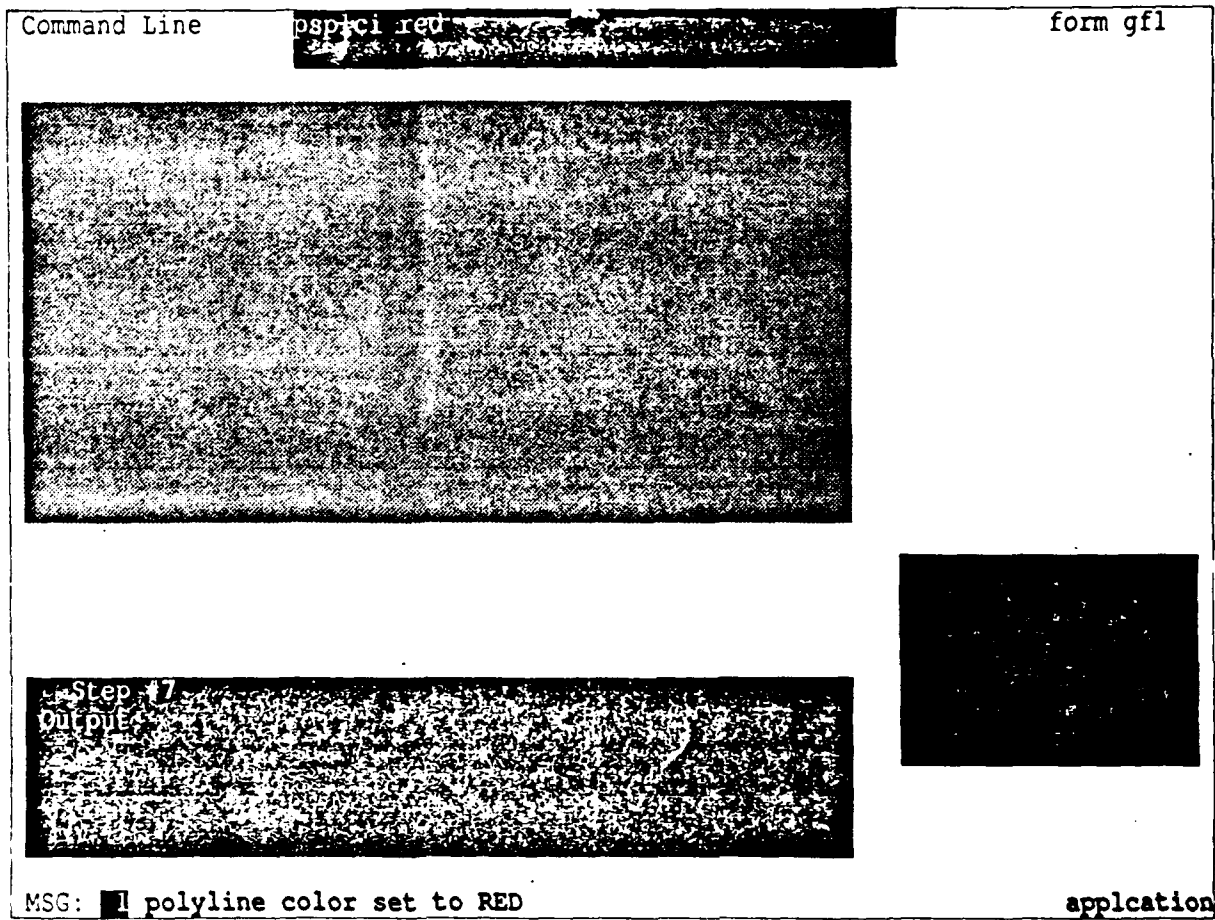


Figure 5-8b (AFTER)

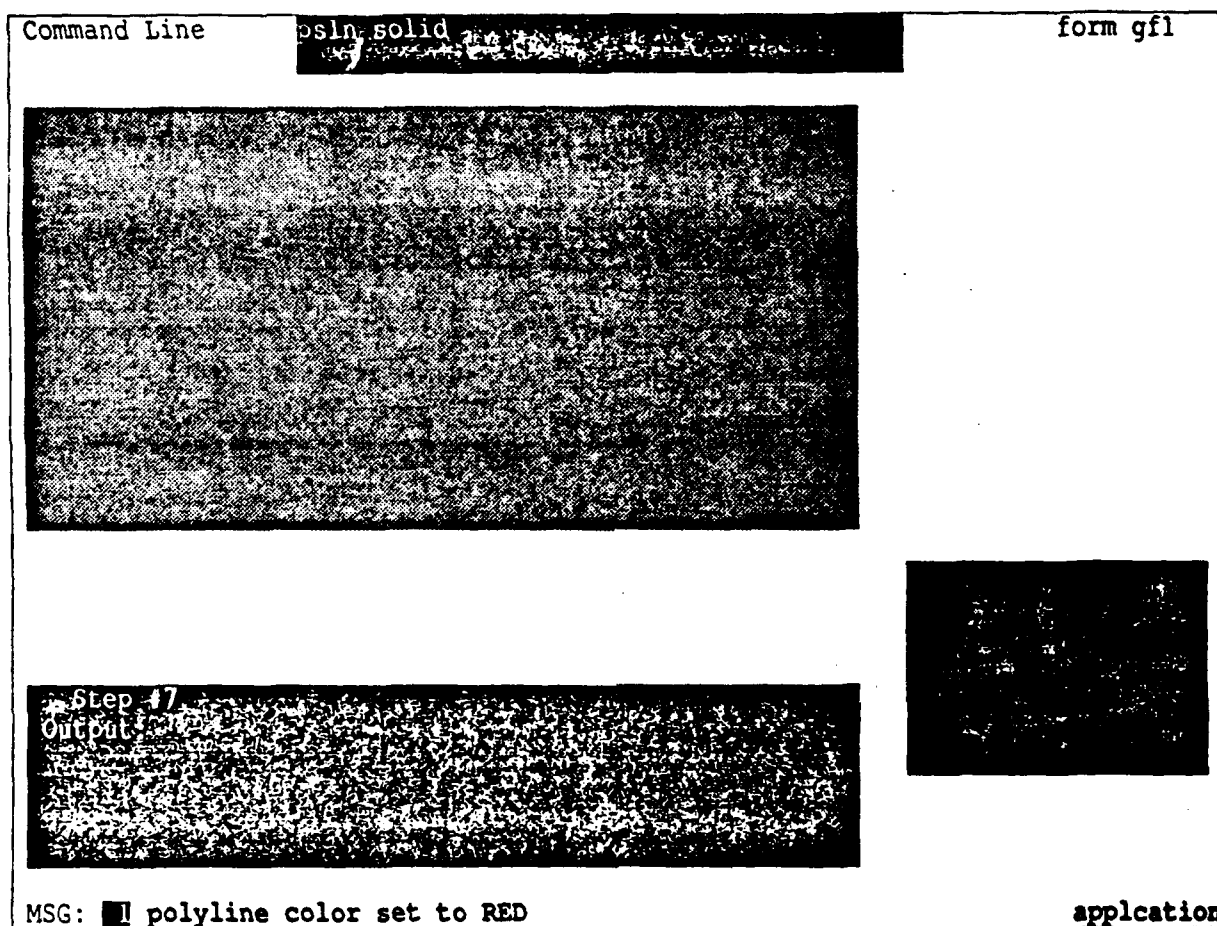


Figure 5-9a (BEFORE)

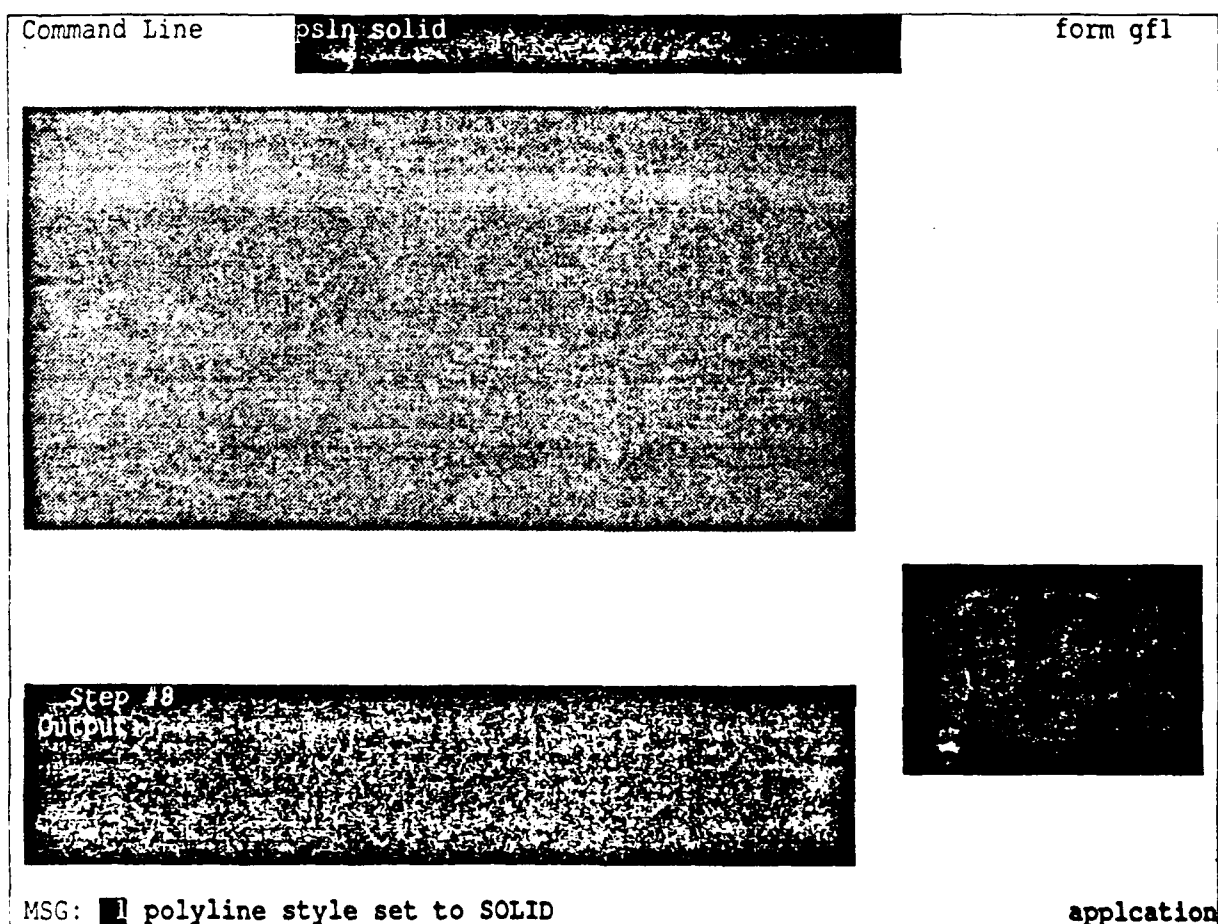


Figure 5-9b (AFTER)

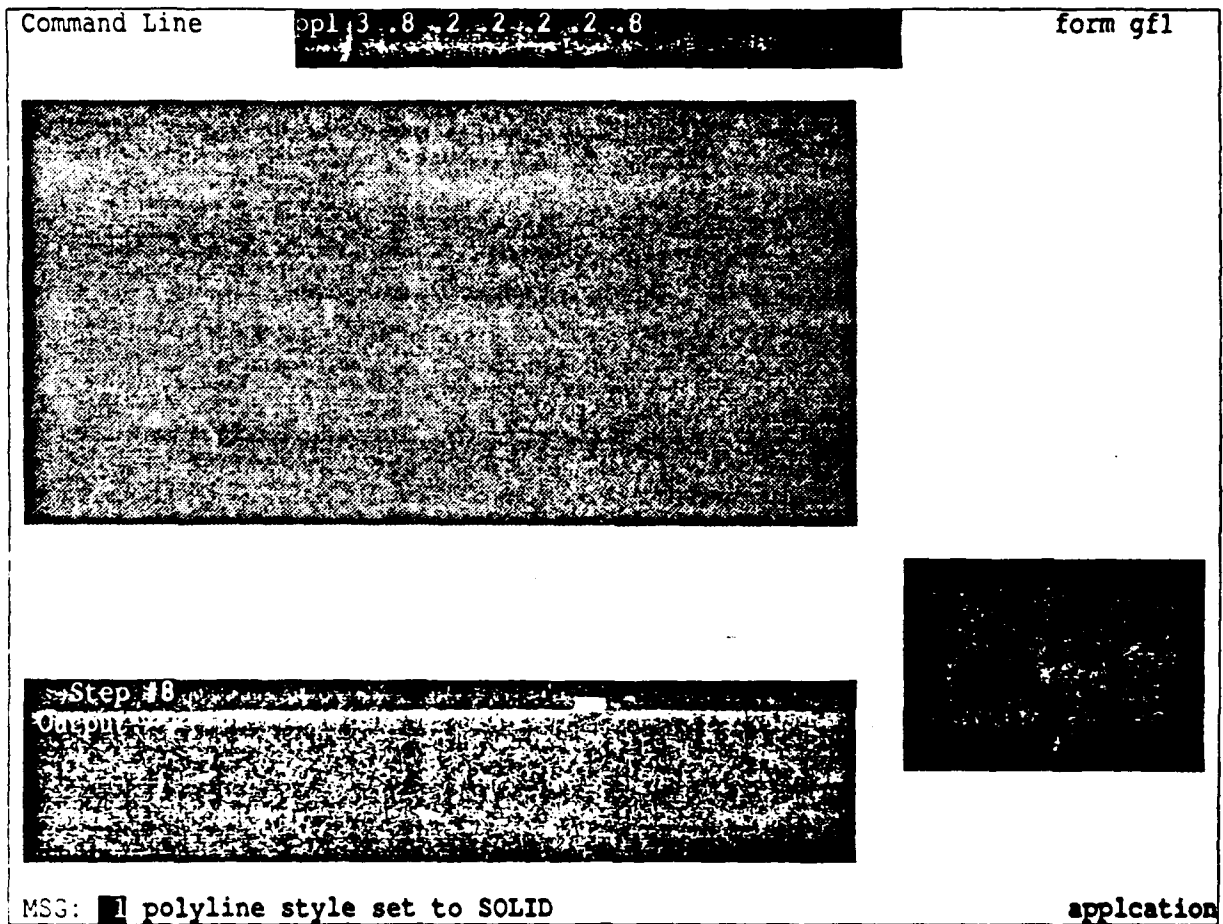


Figure 5-10a (BEFORE)

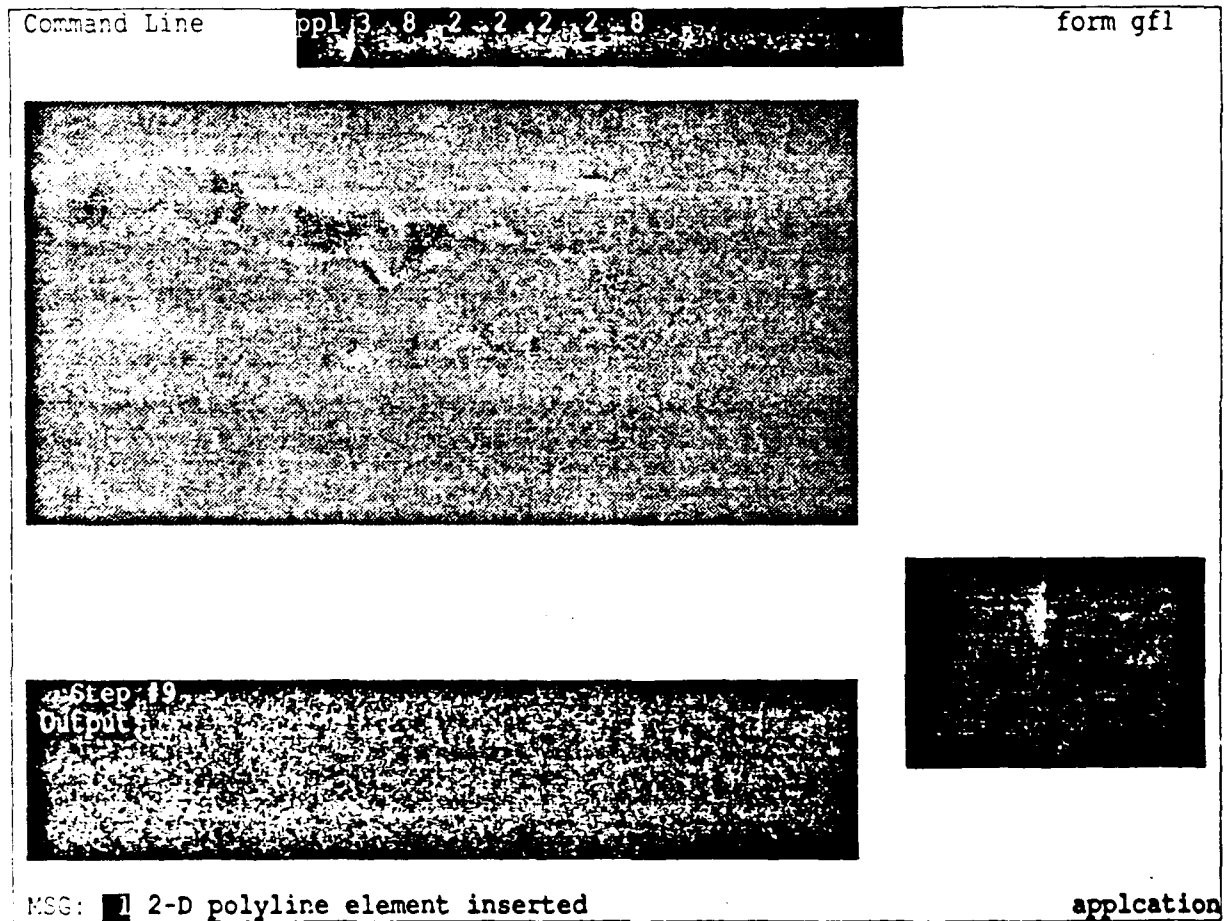


Figure 5-10b (AFTER)

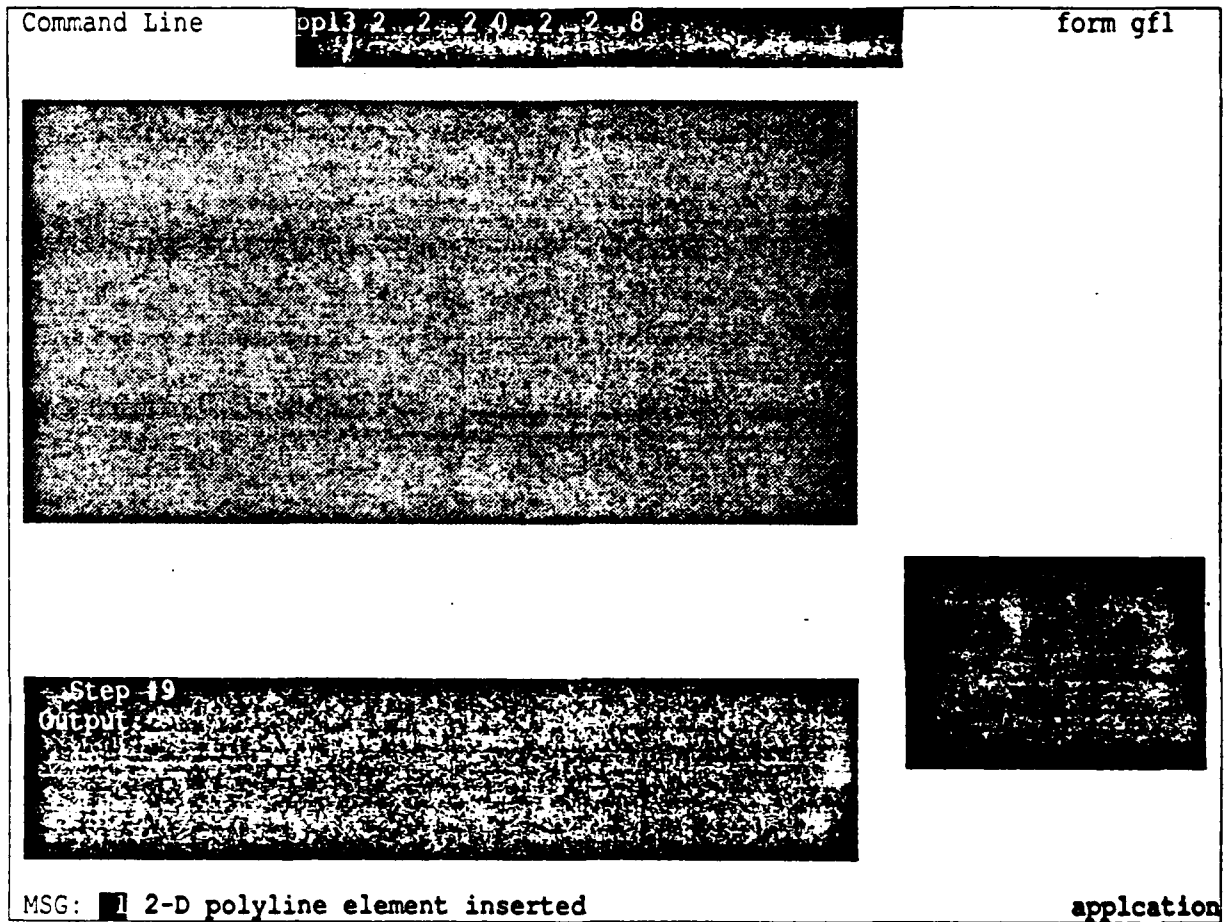


Figure 5-11a (BEFORE)

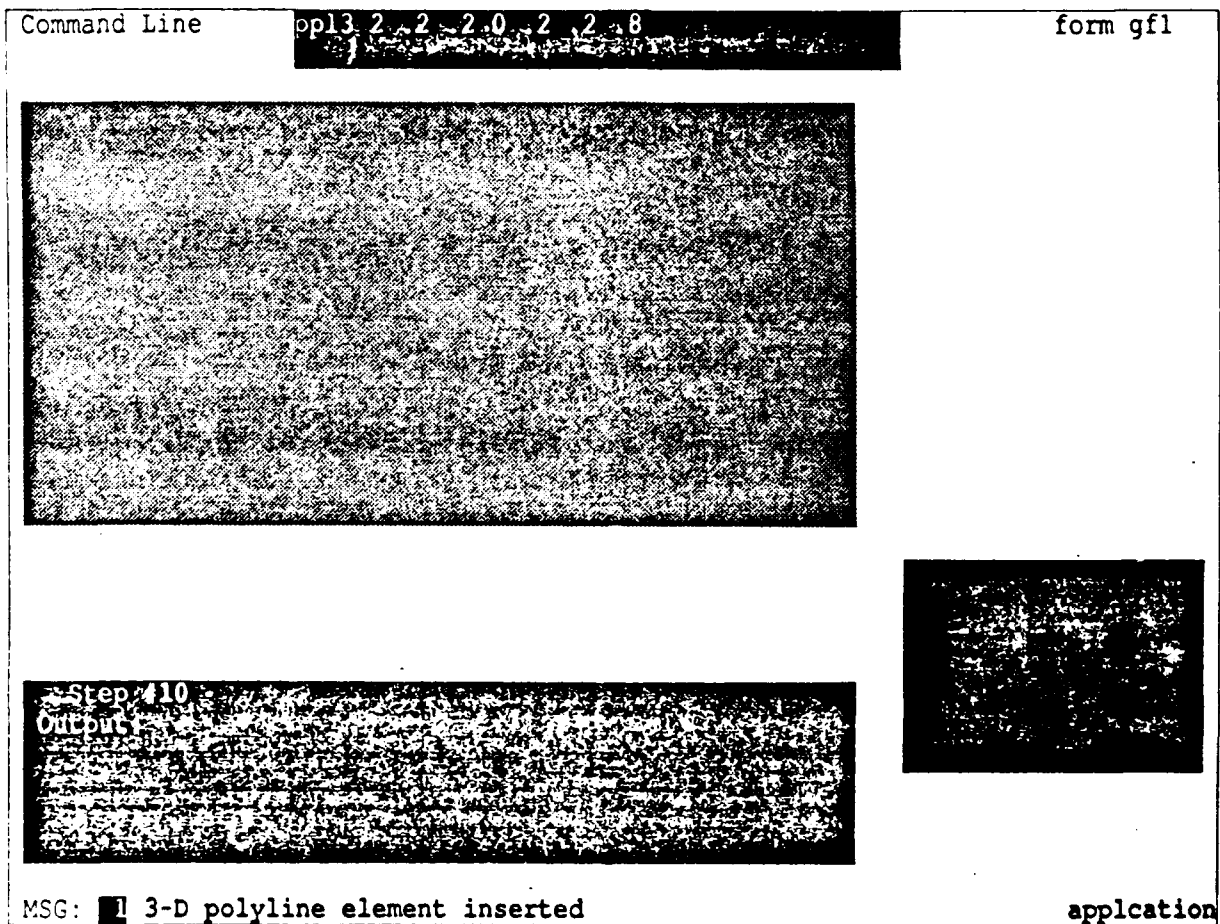


Figure 5-11b (AFTER)

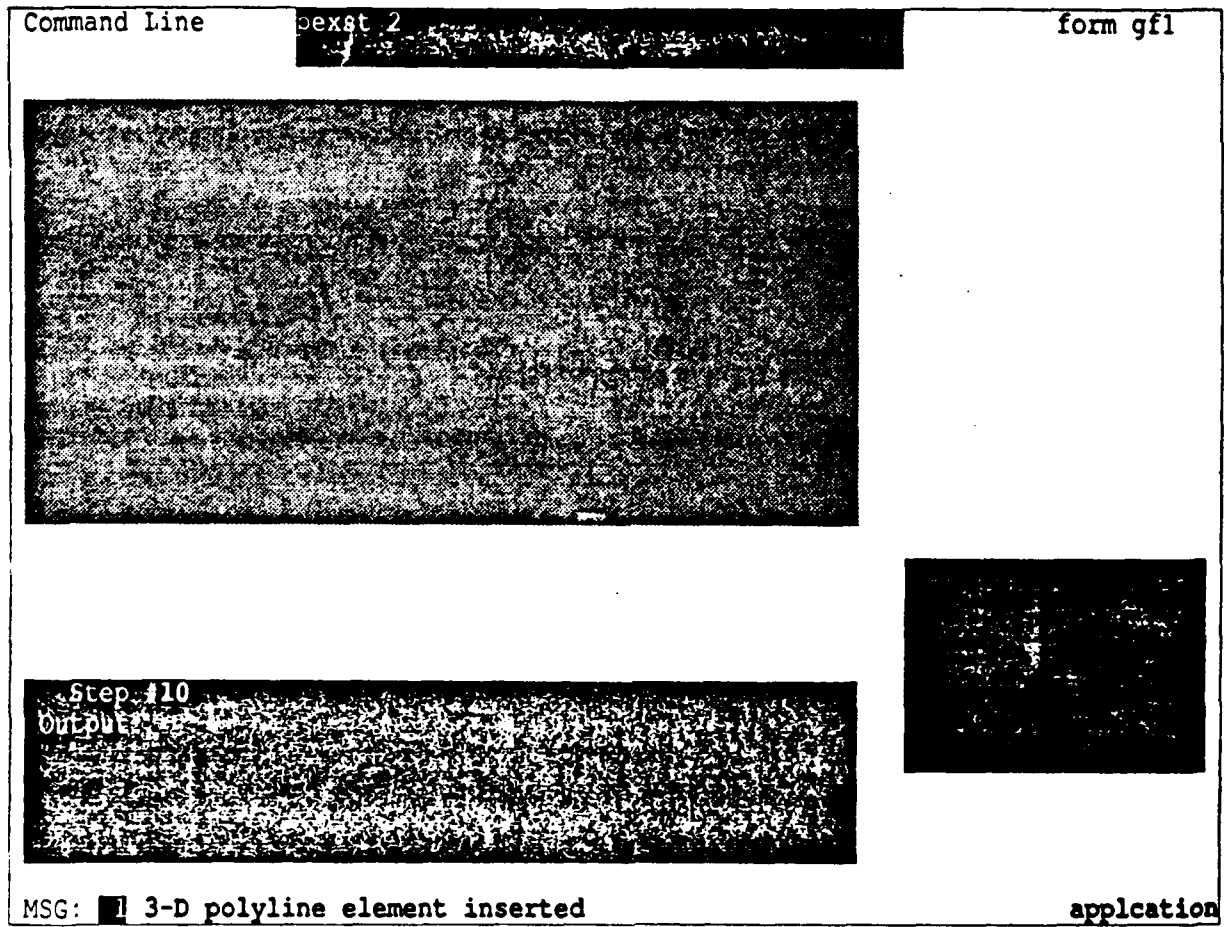


Figure 5-12a (BEFORE)

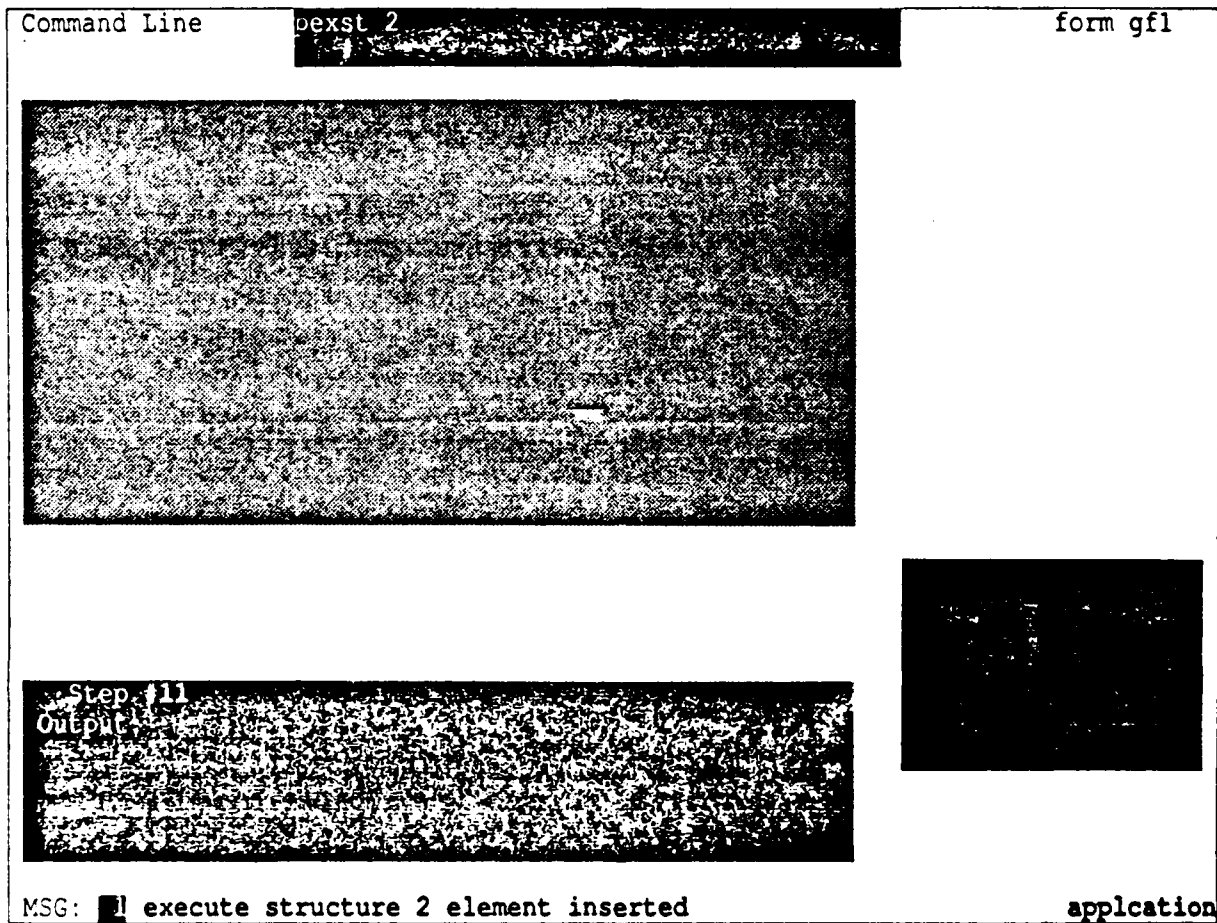


Figure 5-12b (AFTER)

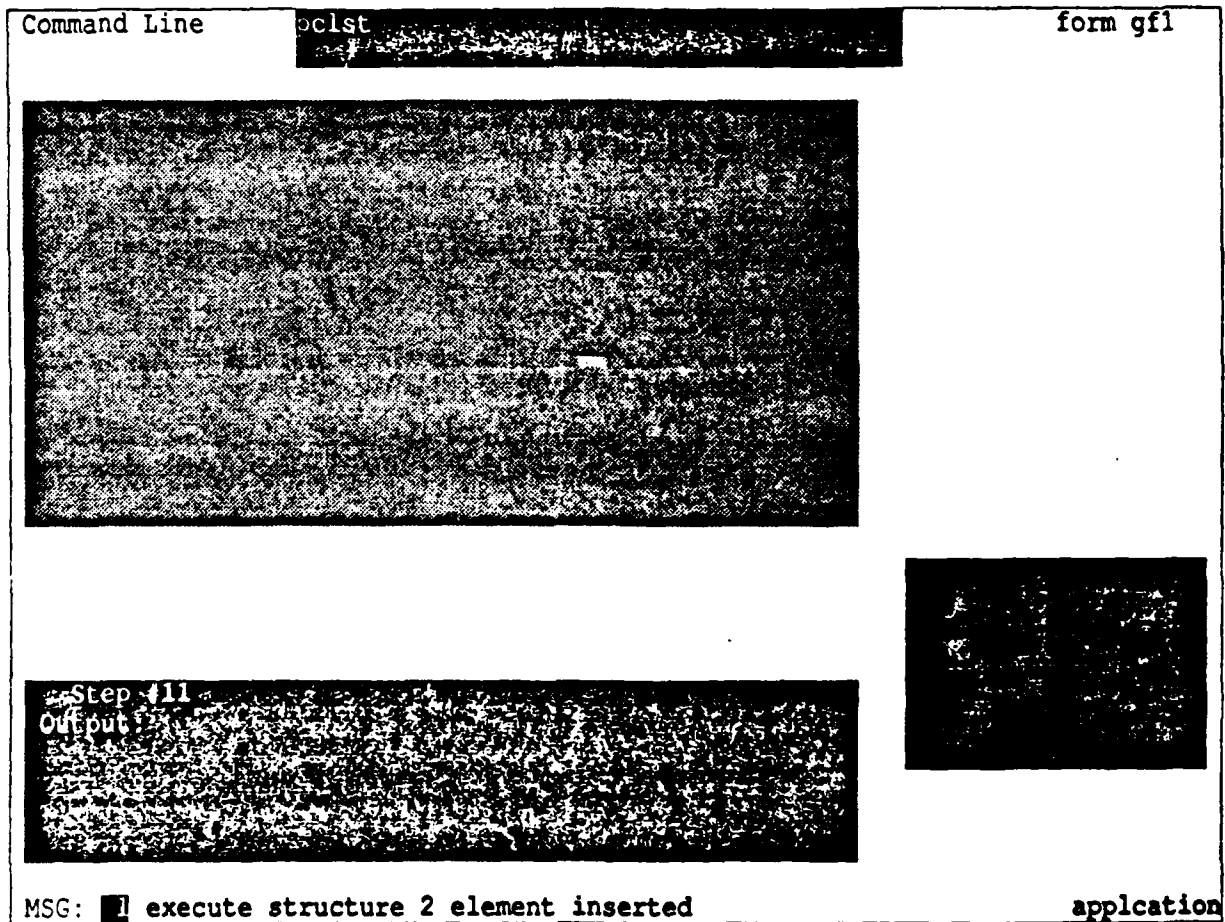


Figure 5-13a (BEFORE)

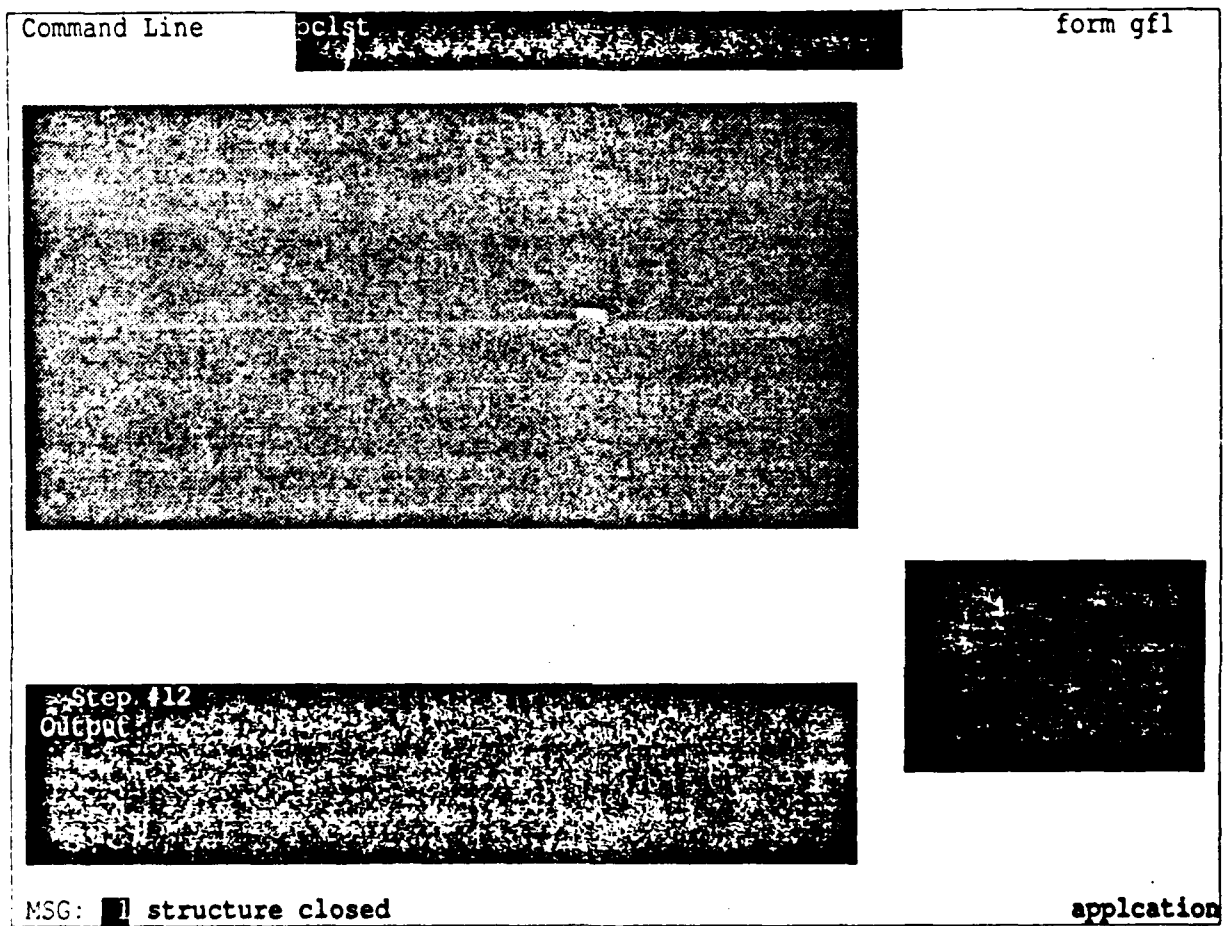


Figure 5-13b (AFTER)

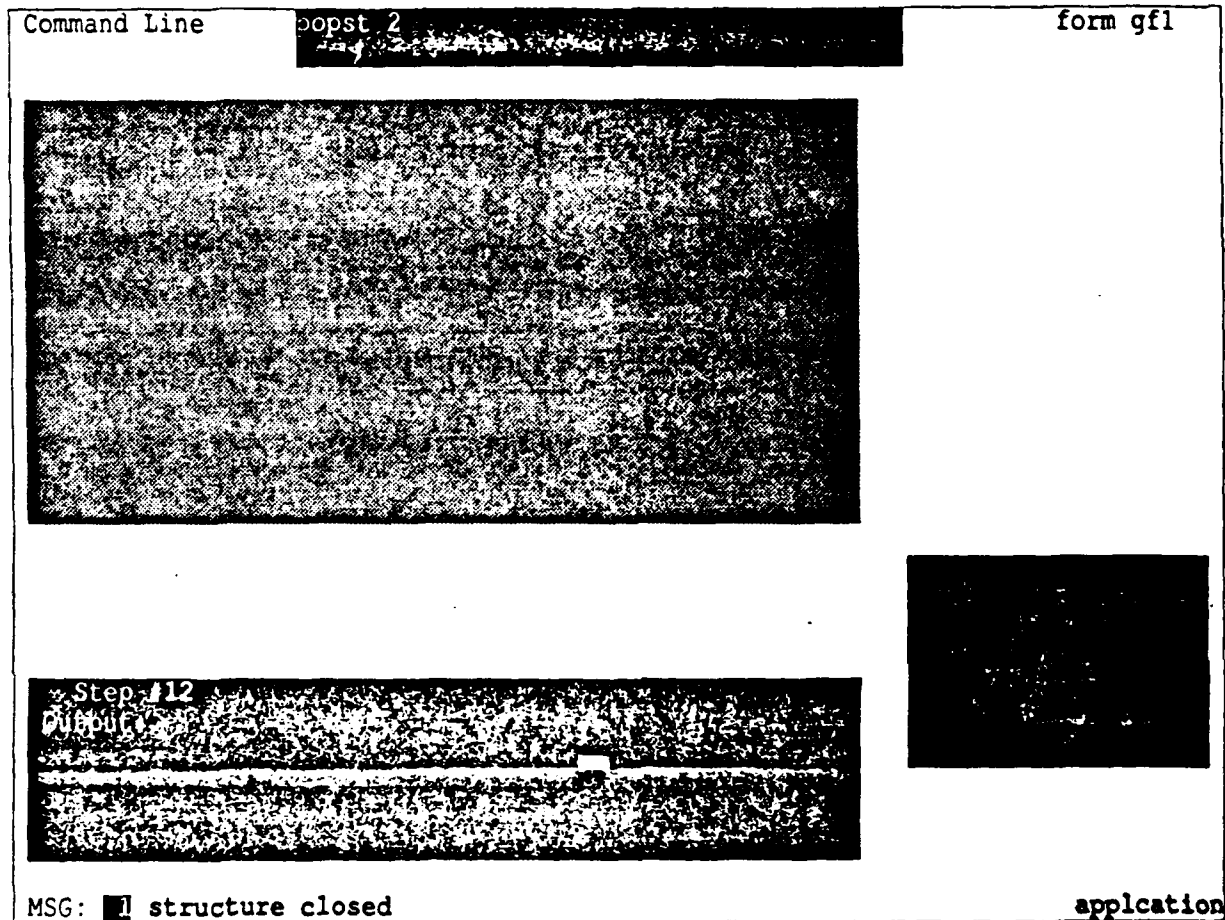


Figure 5-14a (BEFORE)

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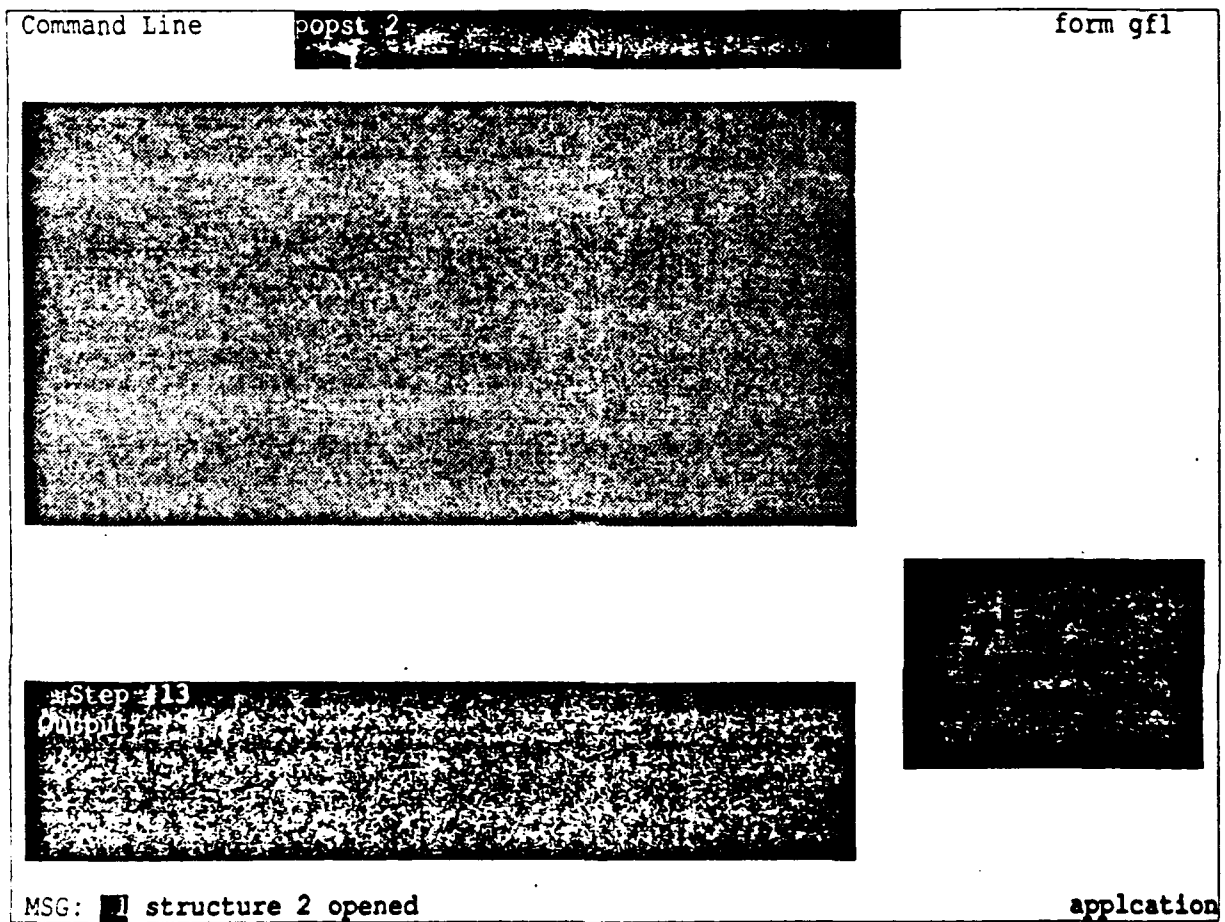


Figure 5-14b (AFTER)

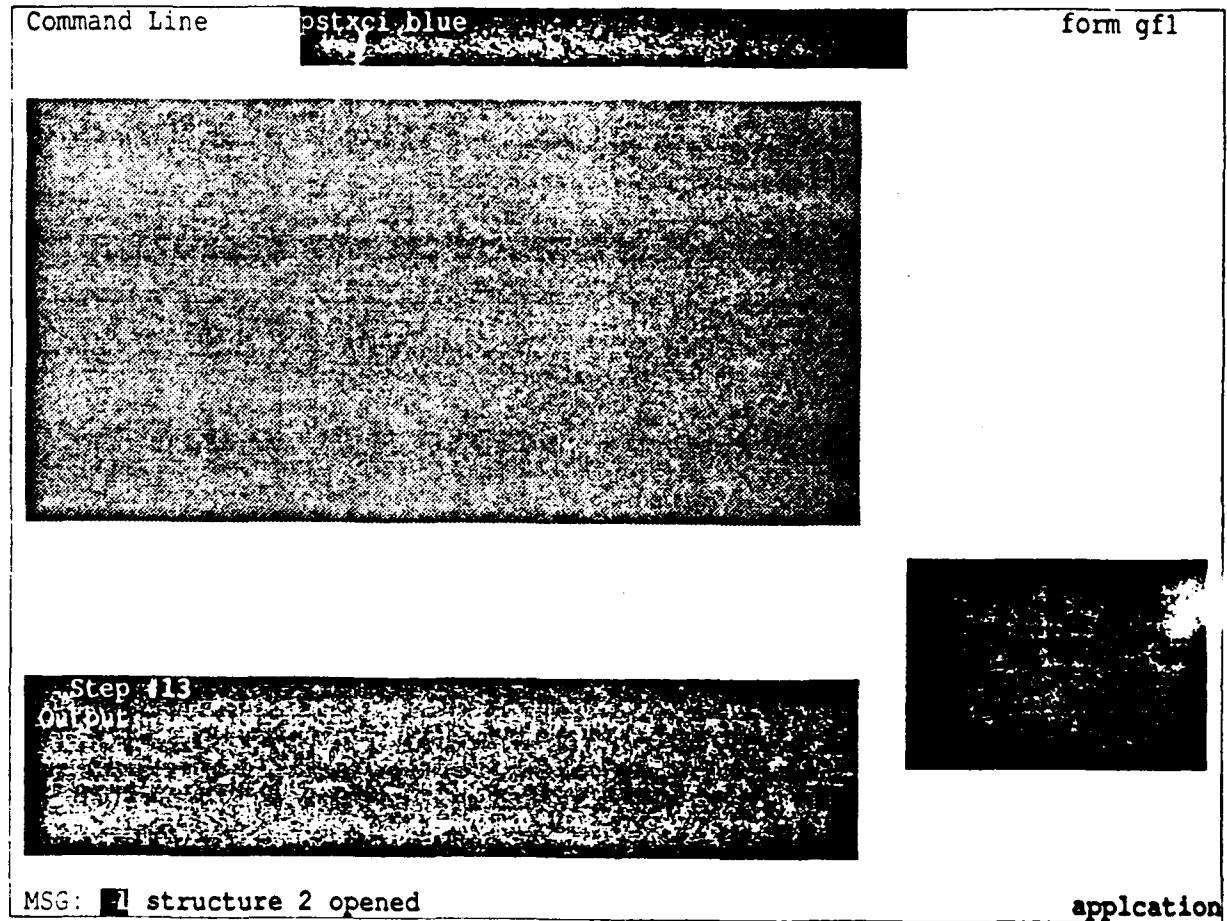


Figure 5-15a (BEFORE)

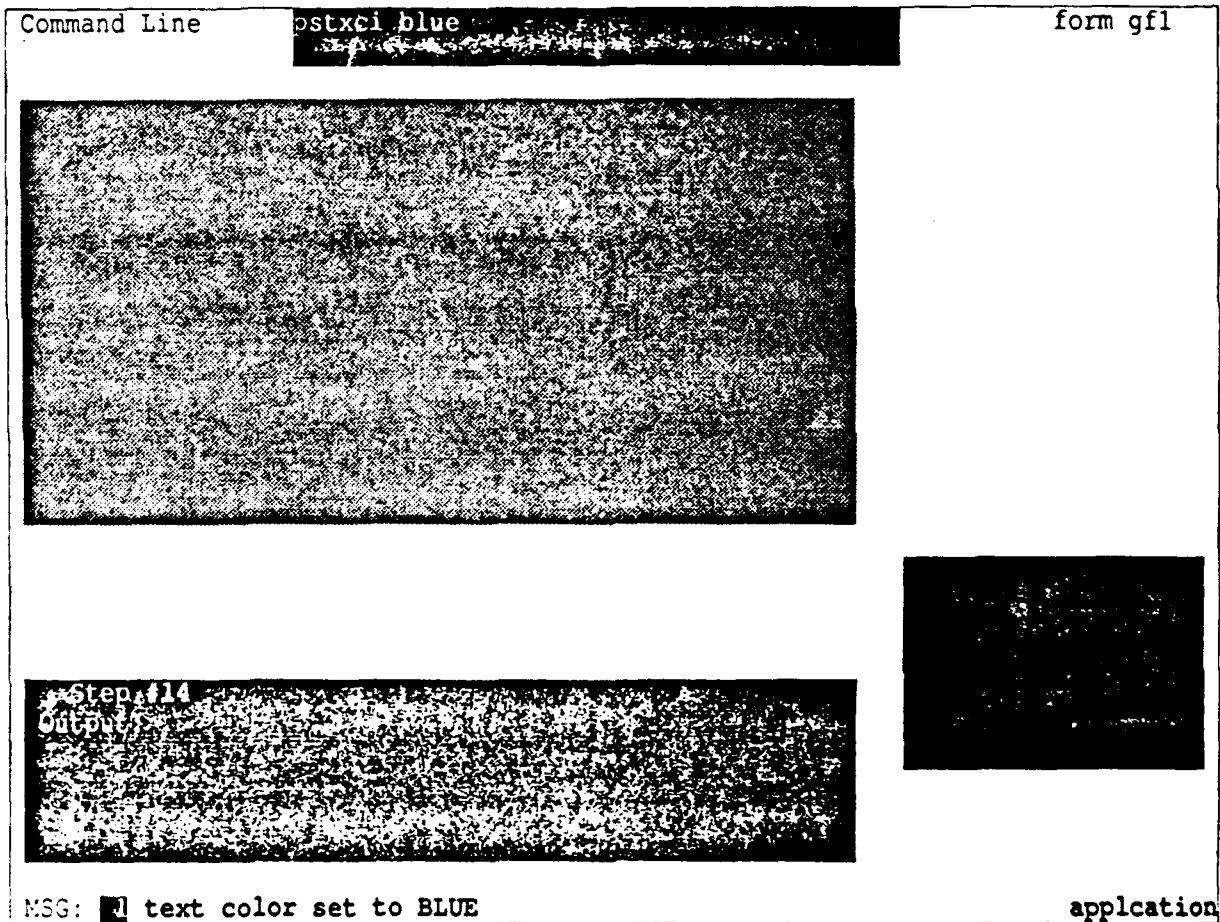


Figure 5-15b (AFTER)

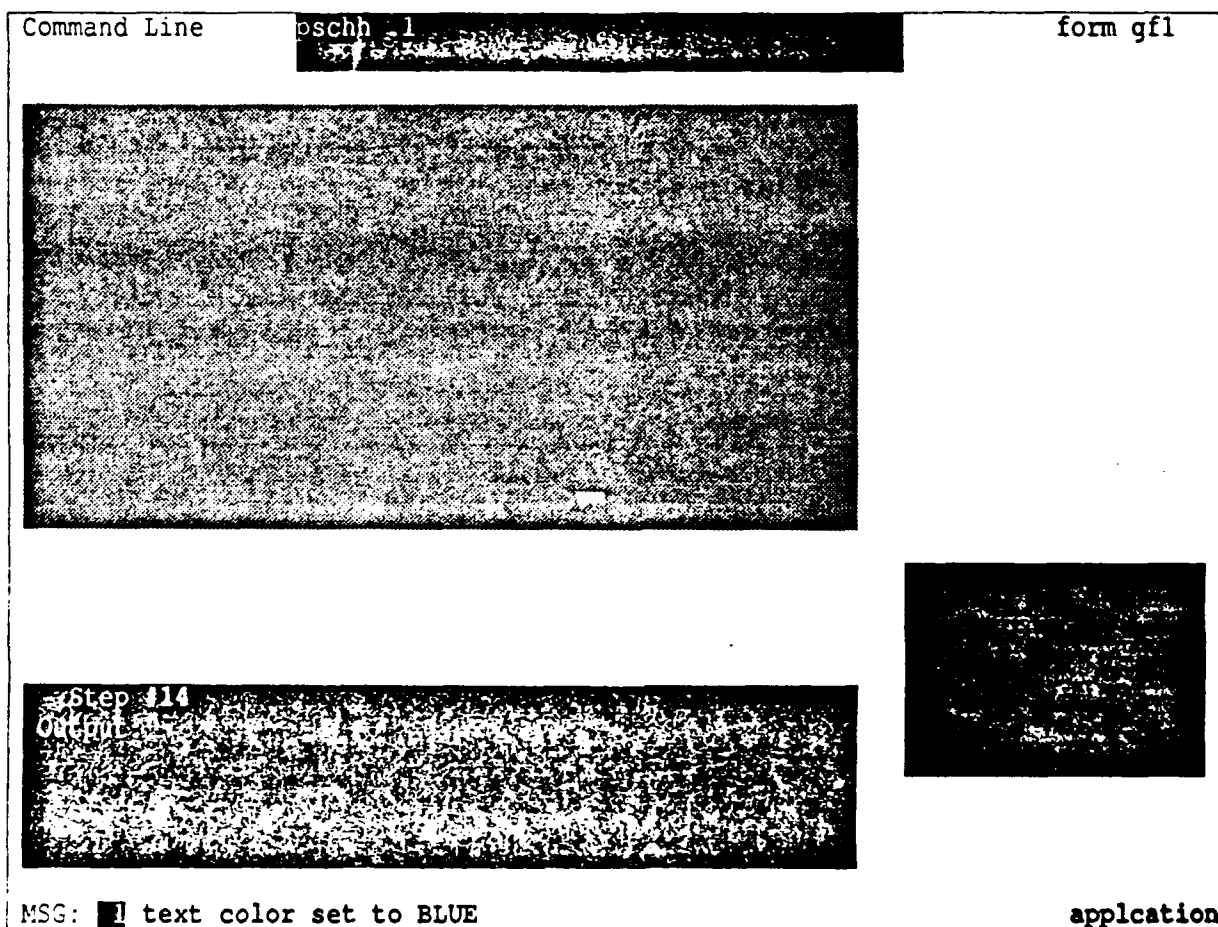


Figure 5-16a (BEFORE)

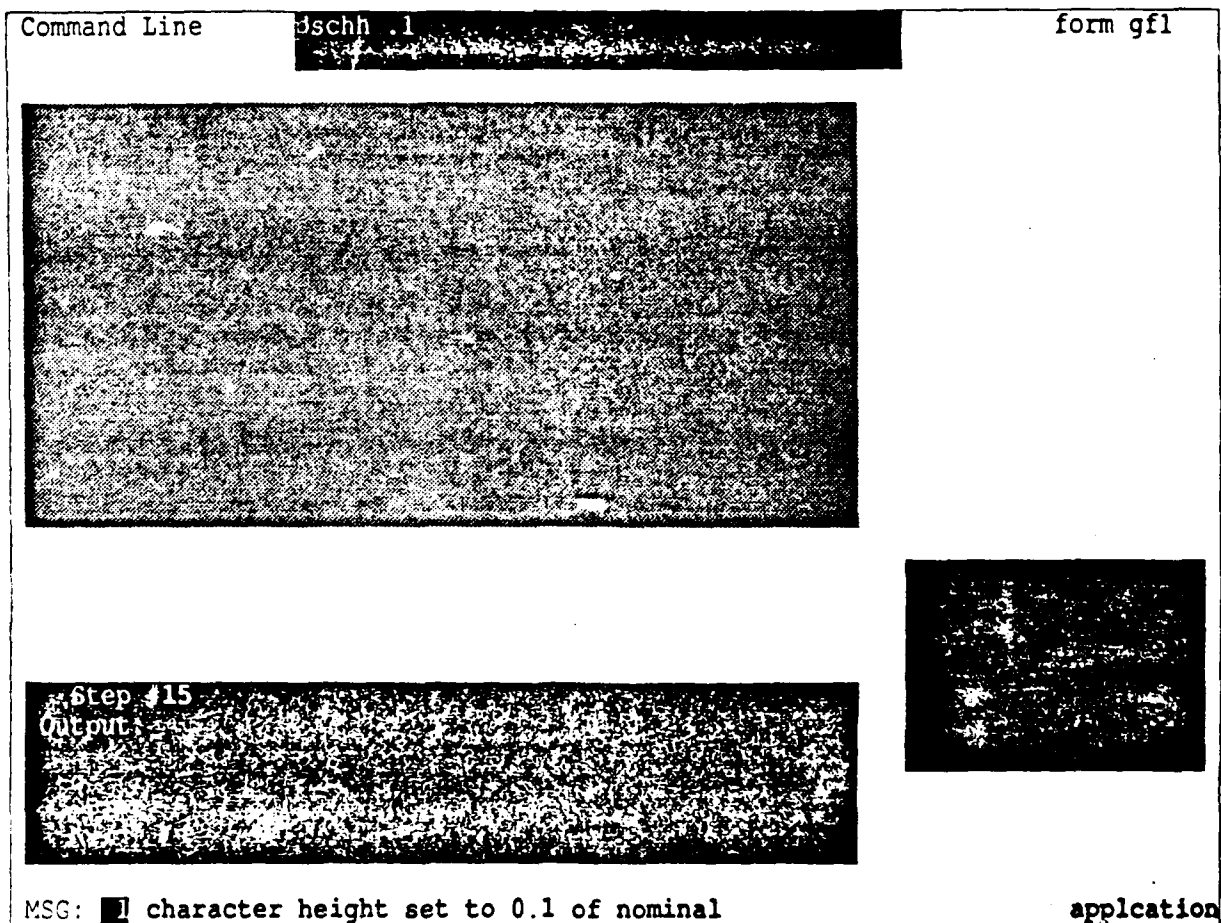


Figure 5-16b (AFTER)

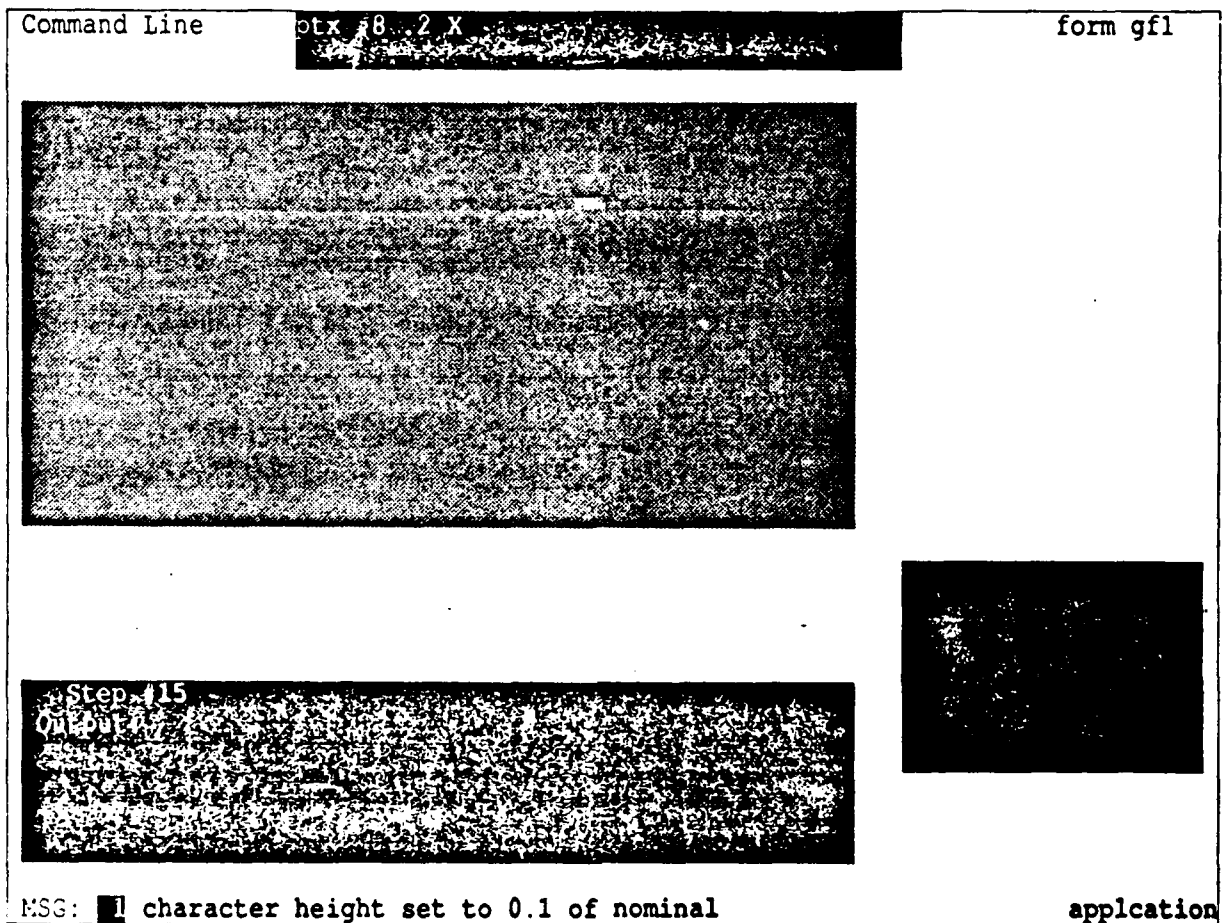


Figure 5-17a (BEFORE)

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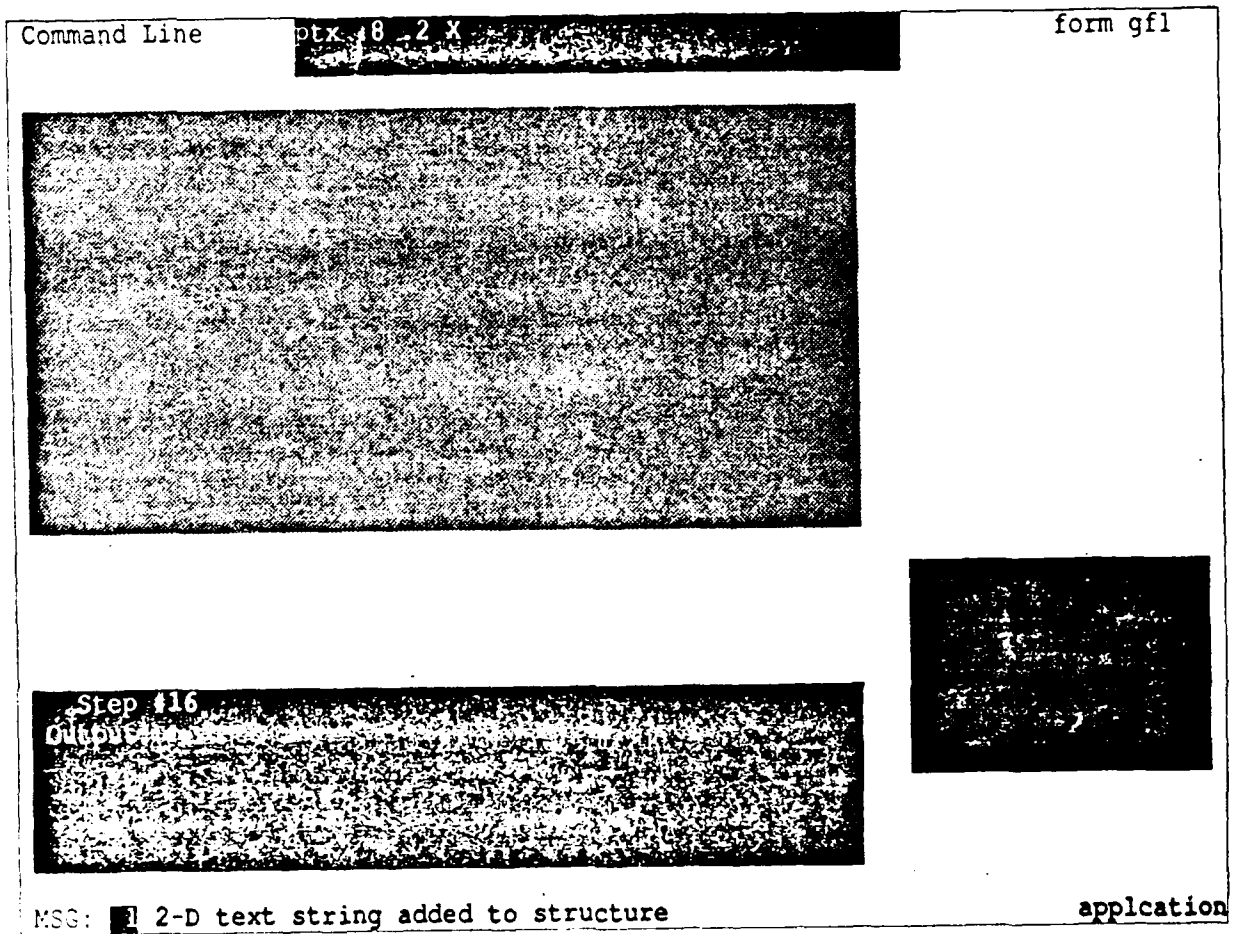


Figure 5-17b (AFTER)

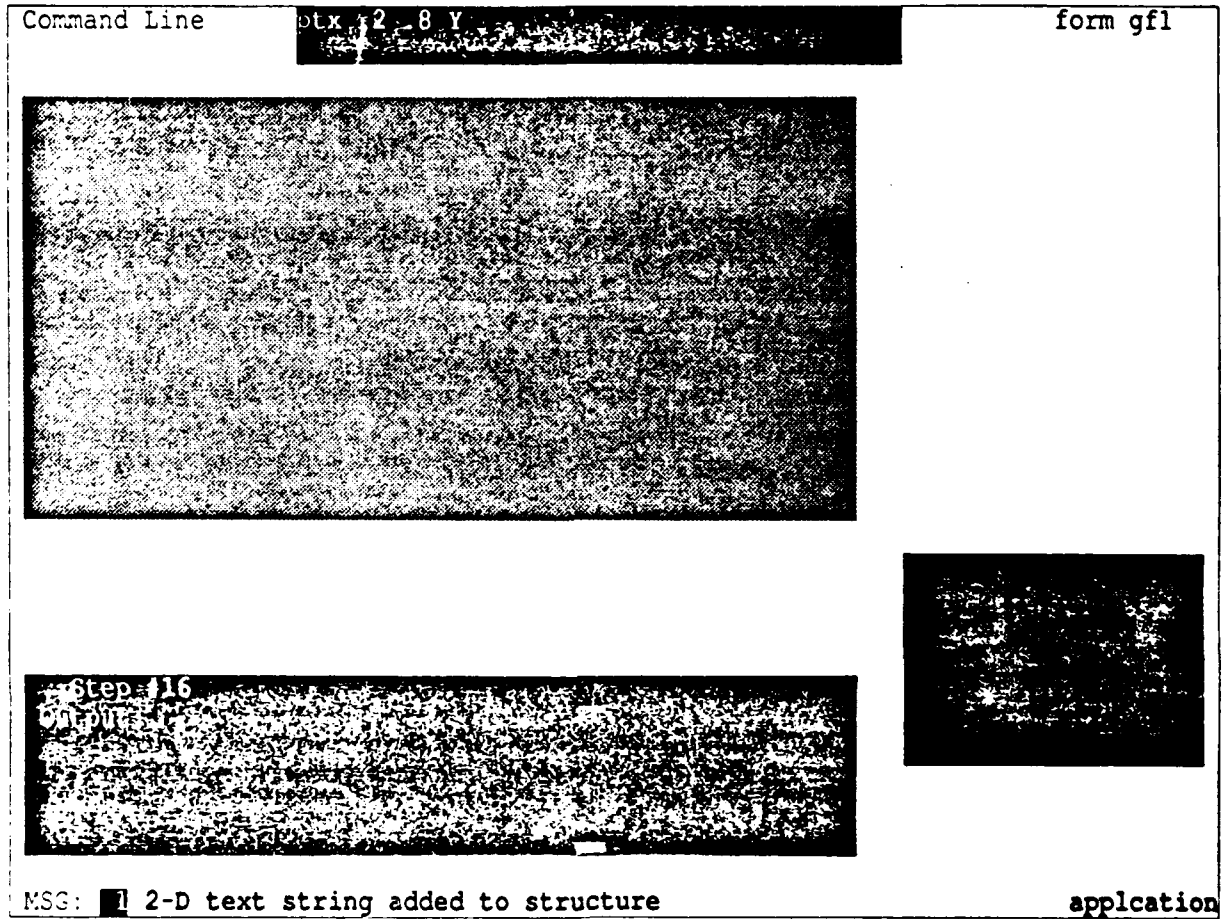


Figure 5-18a (BEFORE)

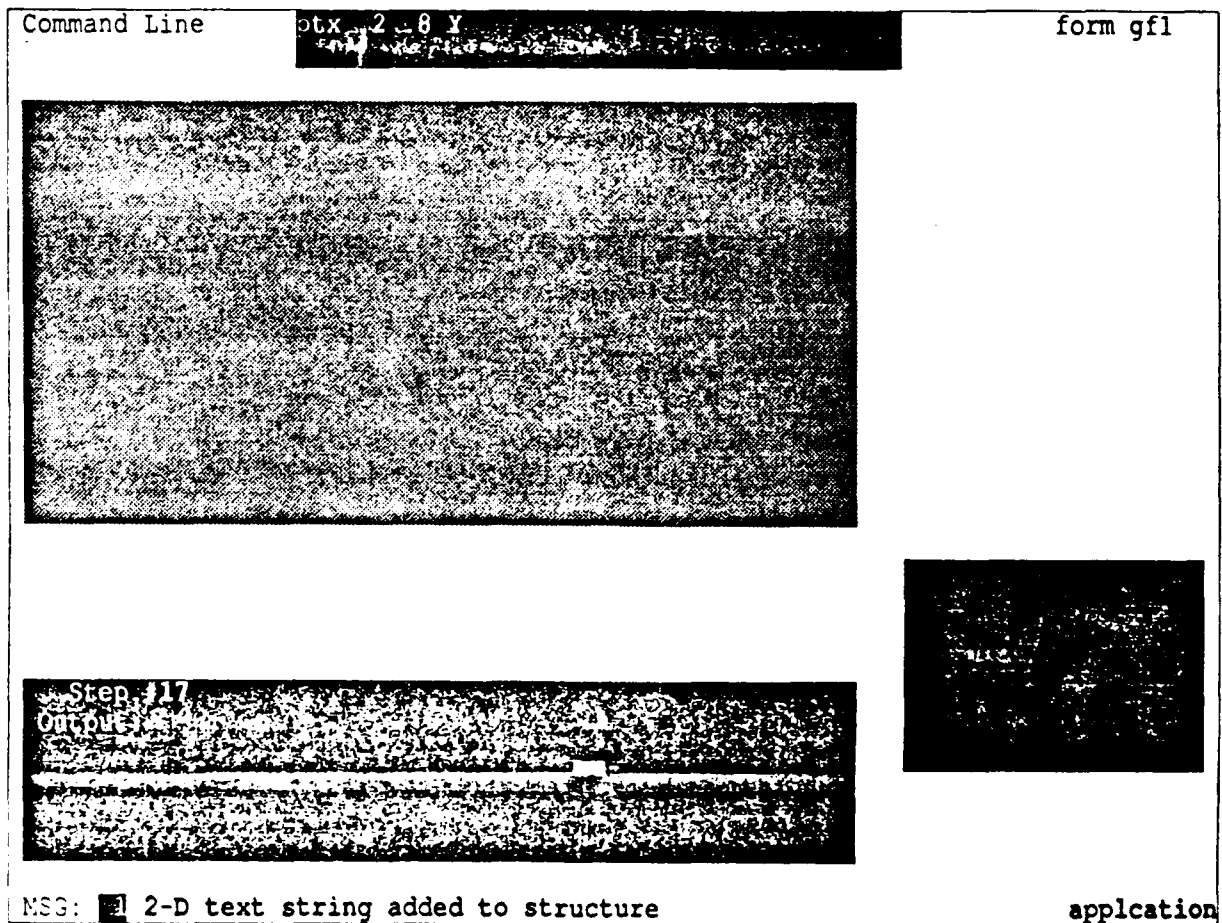


Figure 5-18b (AFTER)

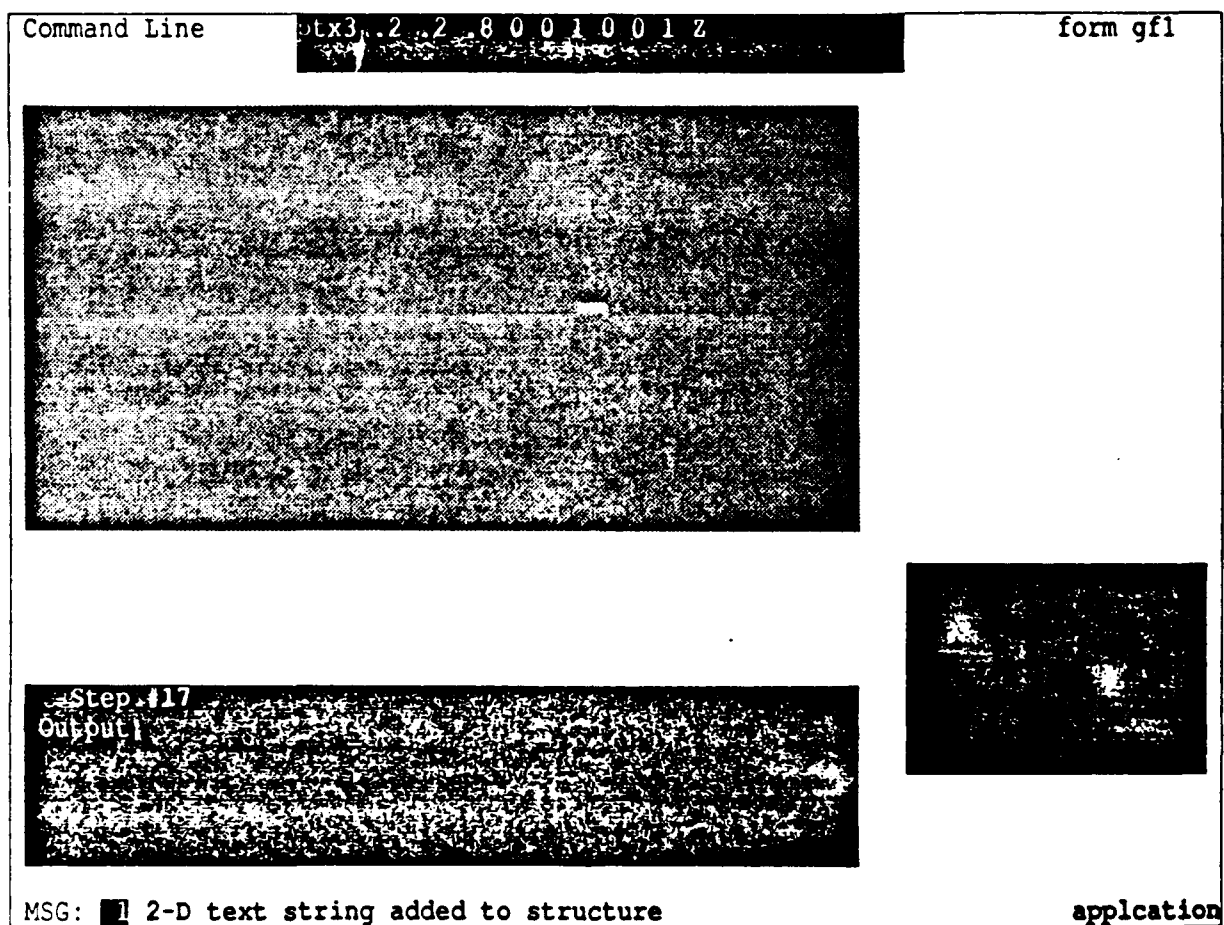


Figure 5-19a (BEFORE)

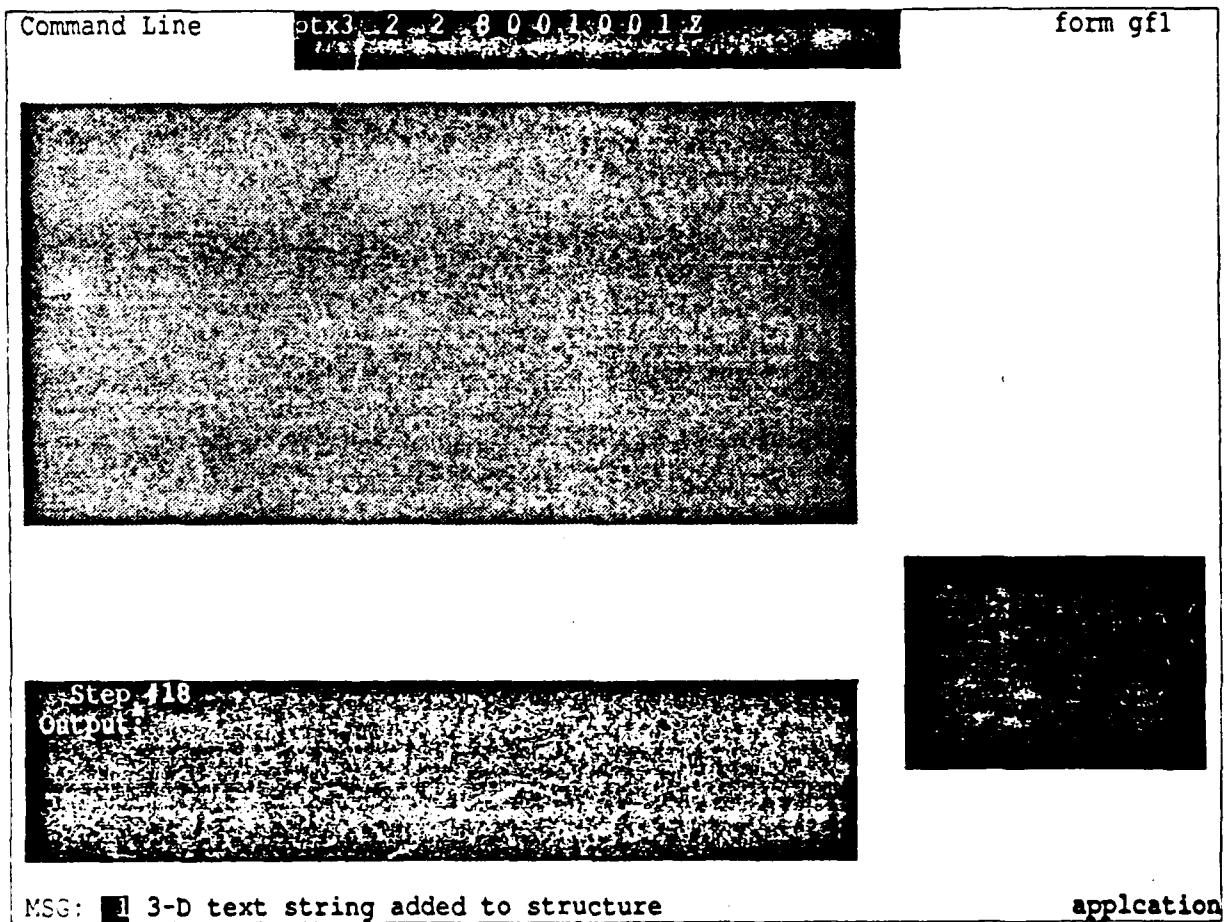


Figure 5-19b (AFTER)

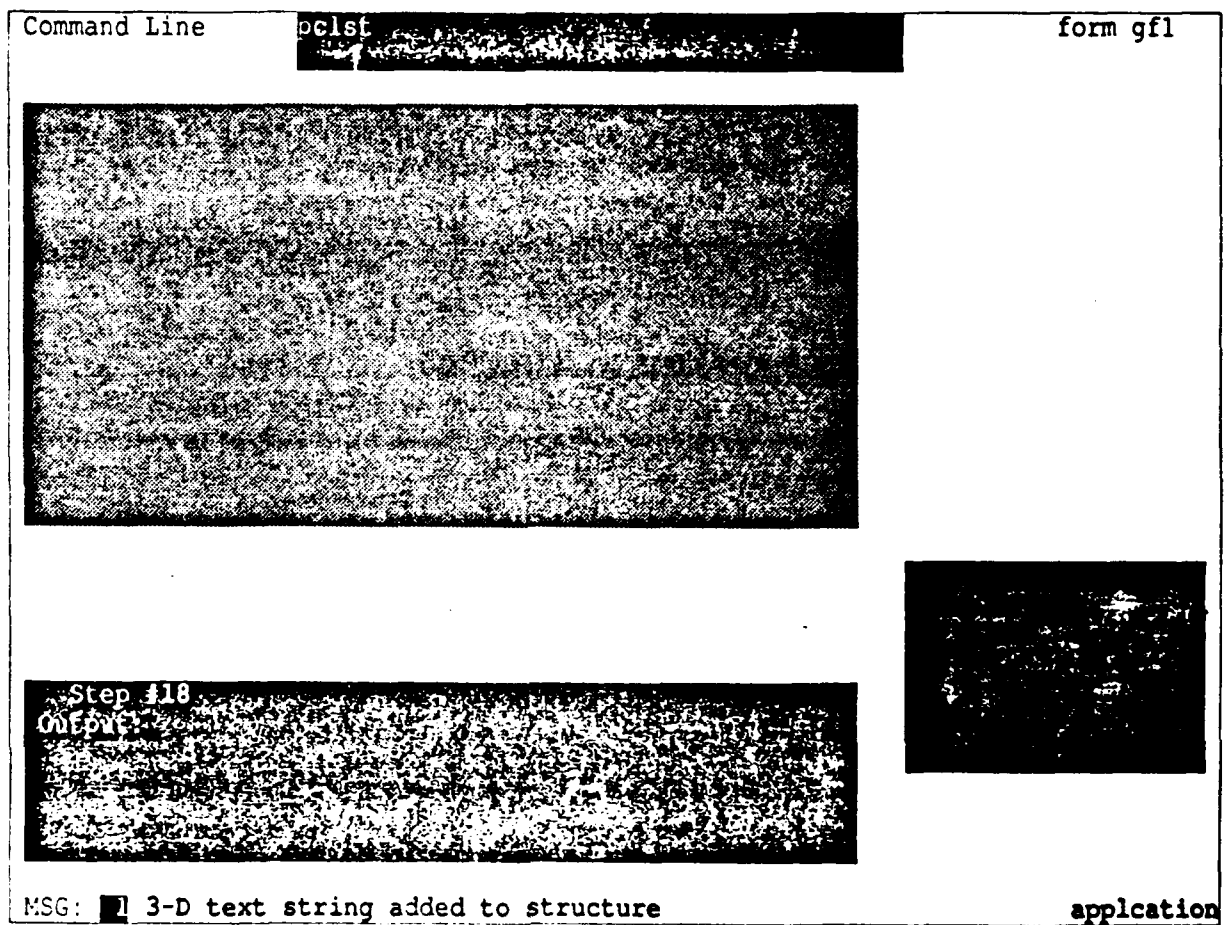


Figure 5-20a (BEFORE)

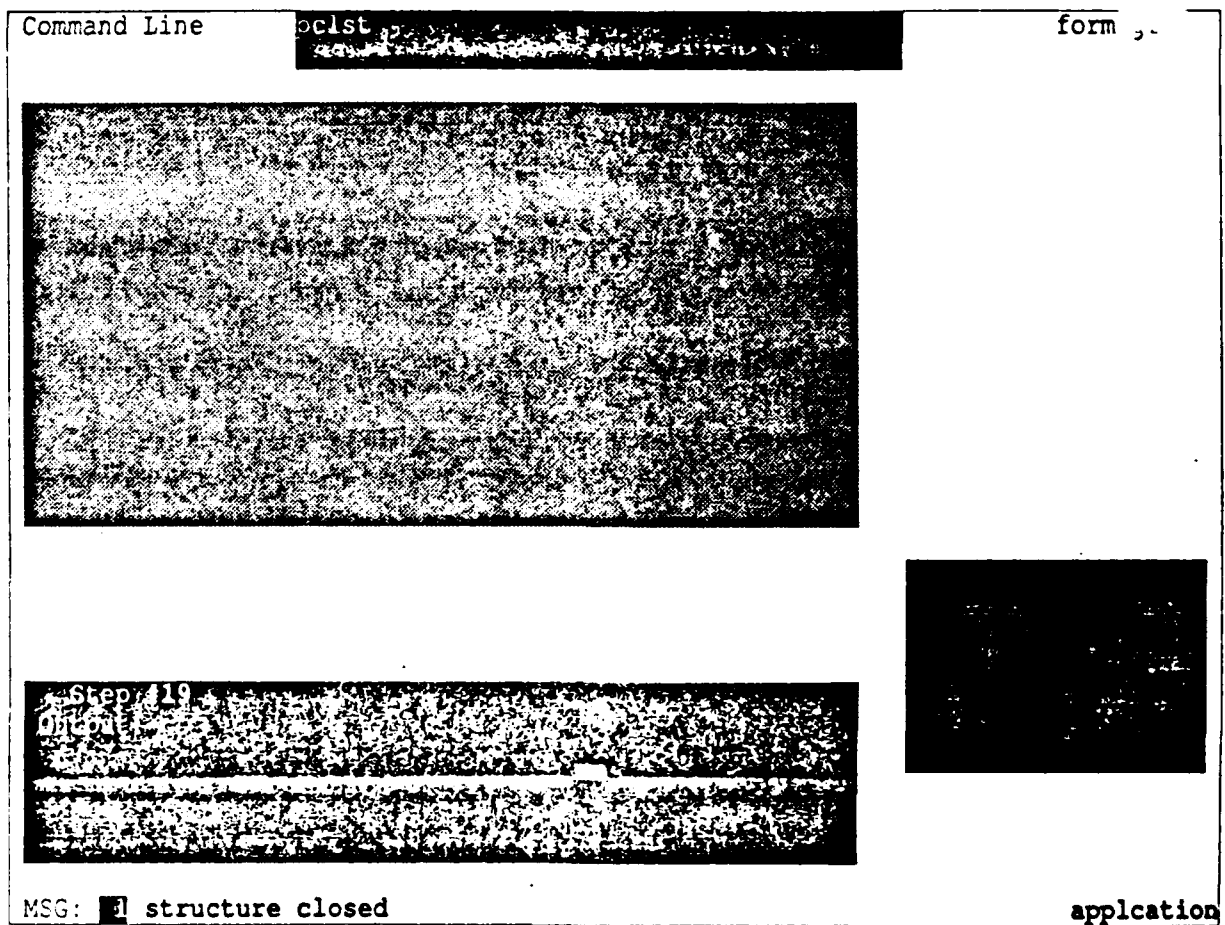


Figure 5-20b (AFTER)

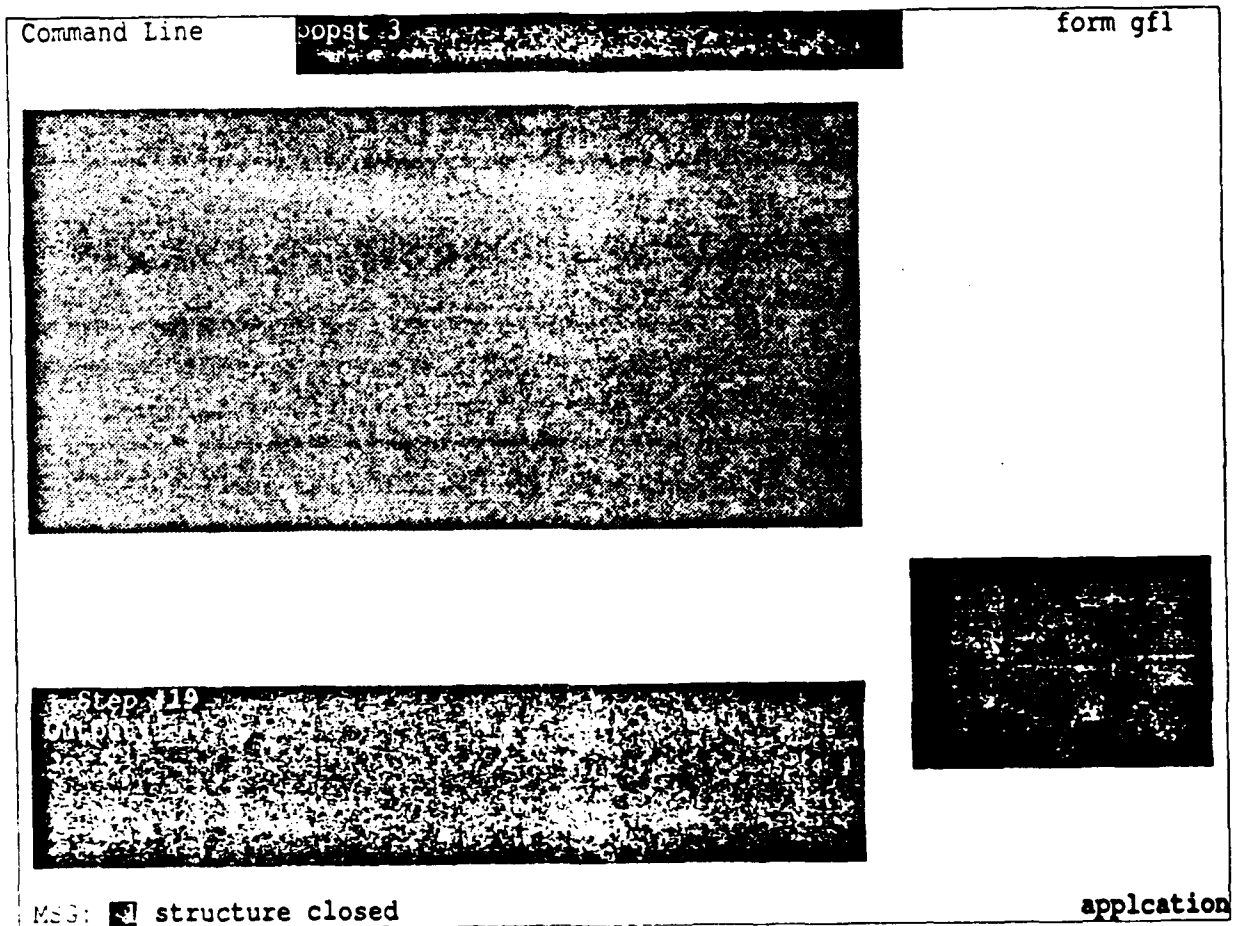


Figure 5-21a (BEFORE)

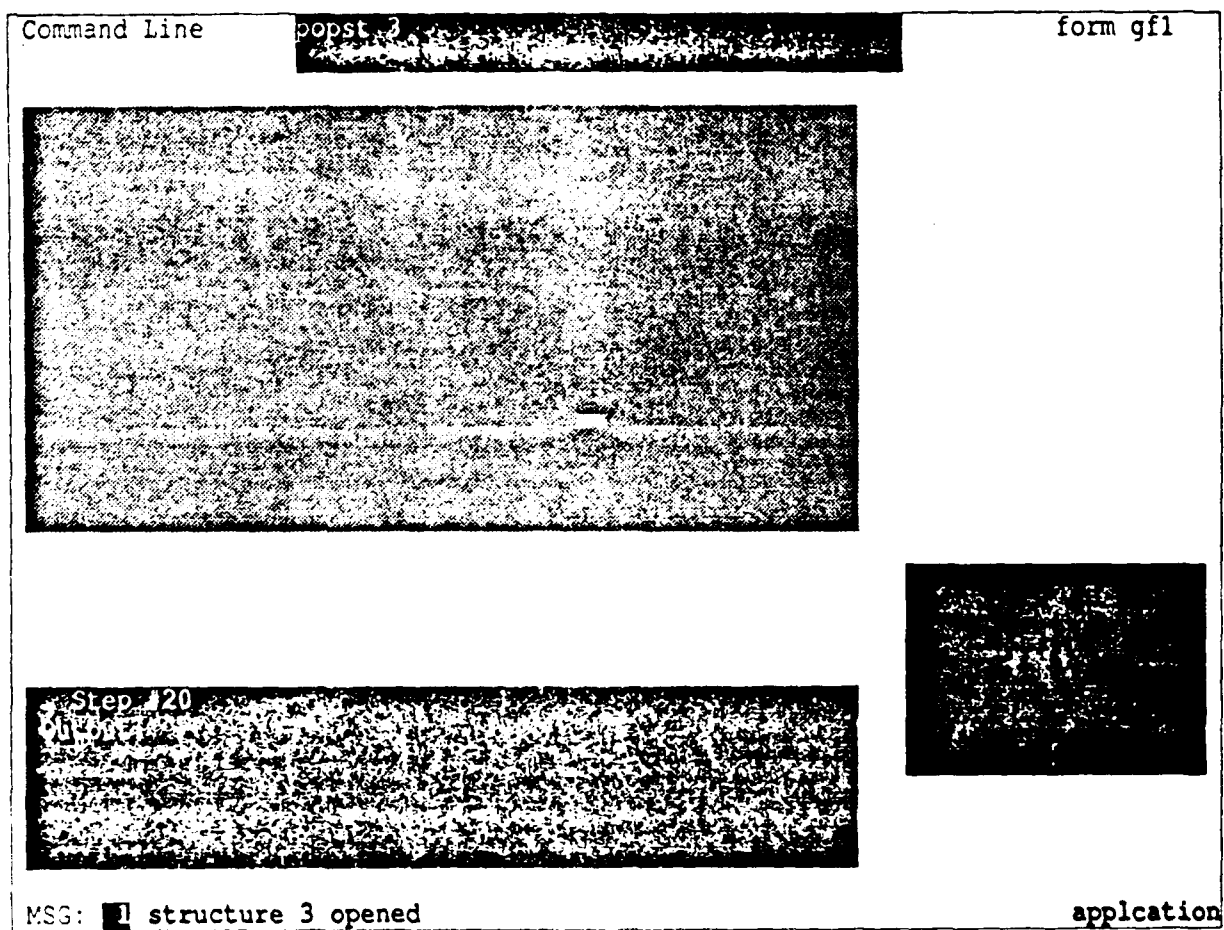


Figure 5-21b (AFTER)

UTP 620344220
30 September 1990

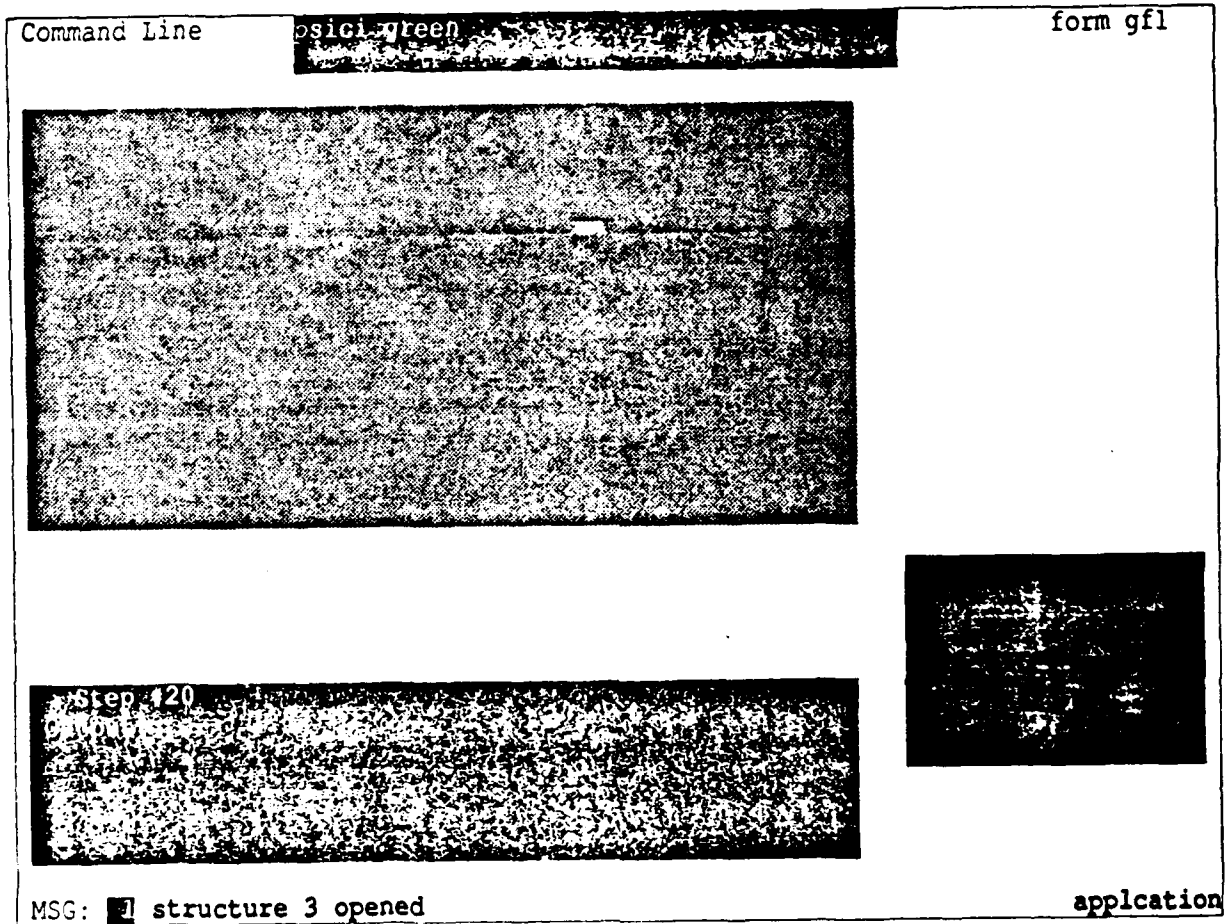


Figure 5-22a (BEFORE)

UTP 620344220
30 September 1990

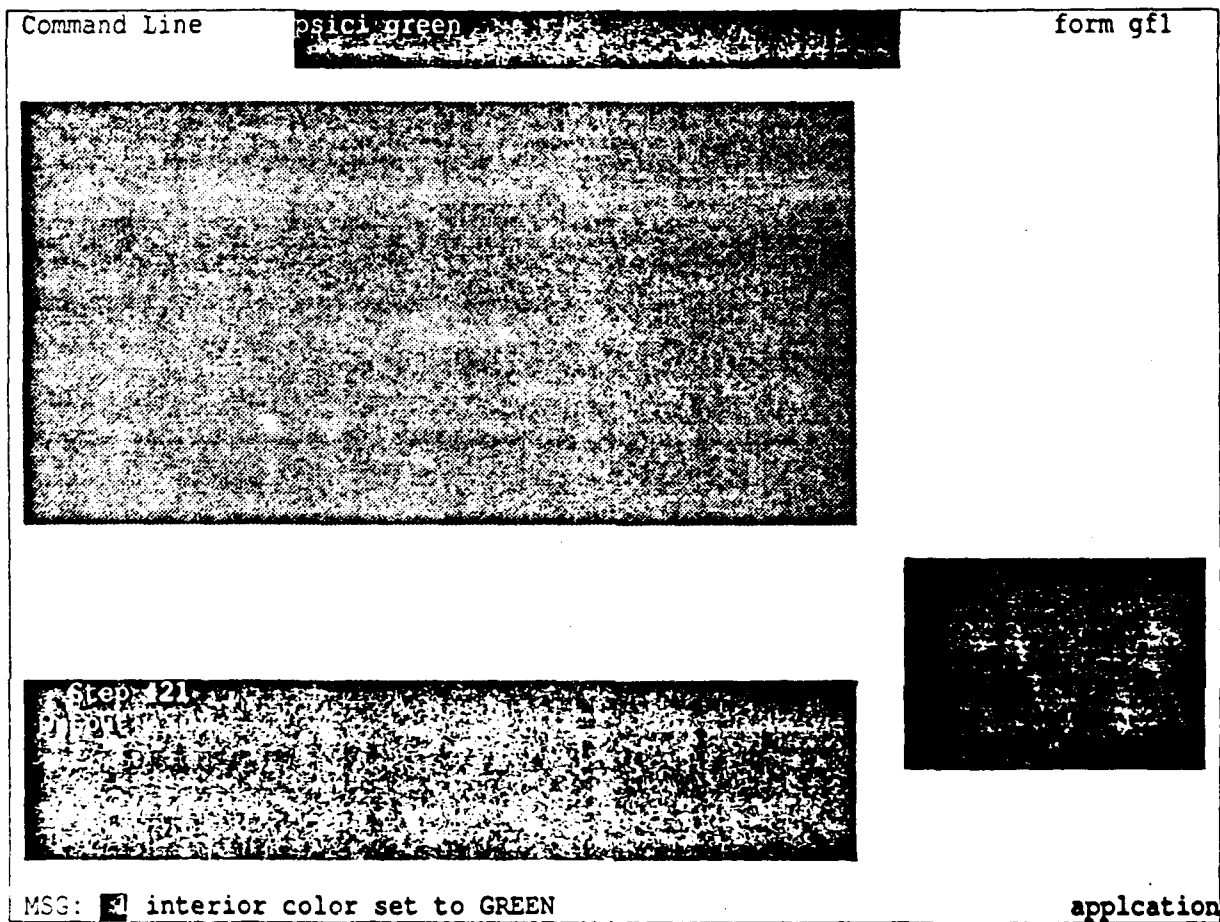


Figure 5-22b (AFTER)

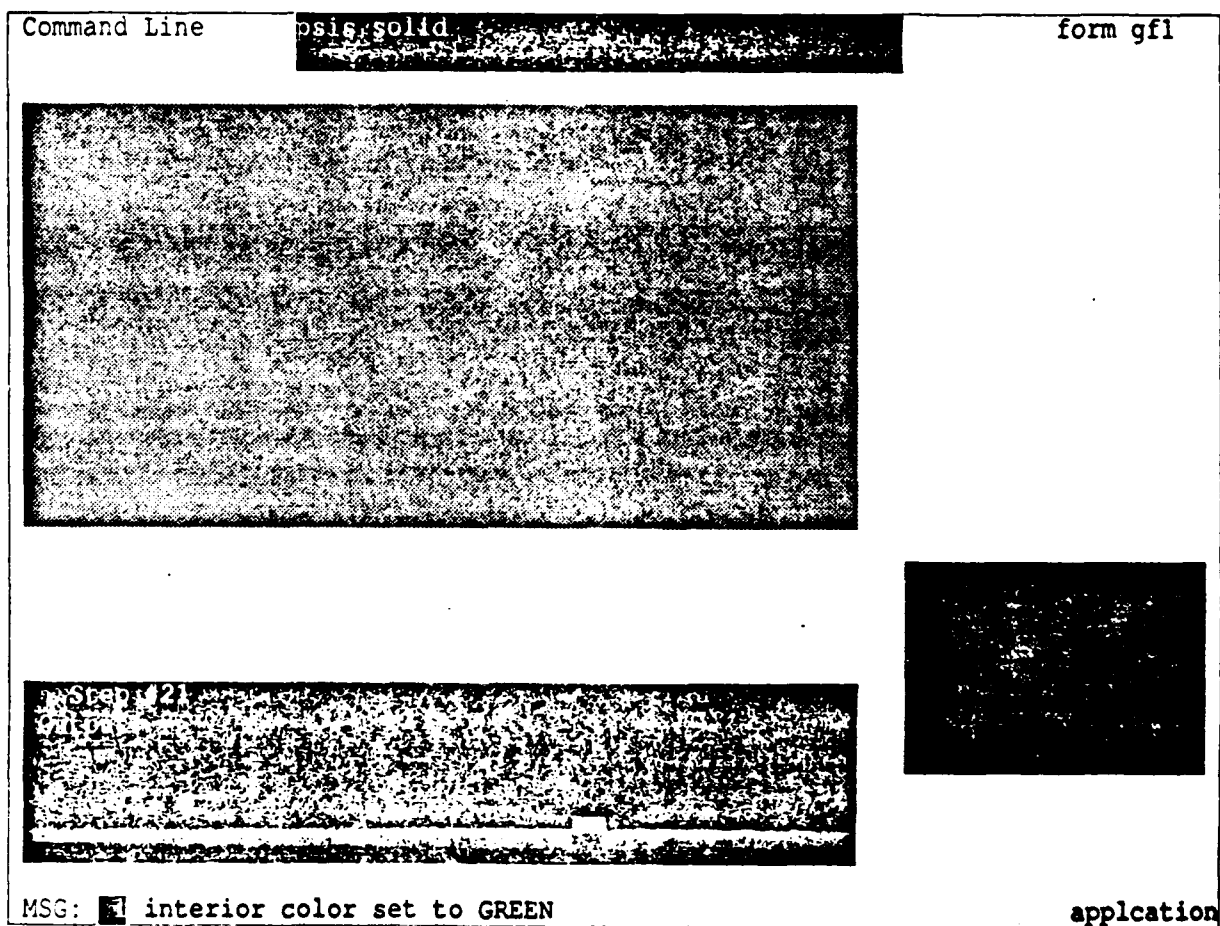


Figure 5-23a (BEFORE)

UTP 620344220
30 September 1990

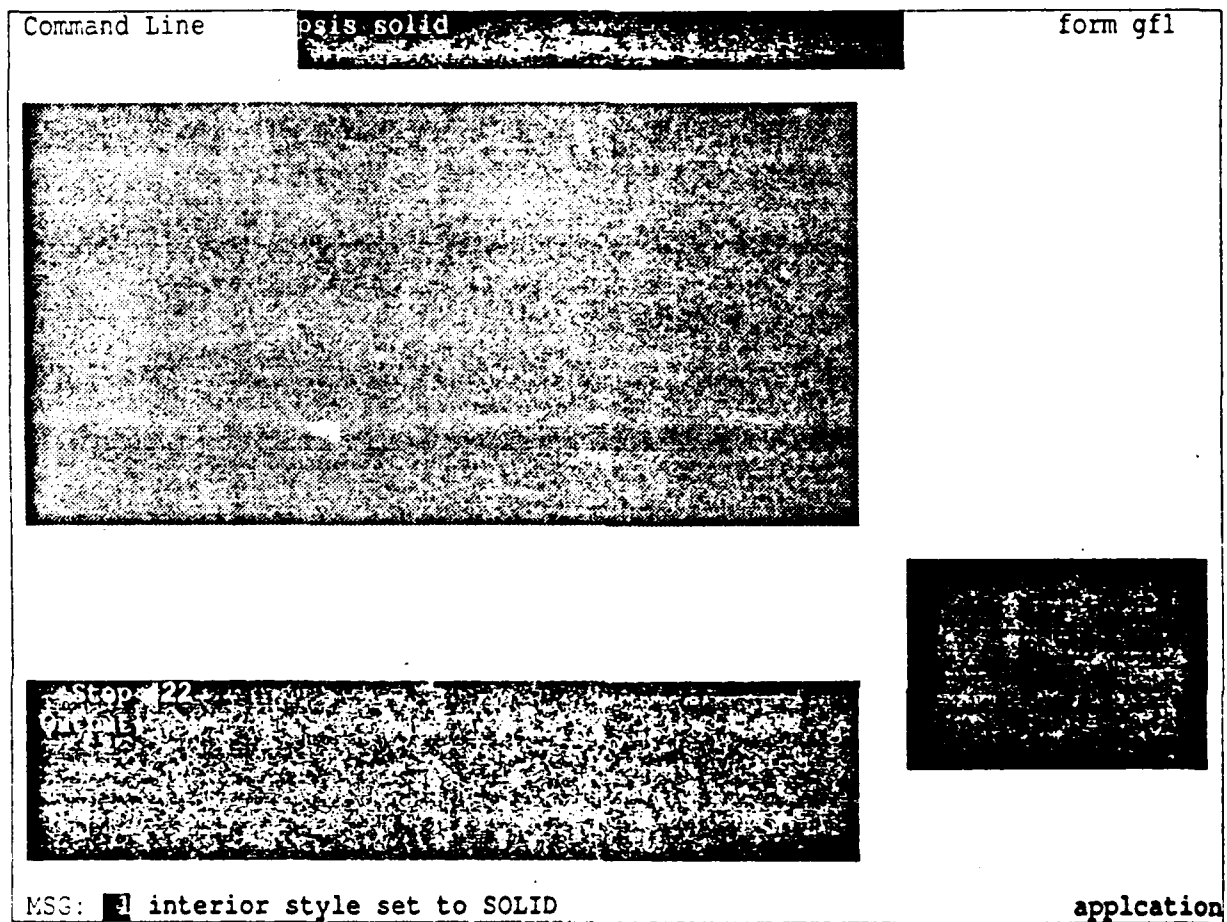


Figure 5-23b (AFTER)

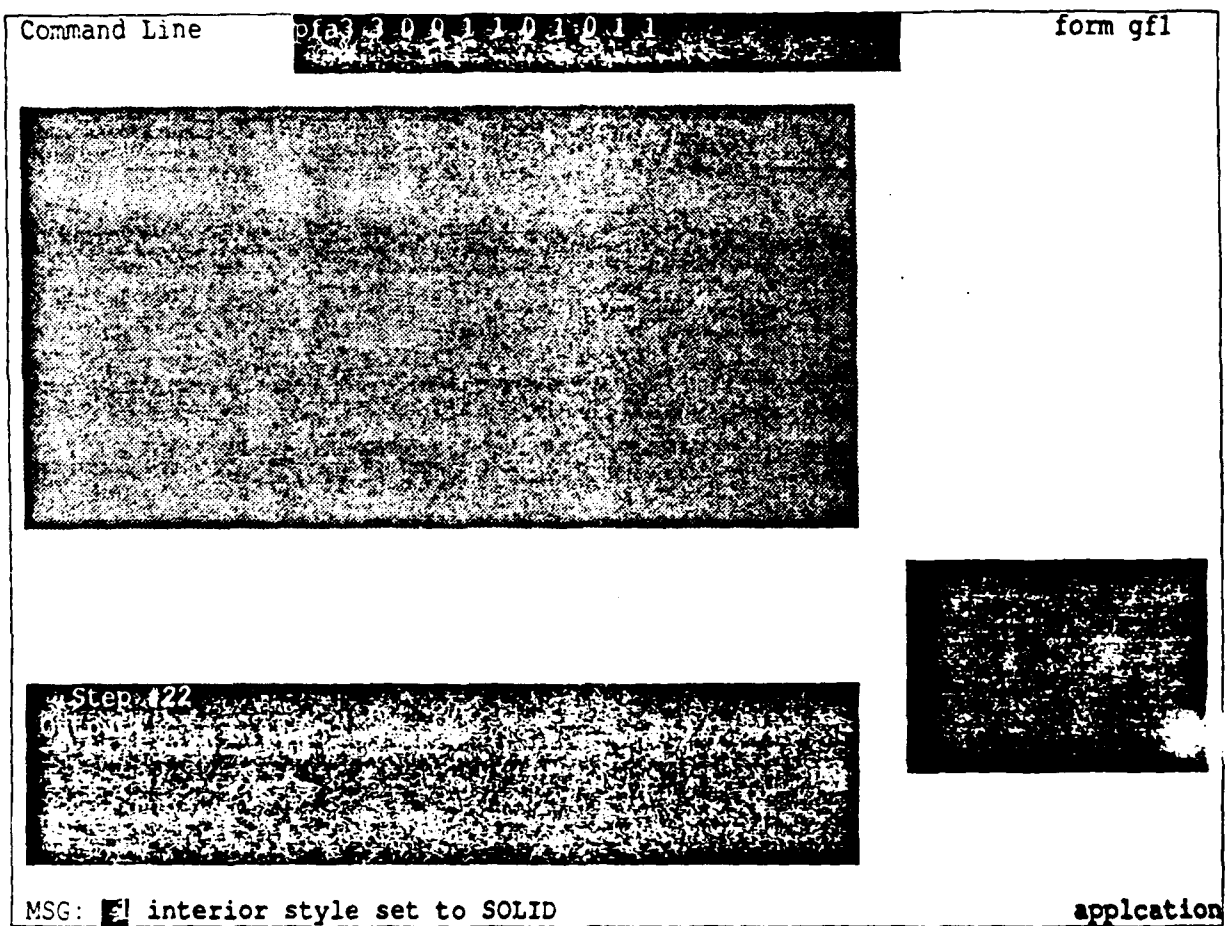


Figure 5-24a (BEFORE)

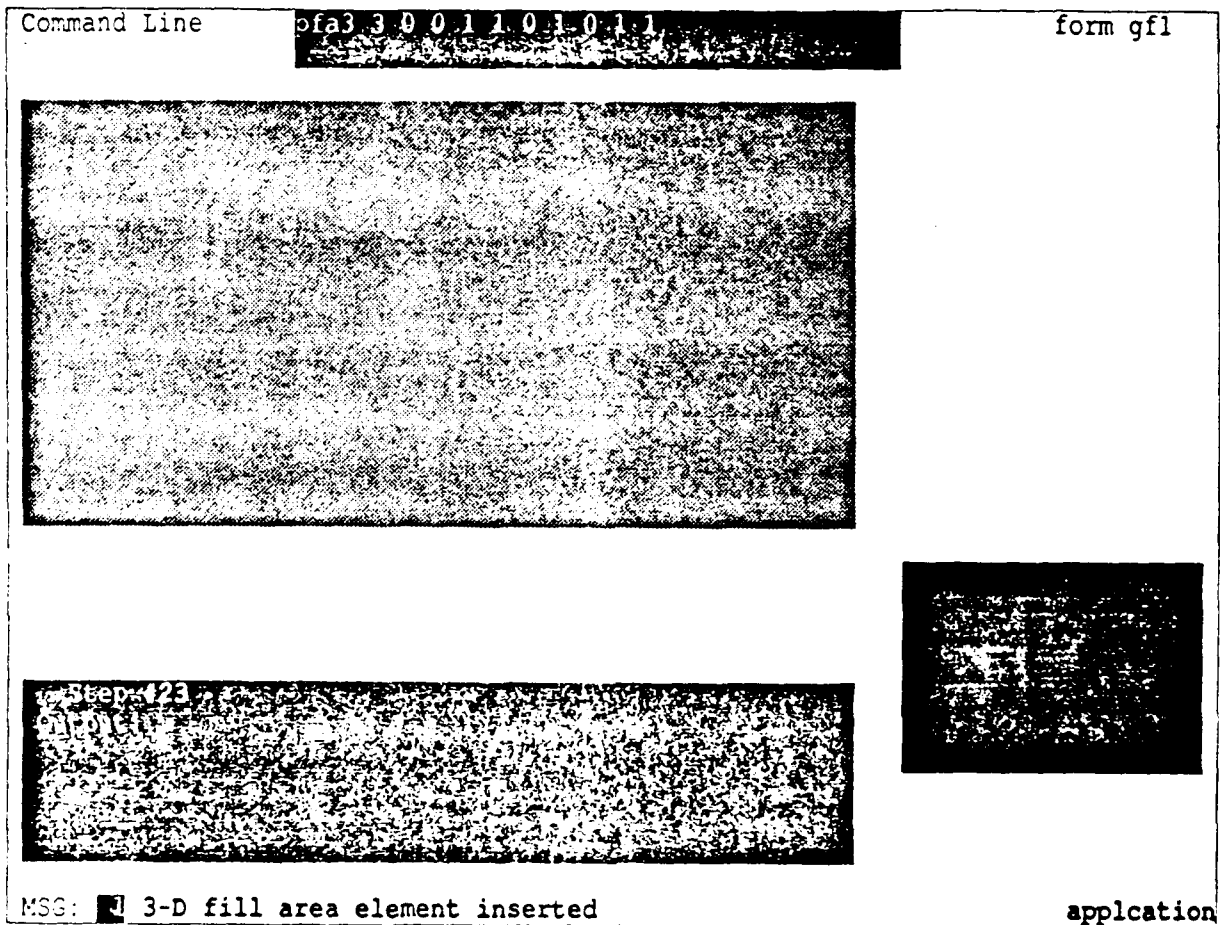


Figure 5-24b (AFTER)

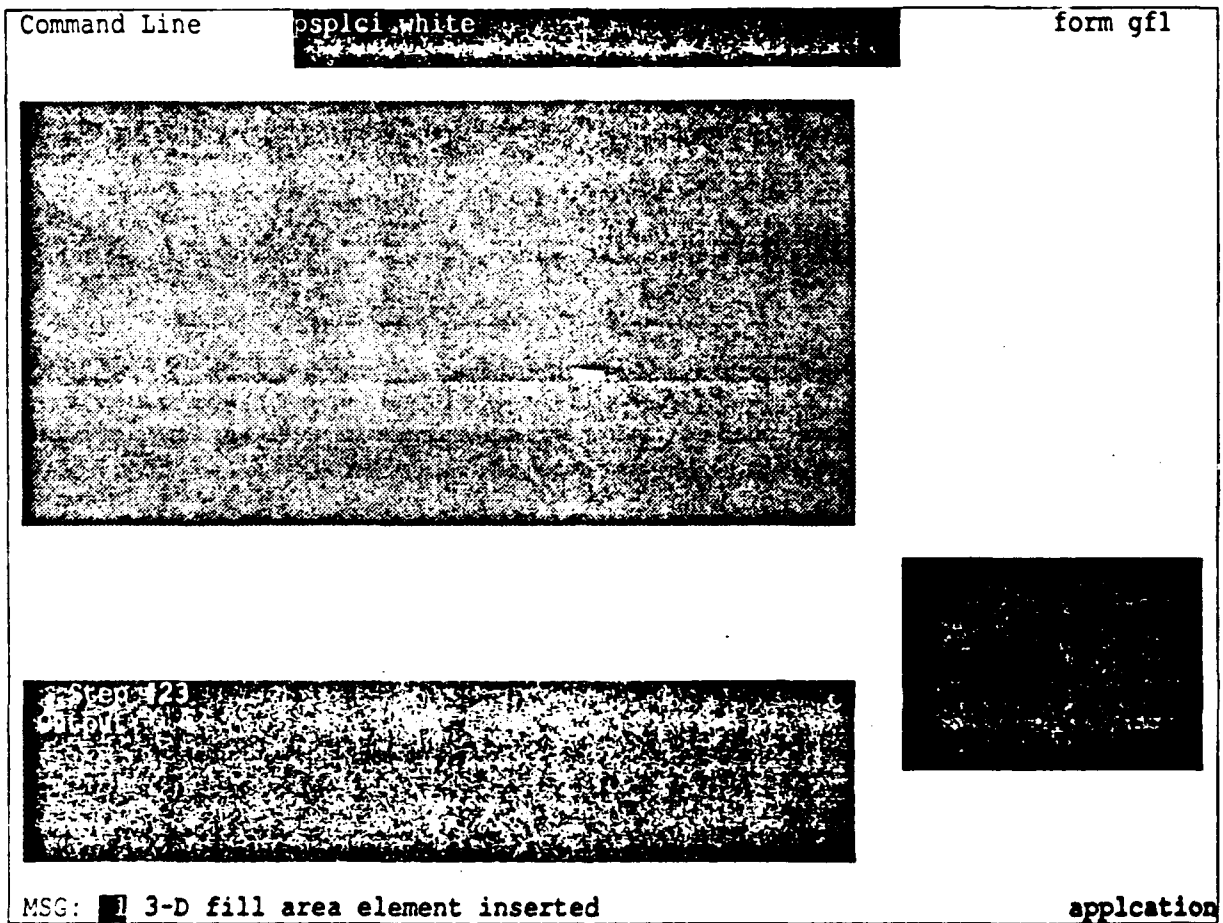


Figure 5-25a (BEFORE)

UTP 620344220
30 September 1990

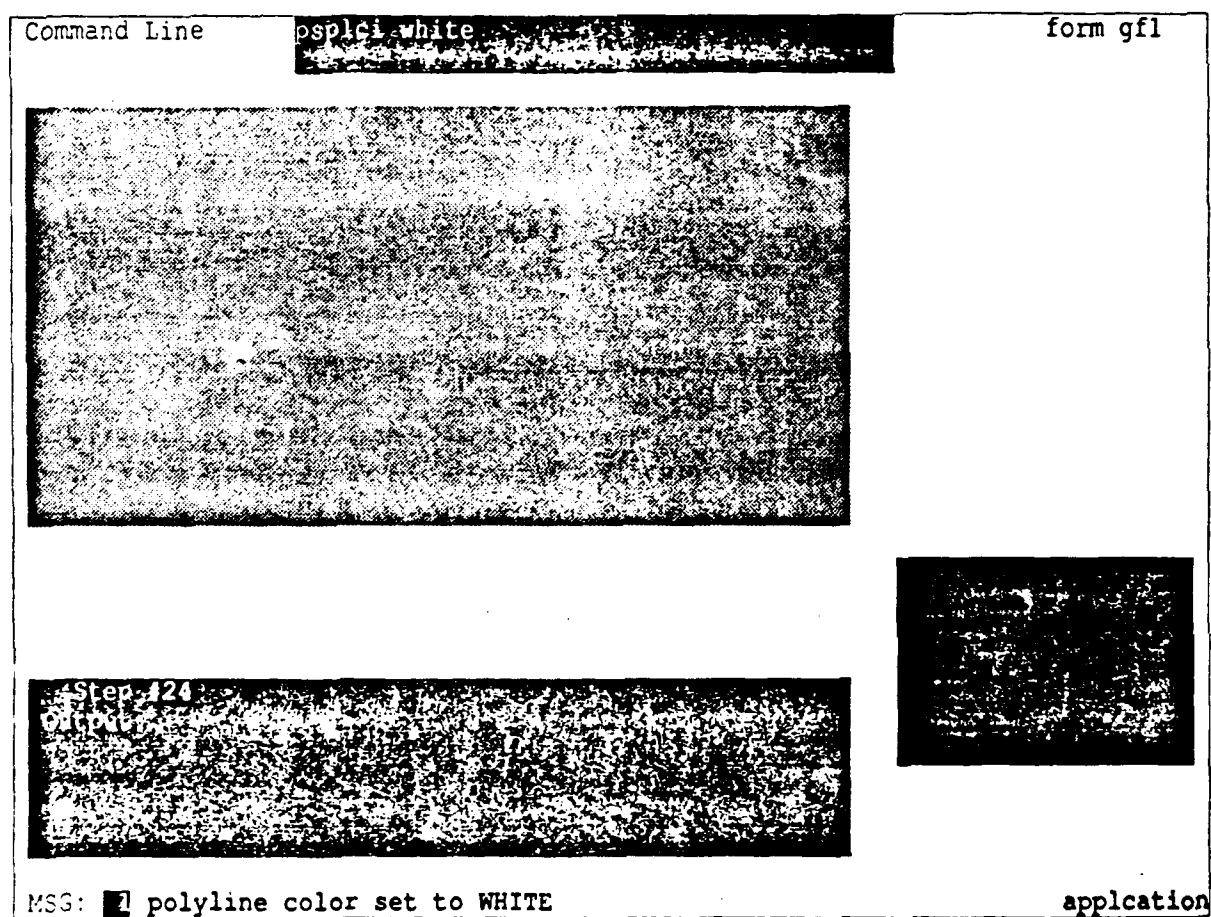


Figure 5-25b (AFTER)

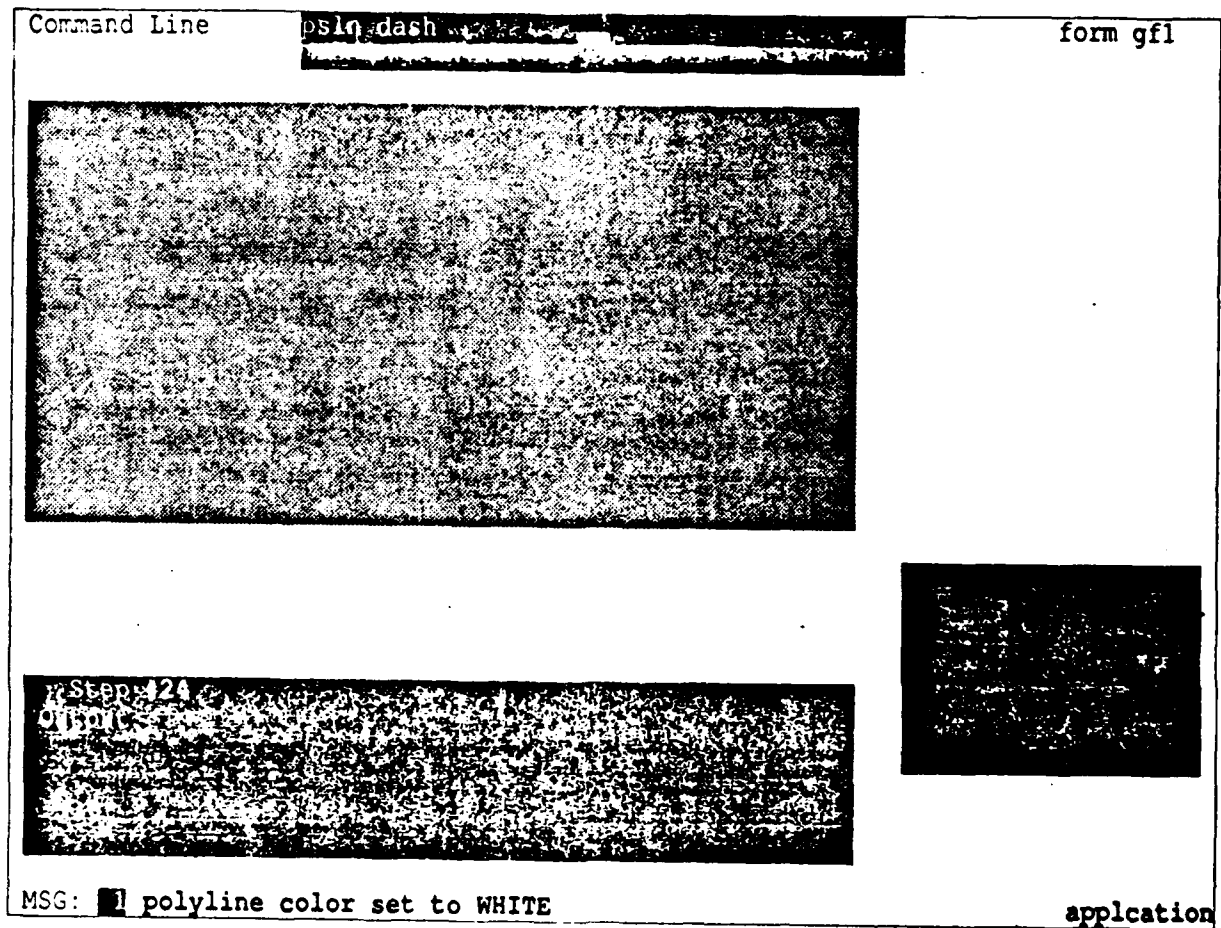


Figure 5-26a (BEFORE)

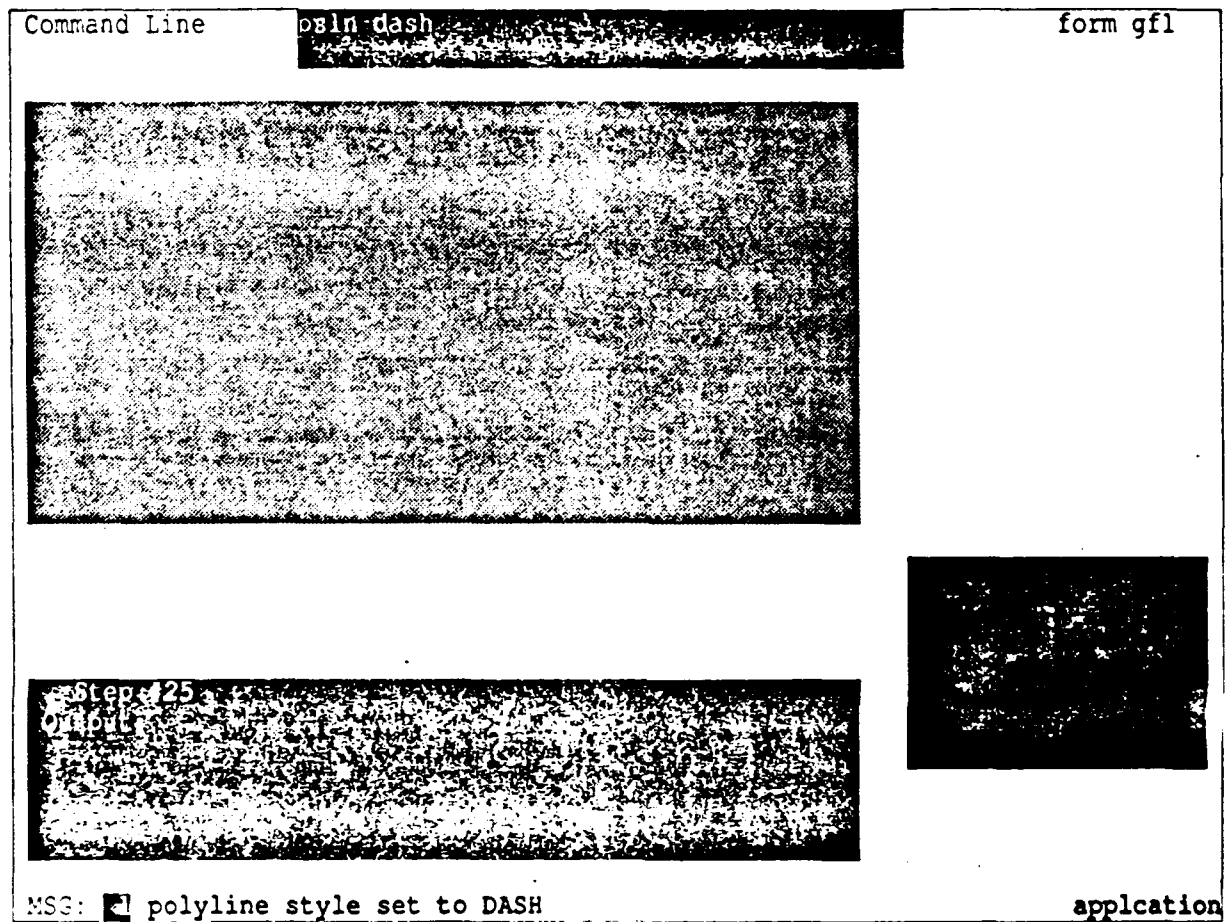


Figure 5-26b (AFTER)

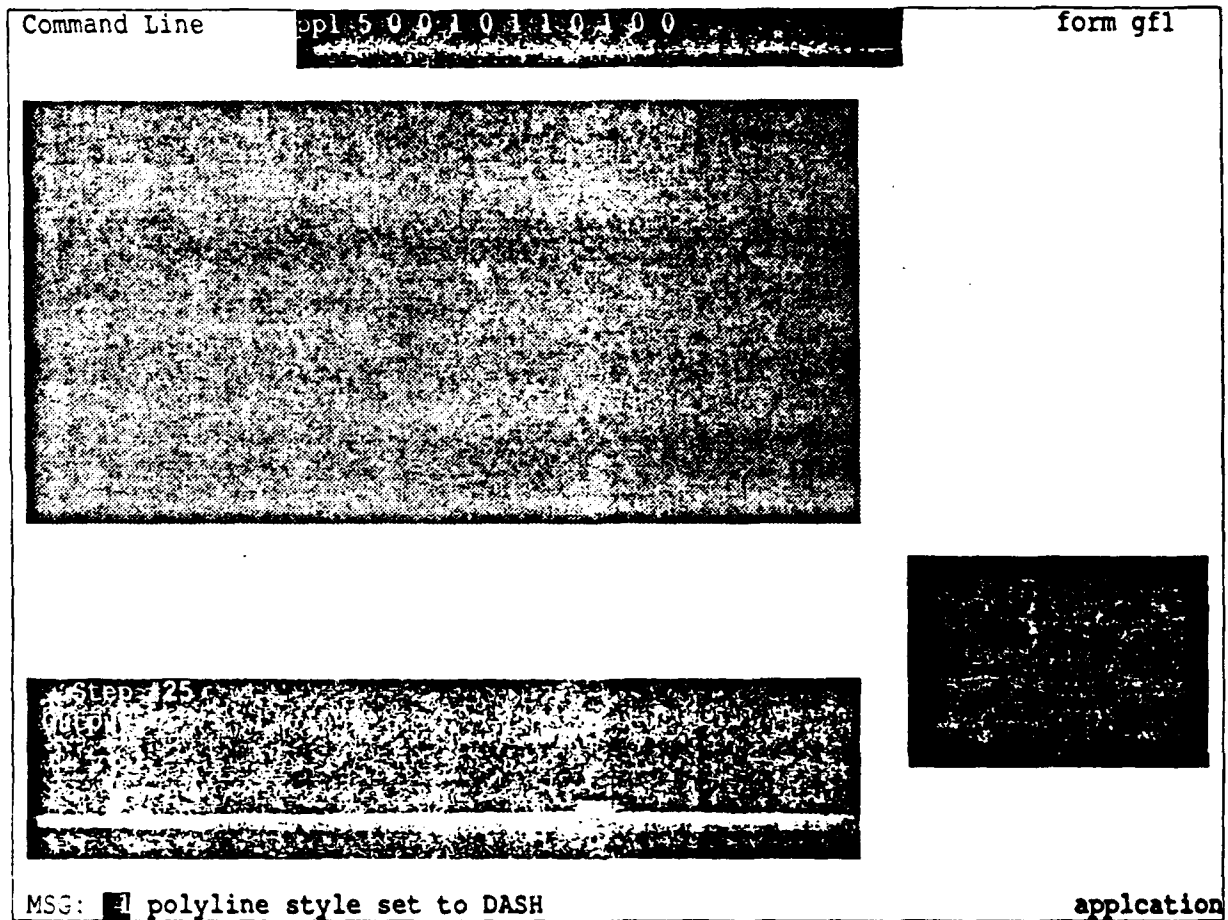


Figure 5-27a (BEFORE)

UTP 620344220
30 September 1990

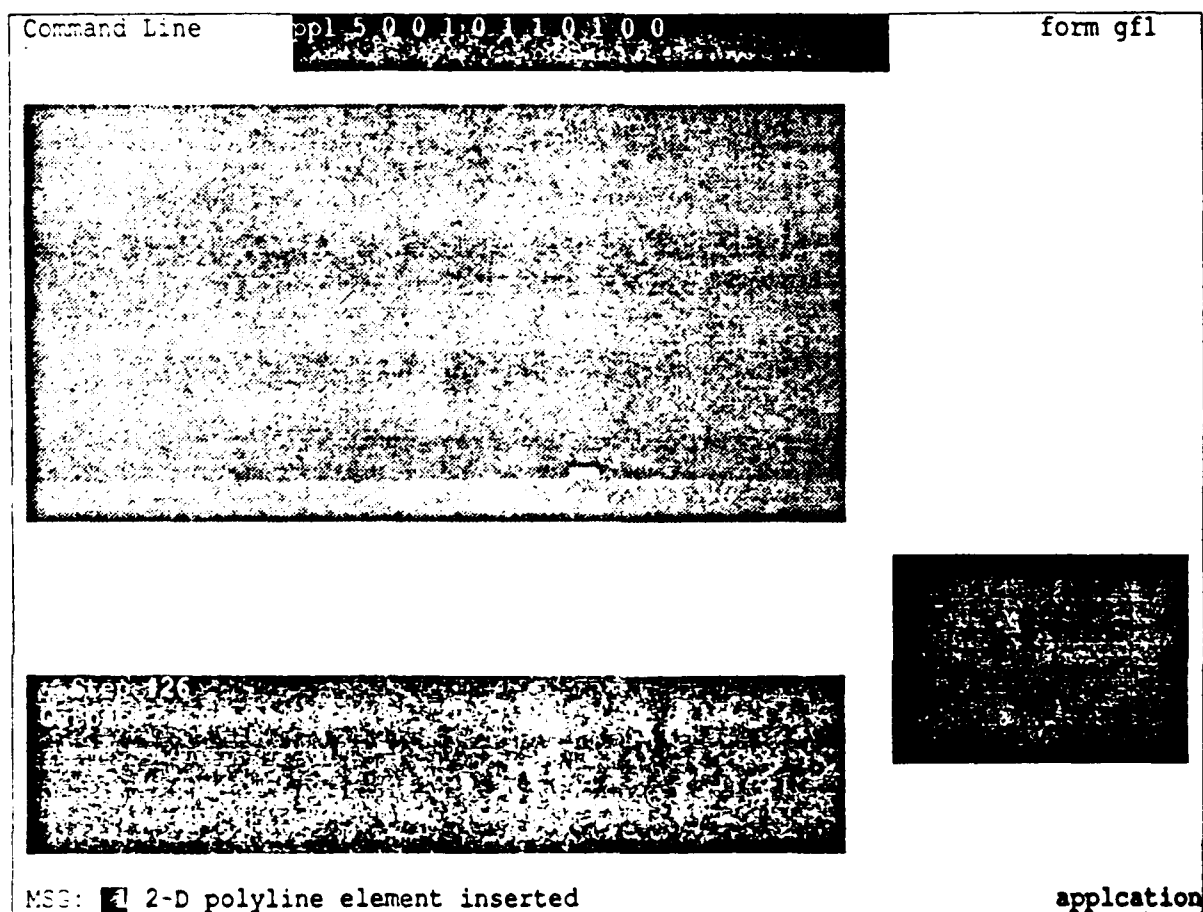


Figure 5-27b (AFTER)

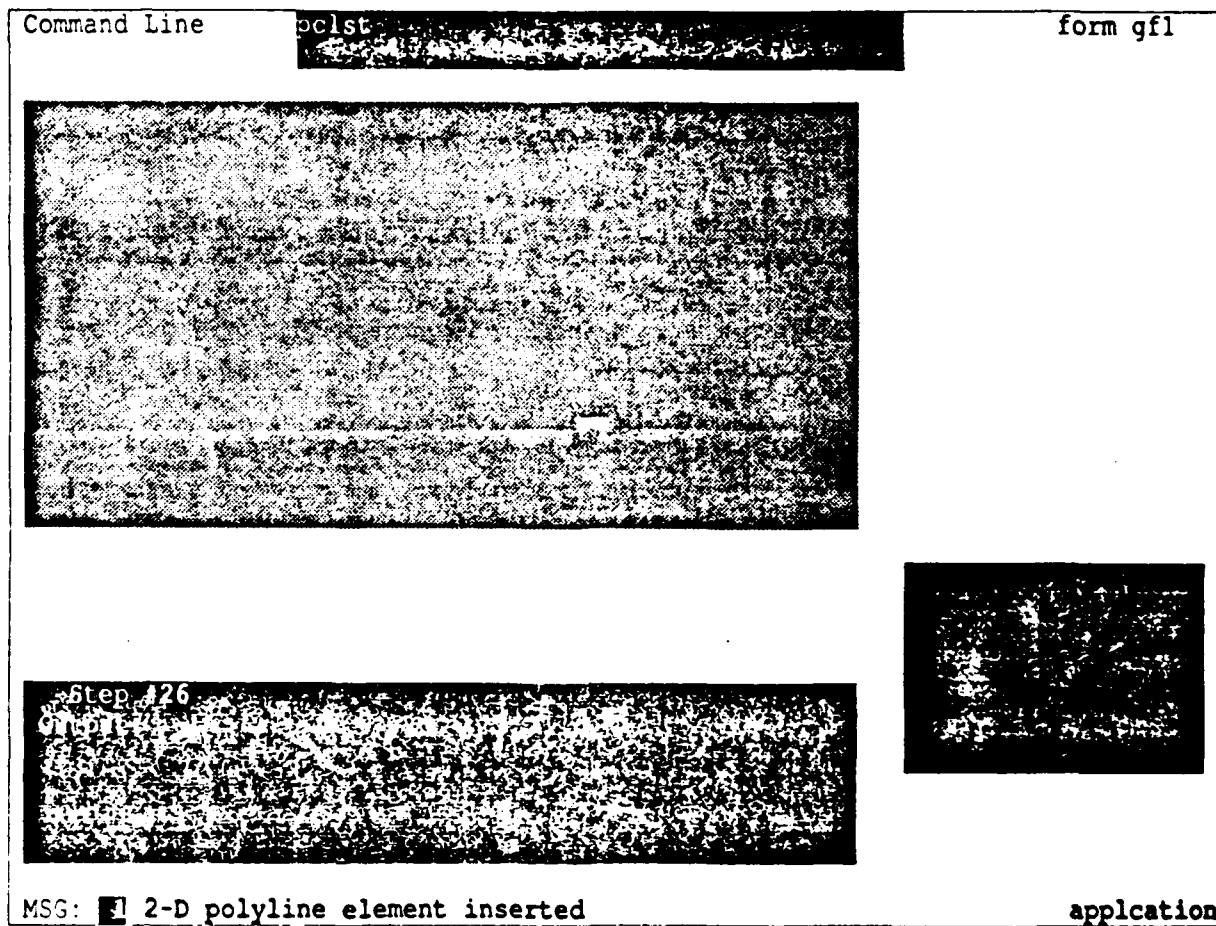


Figure 5-28a (BEFORE)

UTP 620344220
30 September 1990

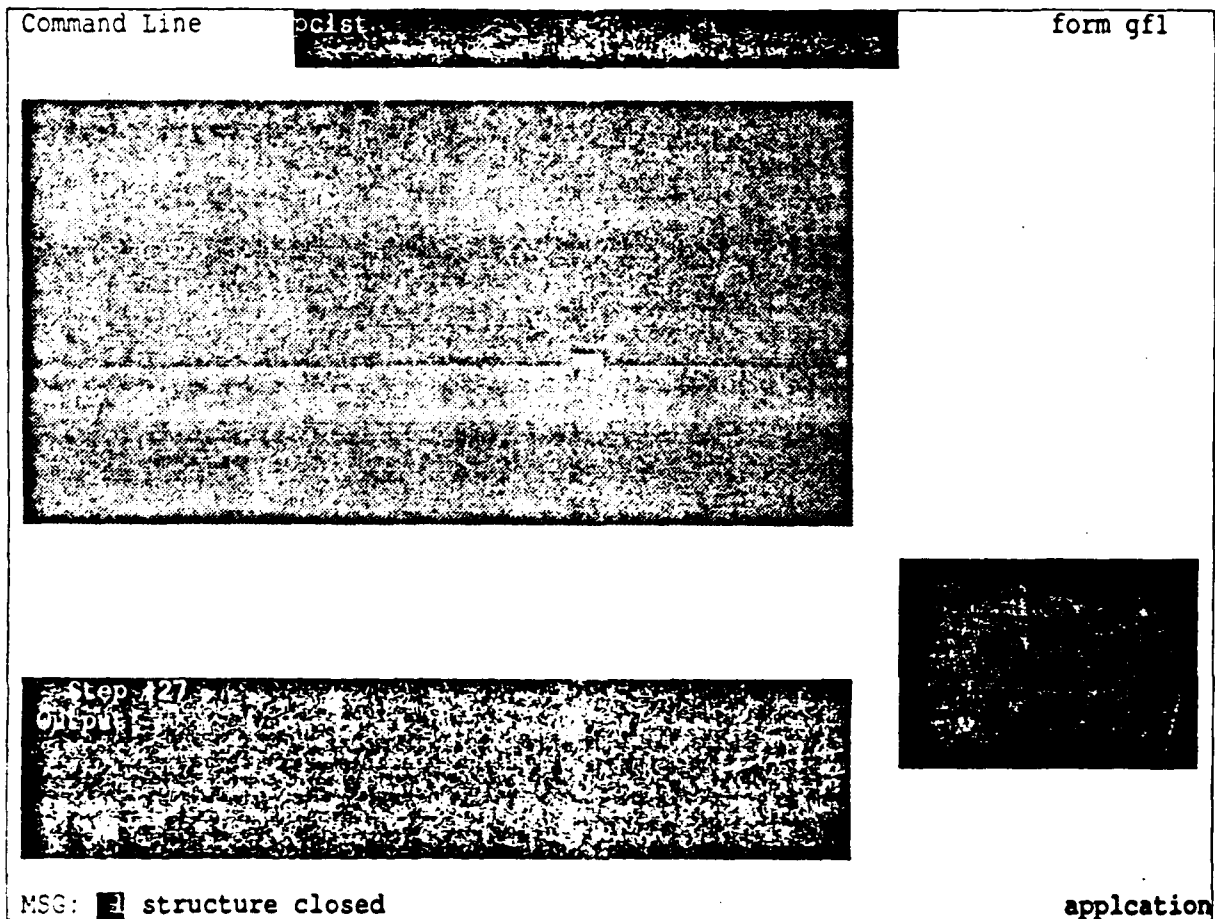


Figure 5-28b (AFTER)

UTP 620344220
30 September 1990

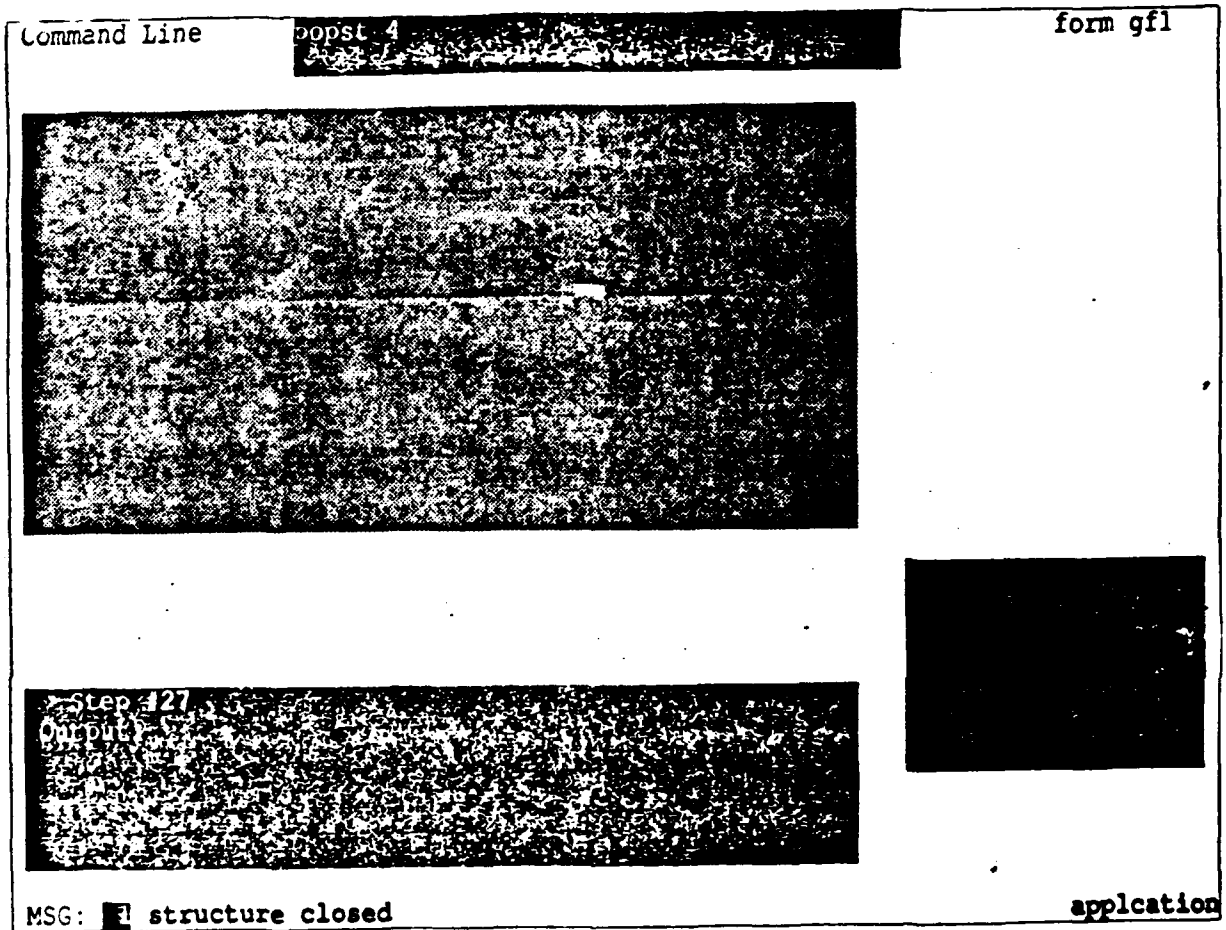


Figure 5-29a (BEFORE)

UTP 620344220
30 September 1990

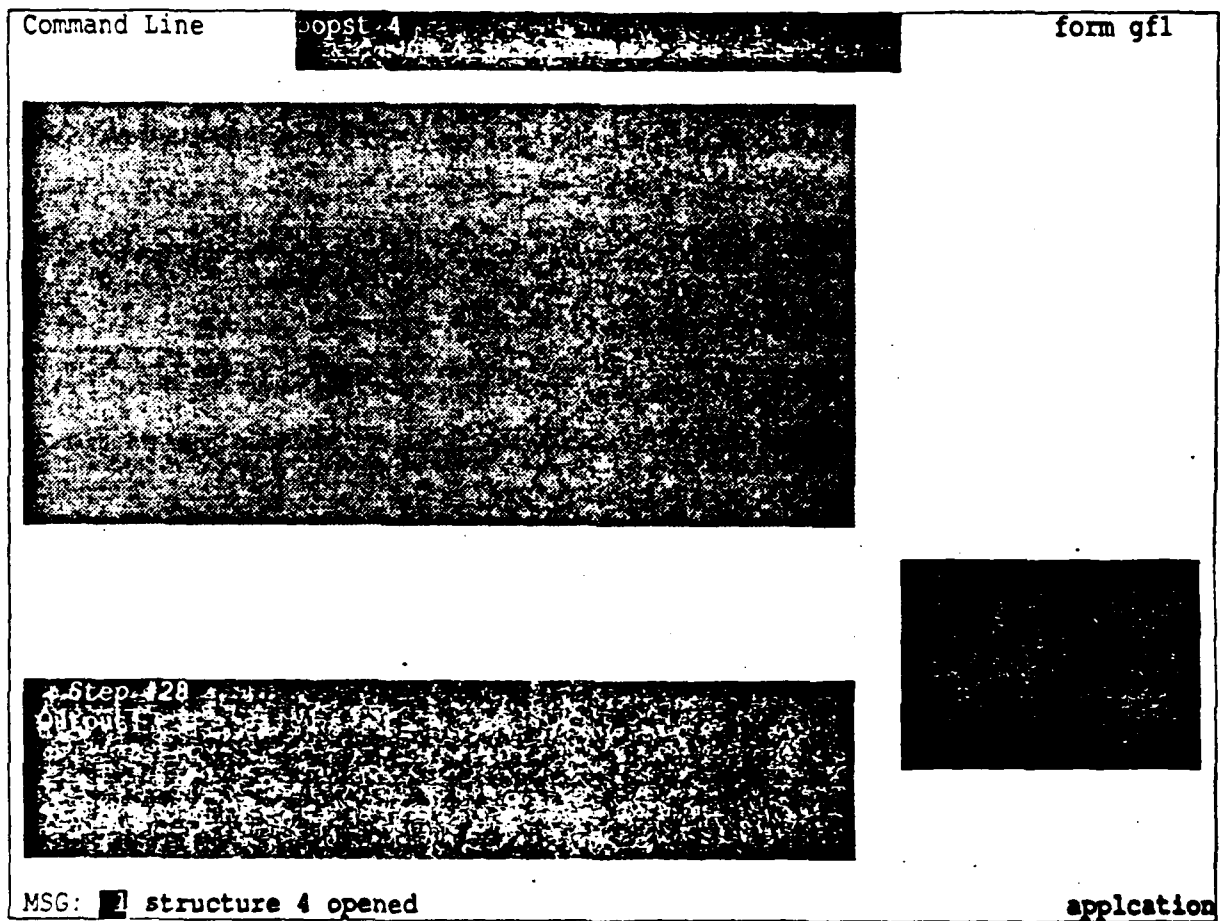


Figure 5-29b (AFTER)

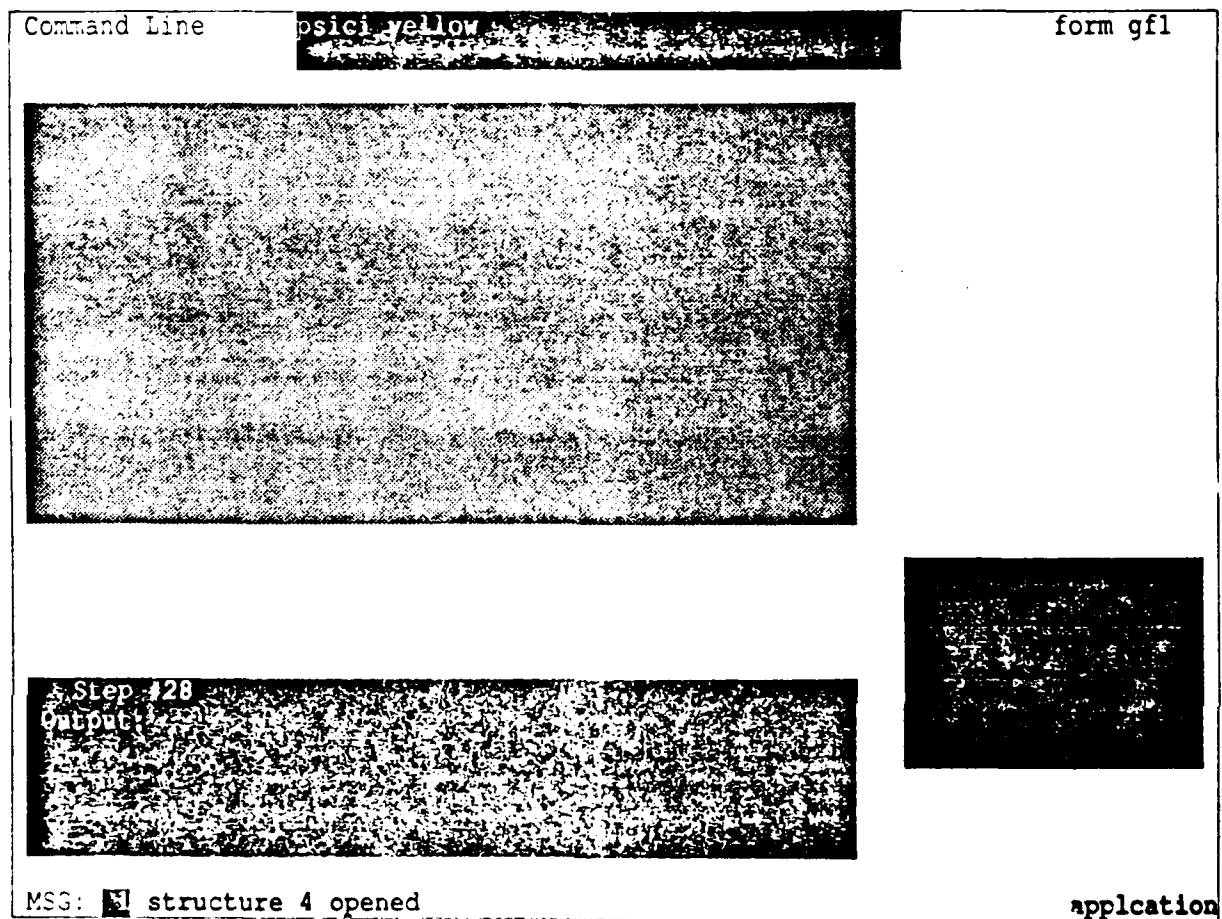


Figure 5-30a (BEFORE)

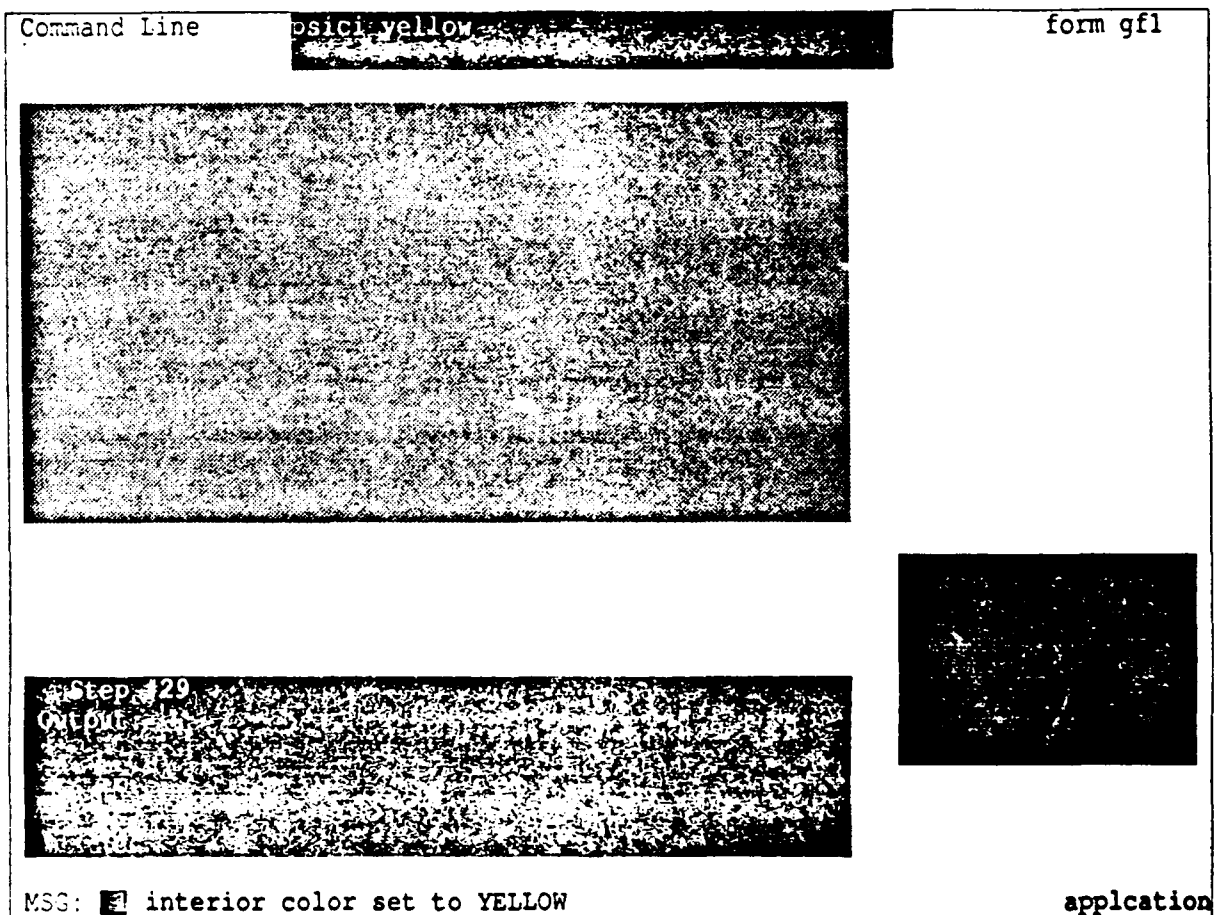


Figure 5-30b (AFTER)

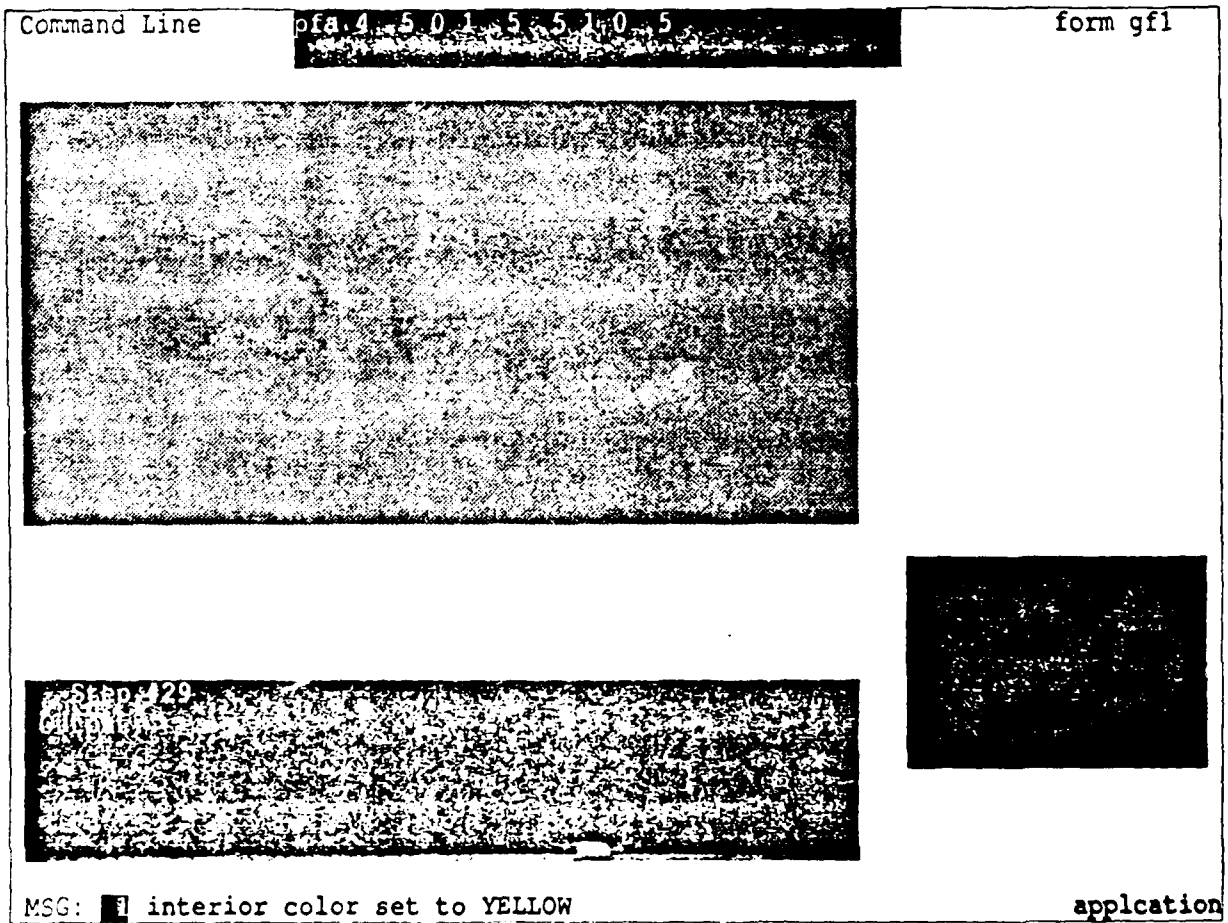


Figure 5-31a (BEFORE)

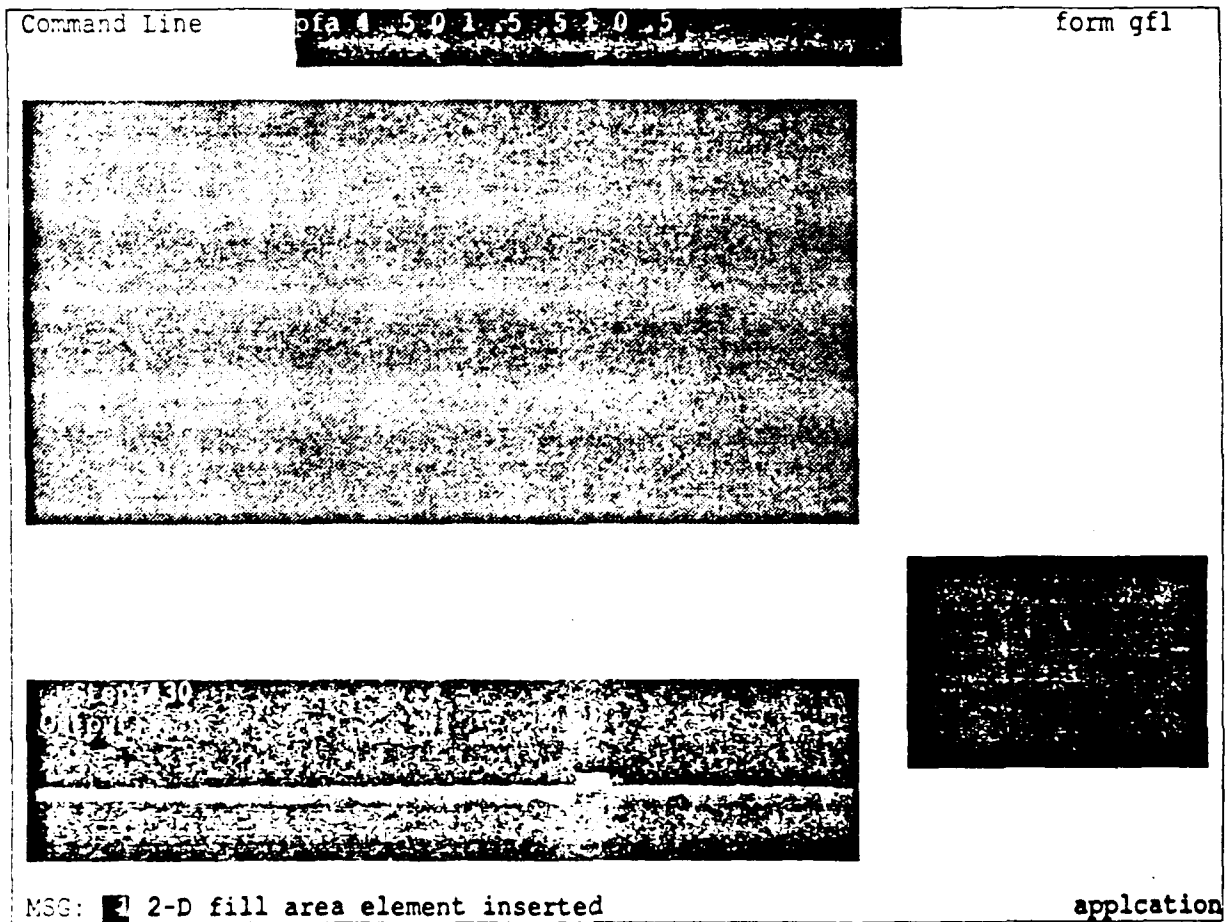


Figure 5-31b (AFTER)

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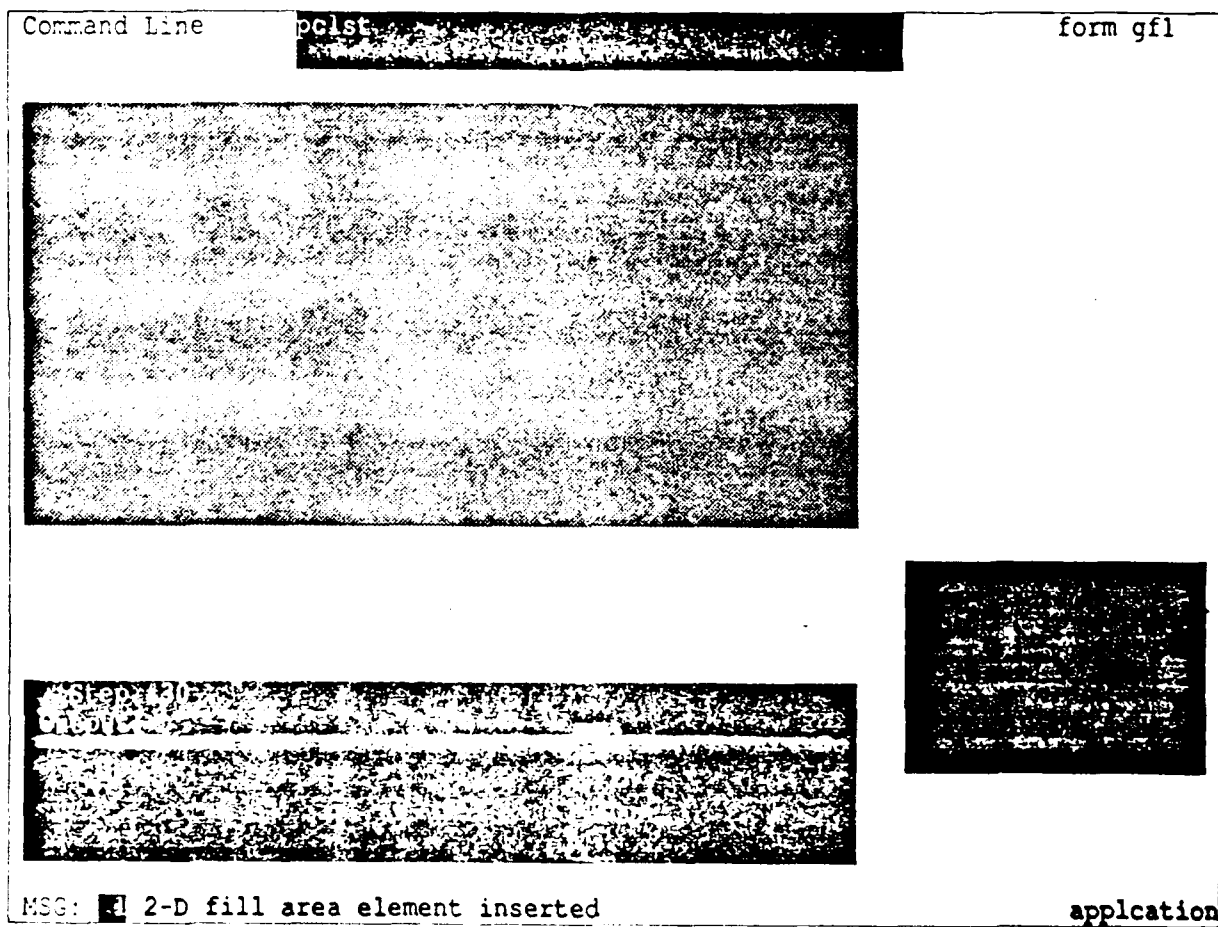


Figure 5-32a (BEFORE)

UTP 620344220
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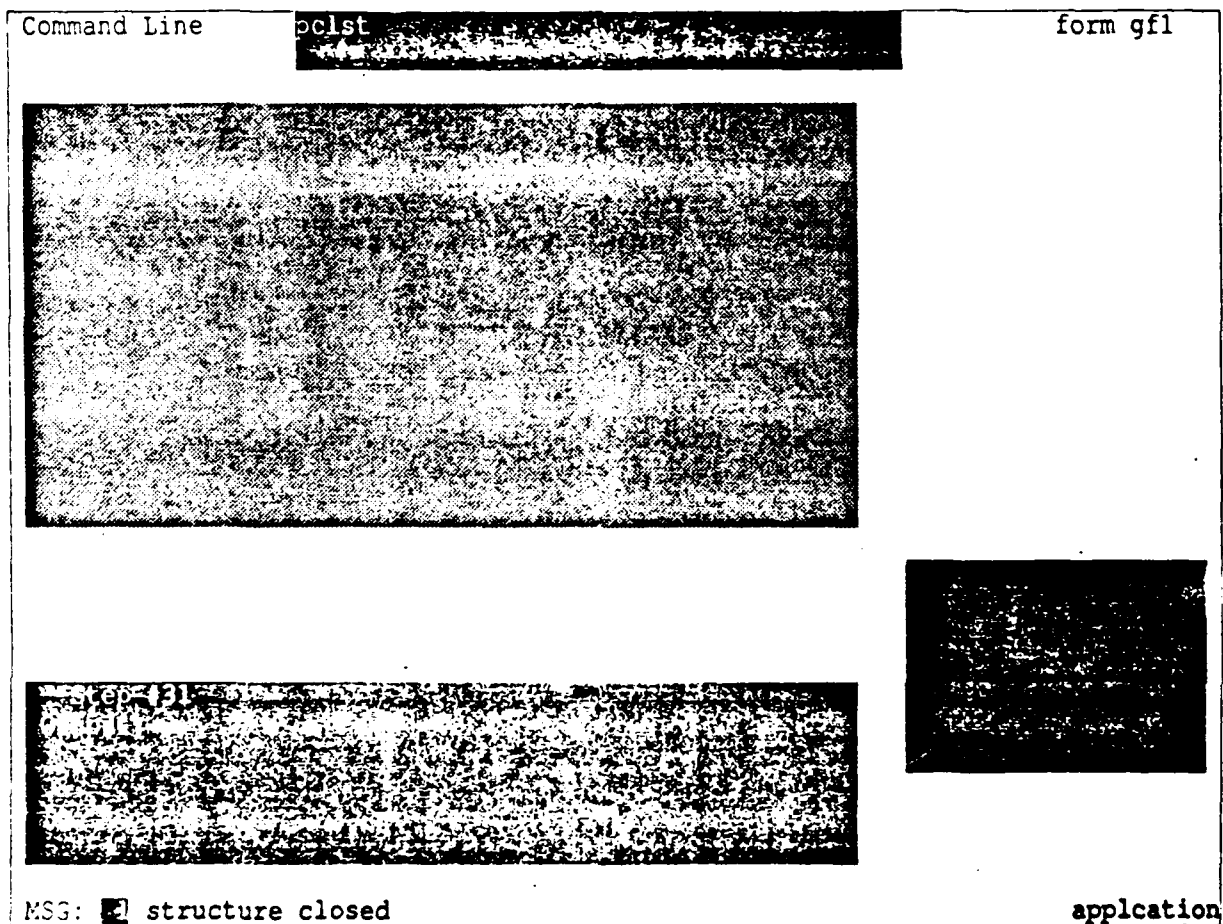


Figure 5-32b (AFTER)

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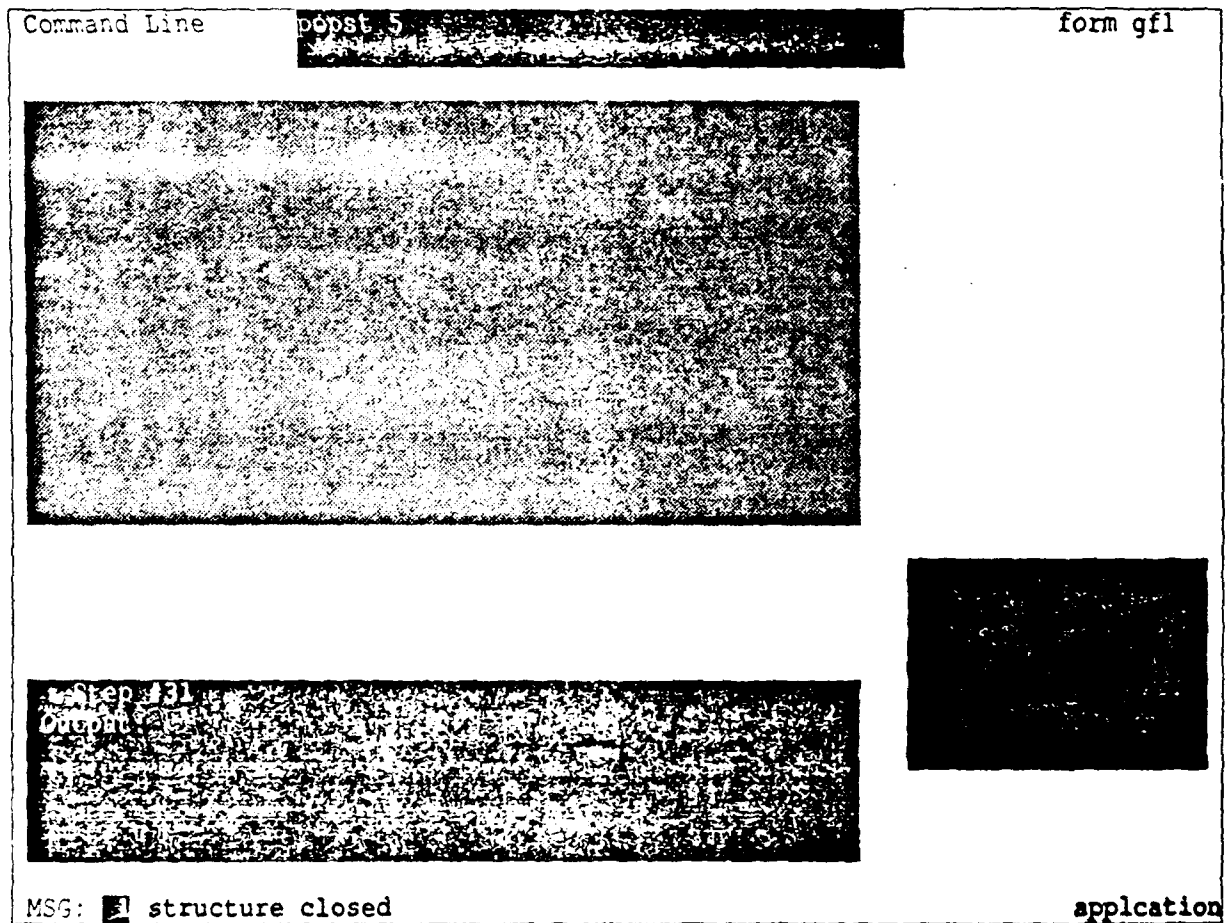


Figure 5-33a (BEFORE)

UTP 620344220
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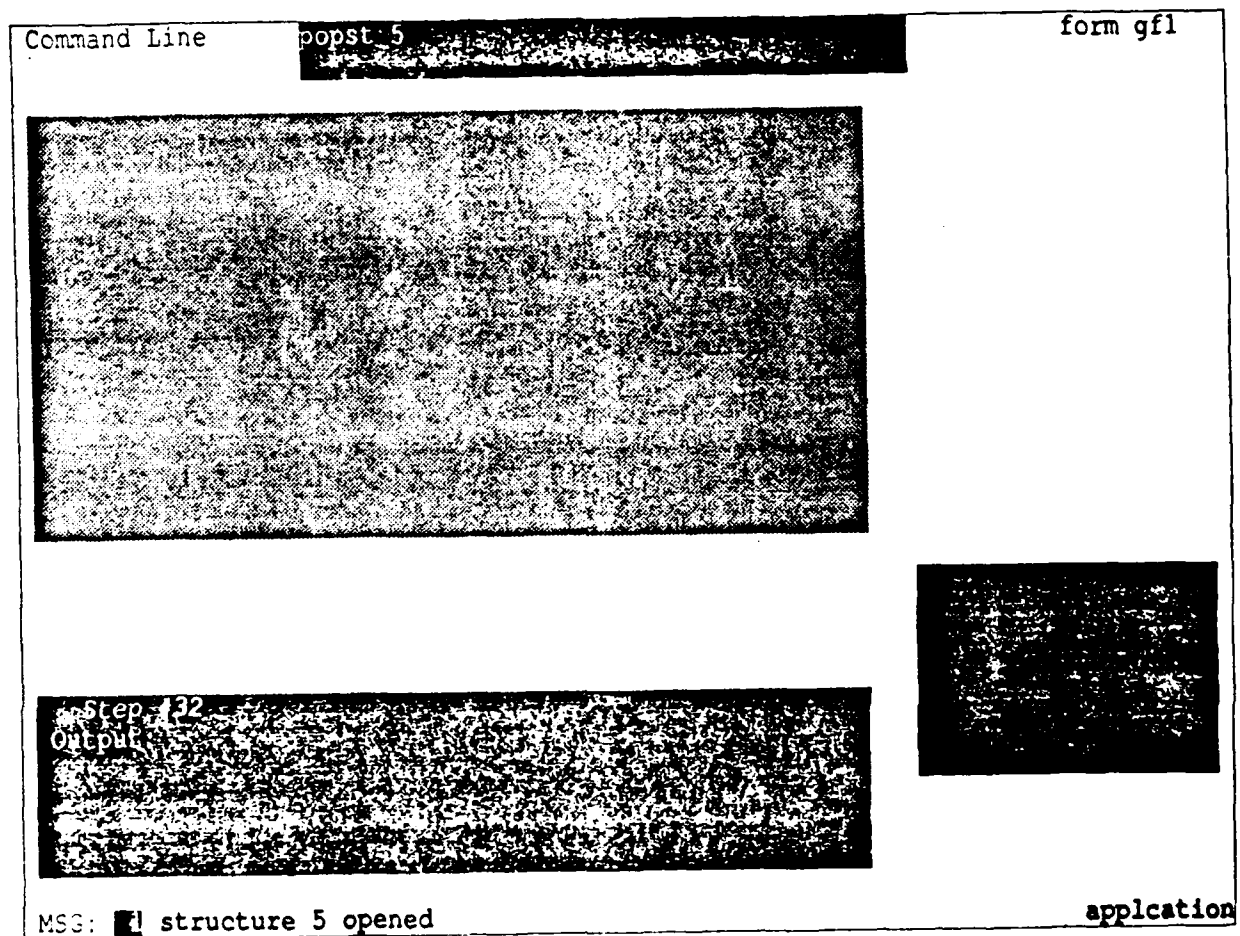


Figure 5-33b (AFTER)

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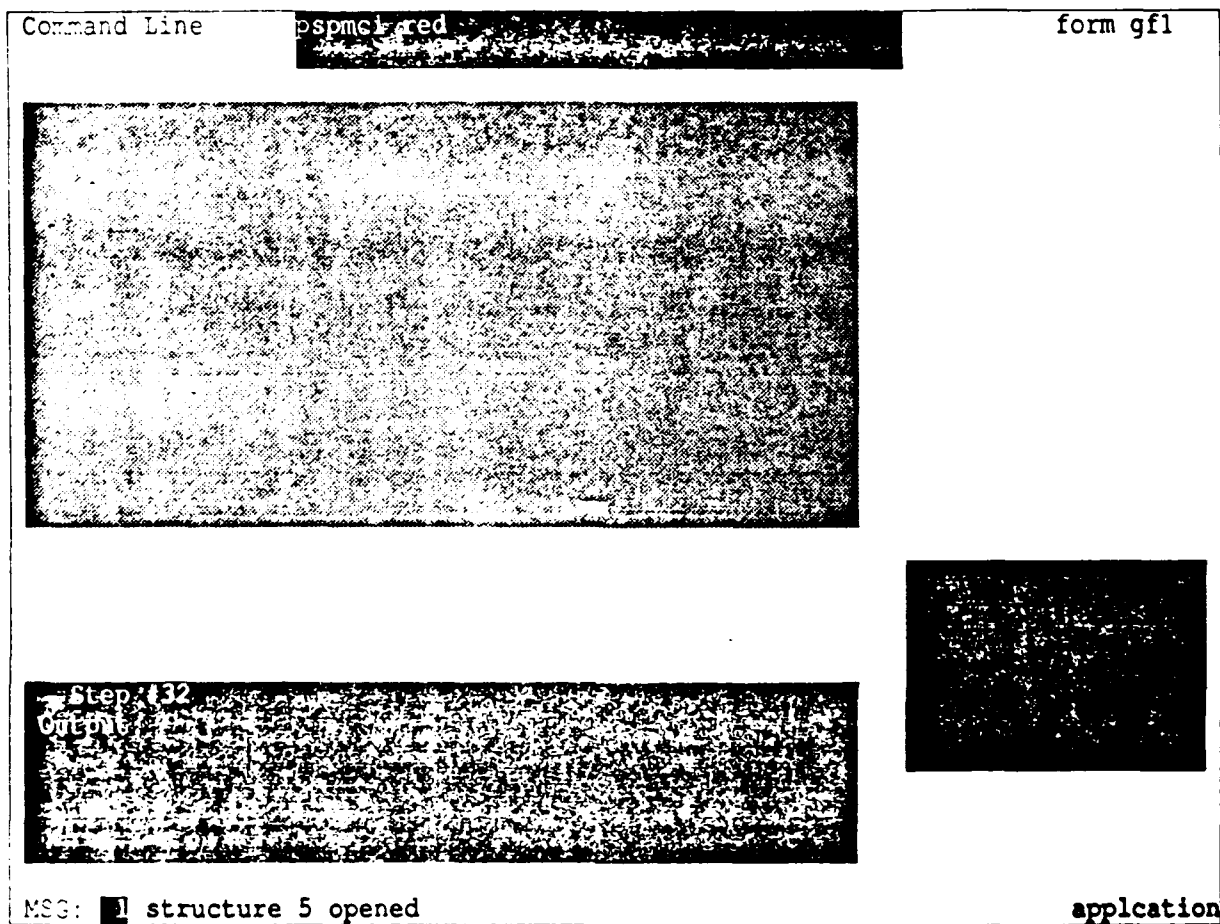


Figure 5-34a (BEFORE)

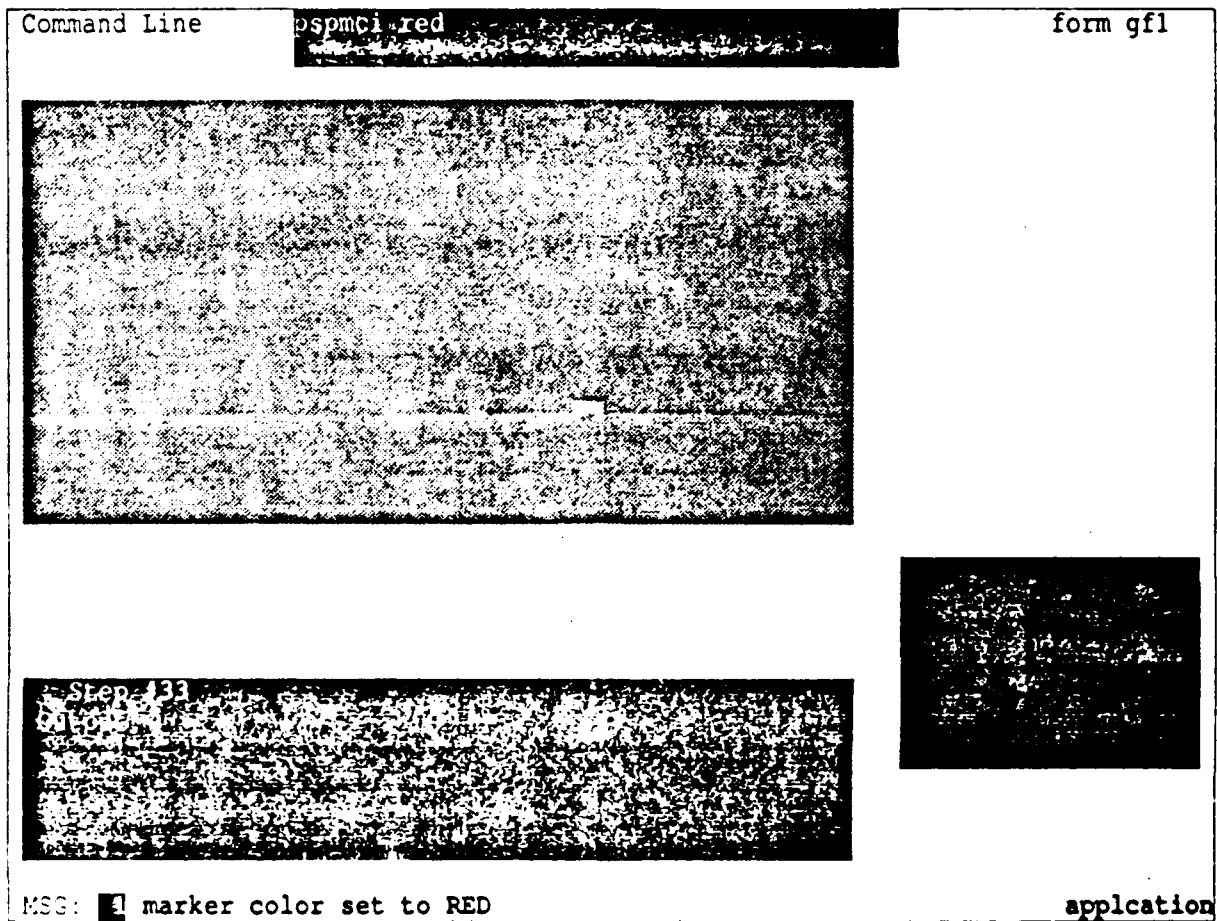


Figure 5-34b (AFTER)

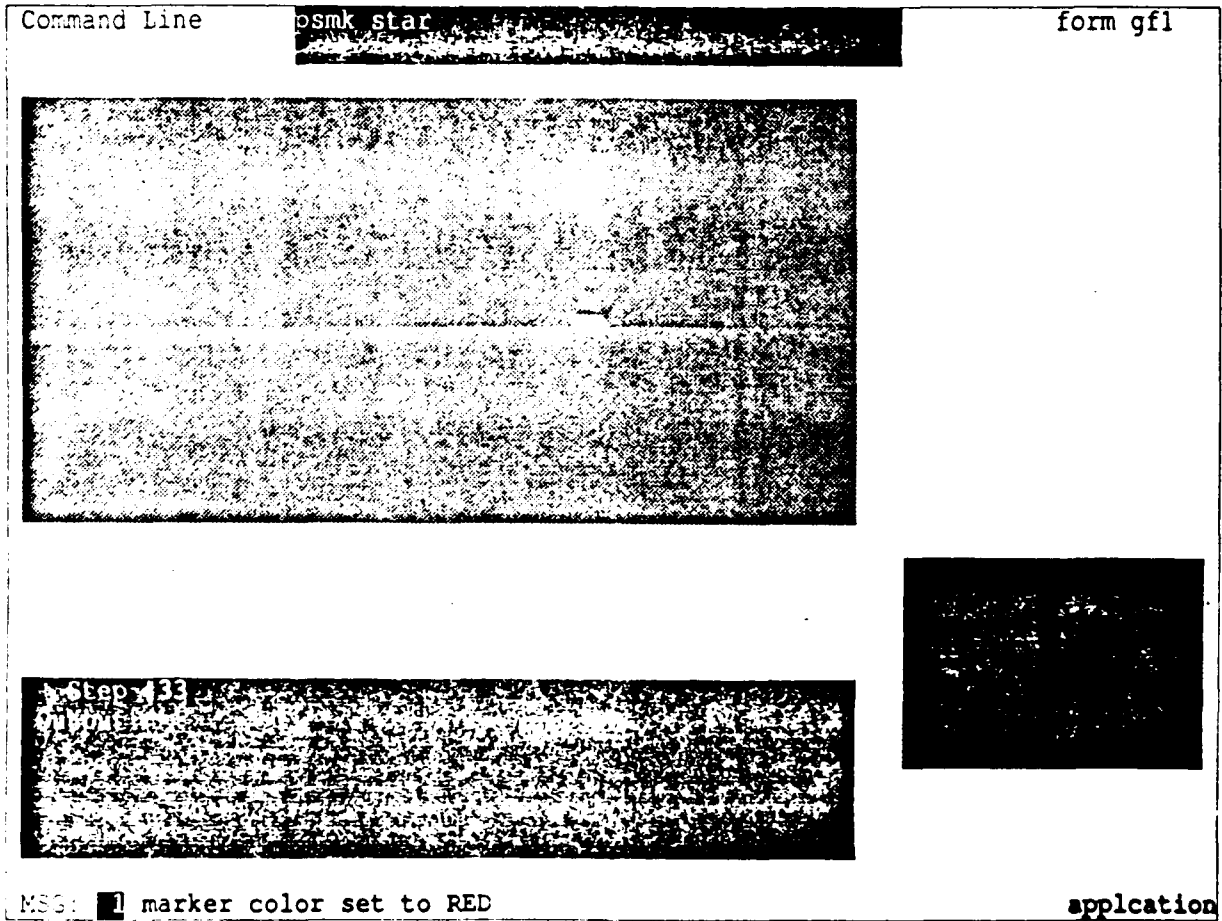


Figure 5-35a (BEFORE)

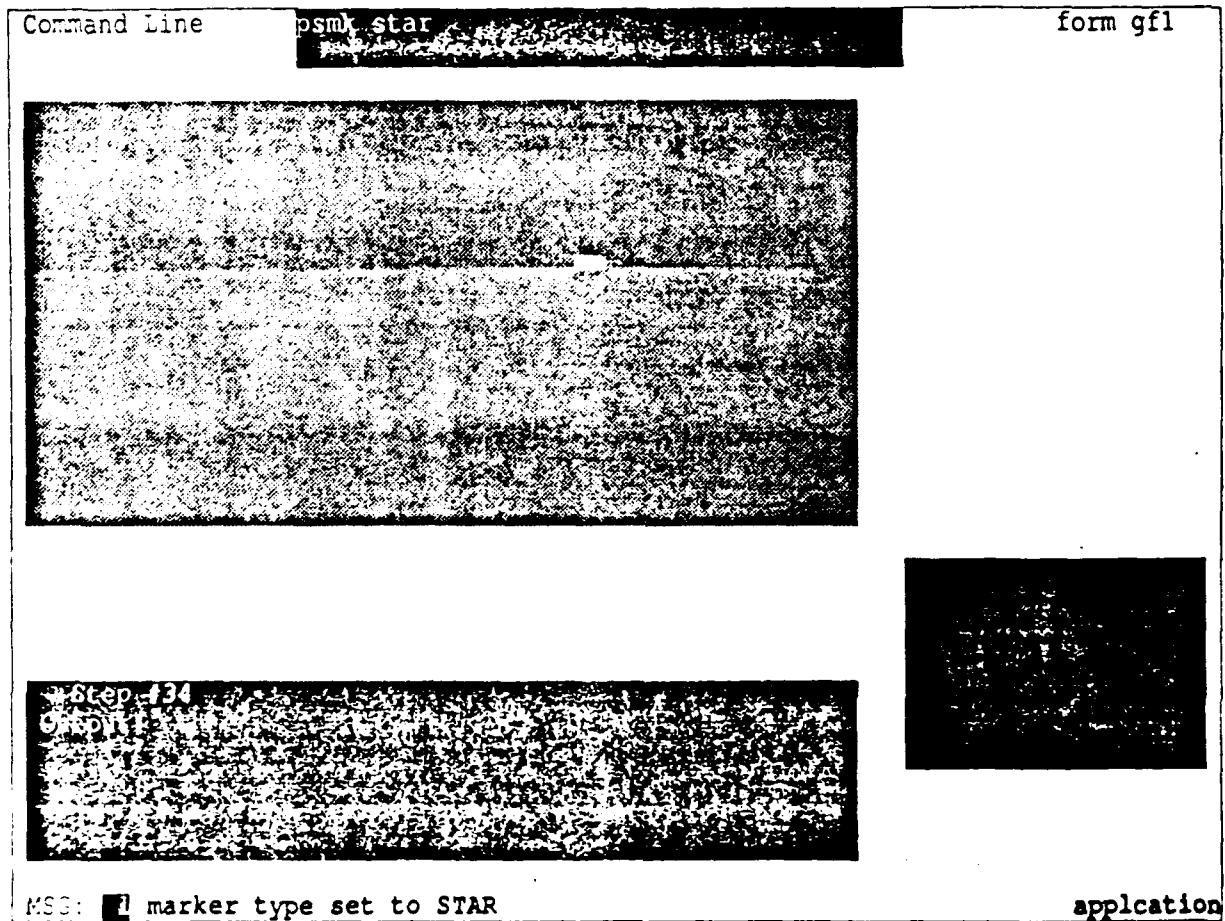


Figure 5-35b (AFTER)

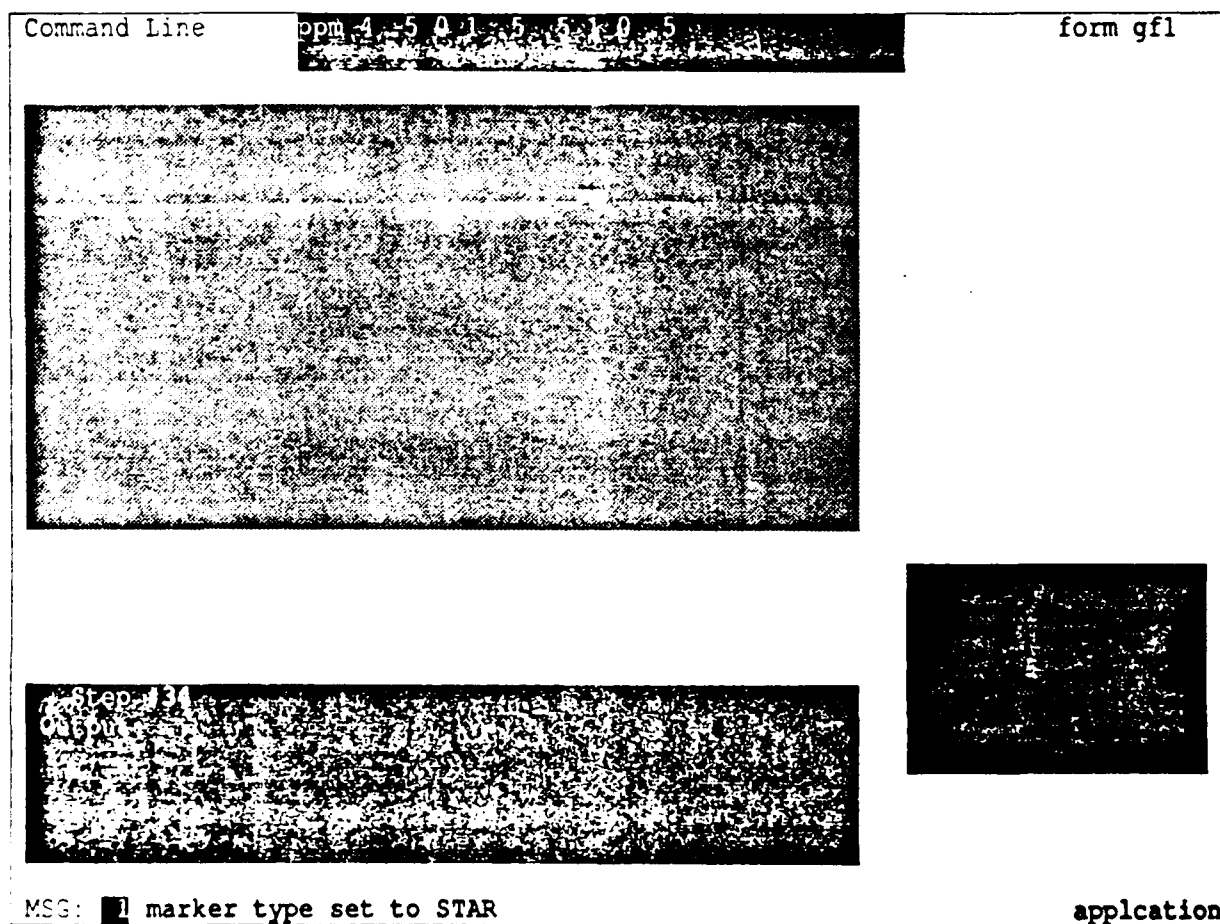


Figure 5-36a (BEFORE)

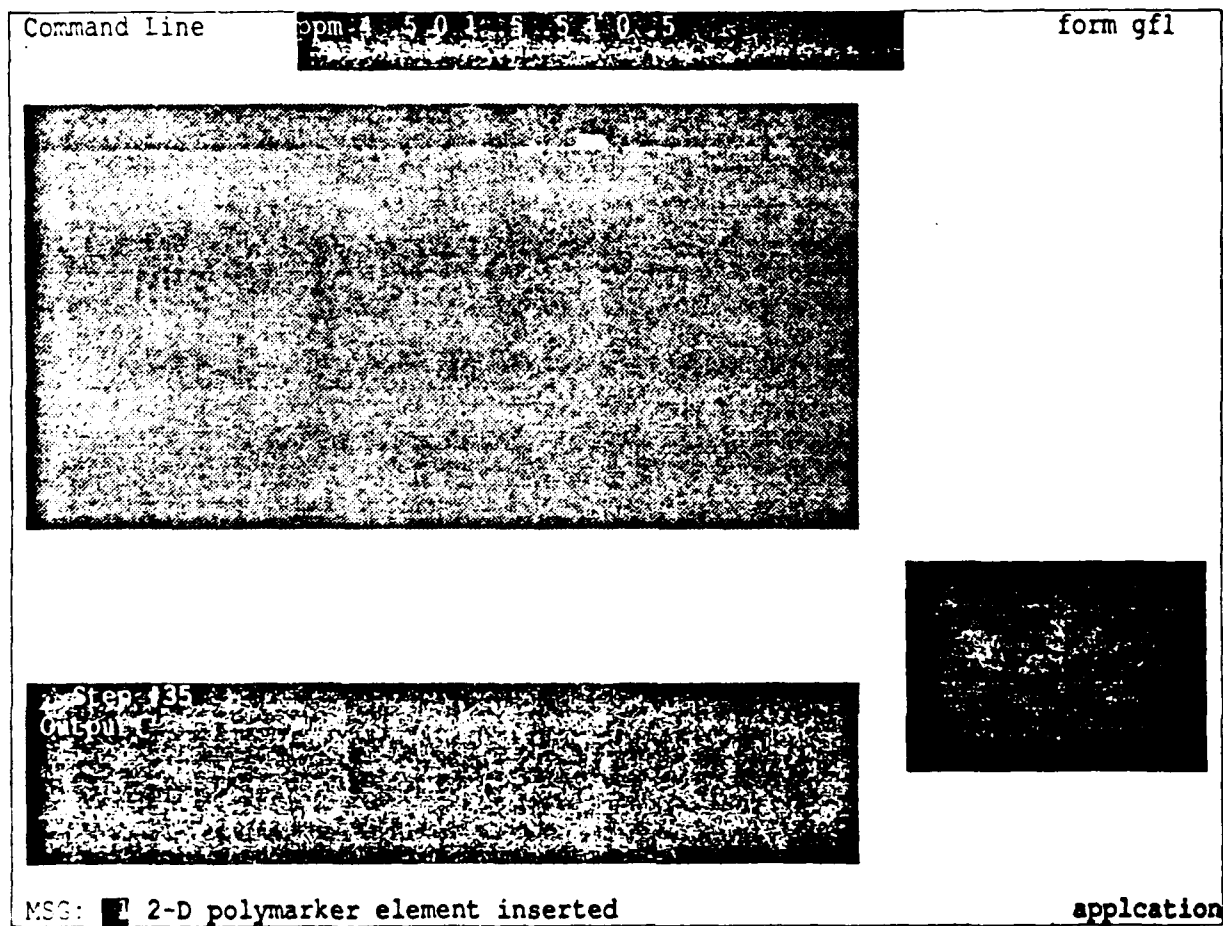


Figure 5-36b (AFTER)

UTP 620344220
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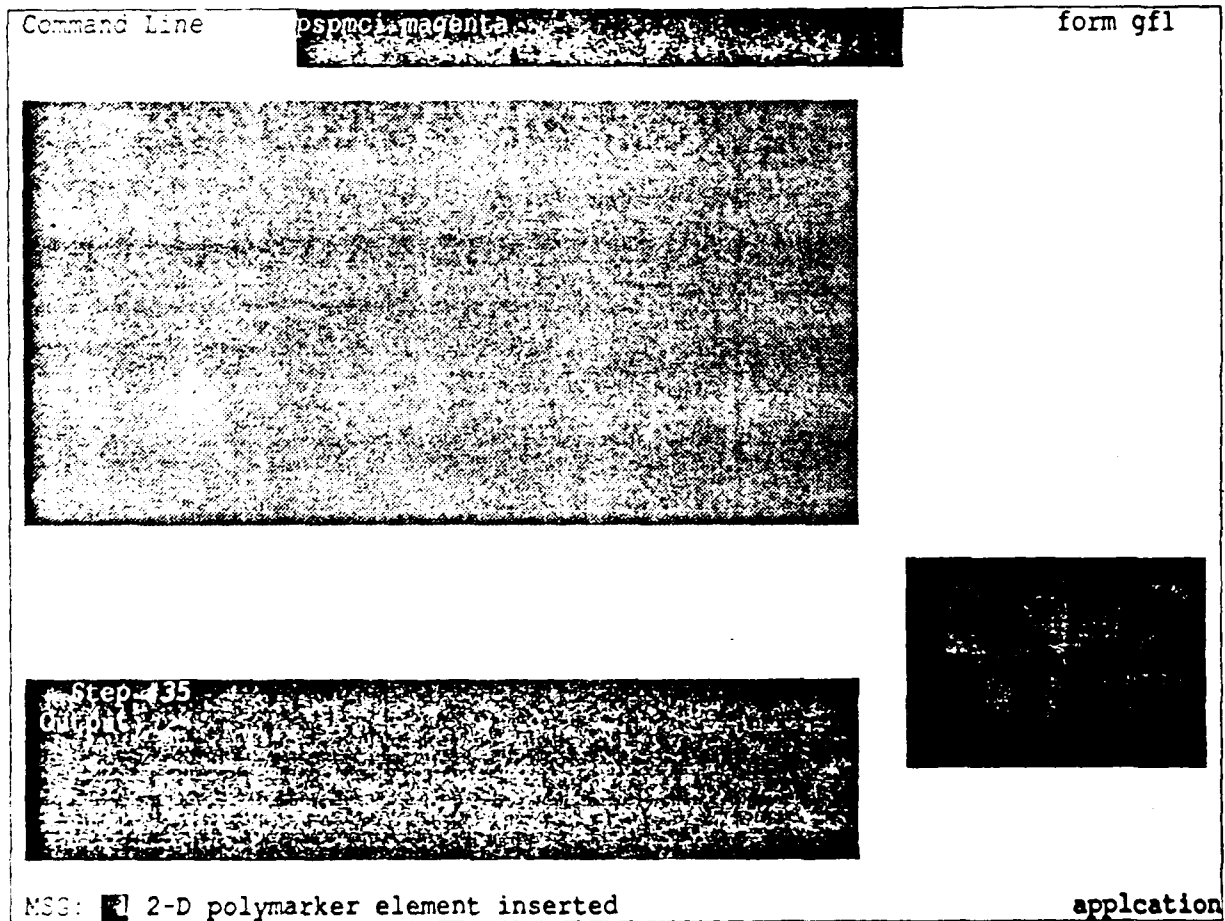


Figure 5-37a (BEFORE)

UTP 620344220
30 September 1990

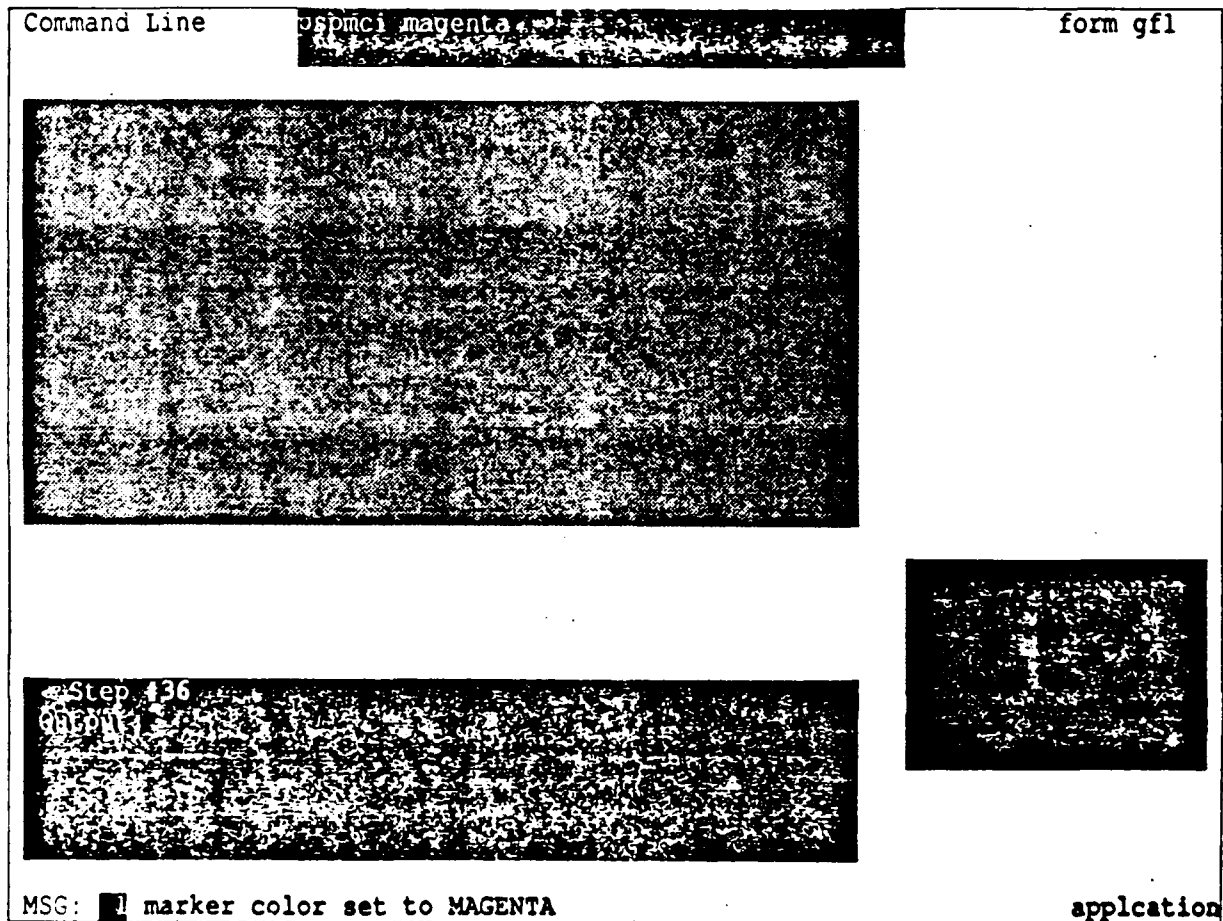


Figure 5-37b (AFTER)

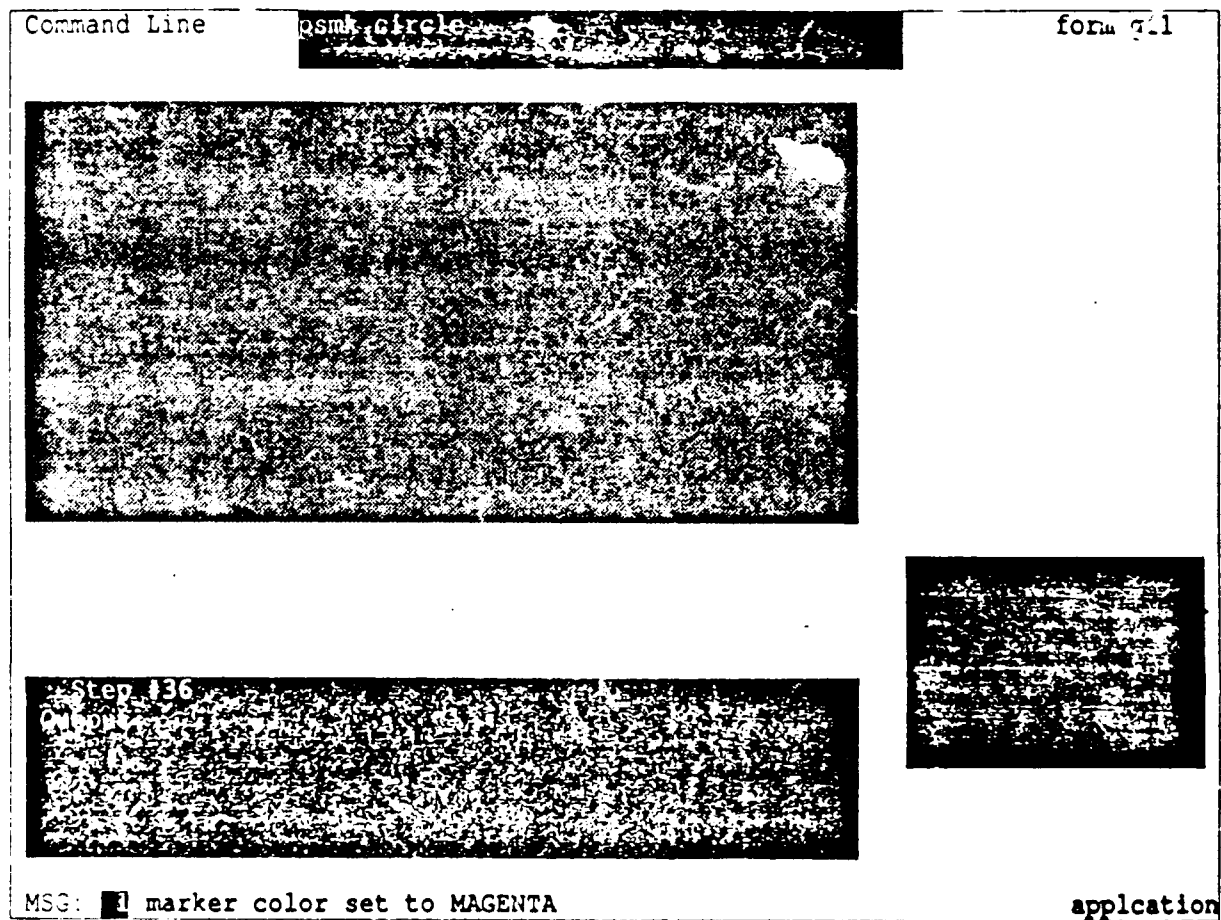


Figure 5-38a (BEFORE)

UTP 620344220
30 September 1990

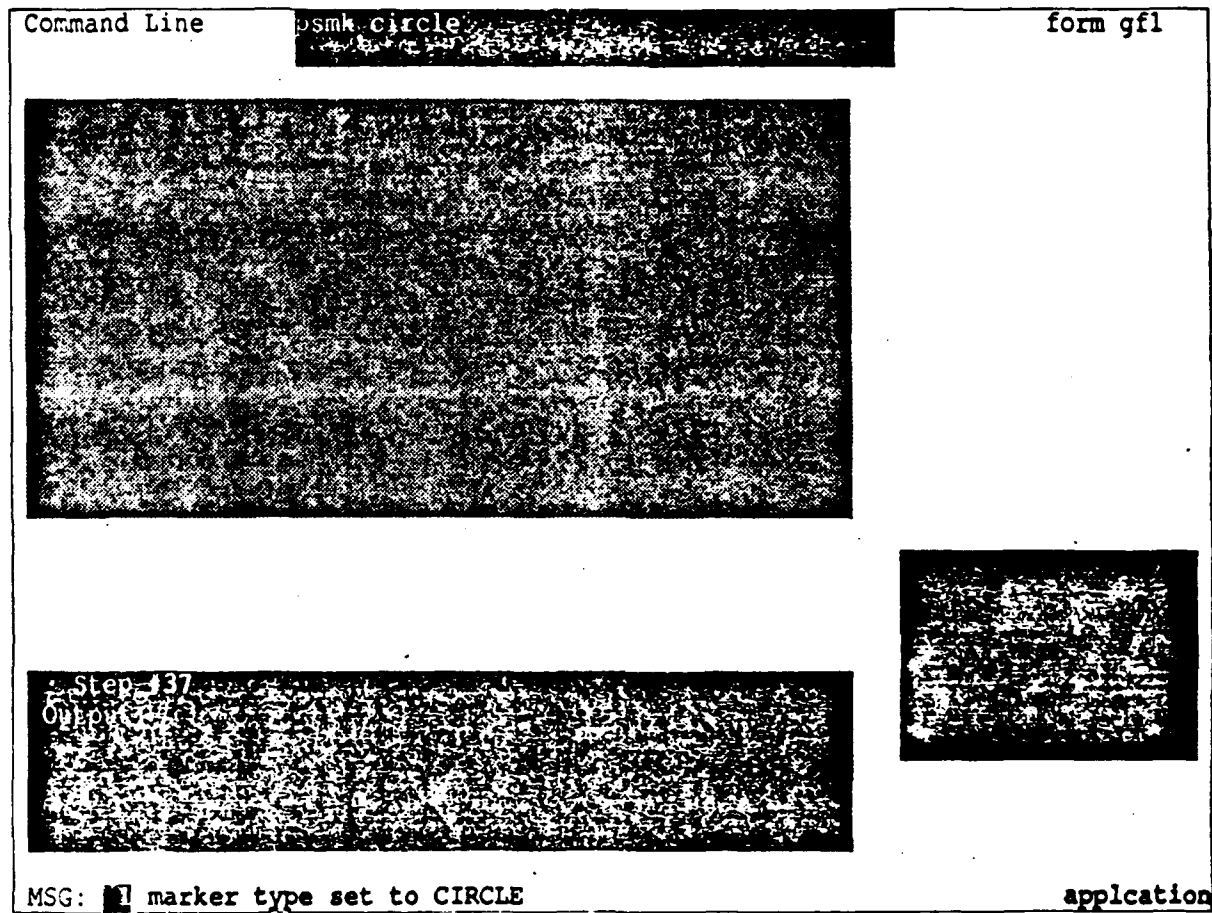


Figure 5-38b (AFTER)

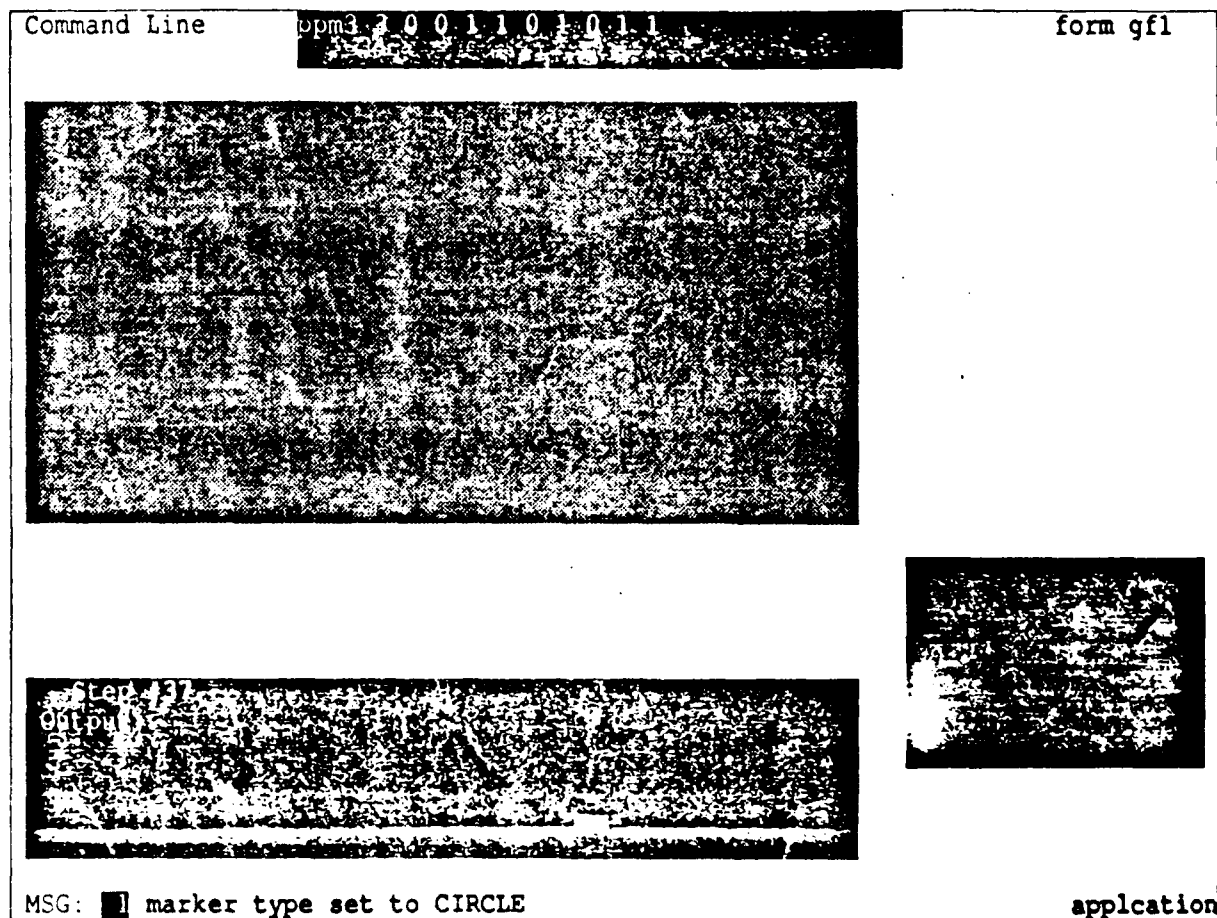


Figure 5-39a (BEFORE)

UTP 620344220
30 September 1990

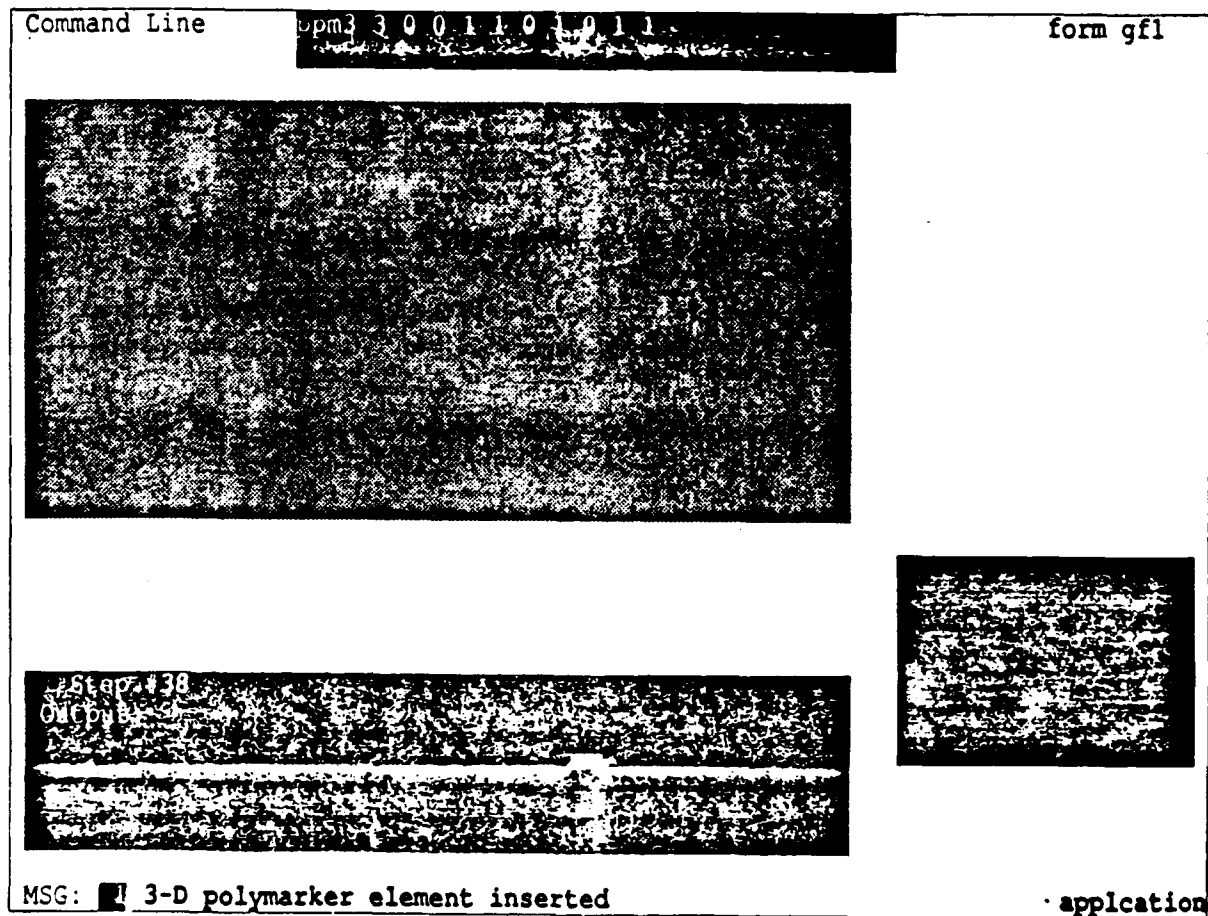


Figure 5-39b (AFTER)

UTP 620344220
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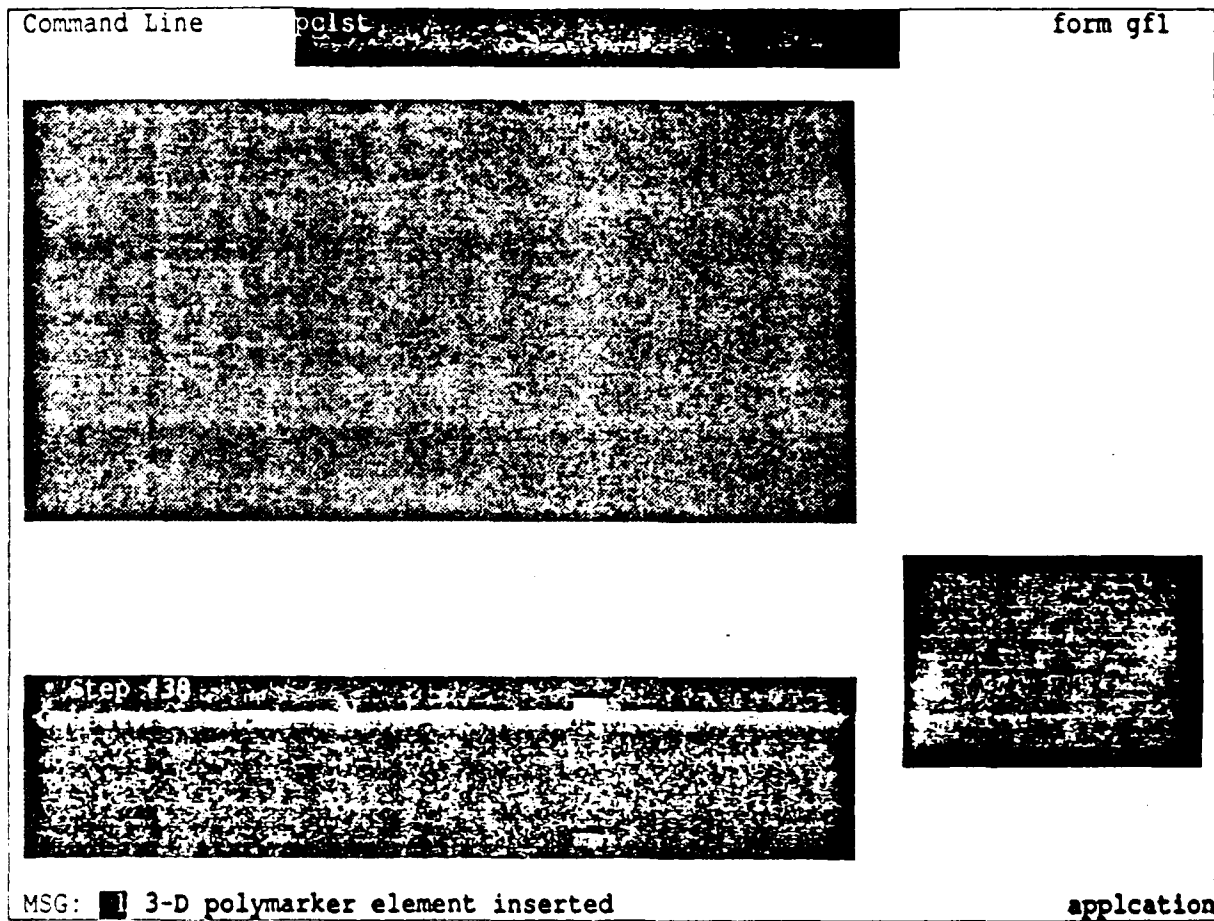


Figure 5-40a (BEFORE)

UTP 620344220
30 September 1990

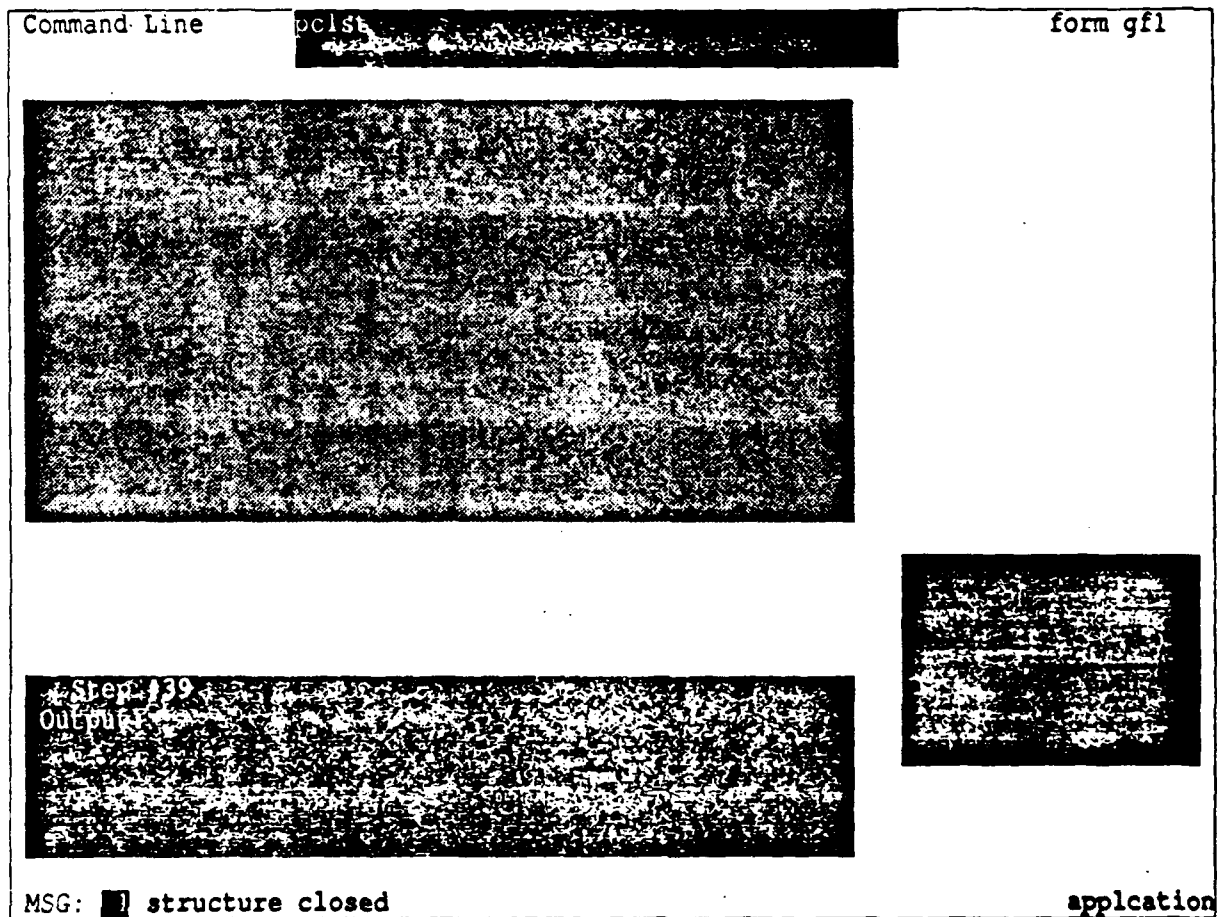


Figure 5-40b (AFTER)

UTP 620344220
30 September 1990

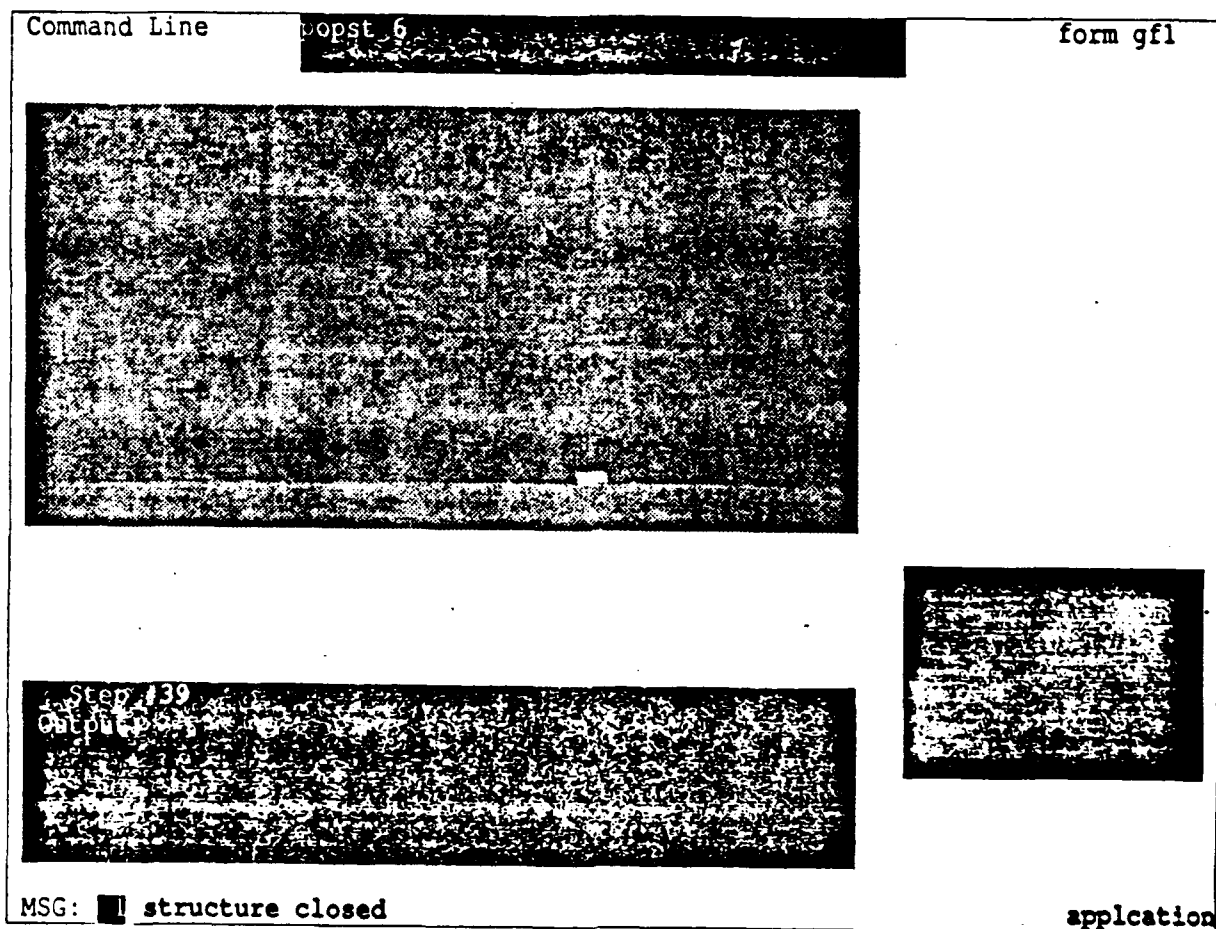


Figure 5-41a (BEFORE)

UTP 620344220
30 September 1990

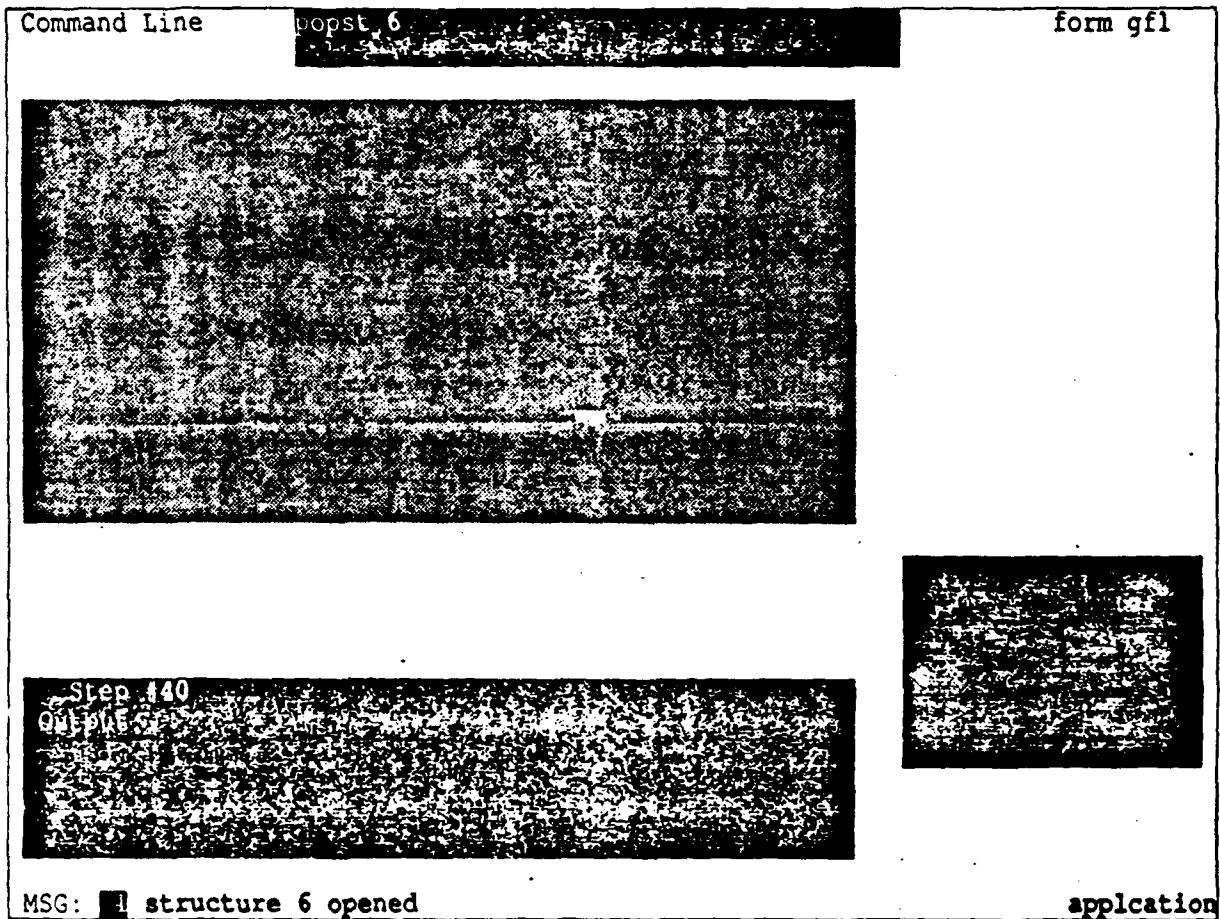


Figure 5-41b (AFTER)

UTP 620344220
30 September 1990

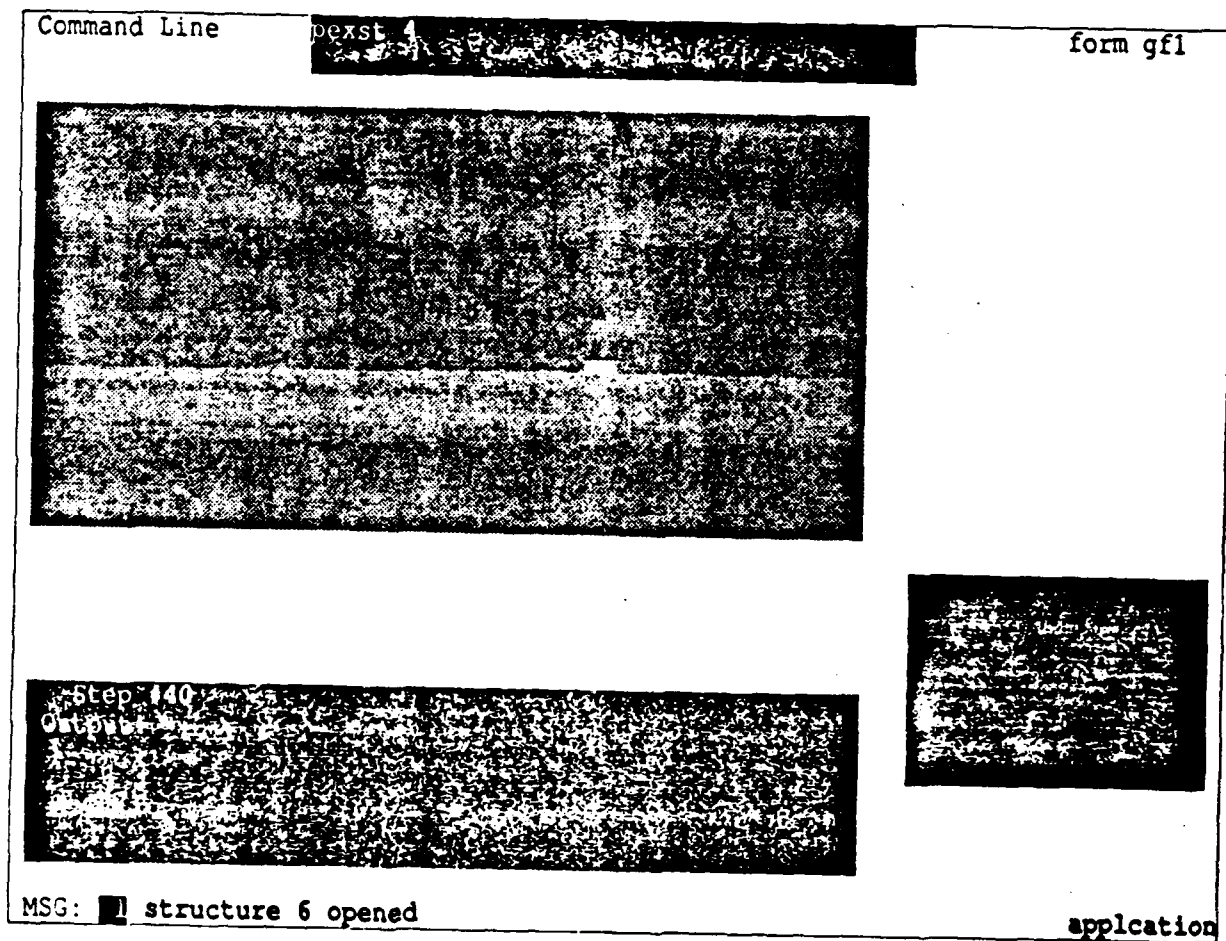


Figure 5-42a (BEFORE)

UTP 620344220
30 September 1990

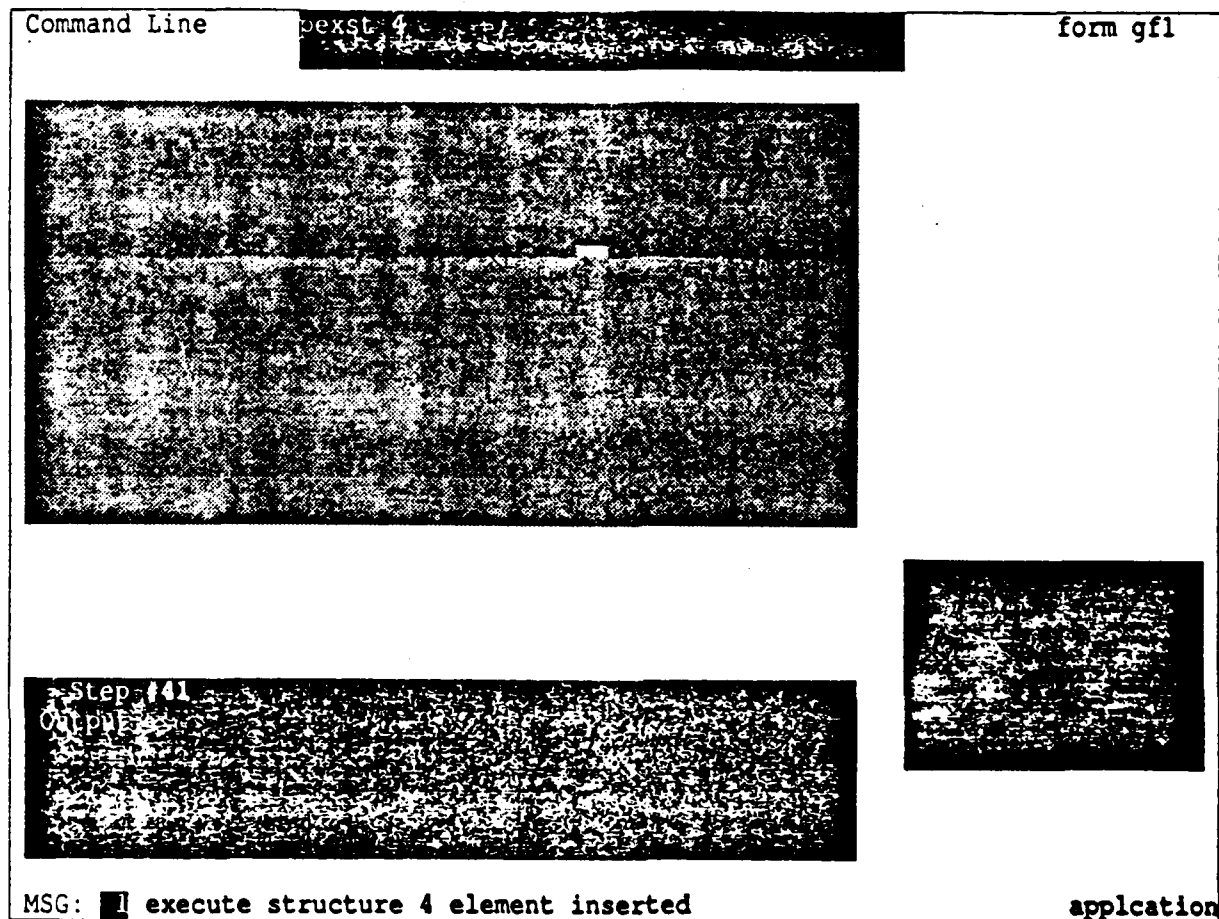


Figure 5-42b (AFTER)

UTP 620344220
30 September 1990

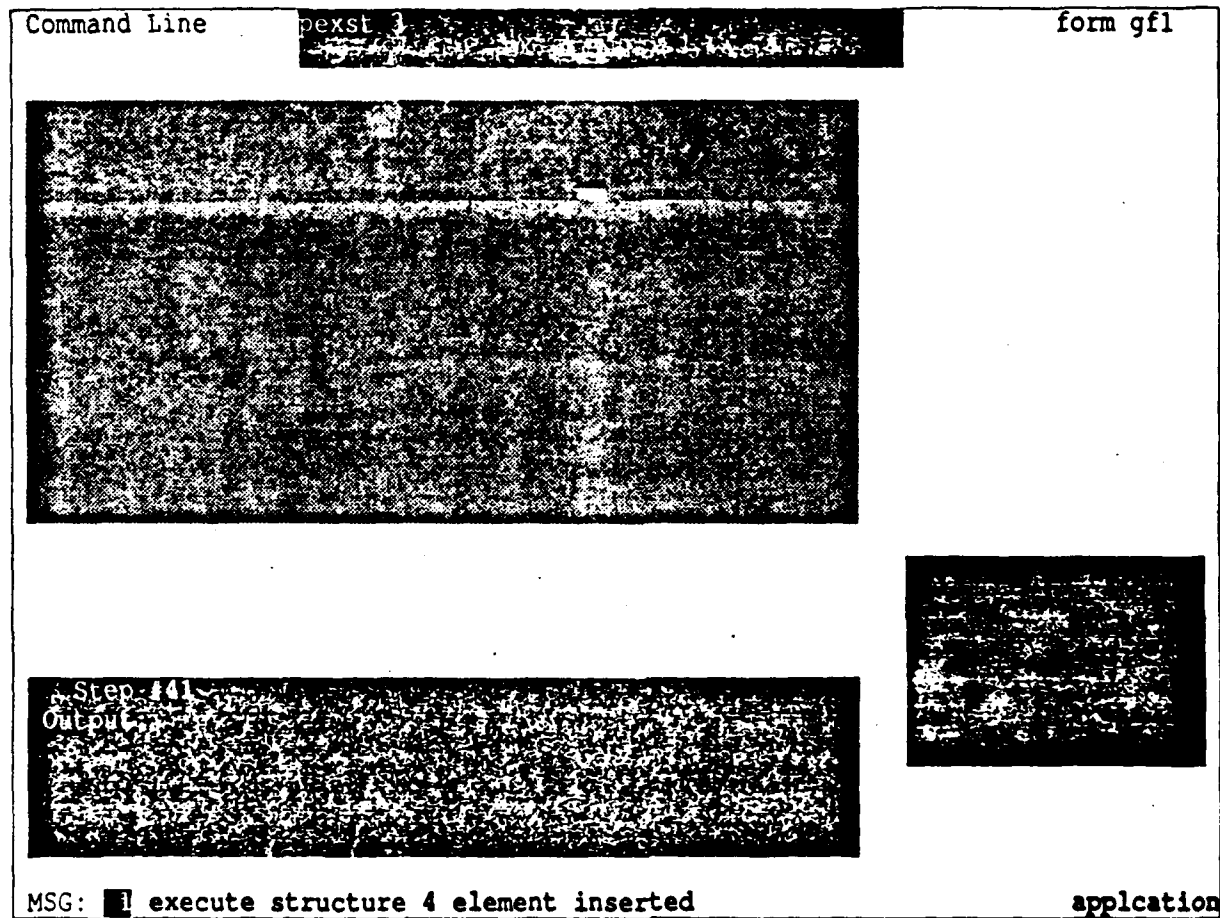


Figure 5-43a (BEFORE)

UTP 620344220
30 September 1990

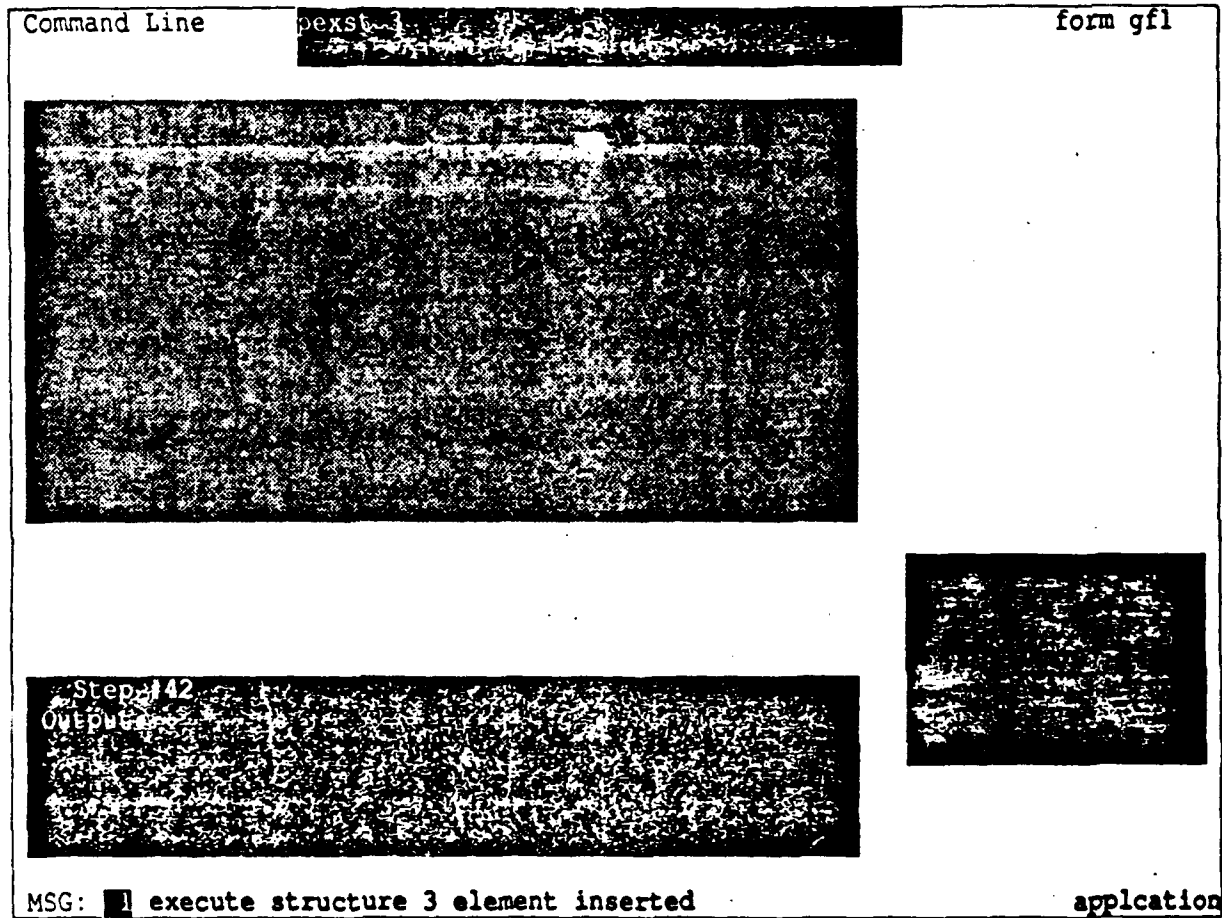


Figure 5-43b (AFTER)

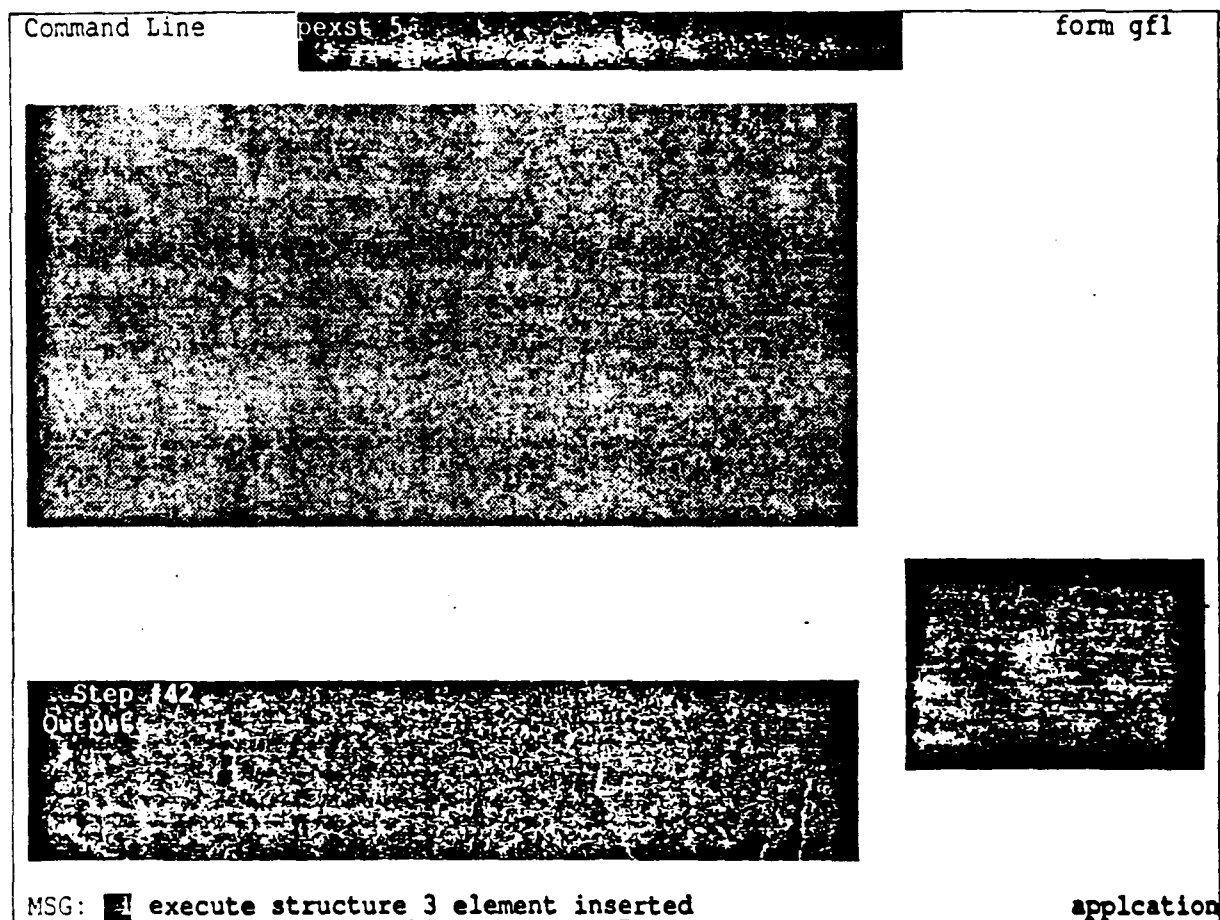


Figure 5-44a (BEFORE)

UTP 620344220
30 September 1990

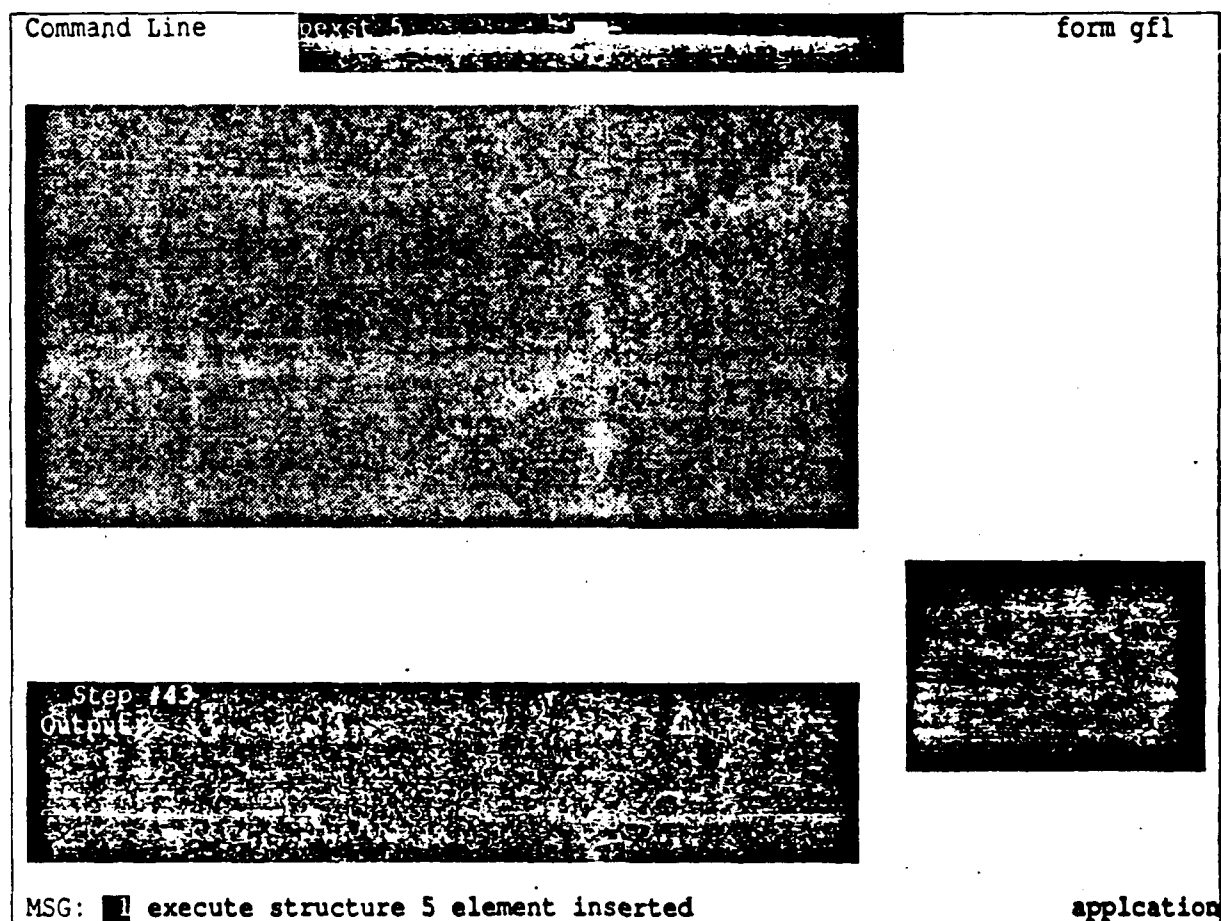


Figure 5-44b (AFTER)

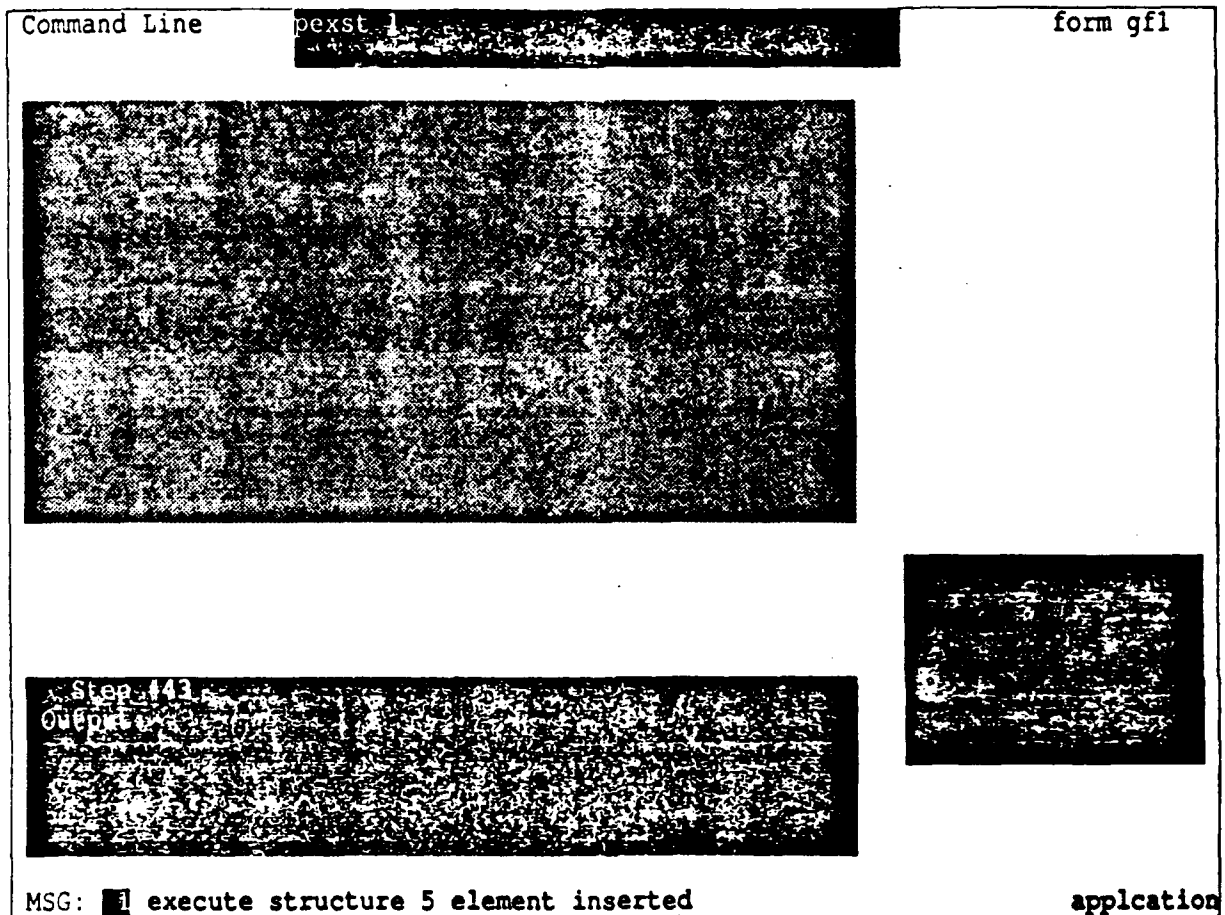


Figure 5-45a (BEFORE)

UTP 620344220
30 September 1990

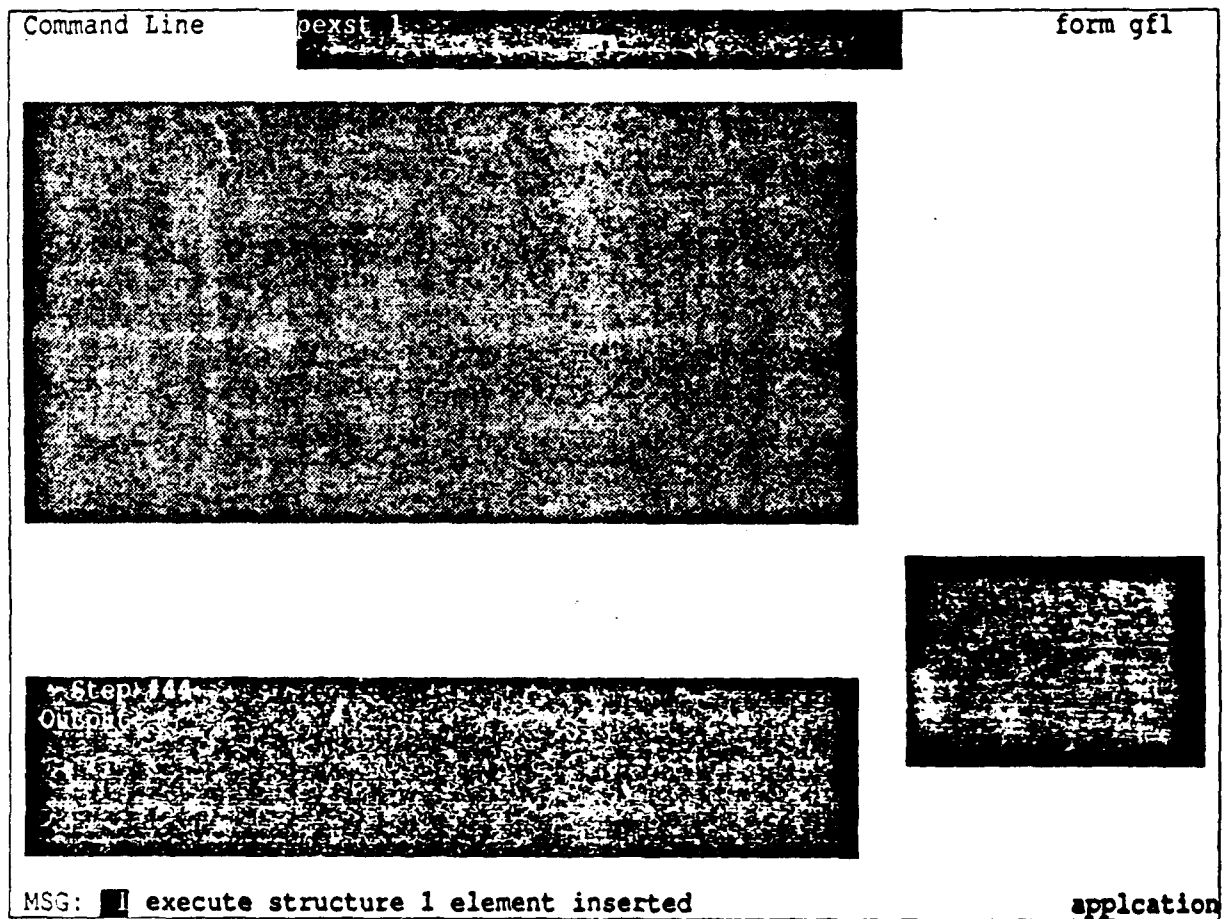


Figure 5-45b (AFTER)

UTP 620344220
30 September 1990

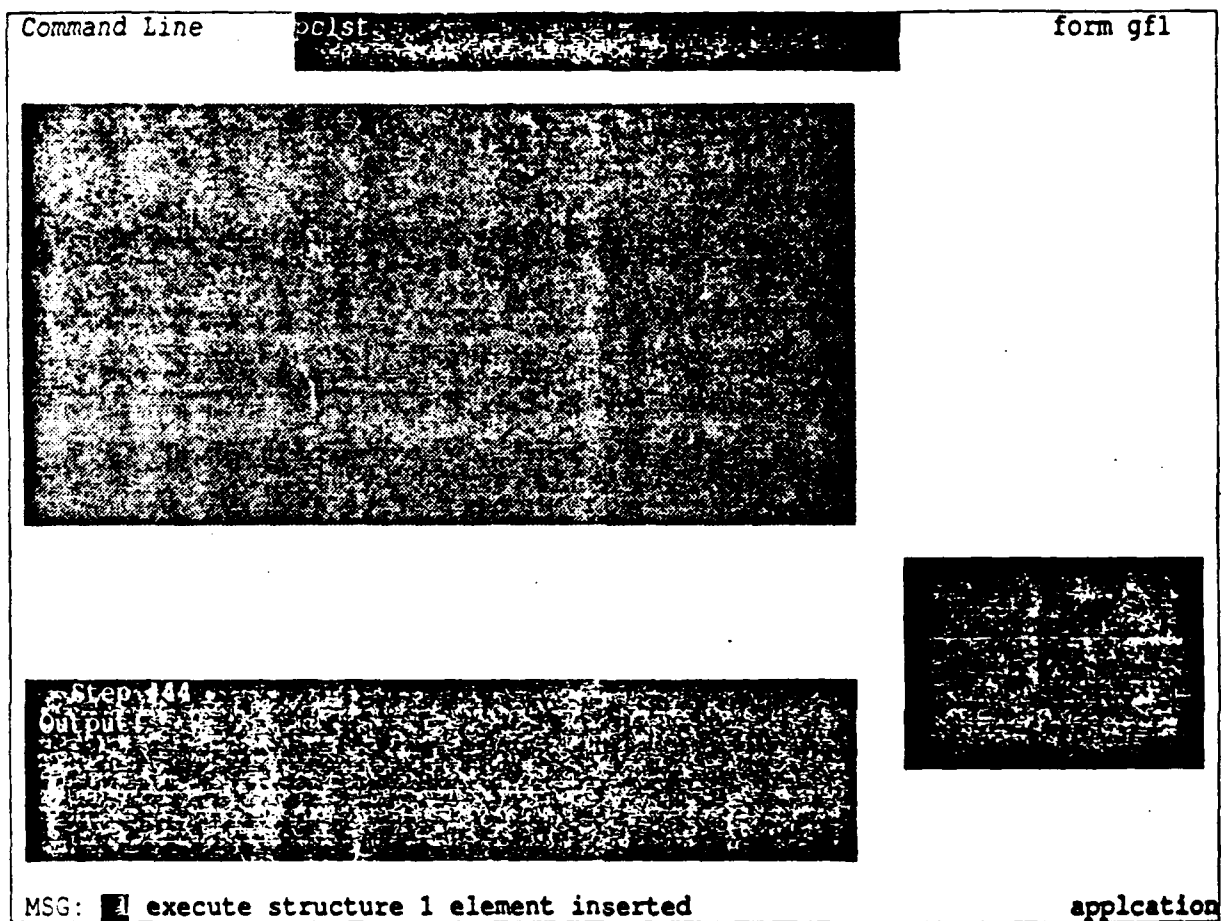


Figure 5-46a (BEFORE)

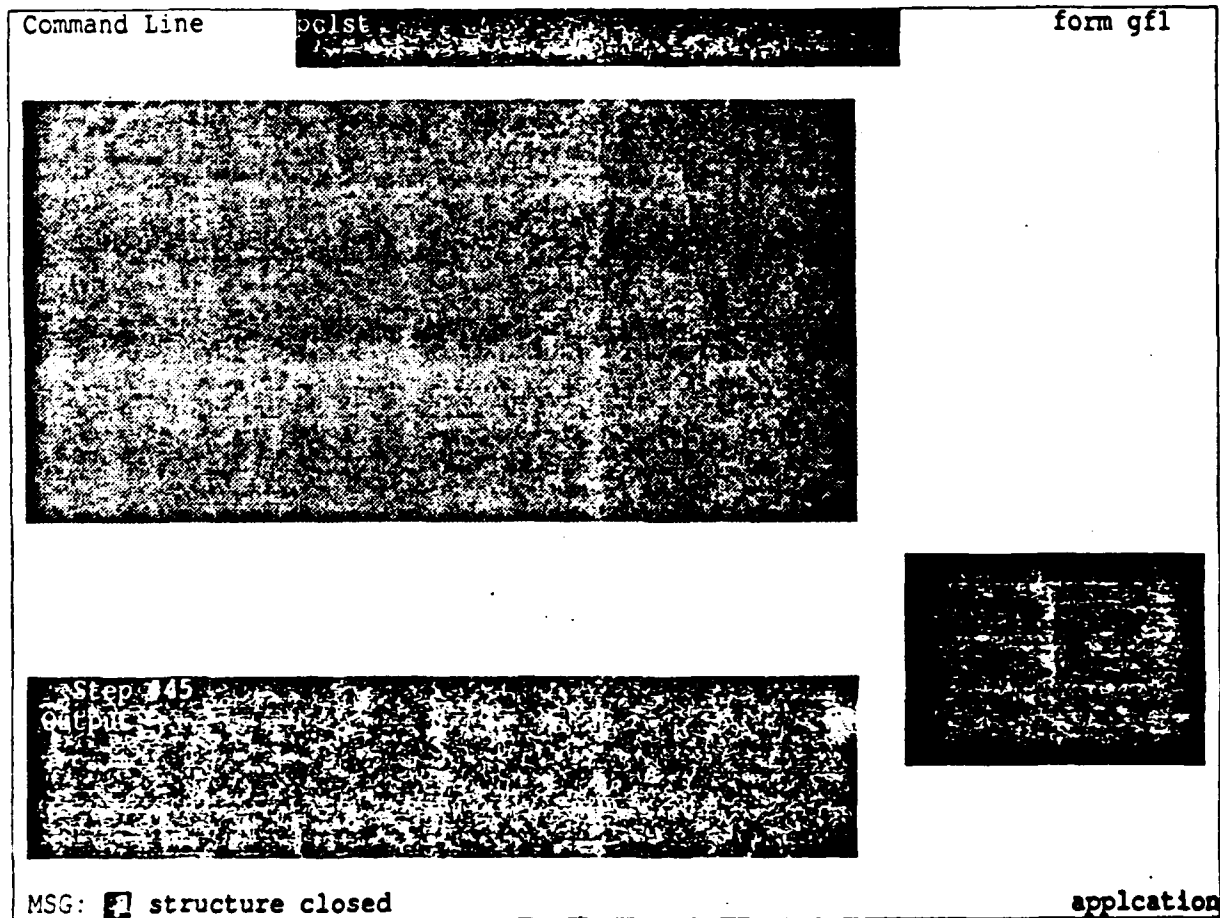


Figure 5-46b (AFTER)

UTP 620344220
30 September 1990

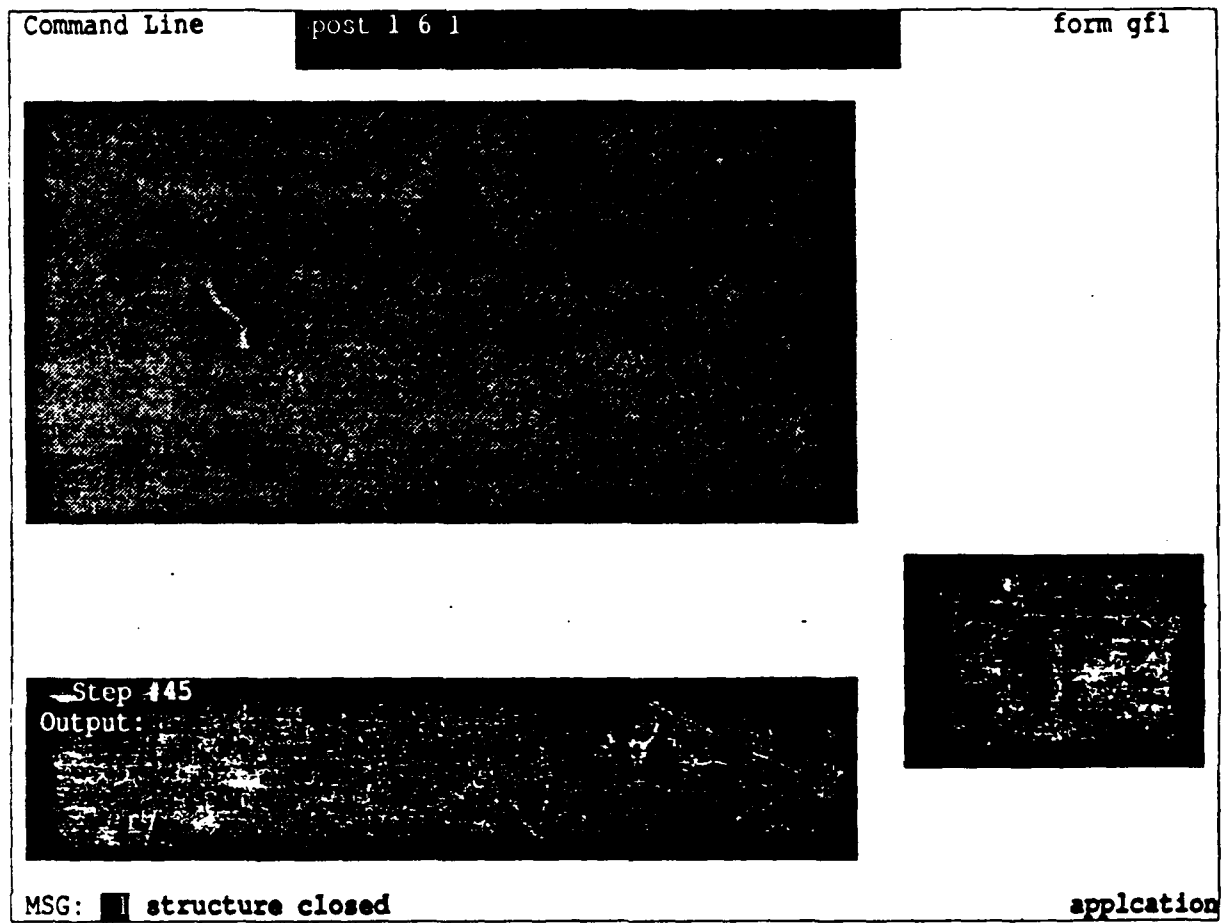


Figure 5-47a (BEFORE)

UTP 620344220
30 September 1990

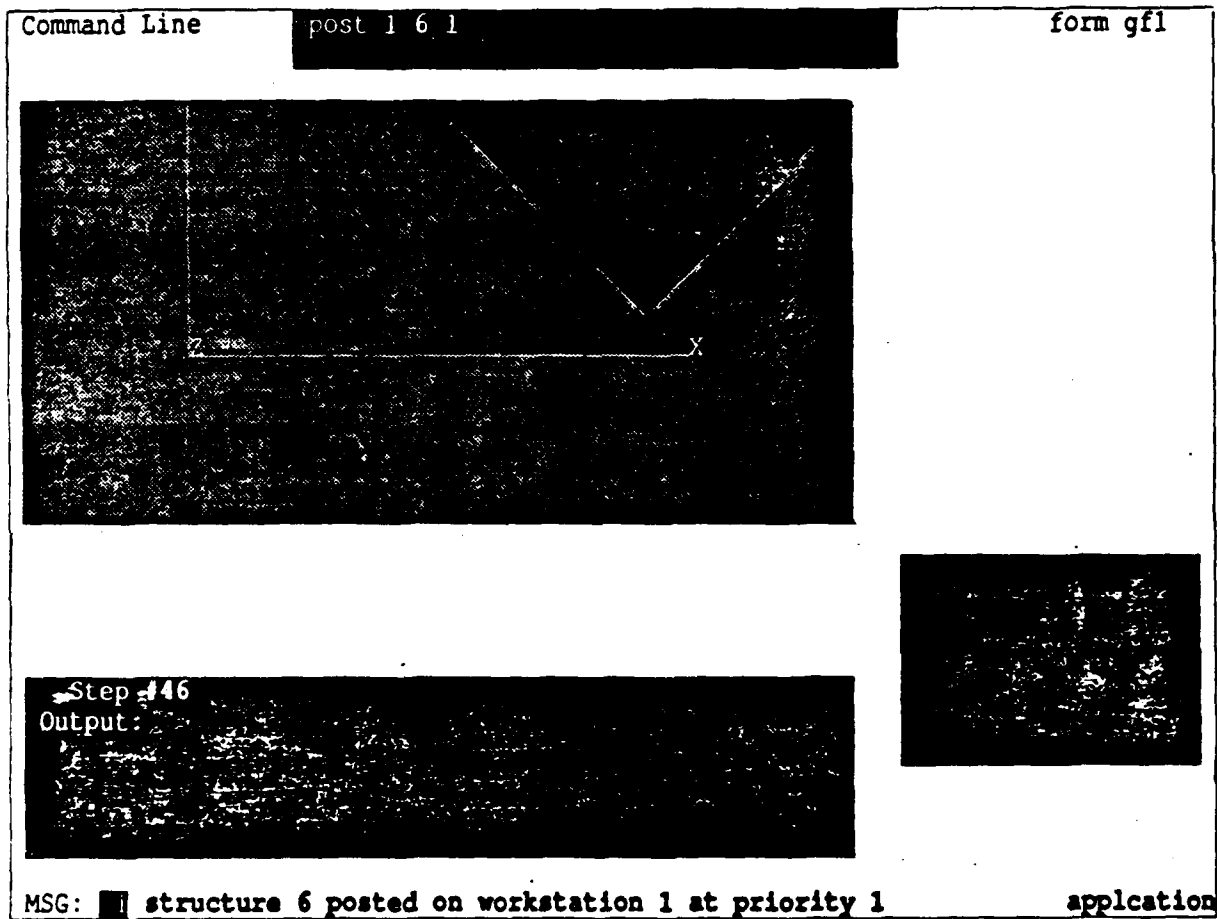


Figure 5-47b (AFTER)

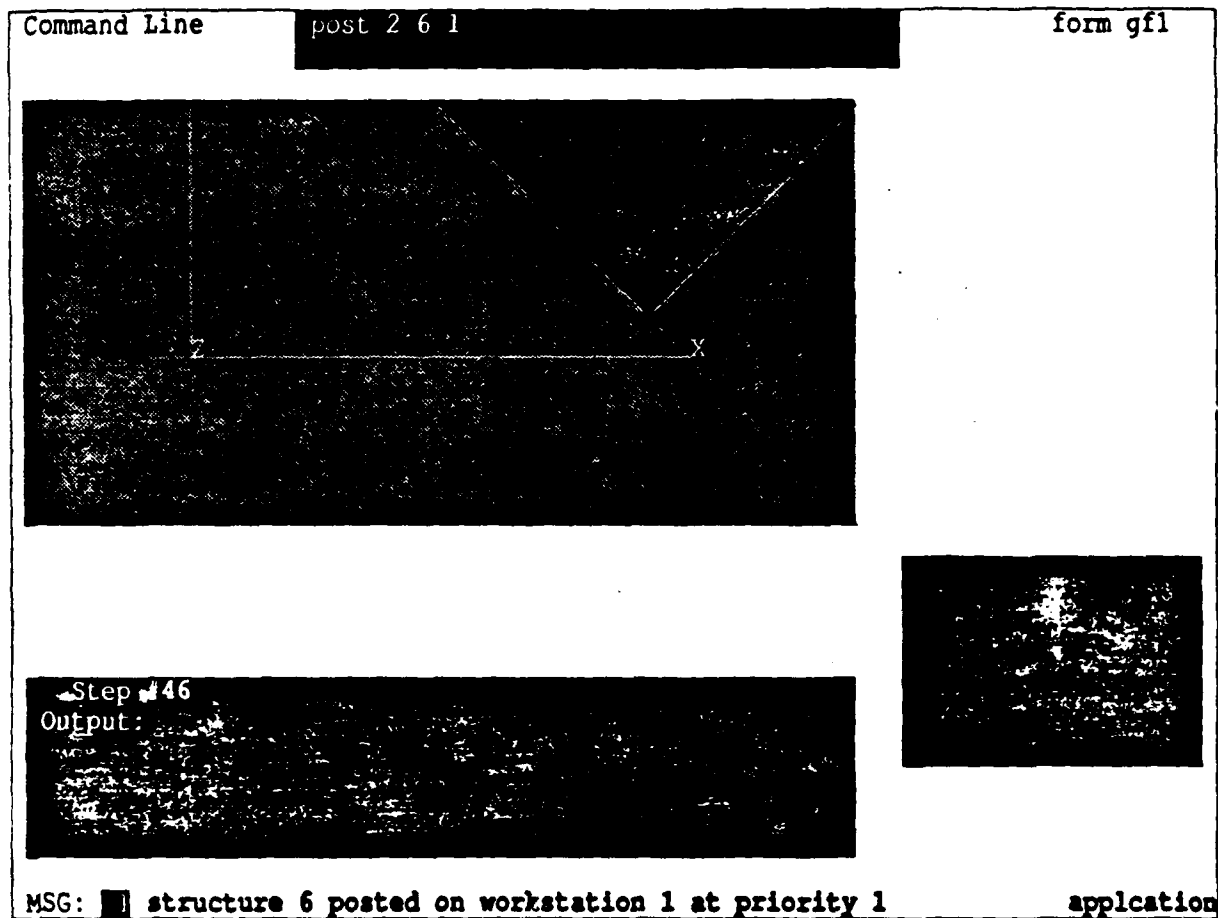


Figure 5-48a (BEFORE)

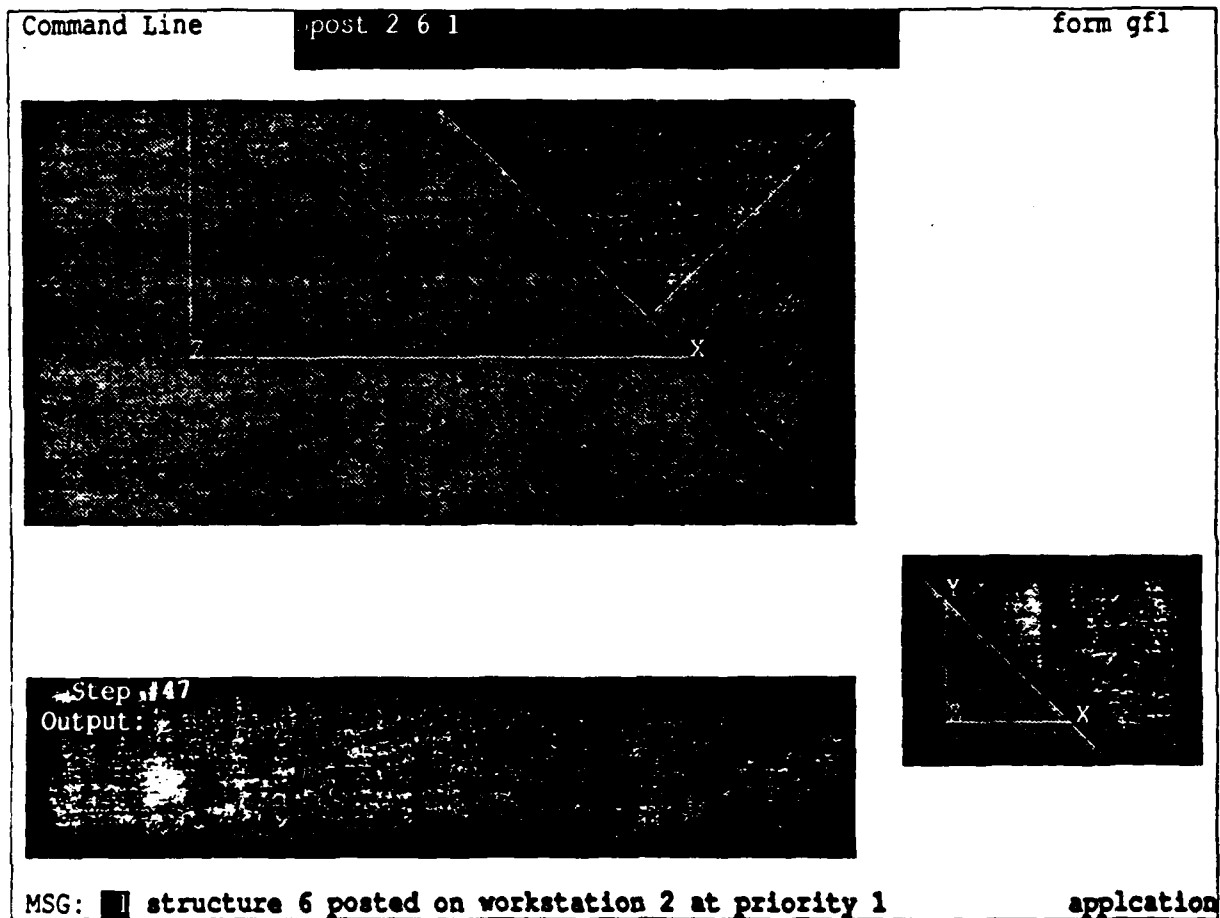


Figure 5-48b (AFTER)

UTP 620344220
30 September 1990

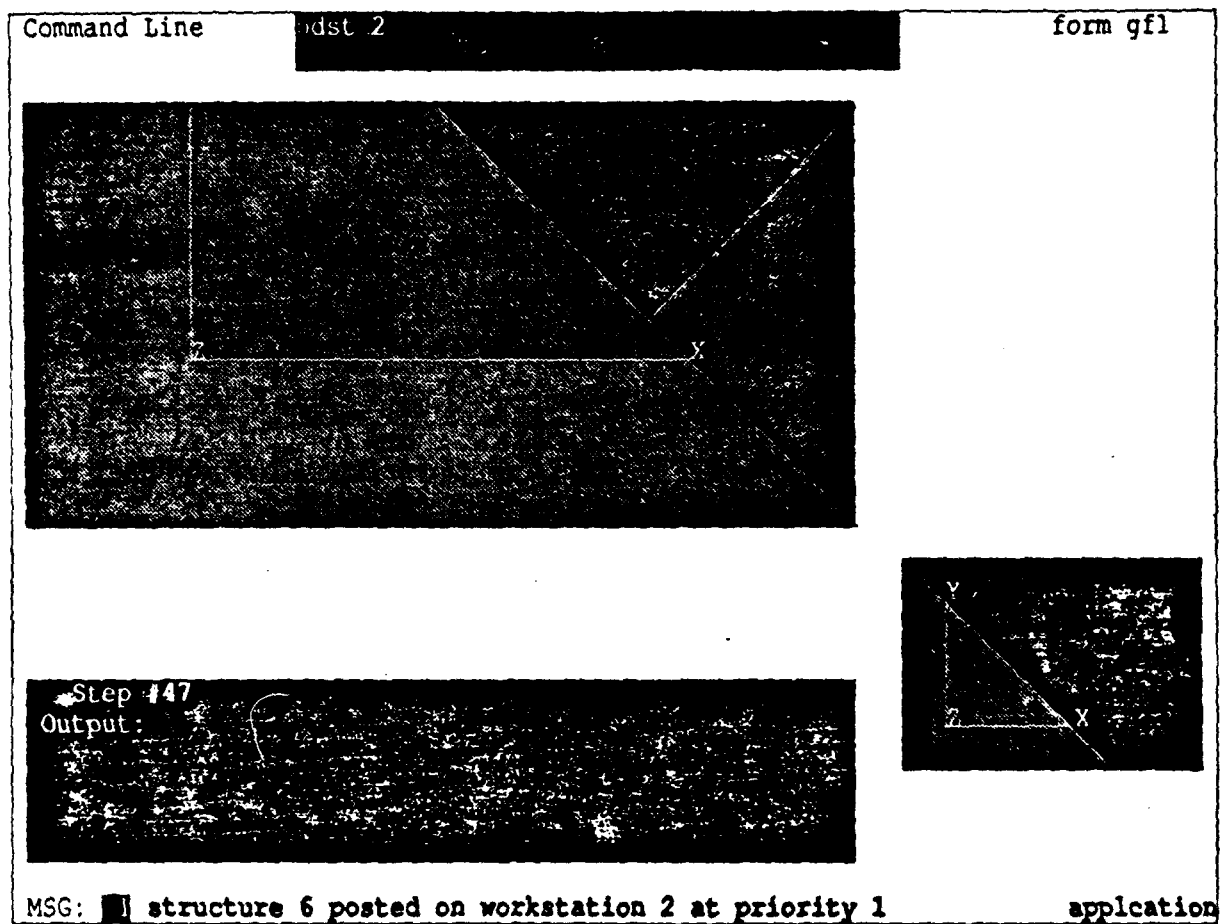


Figure 5-49a (BEFORE)

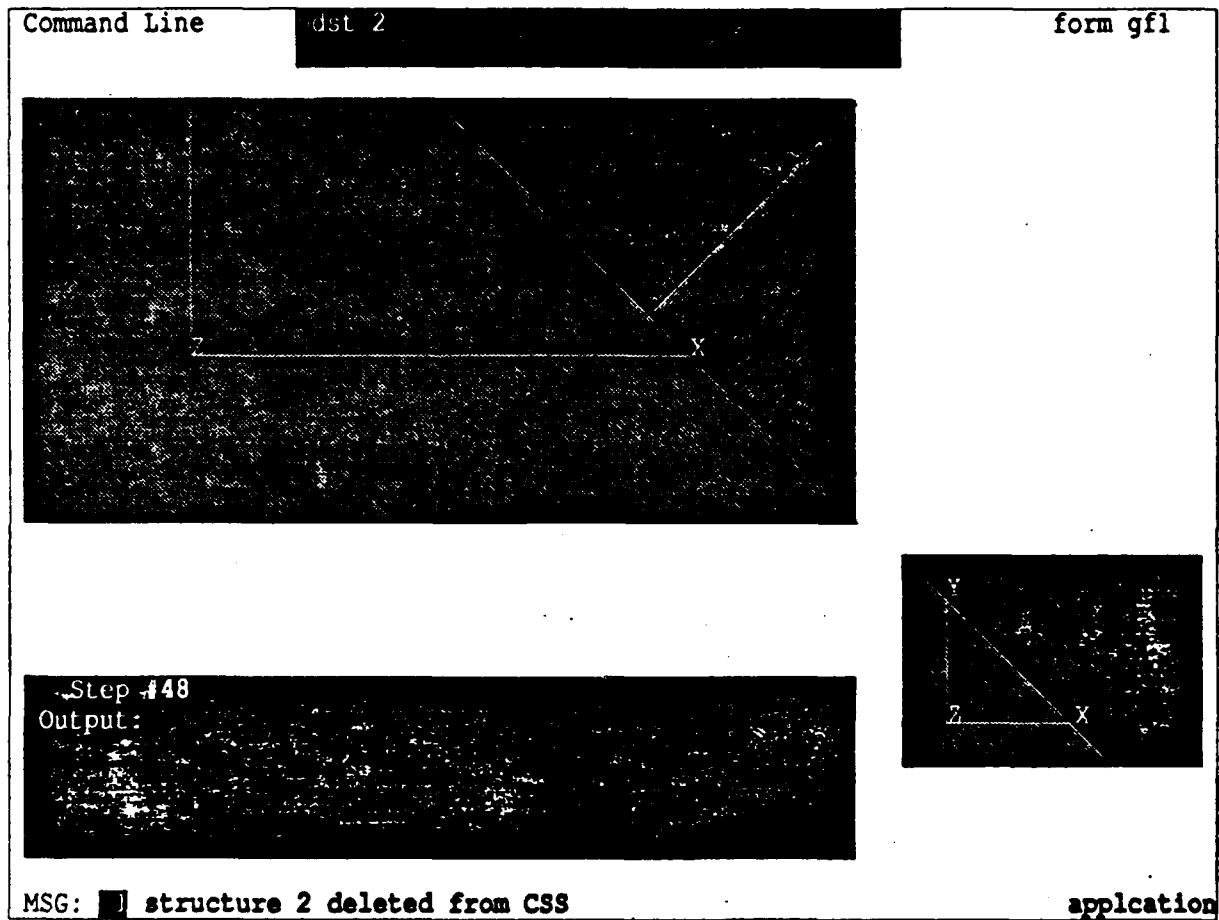


Figure 5-49b (AFTER)

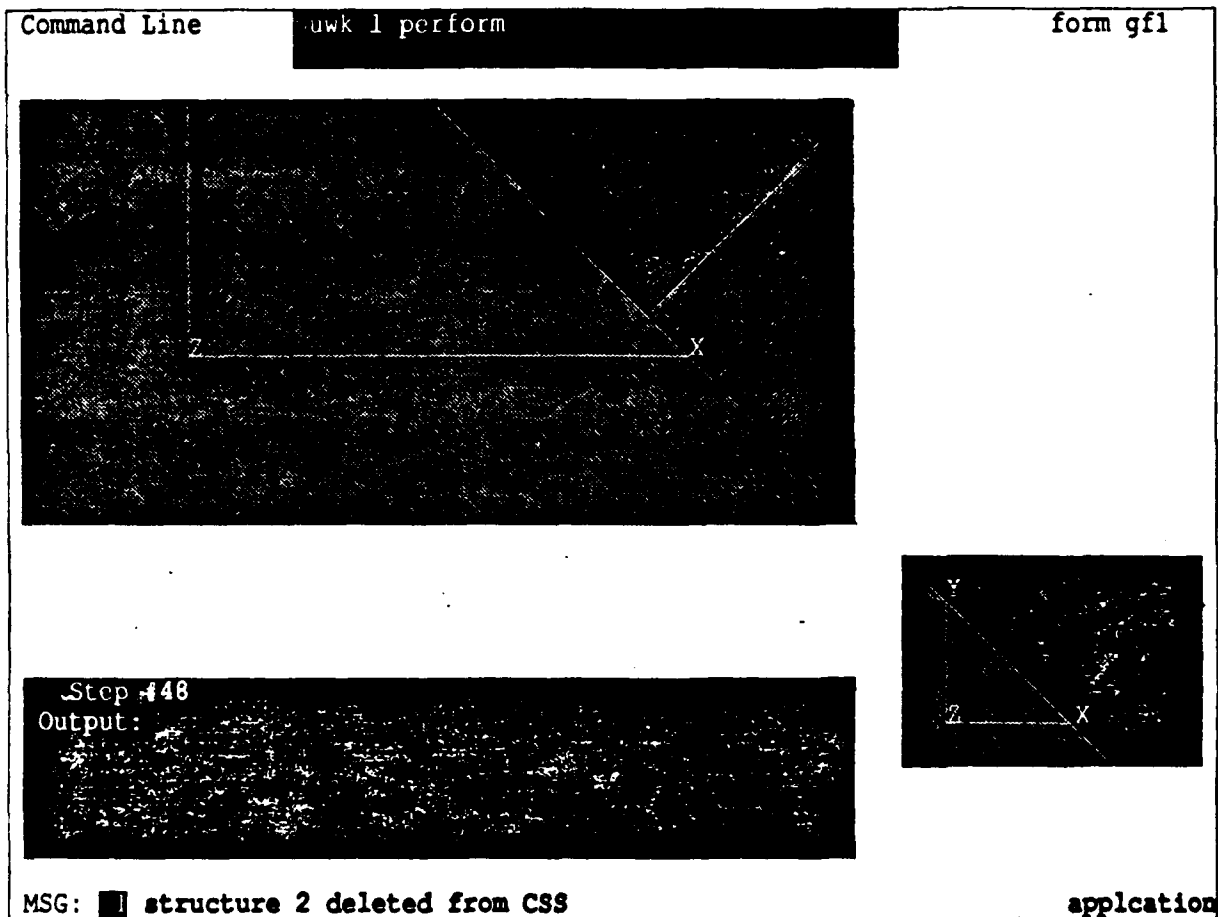


Figure 5-50a (BEFORE)

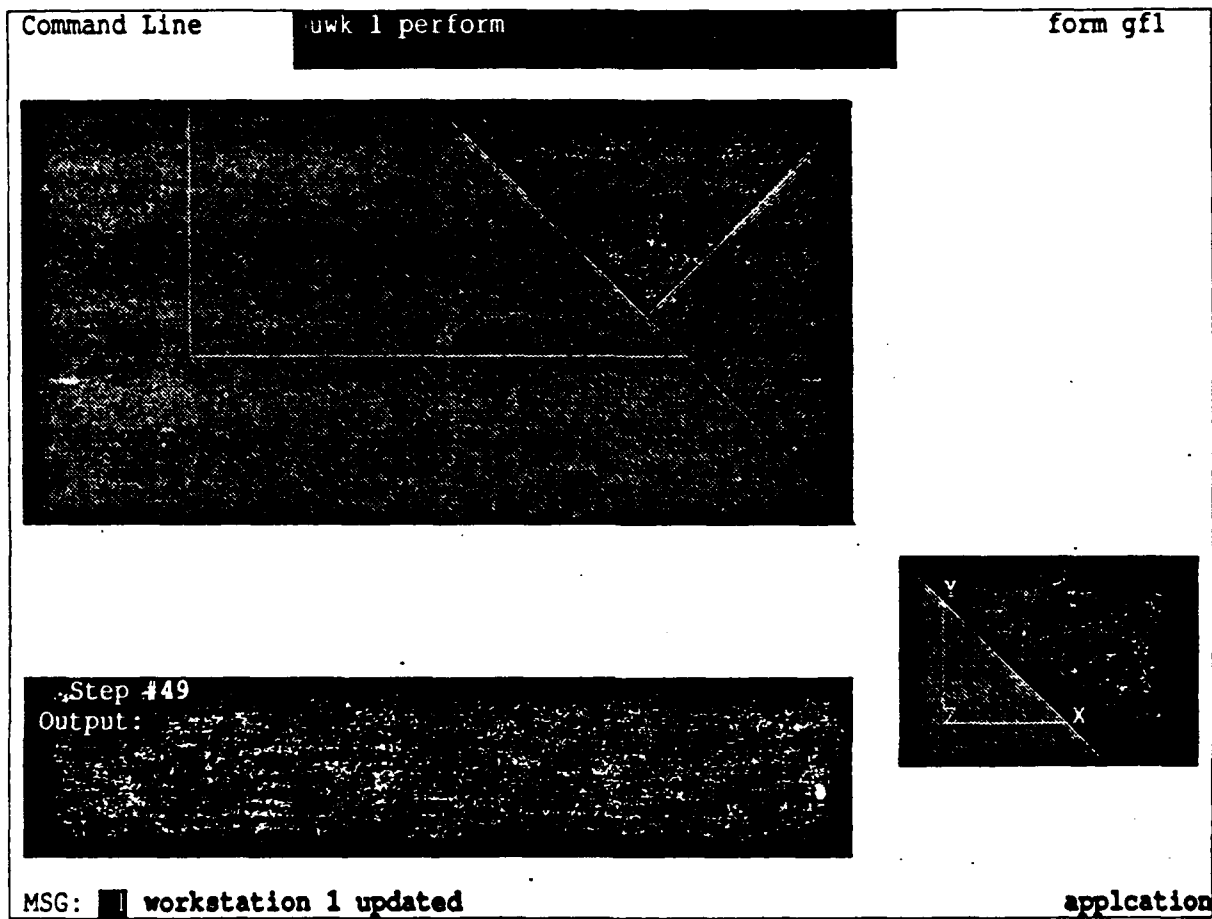


Figure 5-50b (AFTER)

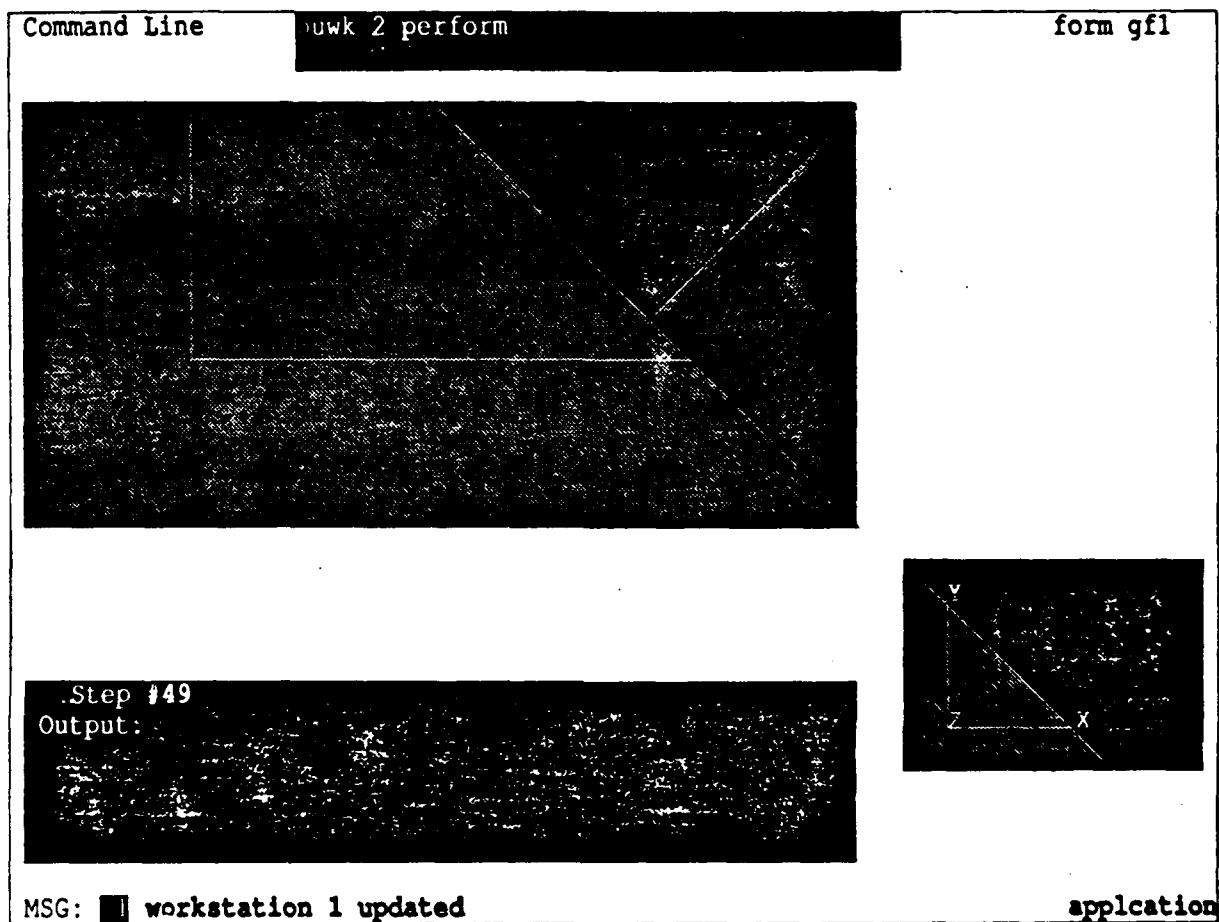


Figure 5-51a (BEFORE)

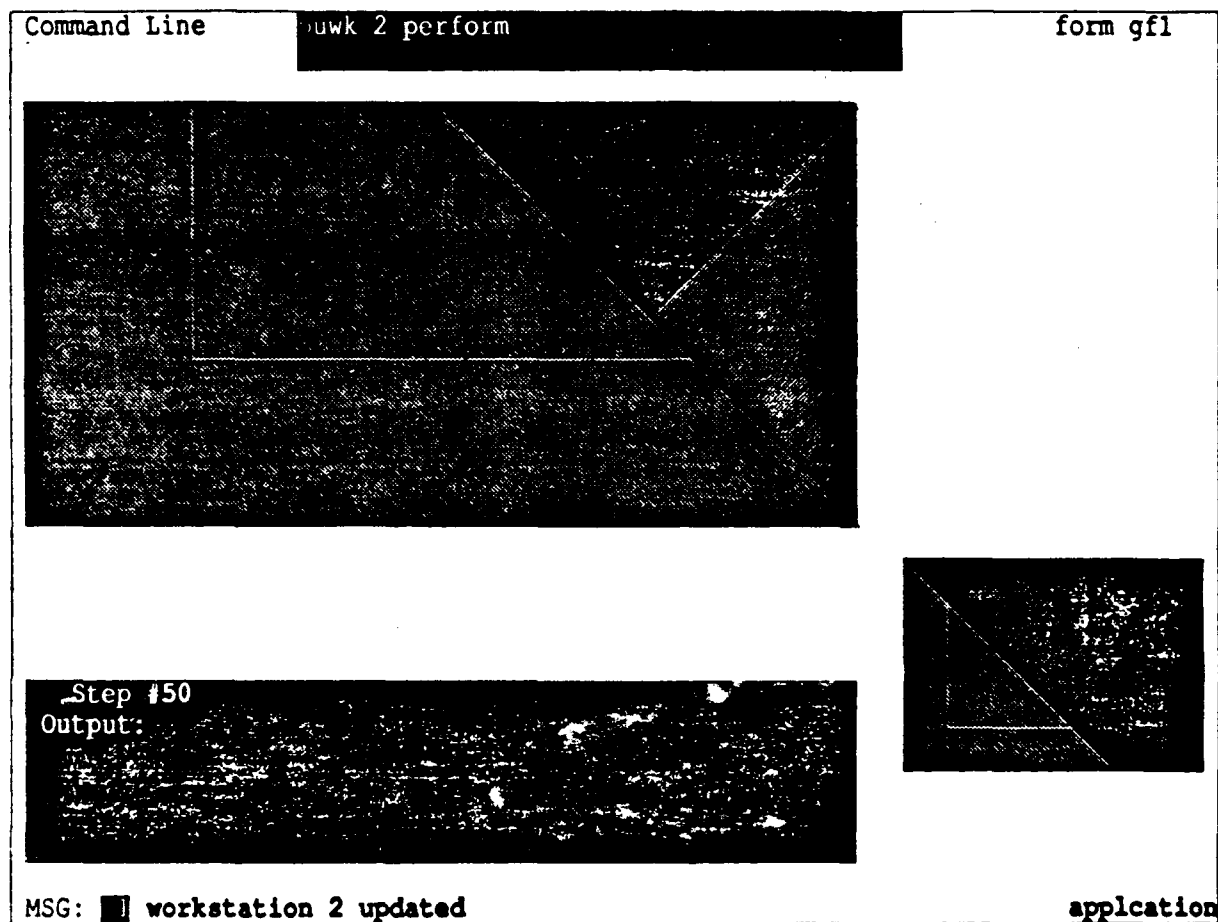


Figure 5-51b (AFTER)

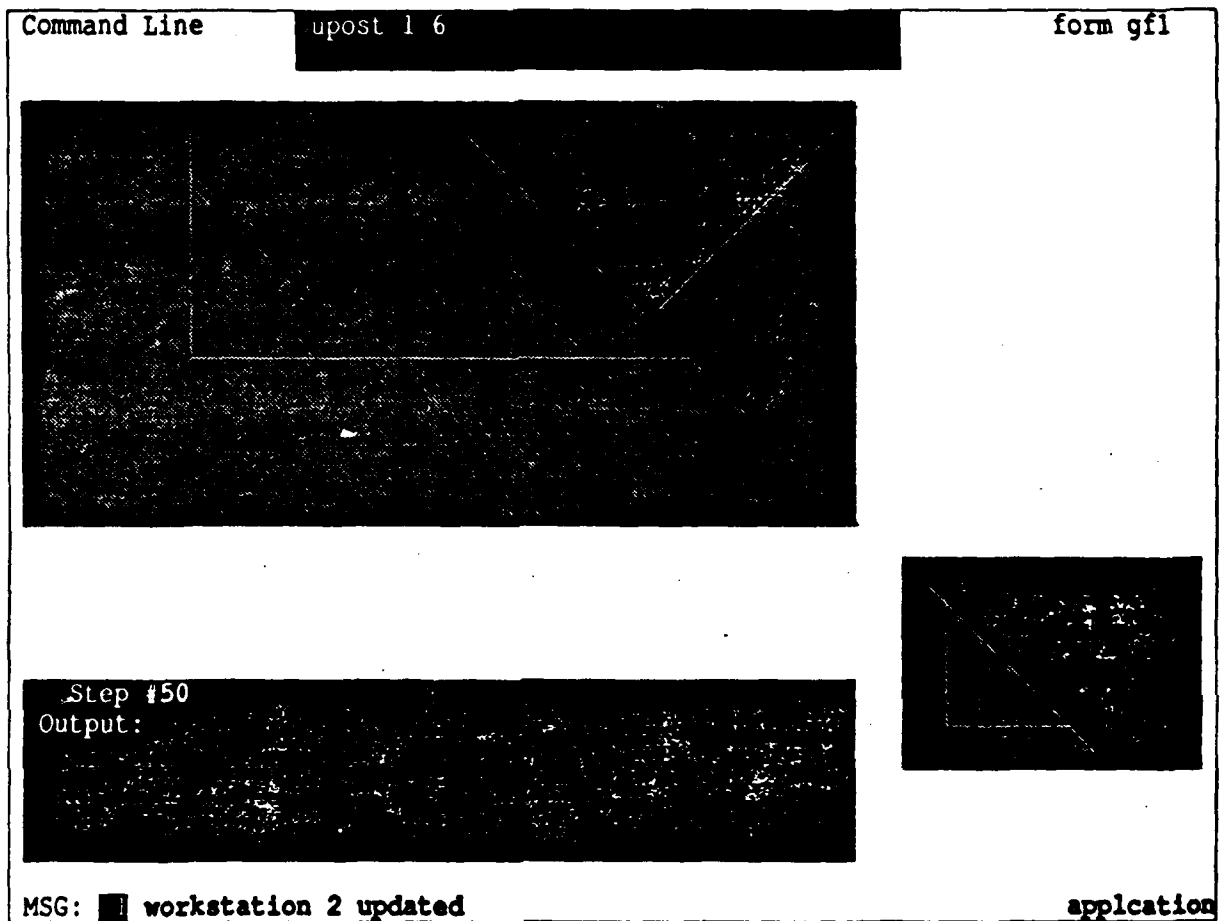


Figure 5-52a (BEFORE)

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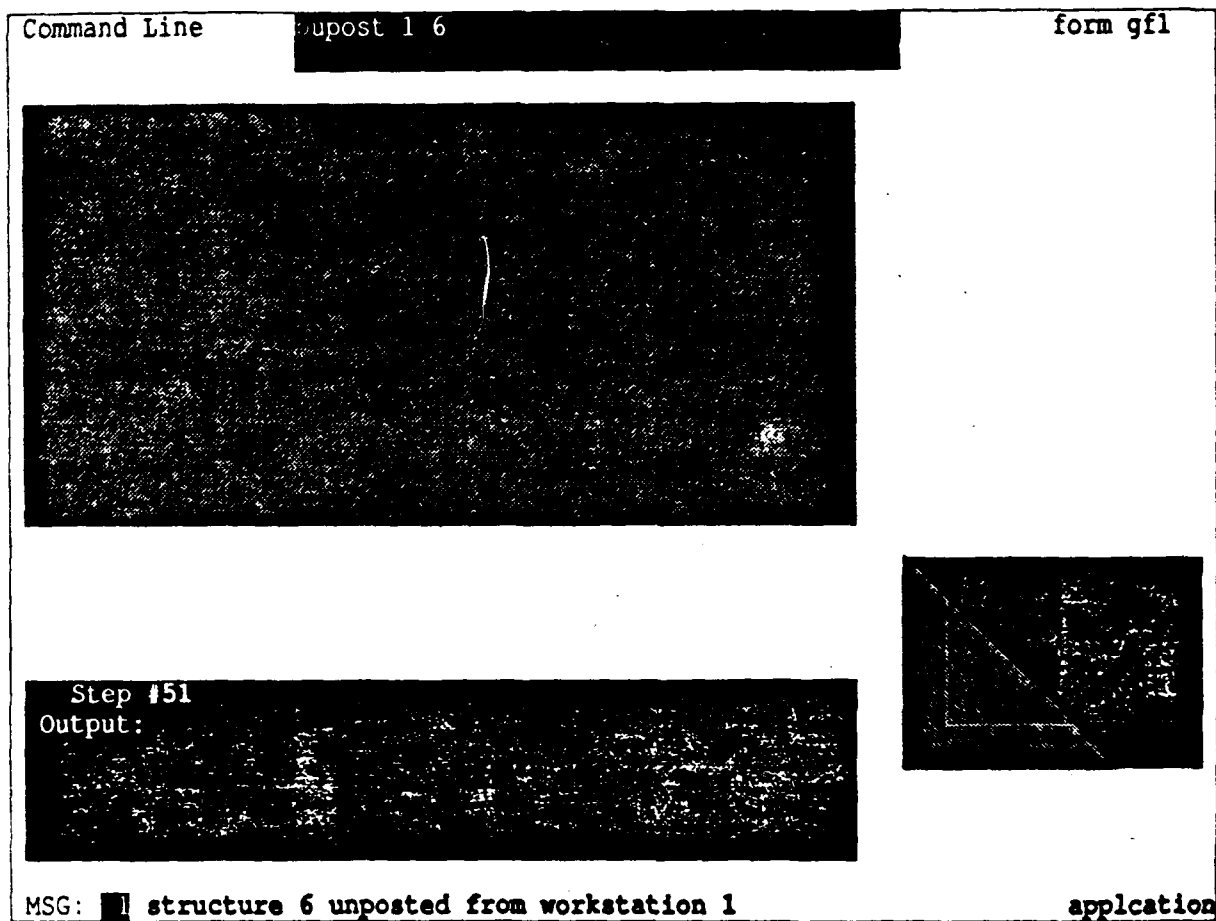


Figure 5-52b (AFTER)

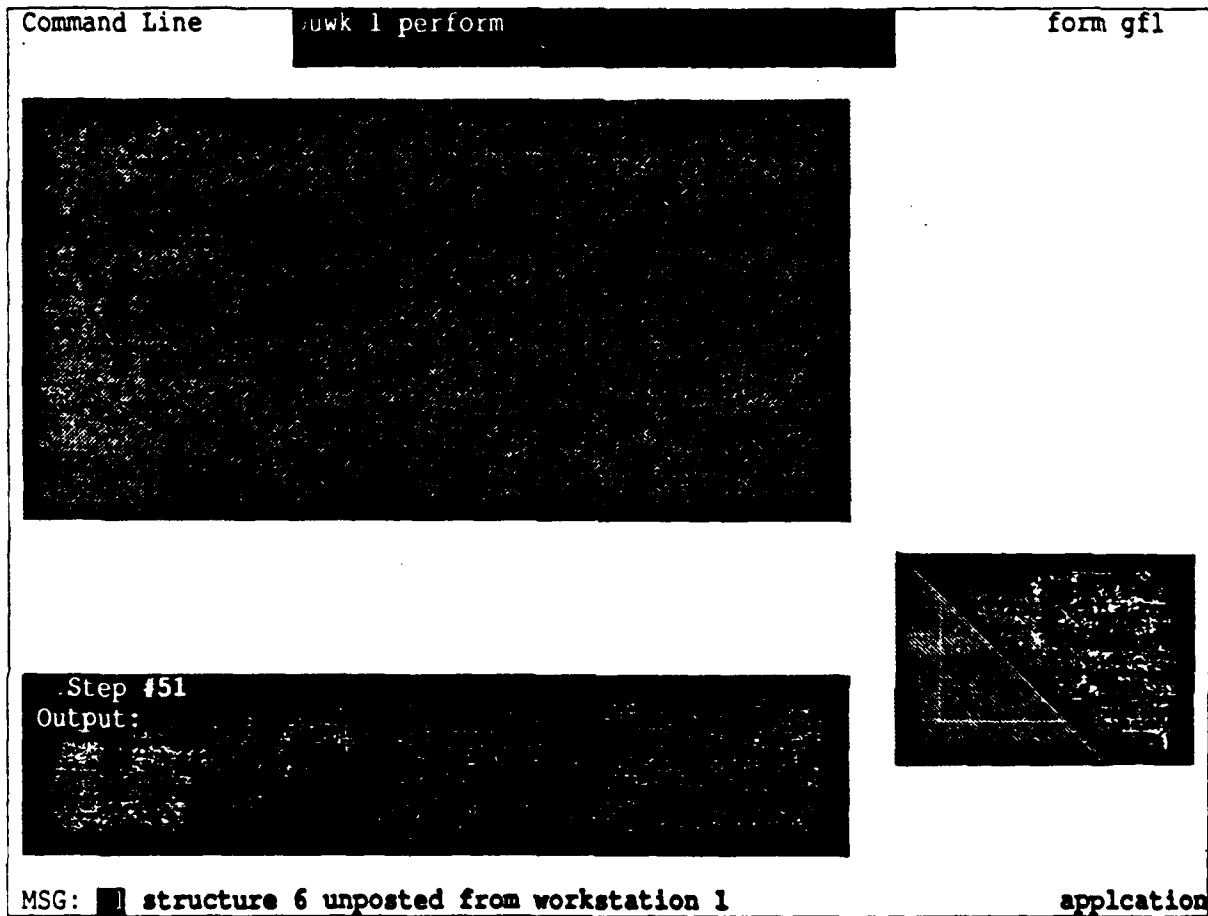


Figure 5-53a (BEFORE)

UTP 620344220
30 September 1990

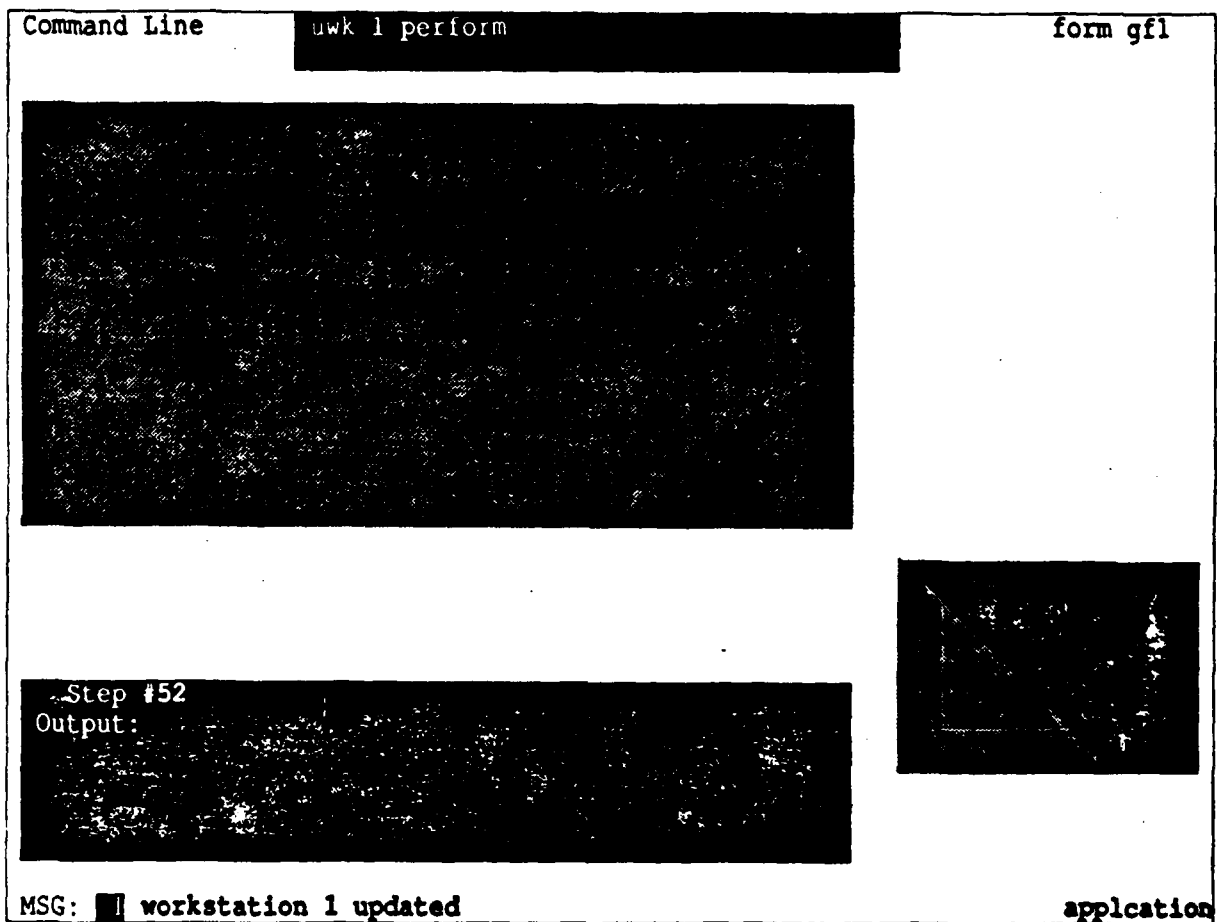


Figure 5-53b (AFTER)

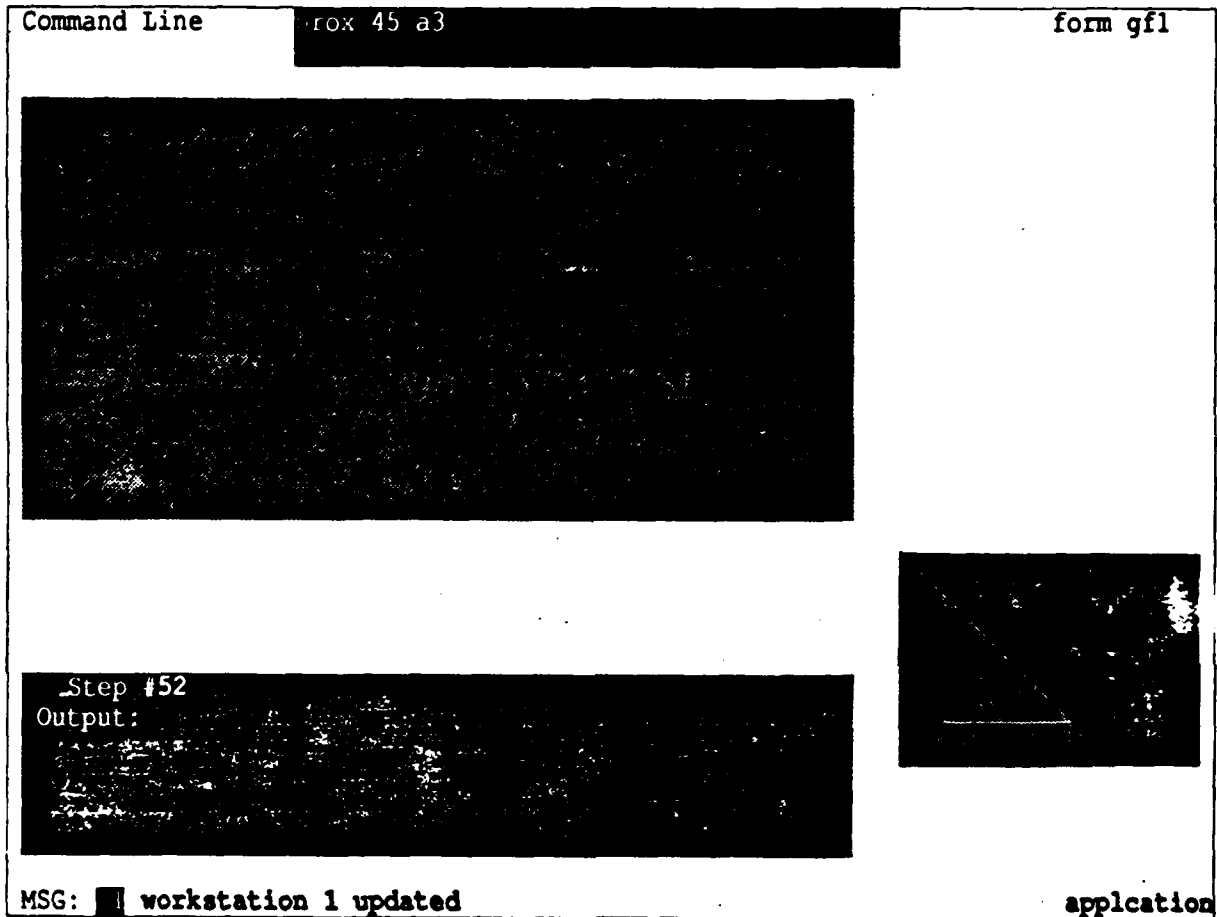


Figure 5-54a (BEFORE)

UTP 620344220
30 September 1990

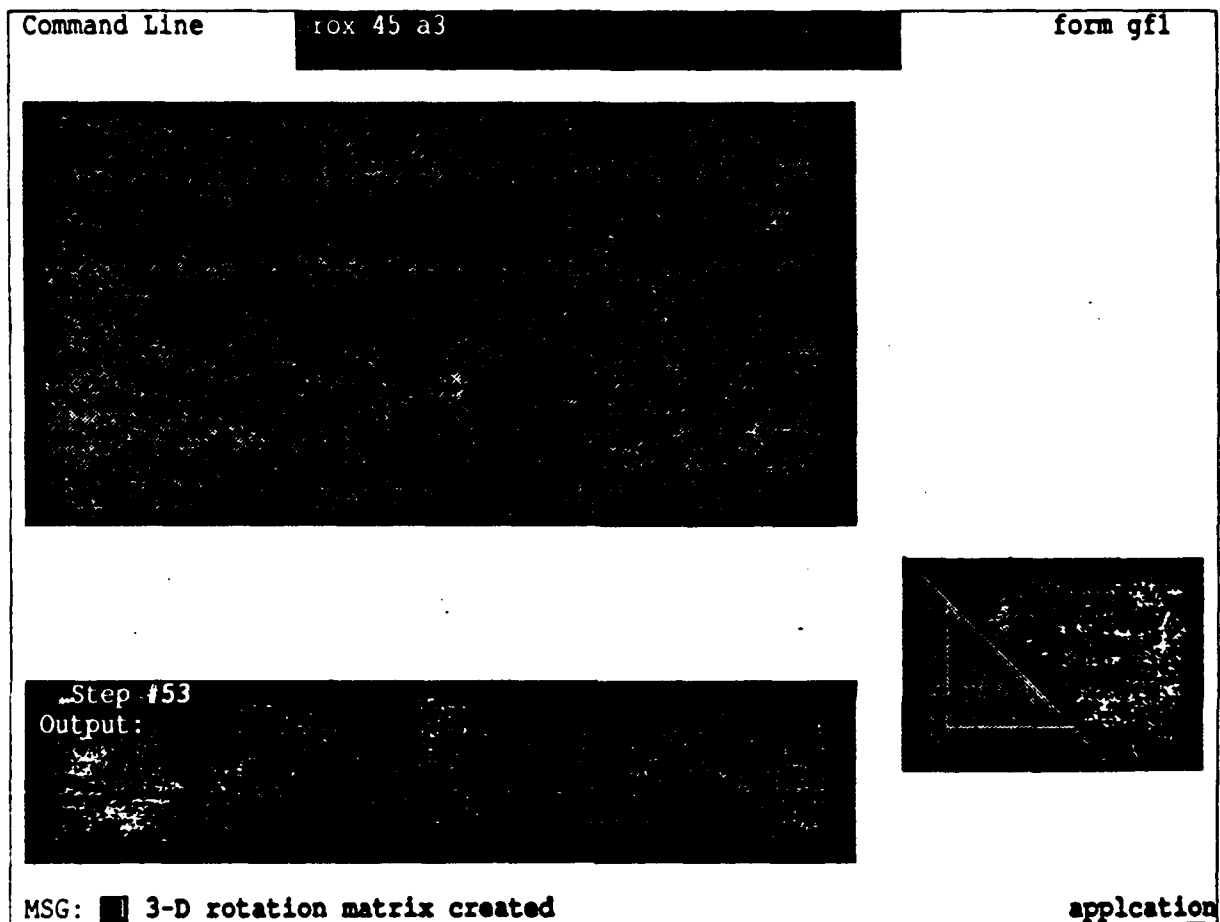


Figure 5-54b (AFTER)

UTP 620344220
30 September 1990

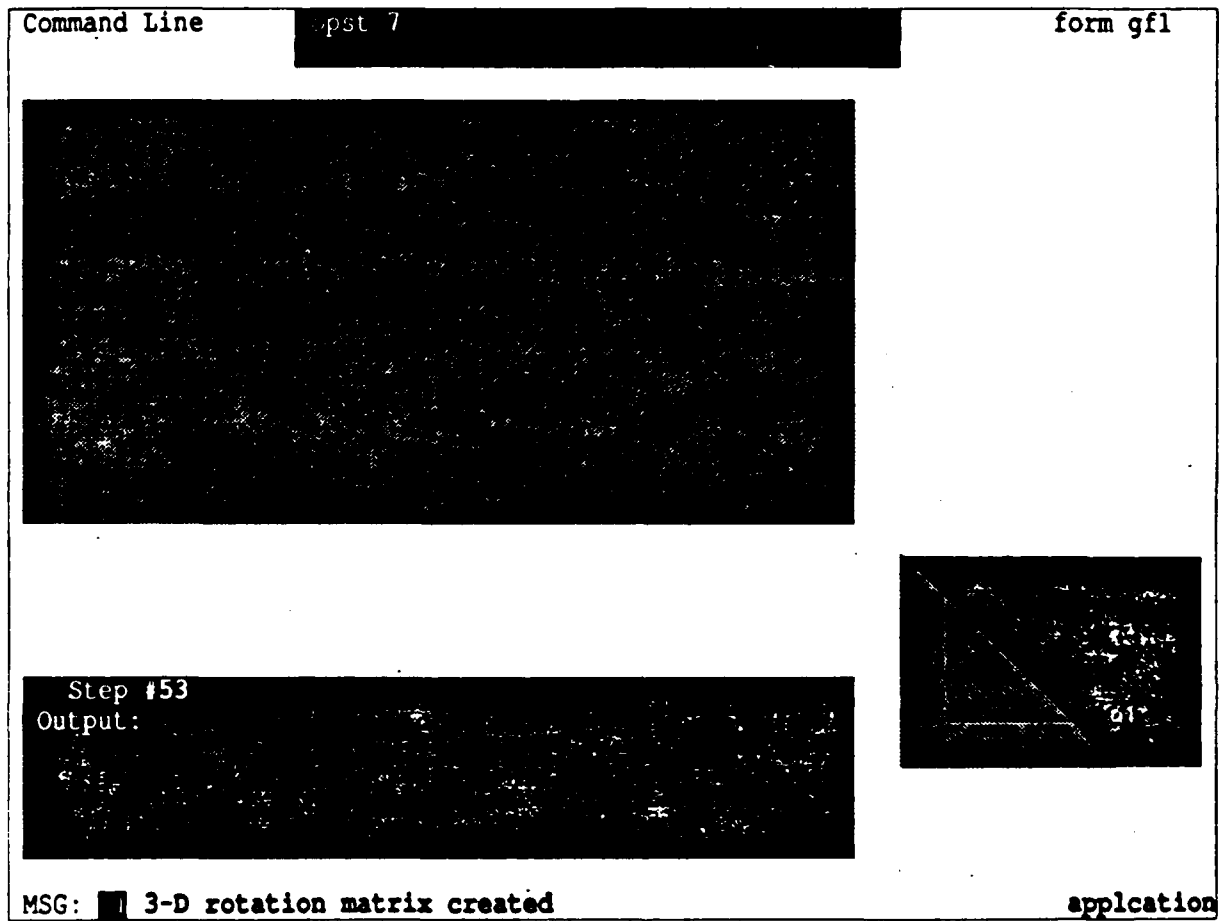


Figure 5-55a (BEFORE)

UTP 620344220
30 September 1990

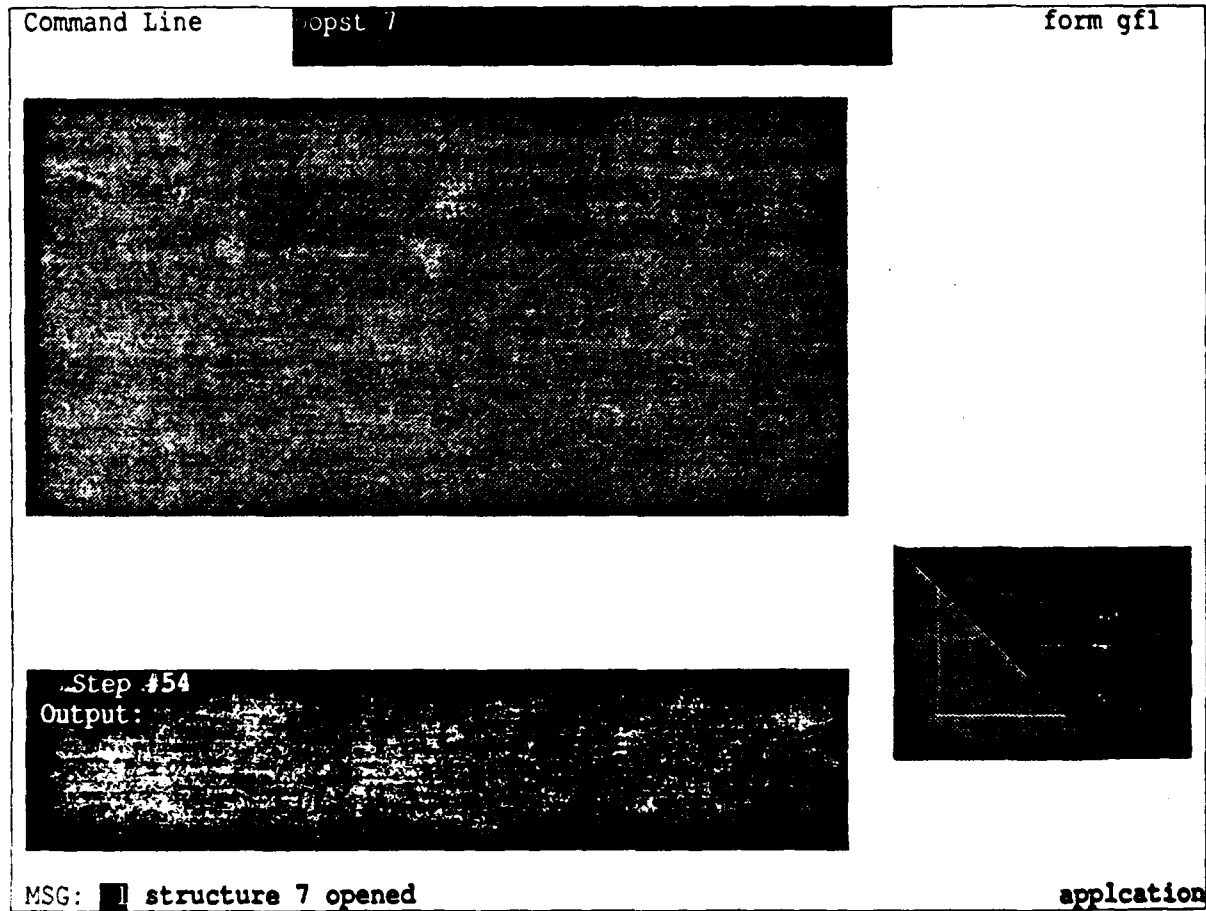


Figure 5-55b (AFTER)

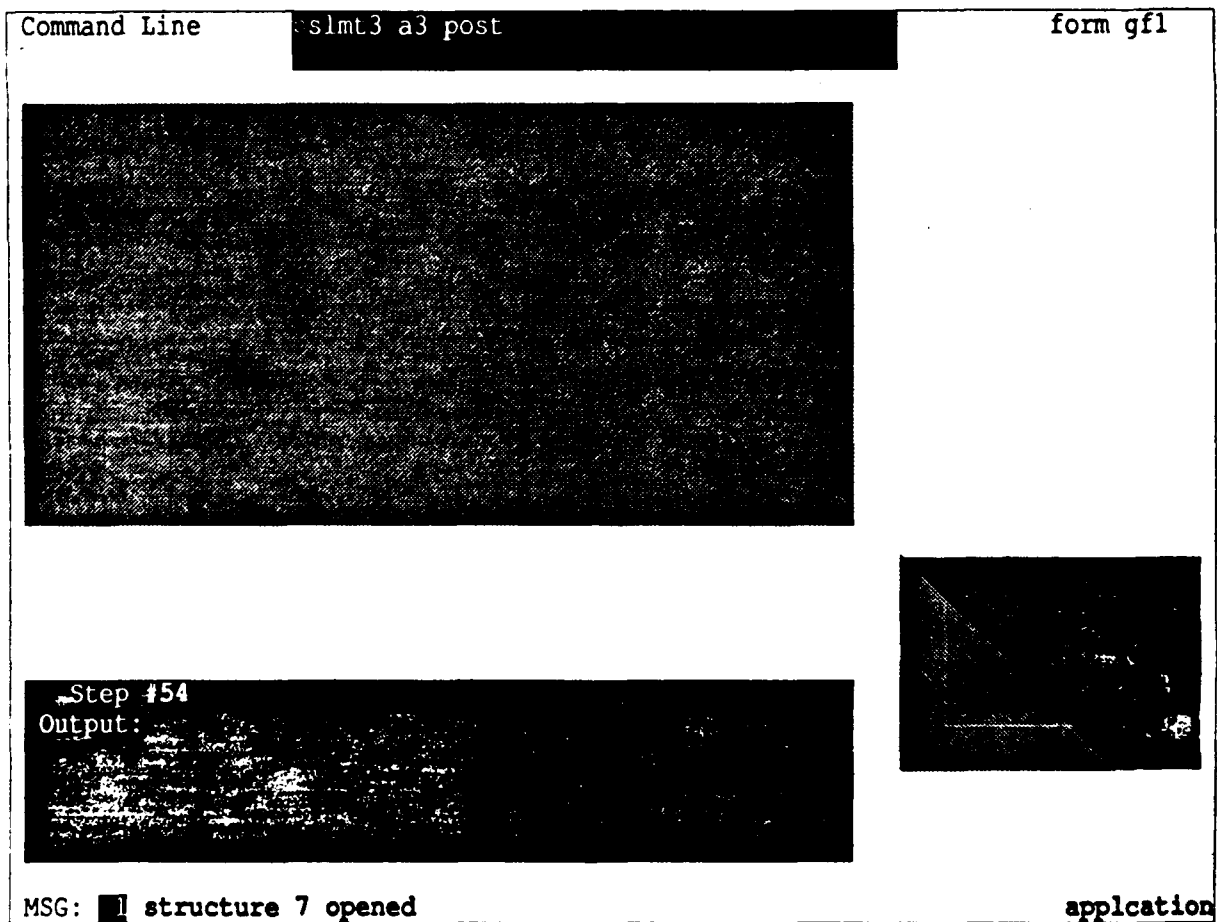


Figure 5-56a (BEFORE)

UTP 620344220
30 September 1990

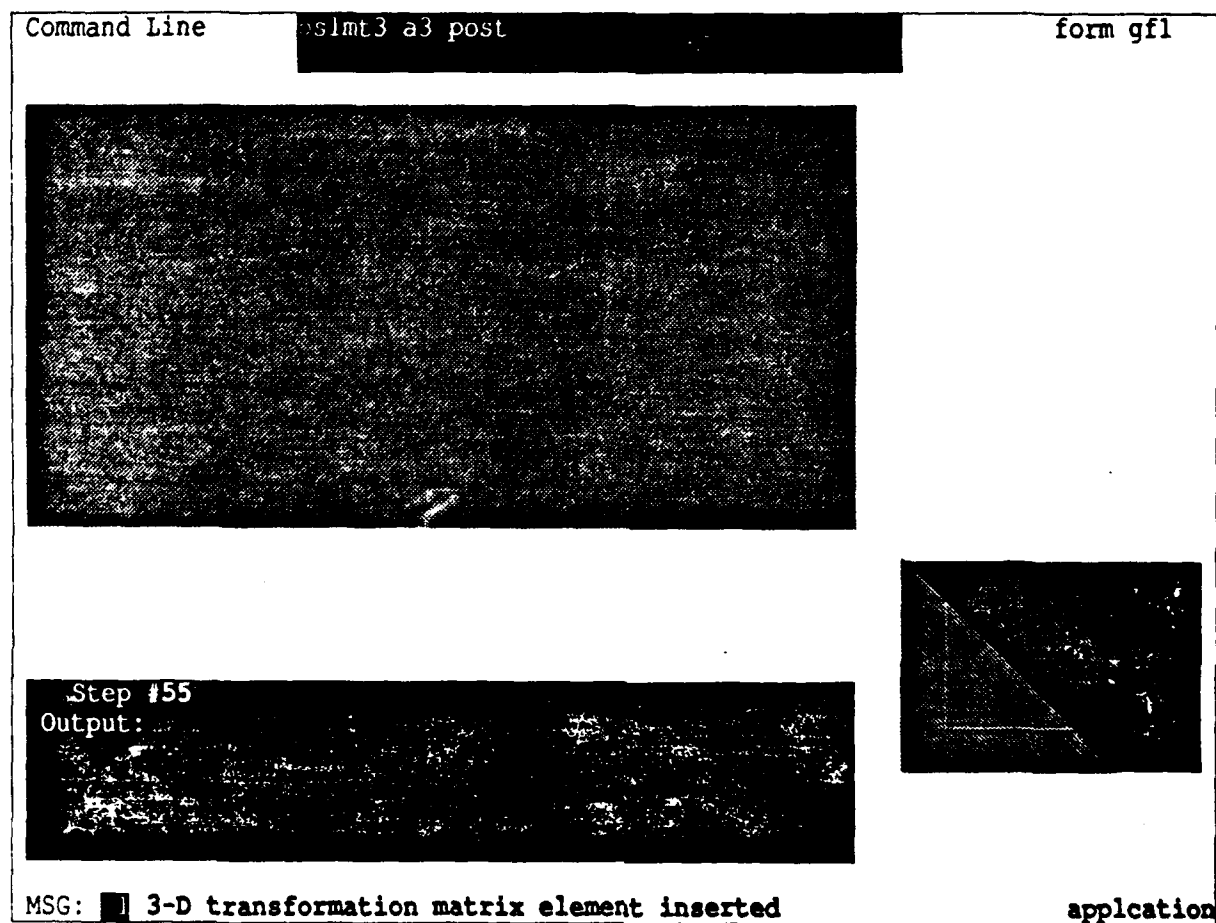


Figure 5-56b (AFTER)

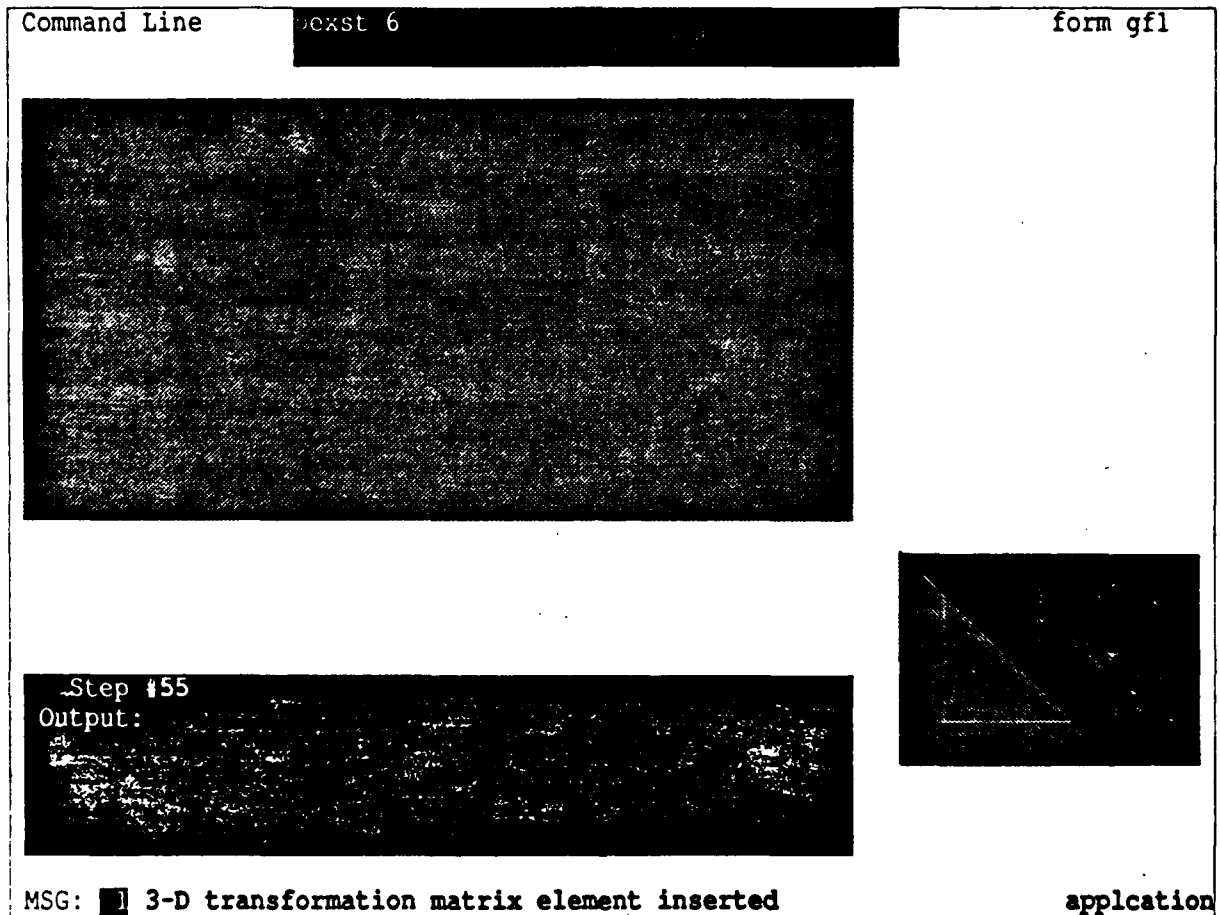


Figure 5-57a (BEFORE)

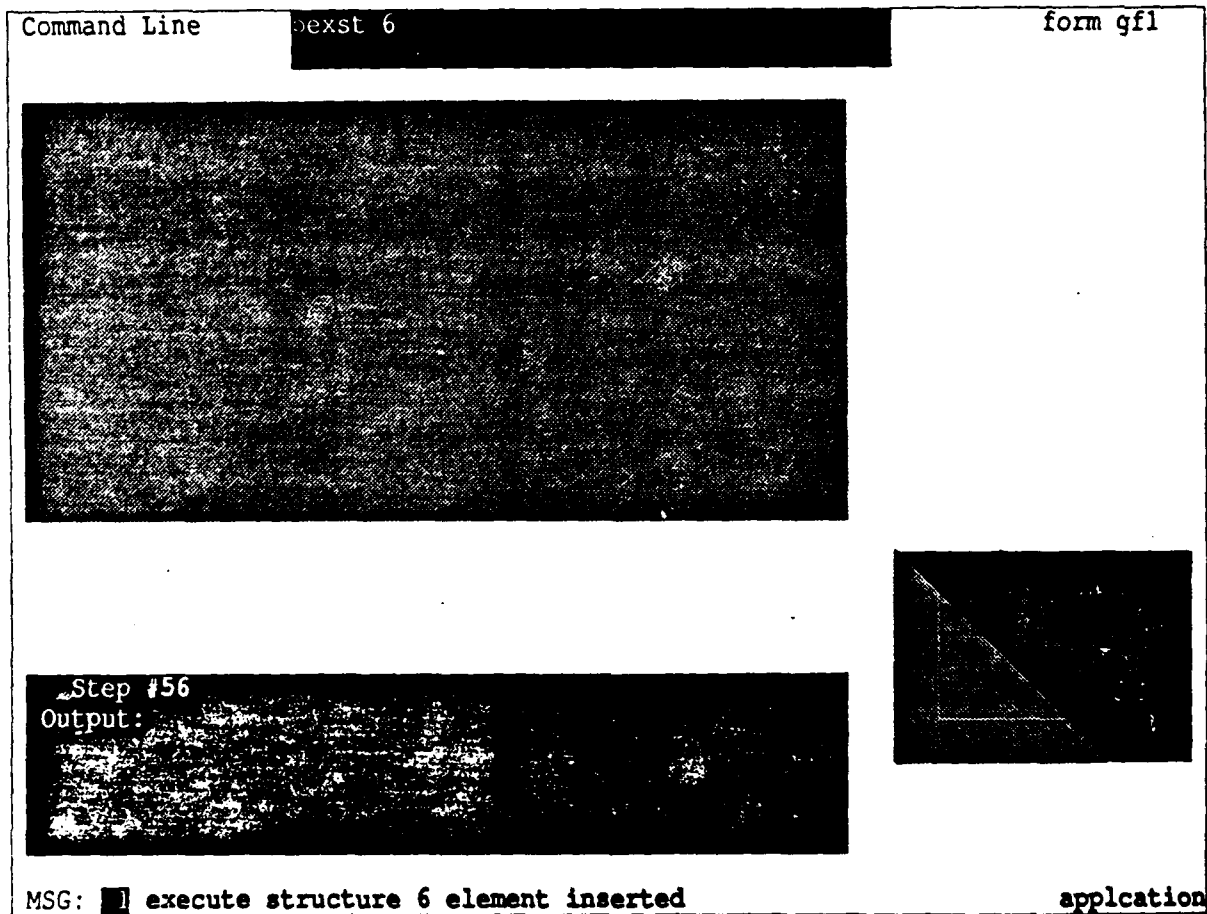


Figure 5-57b (AFTER)

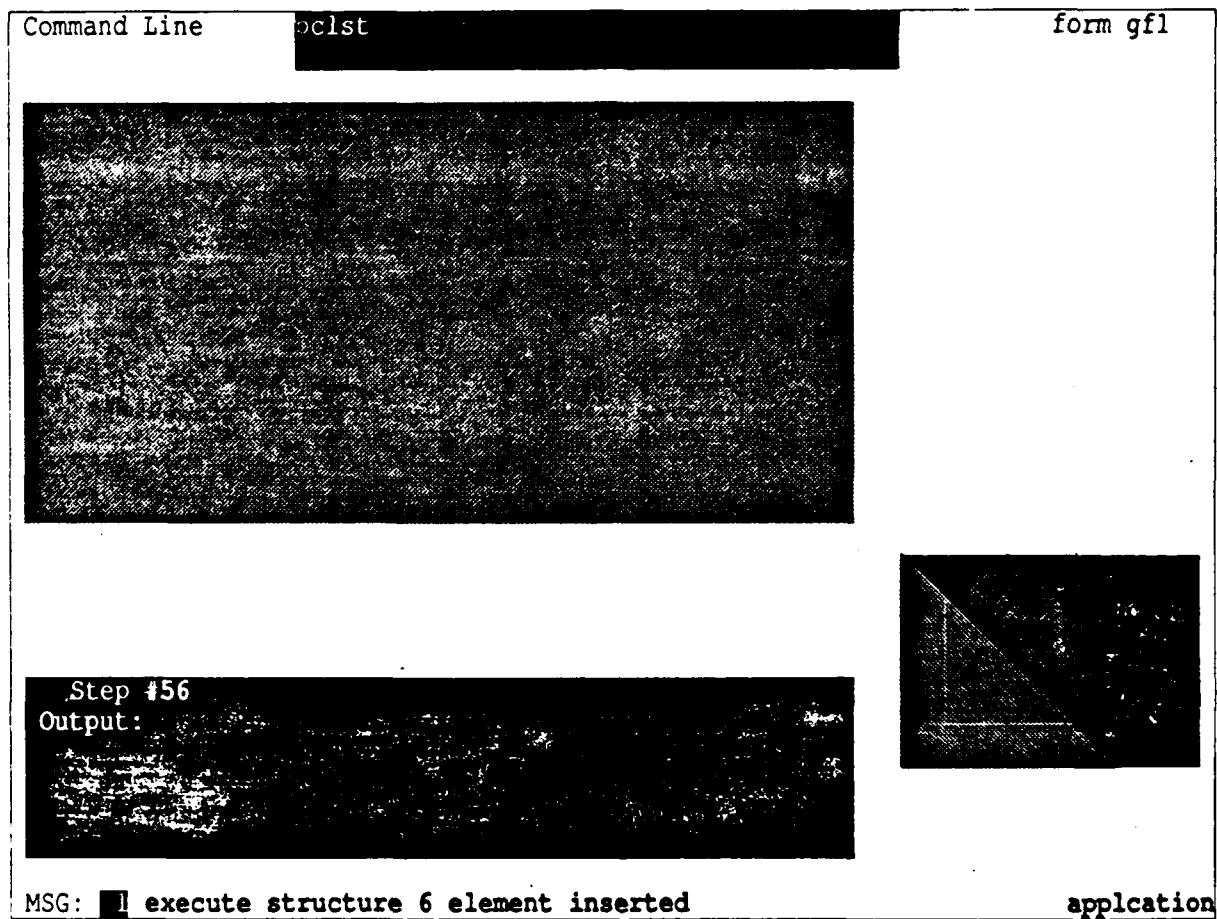


Figure 5-58a (BEFORE)

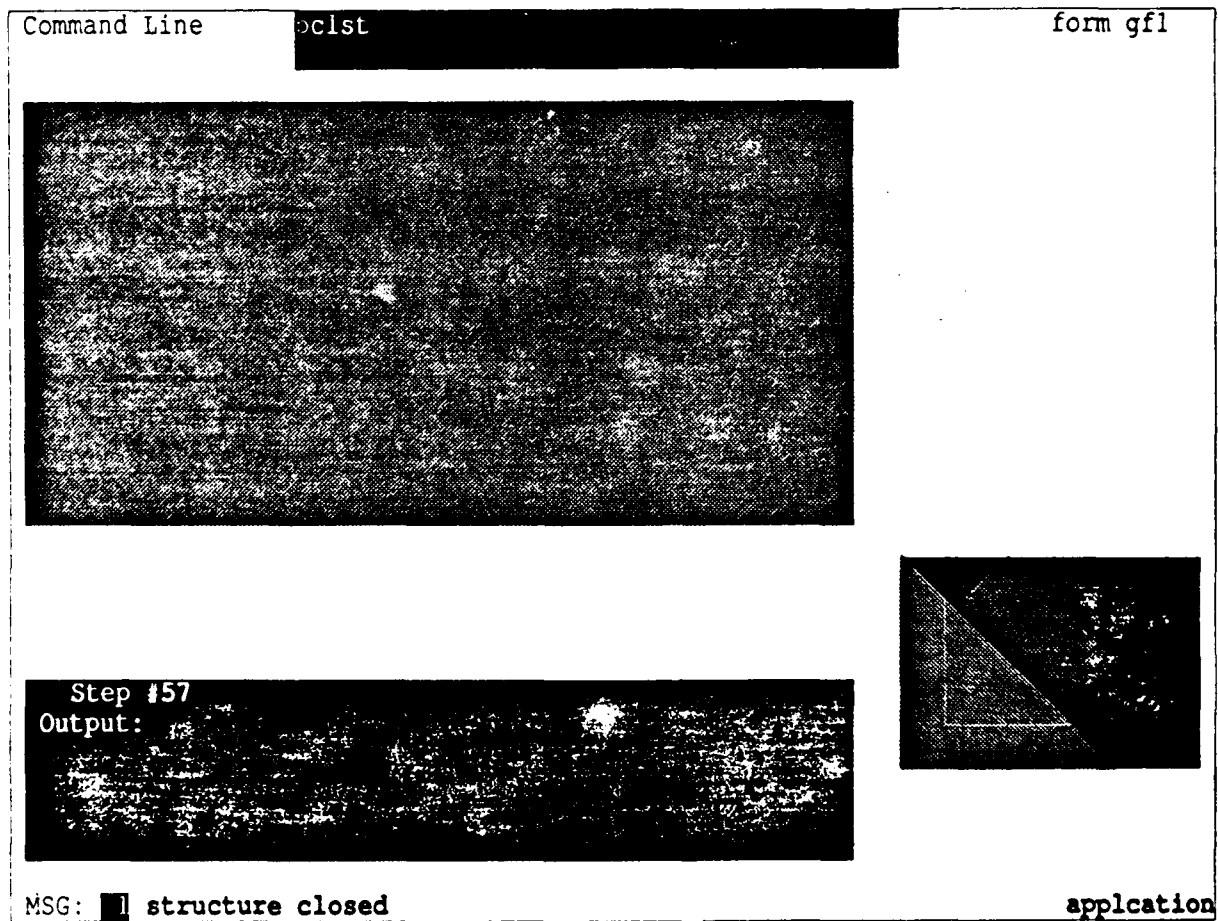


Figure 5-58b (AFTER)

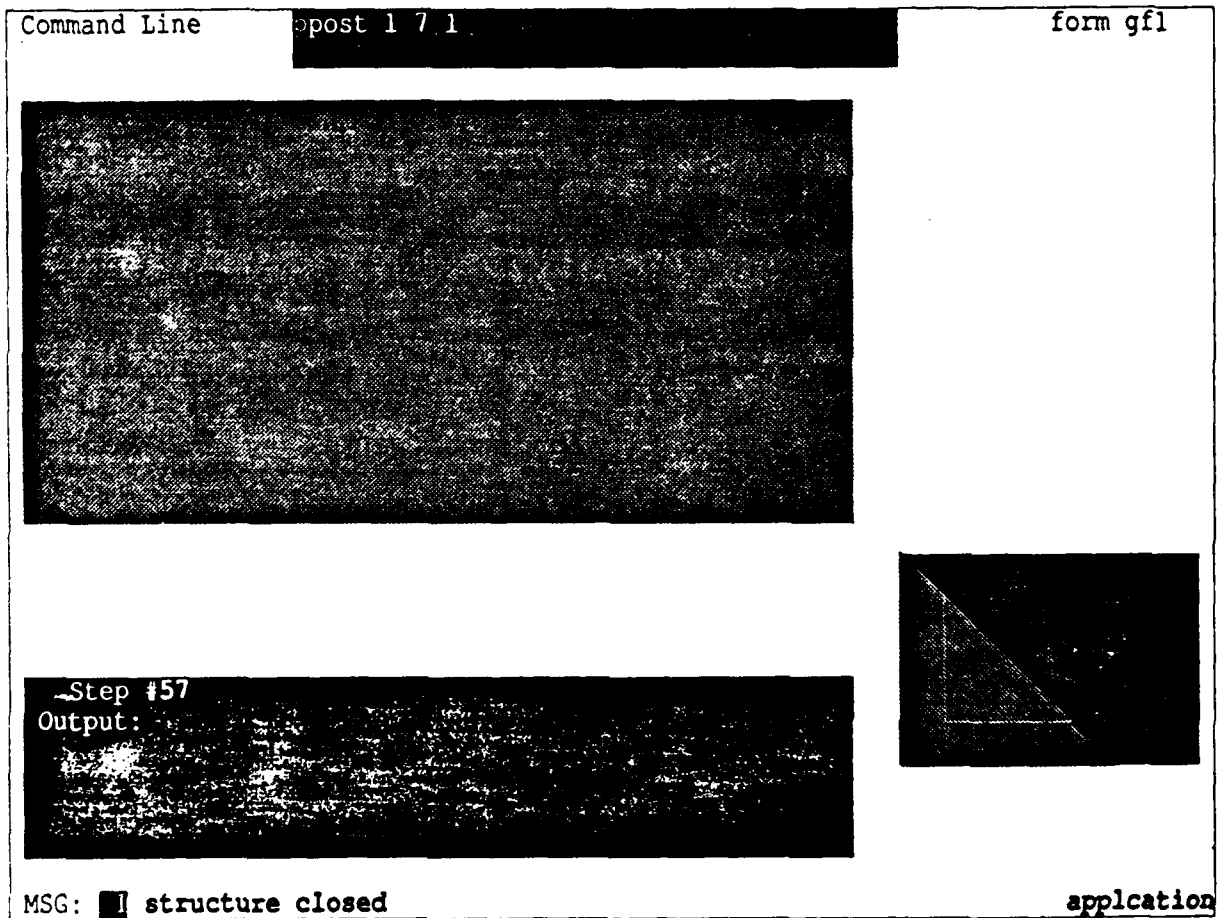


Figure 5-59a (BEFORE)

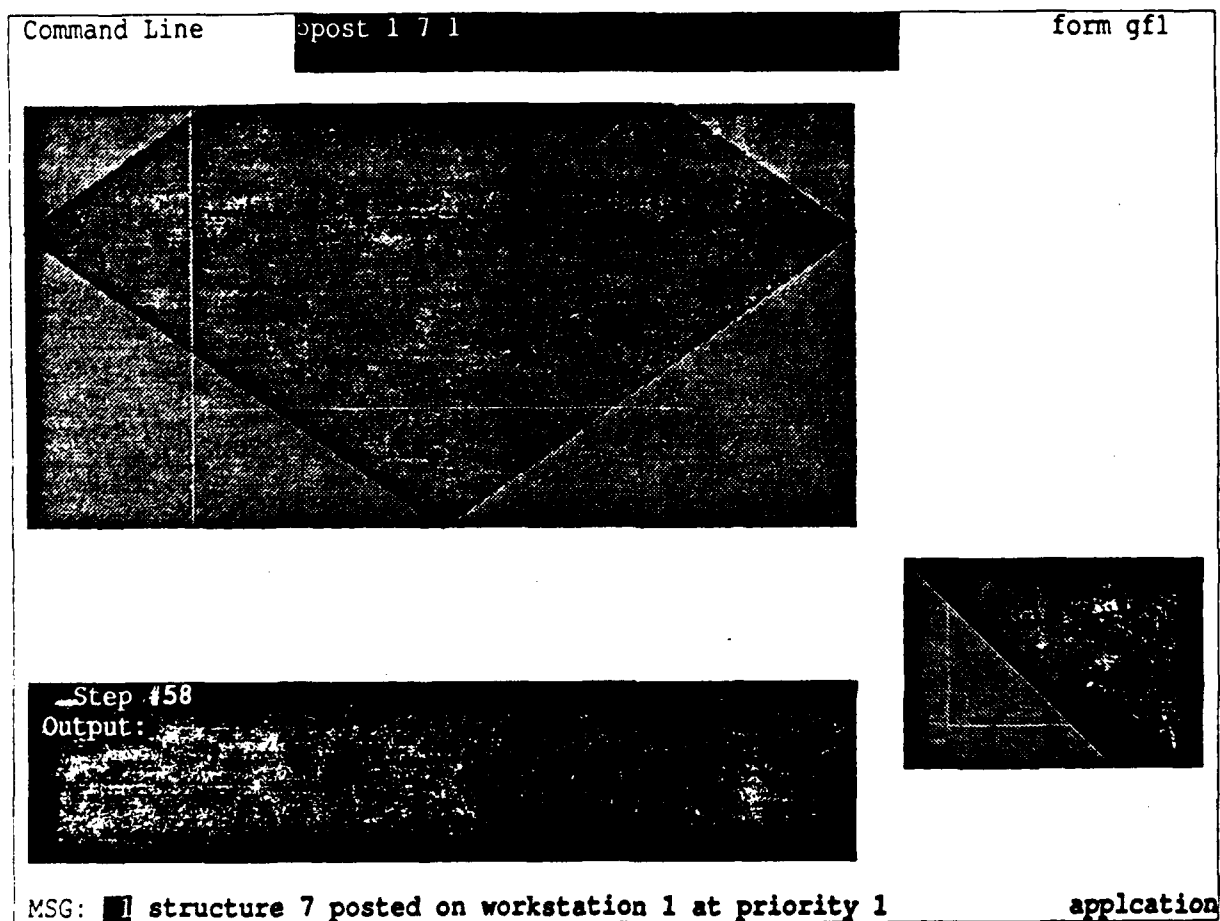


Figure 5-59b (AFTER)

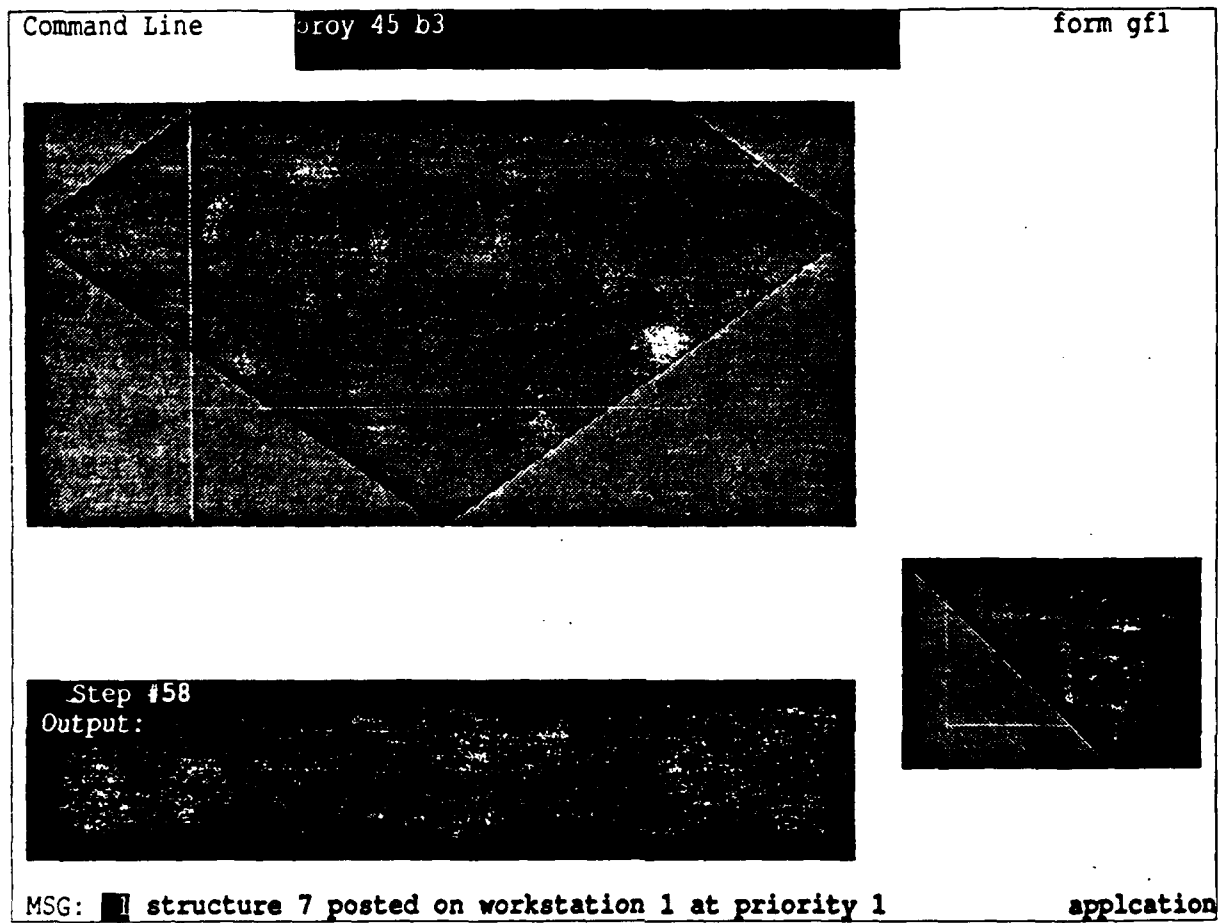


Figure 5-60a (BEFORE)

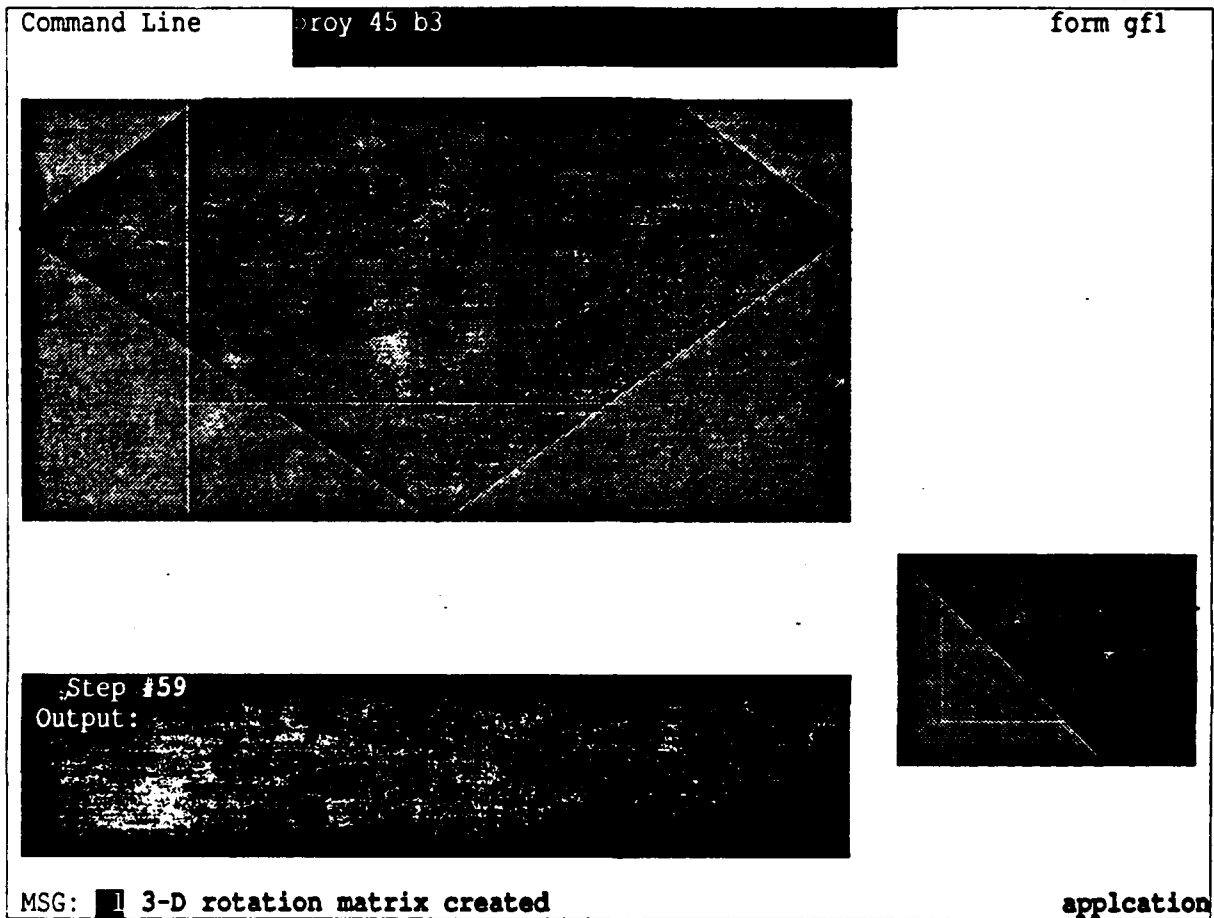


Figure 5-60b (AFTER)

UTP 620344220
30 September 1990

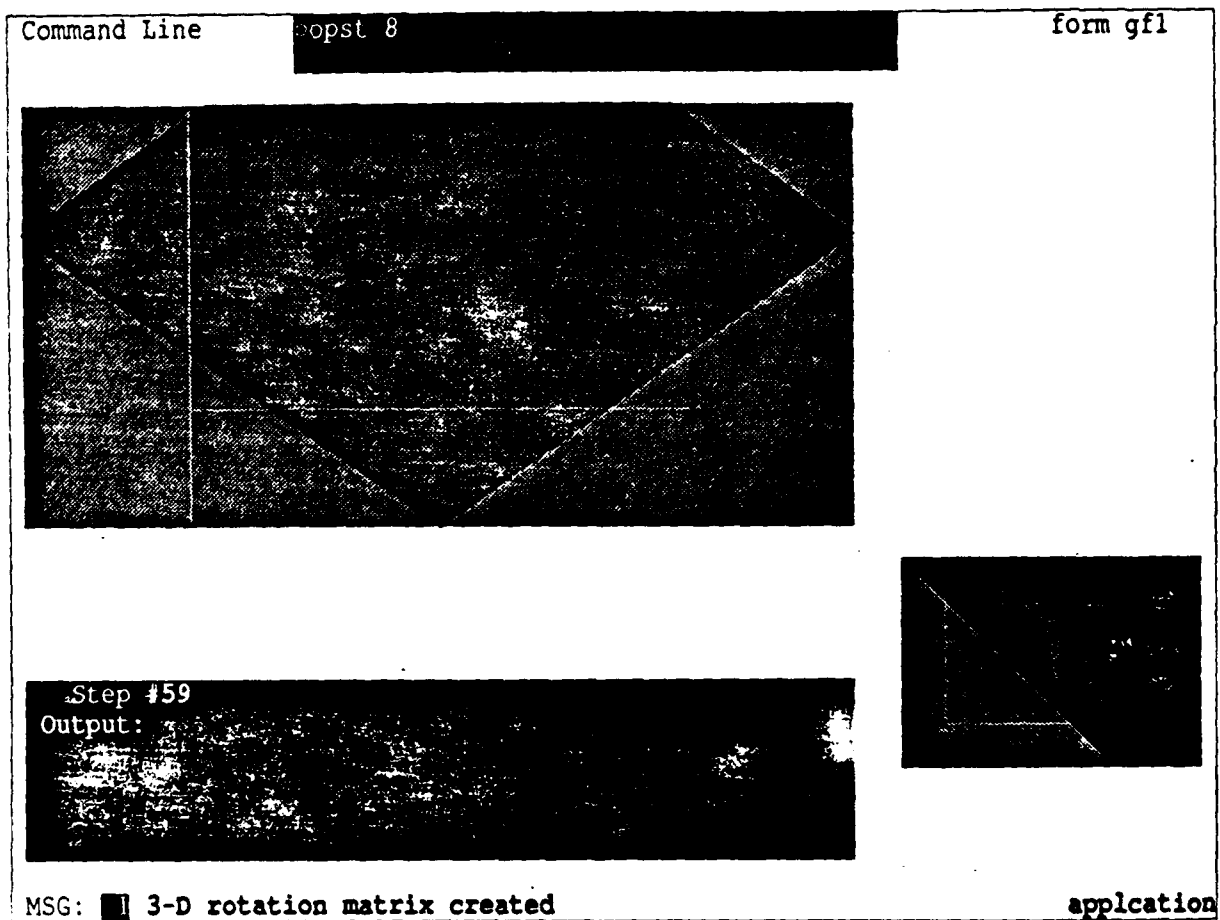


Figure 5-61a (BEFORE)

UTP 620344220
30 September 1990

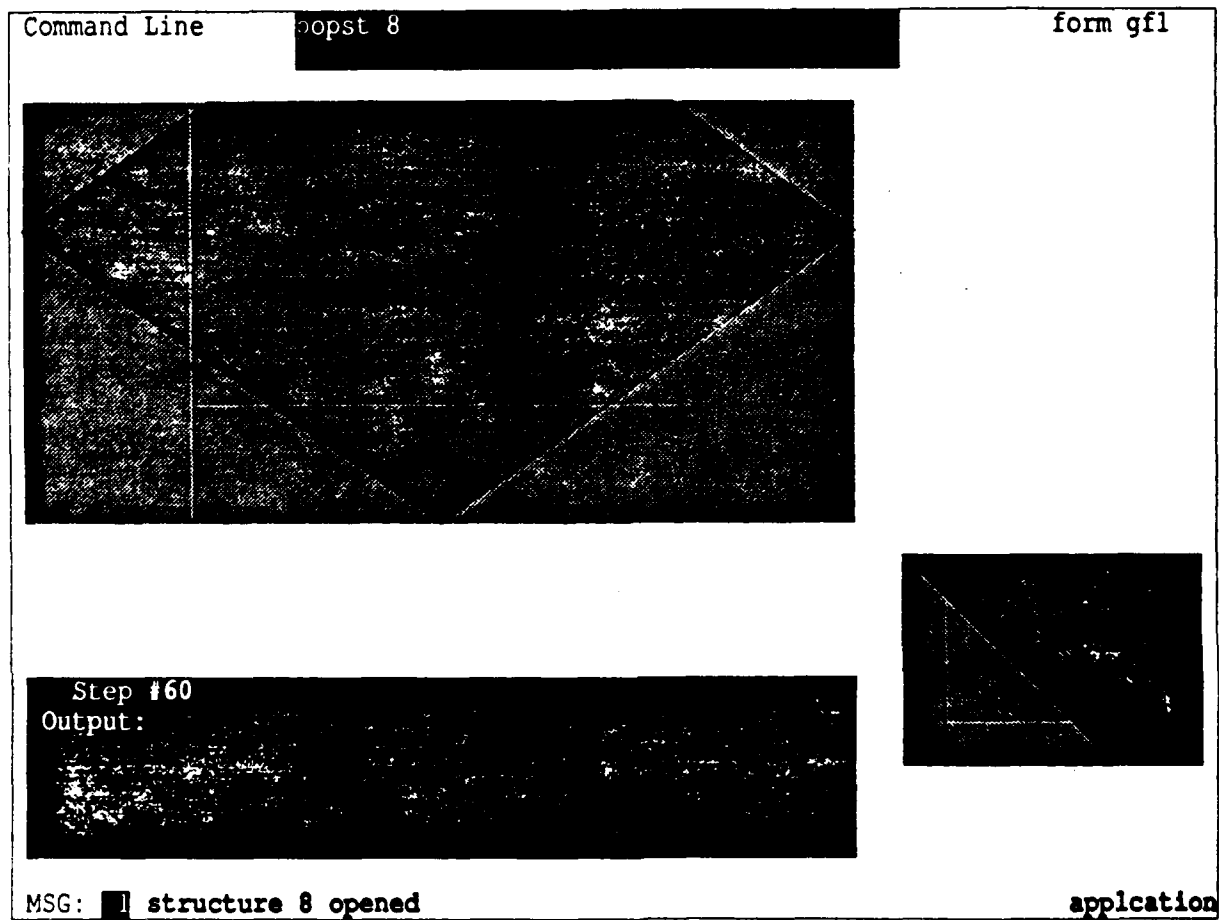


Figure 5-61b (AFTER)

UTP 620344220
30 September 1990

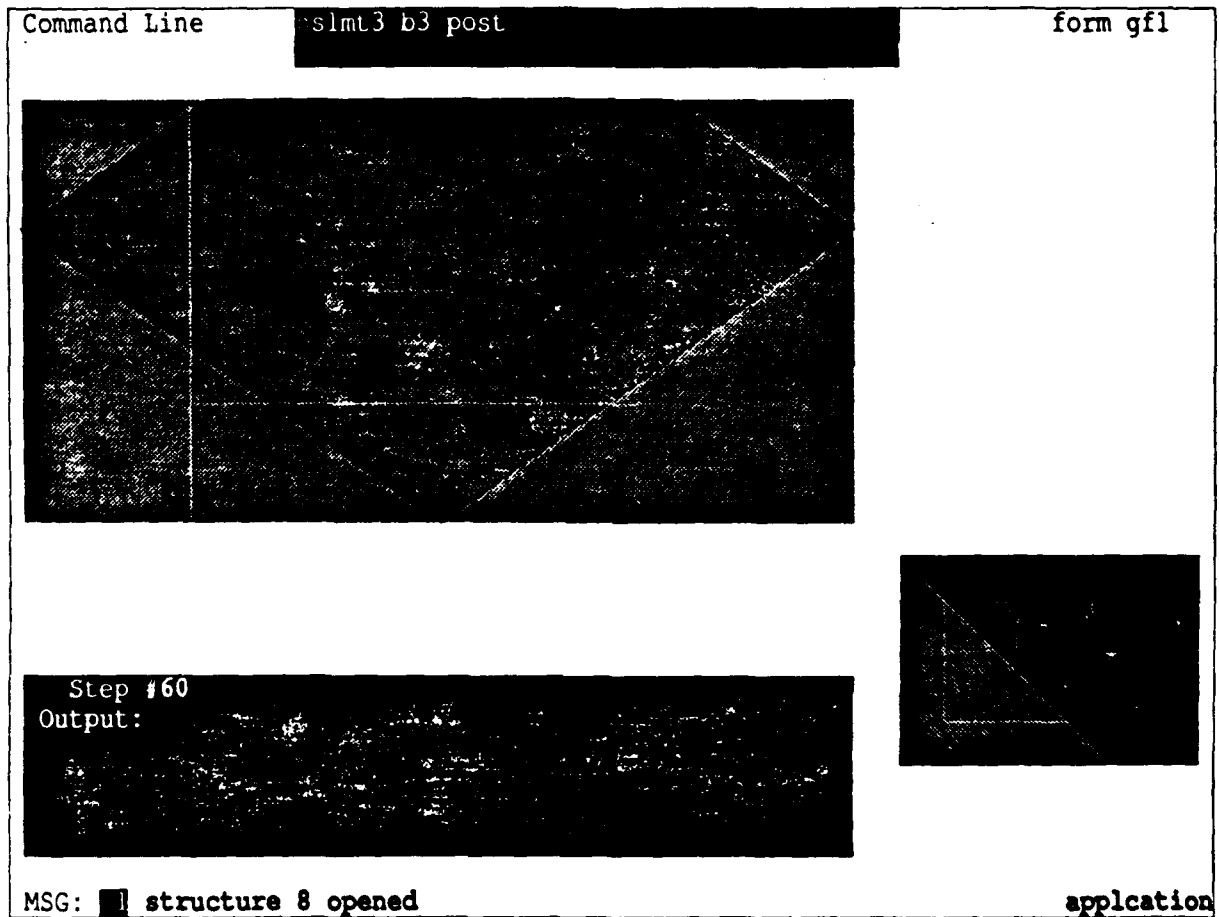


Figure 5-62a (BEFORE)

UTP 620344220
30 September 1990

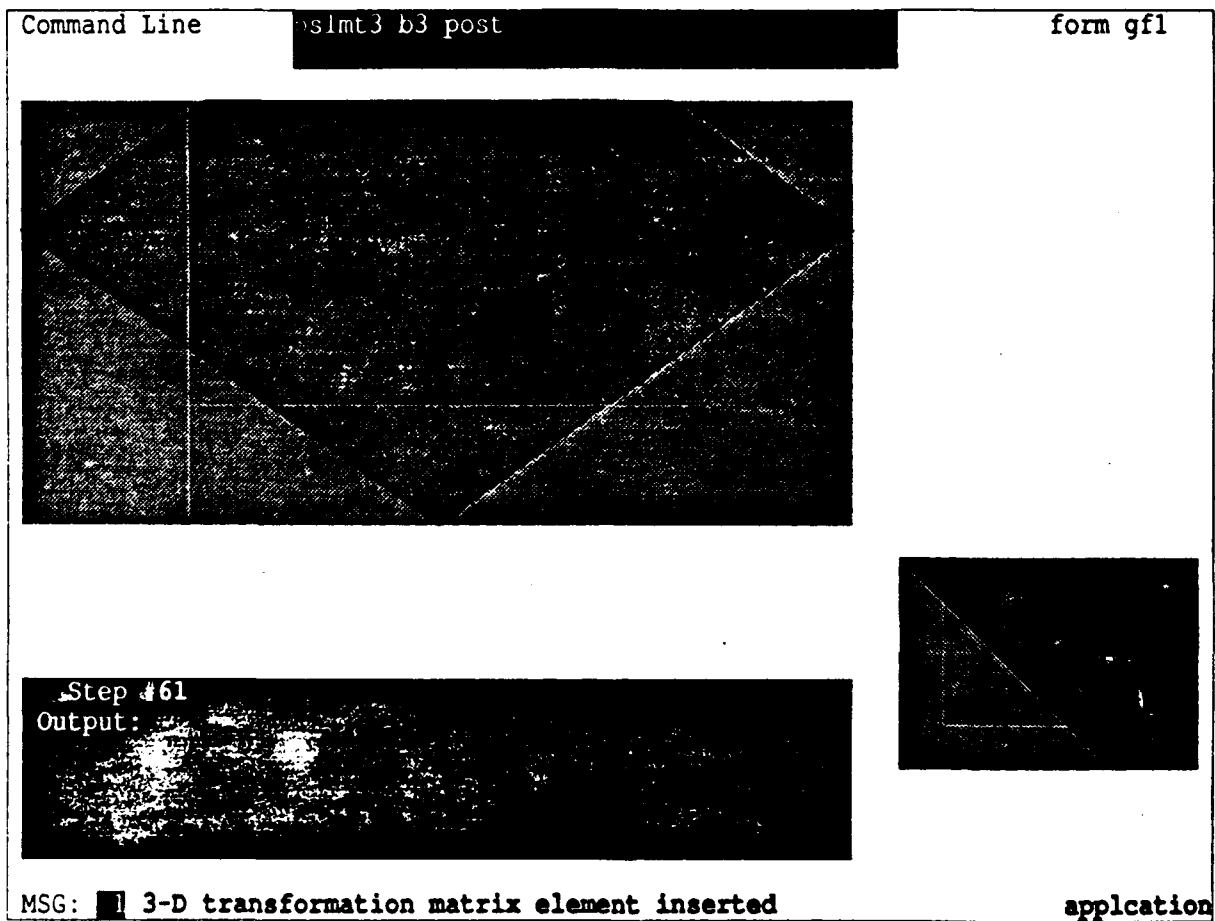


Figure 5-62b (AFTER)

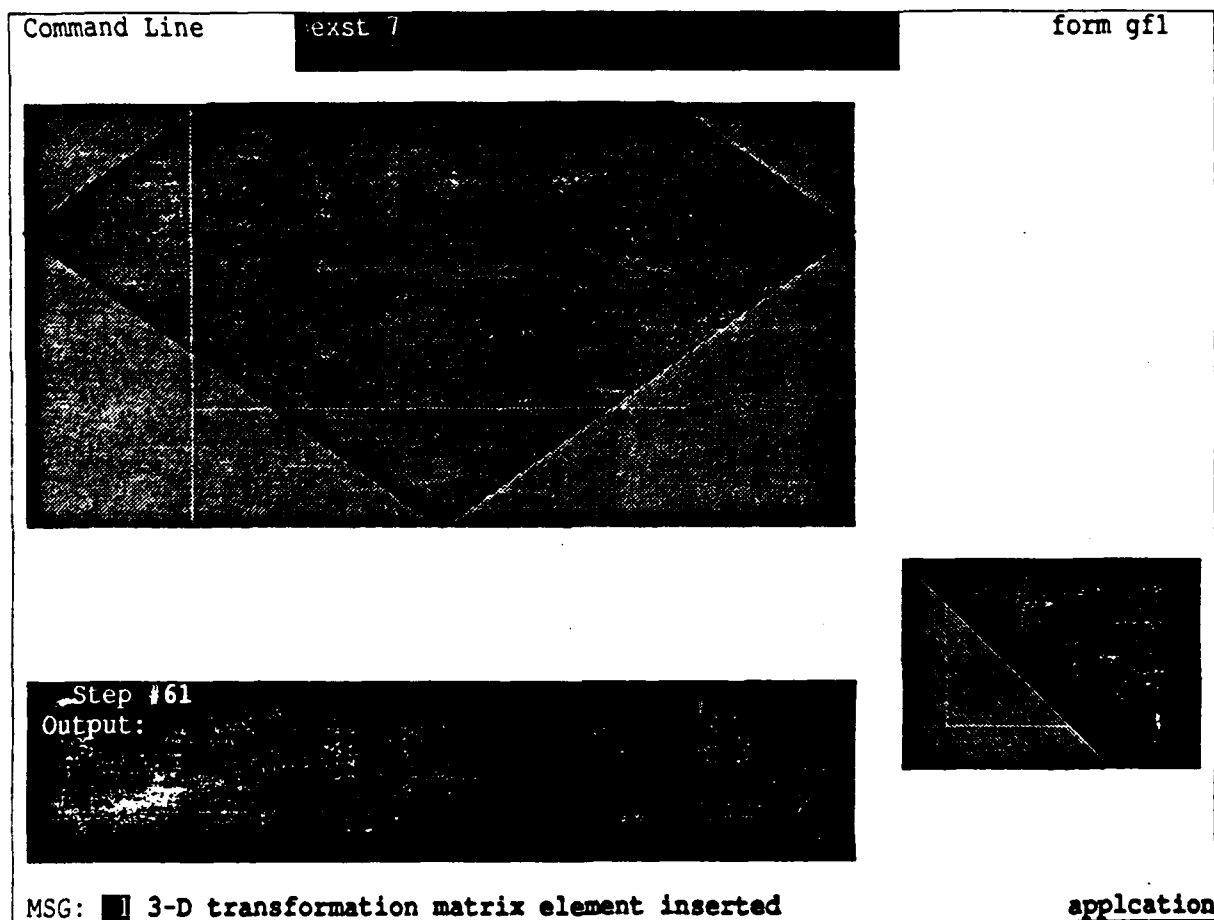


Figure 5-63a (BEFORE)

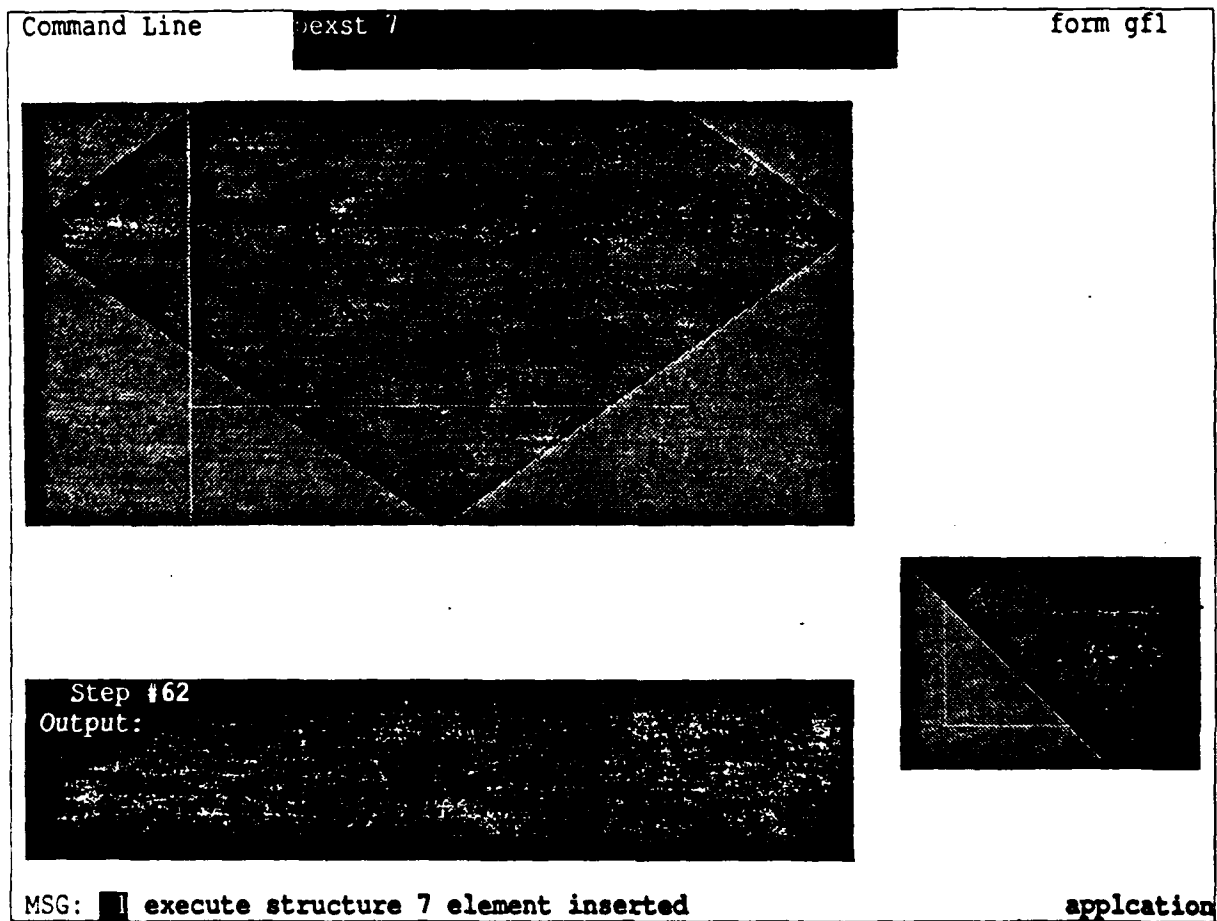


Figure 5-63b (AFTER)

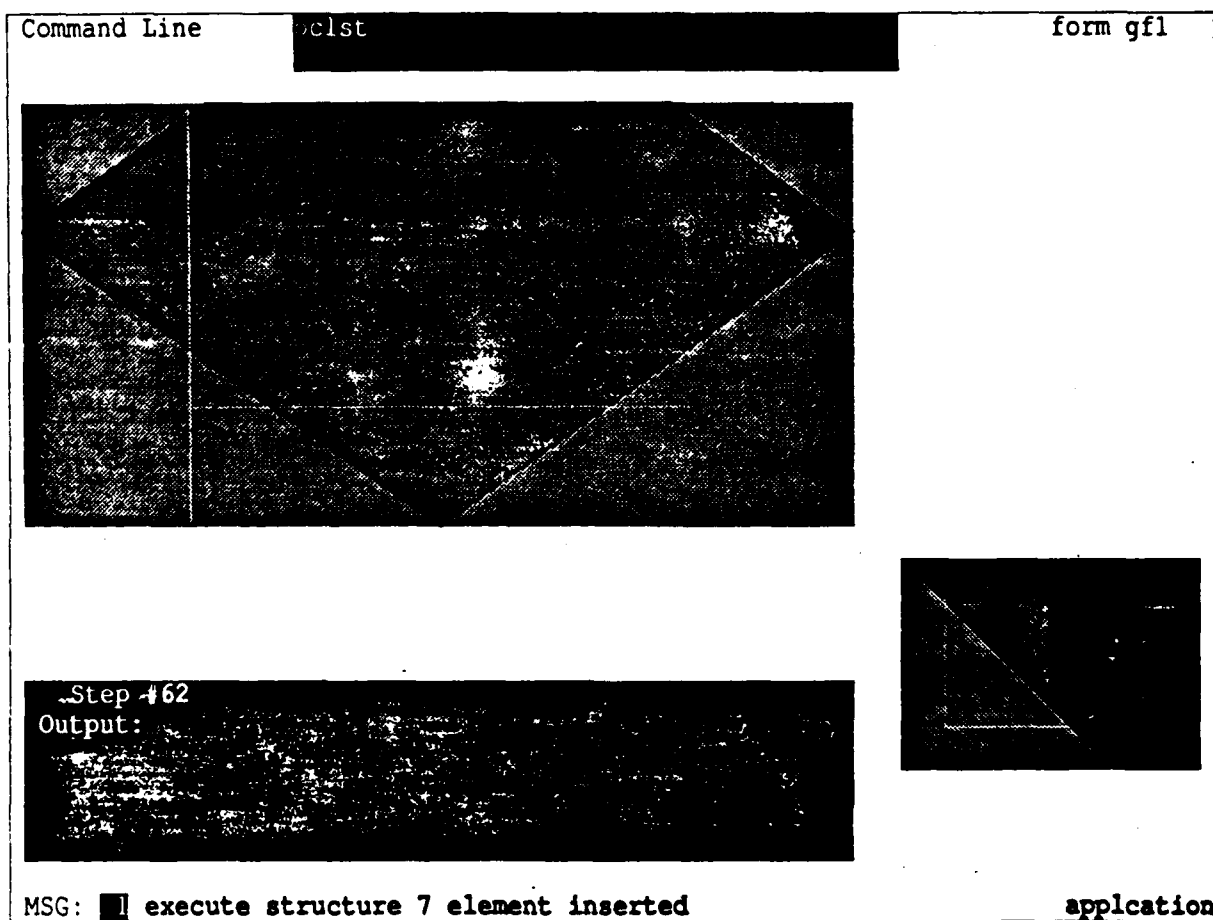


Figure 5-64a (BEFORE)

UTP 620344220
30 September 1990

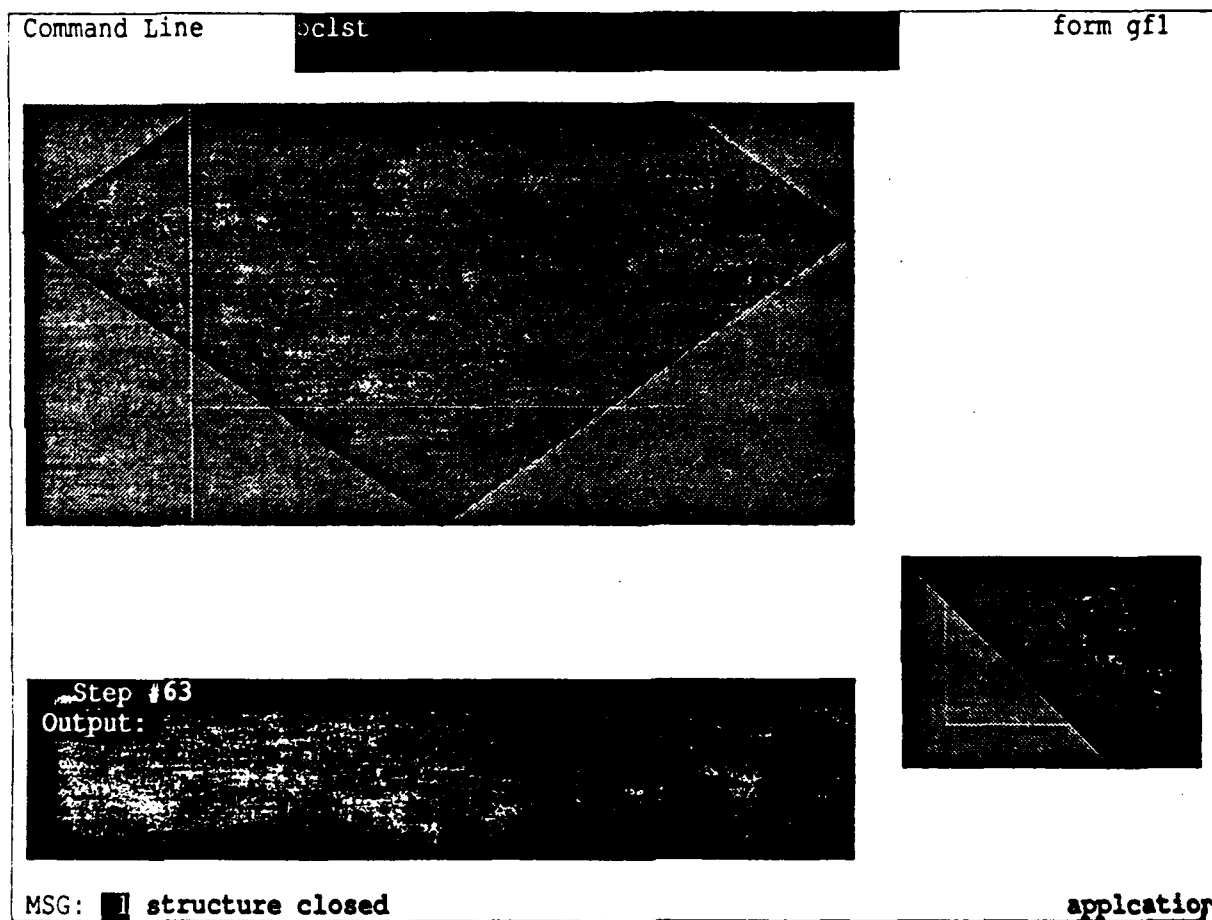


Figure 5-64b (AFTER)

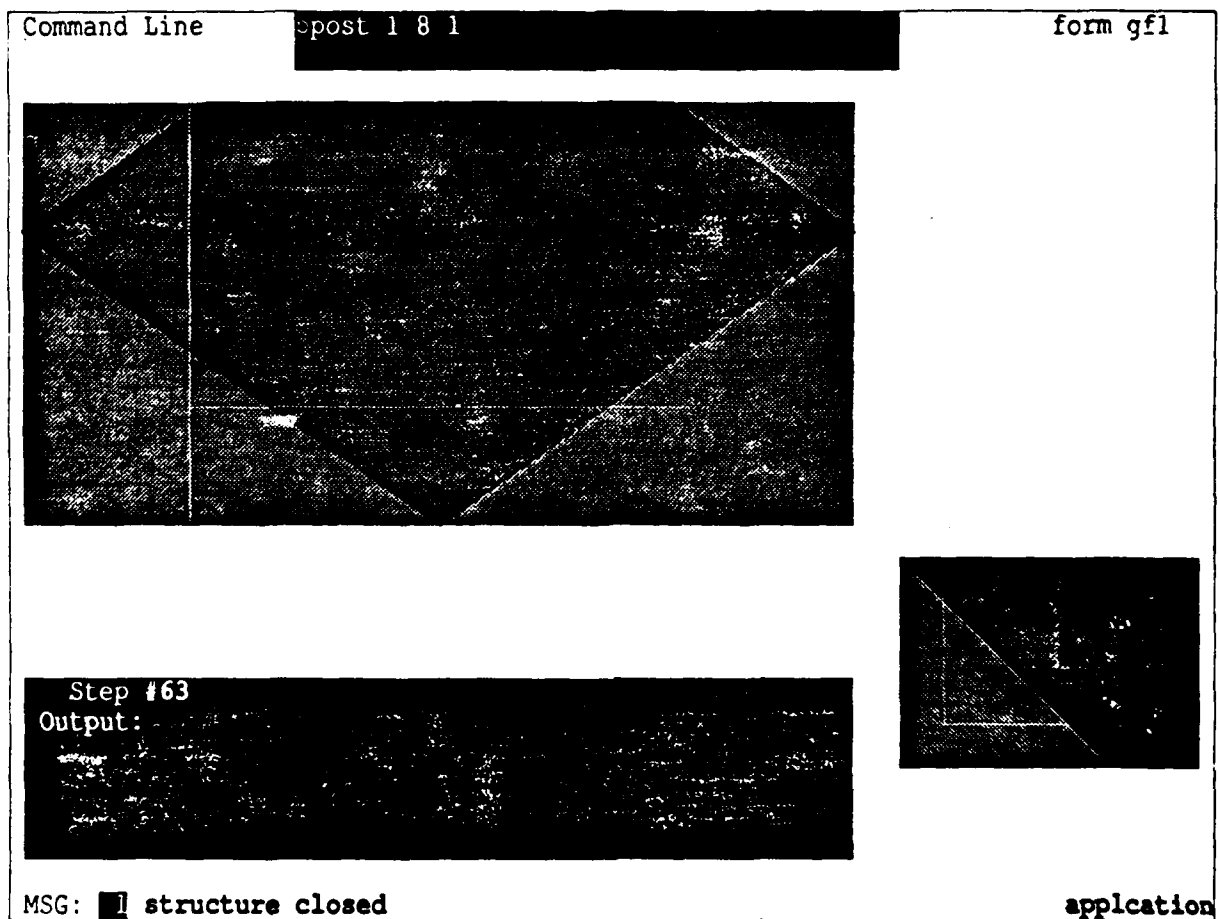


Figure 5-65a (BEFORE)

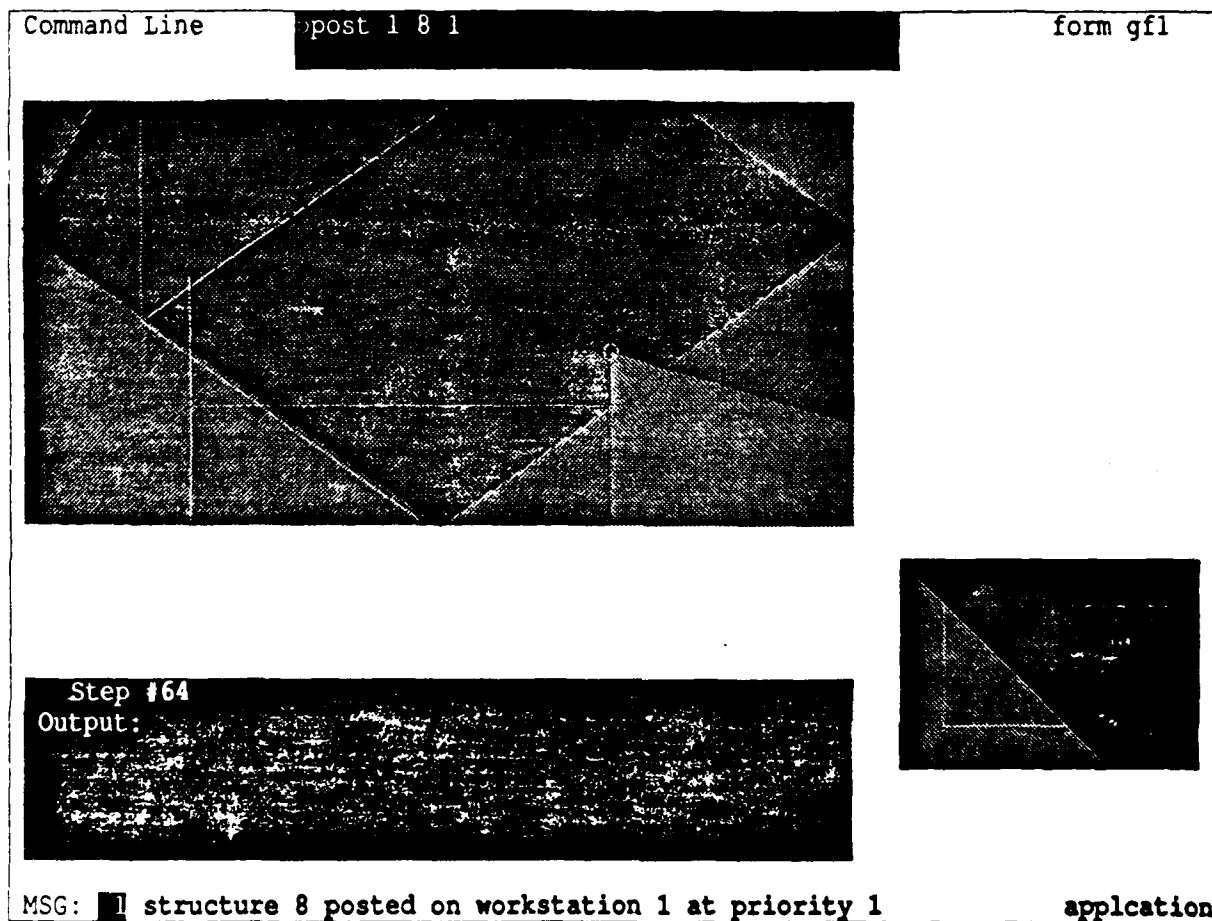


Figure 5-65b (AFTER)

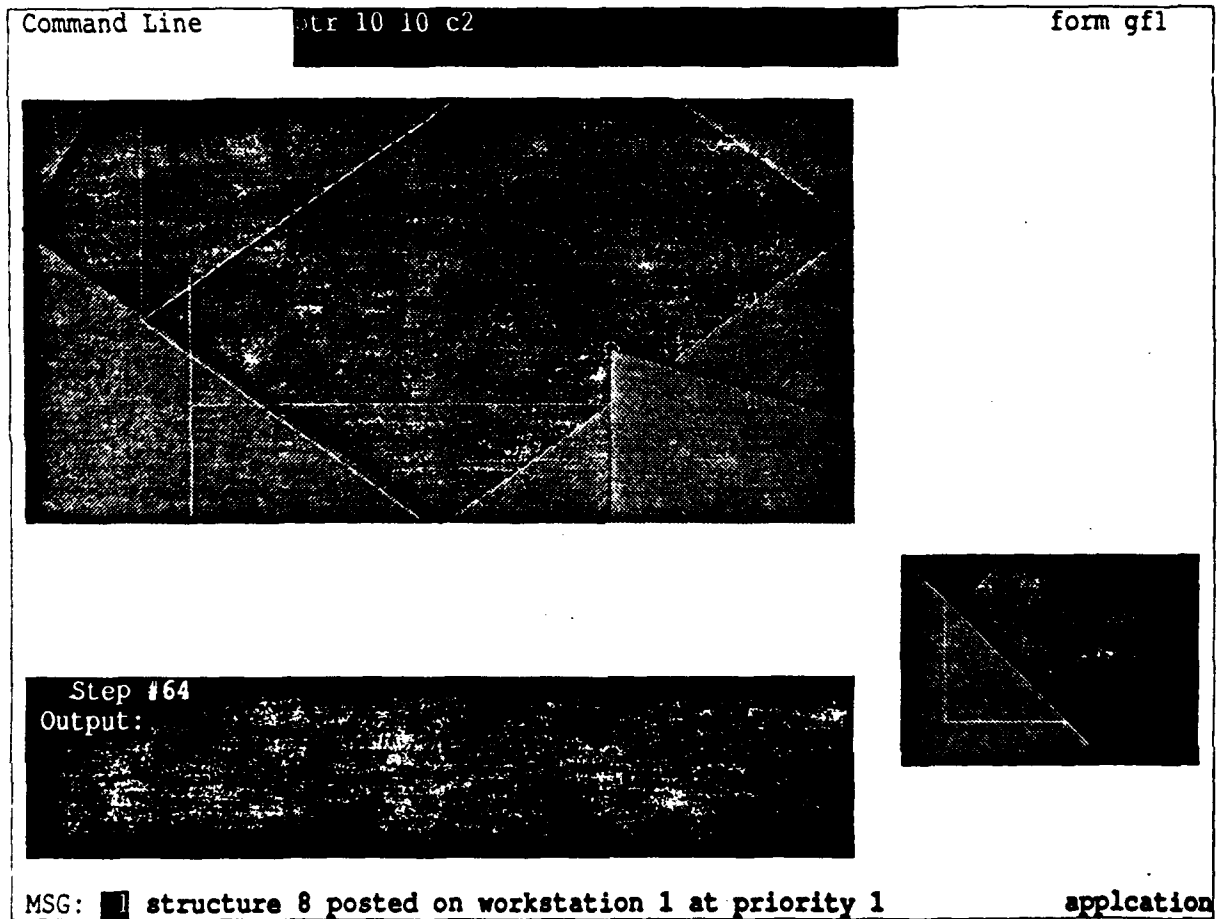


Figure 5-66a (BEFORE)

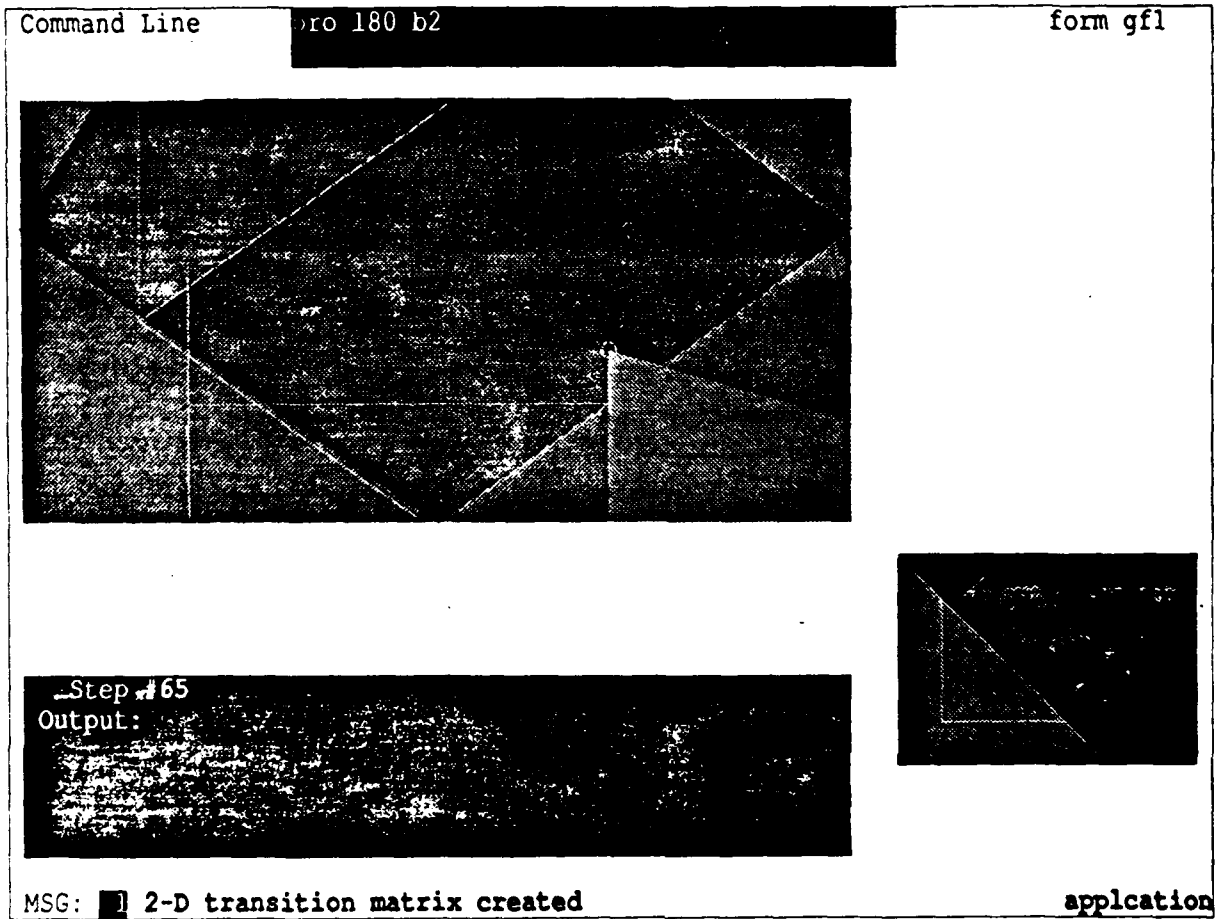


Figure 5-66b (AFTER)

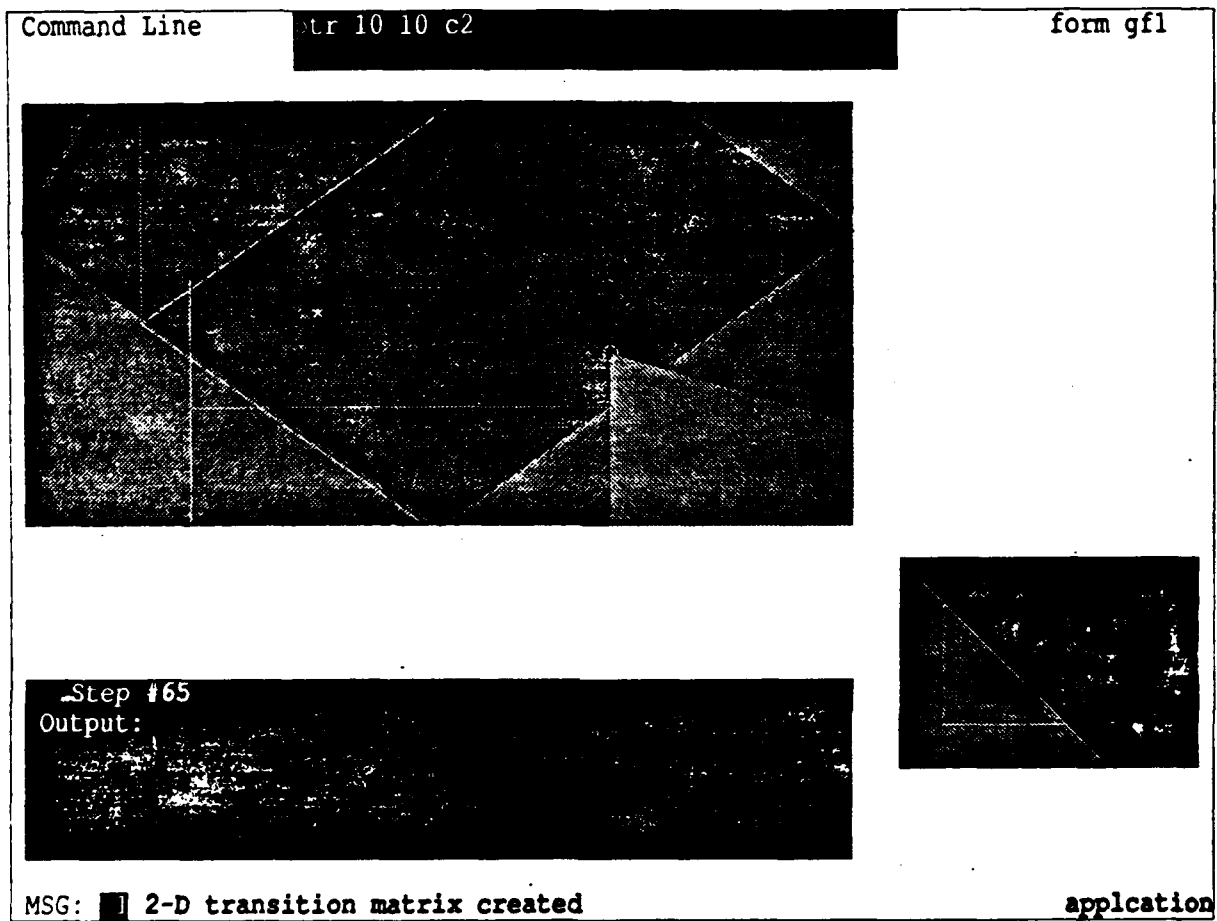


Figure 5-67a (BEFORE)

UTP 620344220
30 September 1990

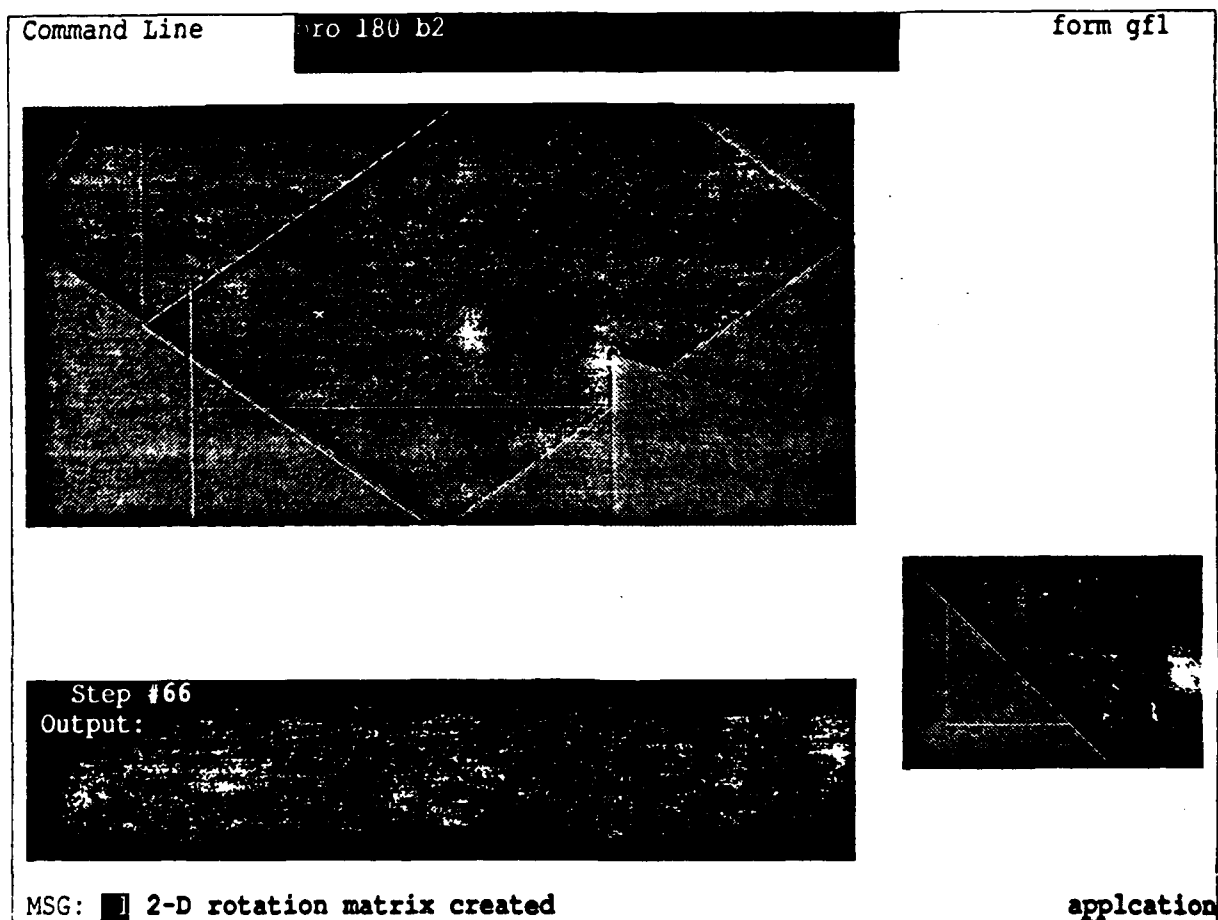


Figure 5-67b (AFTER)

UTP 620344220
30 September 1990

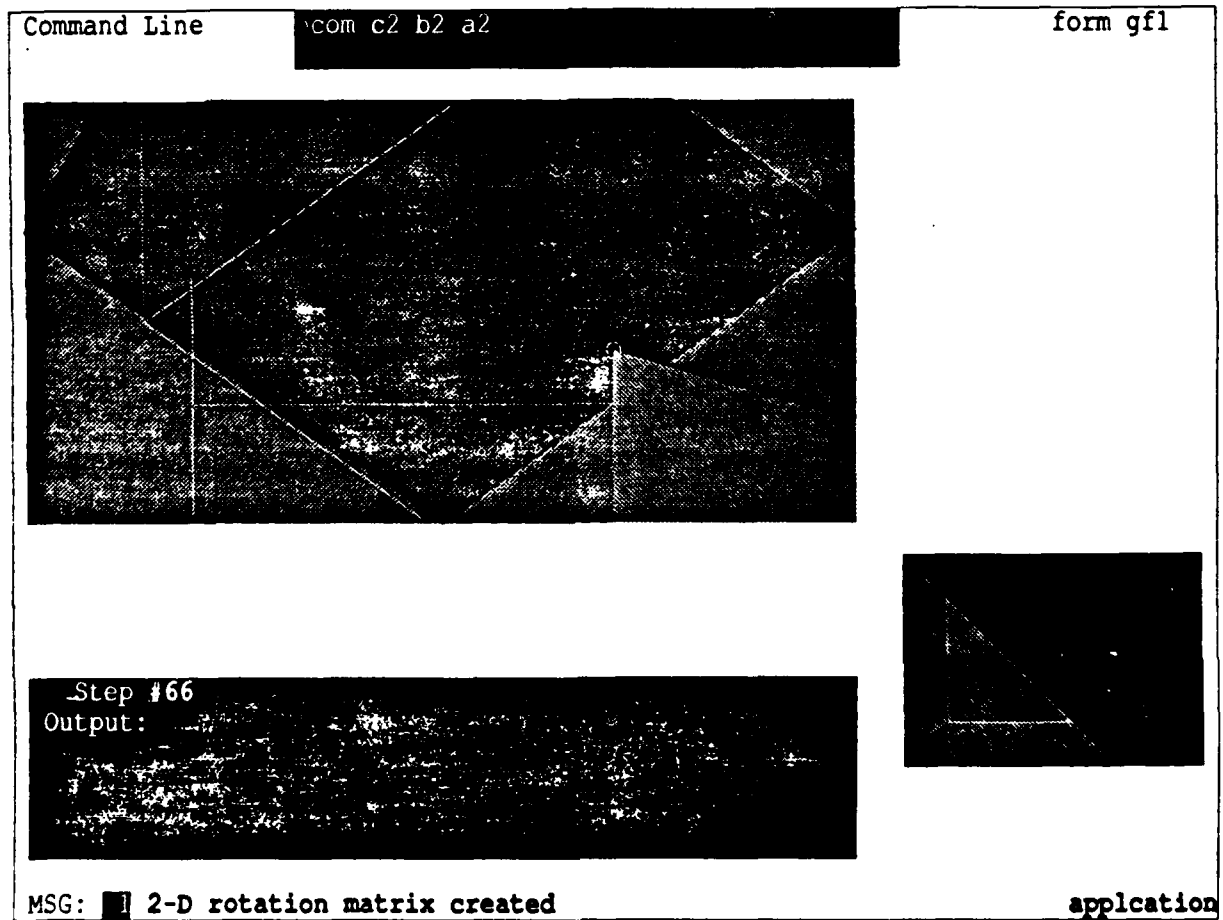


Figure 5-68a (BEFORE)

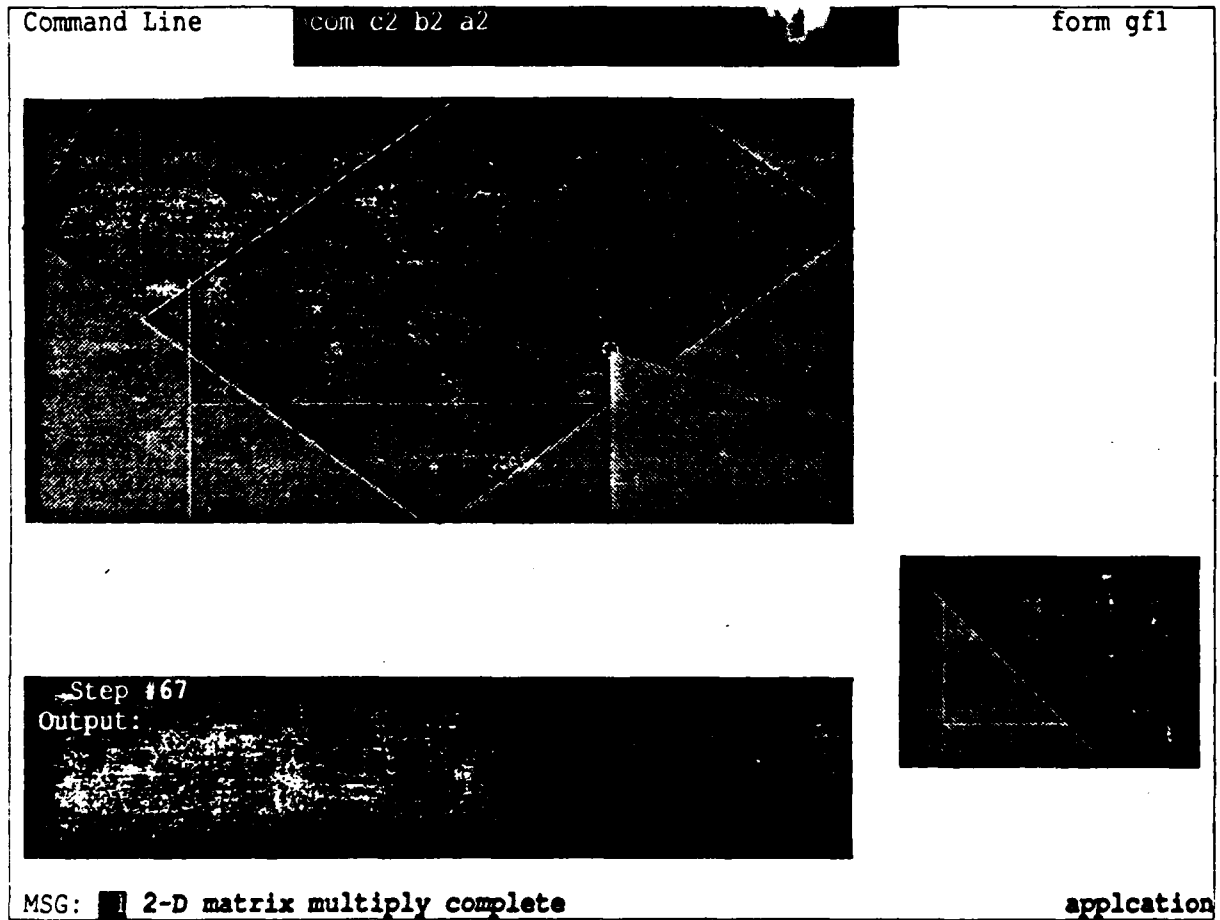


Figure 5-68b (AFTER)

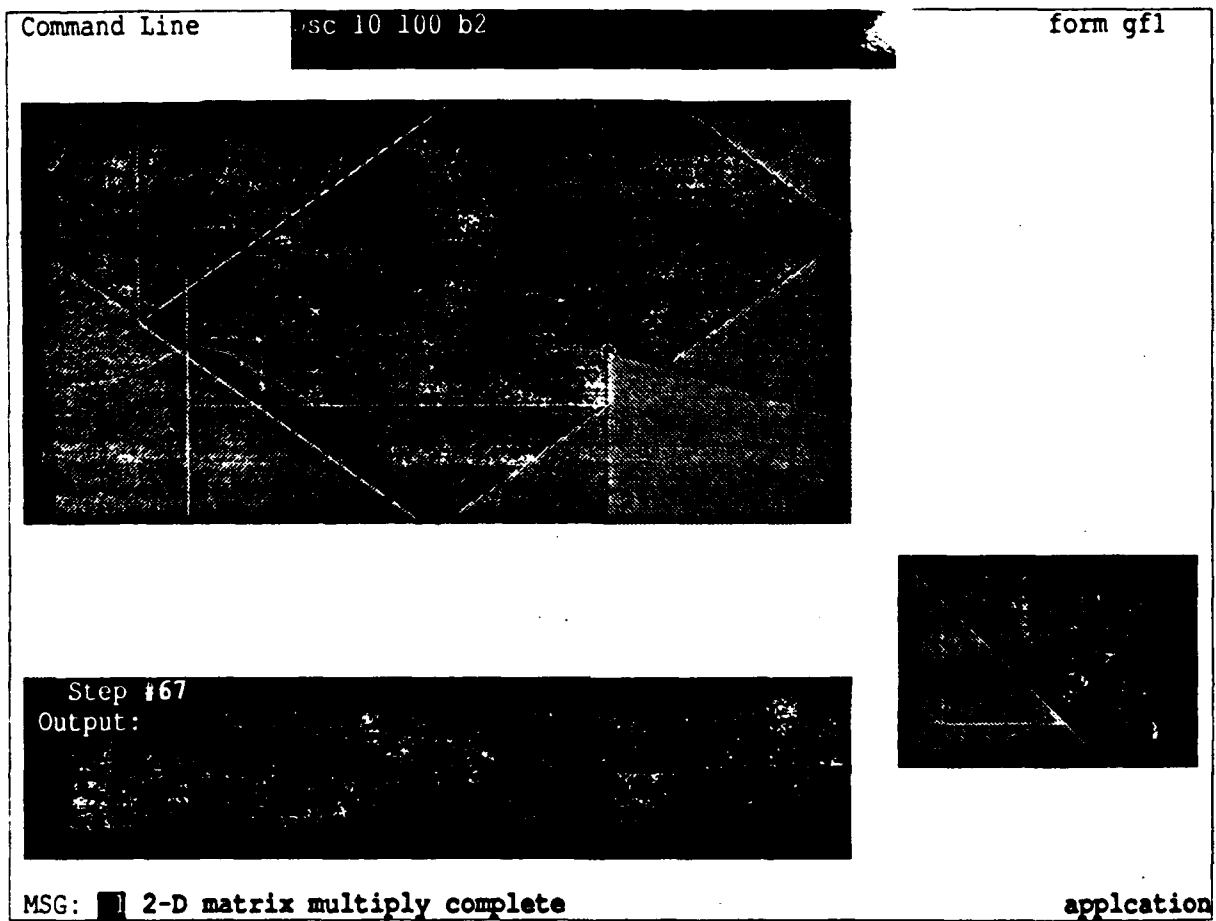


Figure 5-69a (BEFORE)

UTP 620344220
30 September 1990

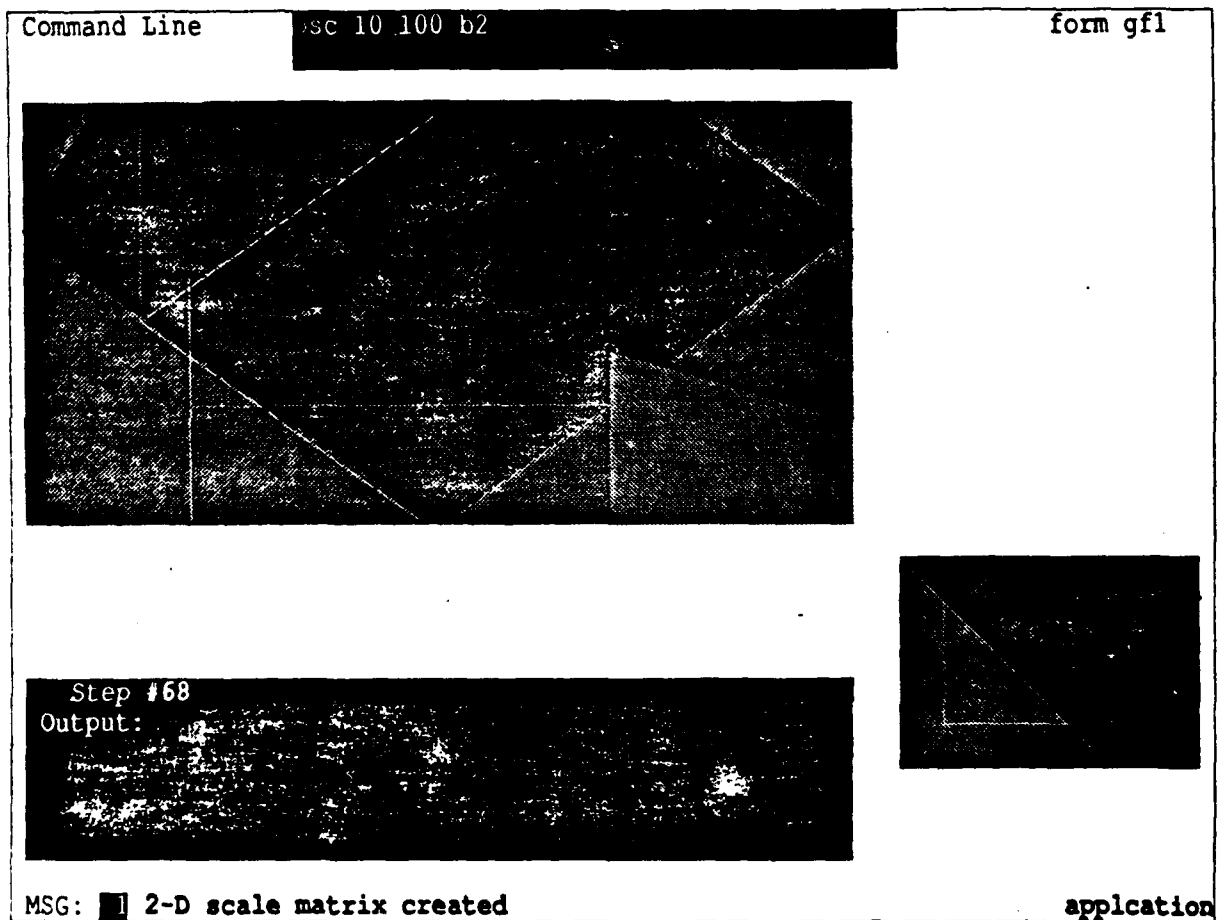


Figure 5-69b (AFTER)

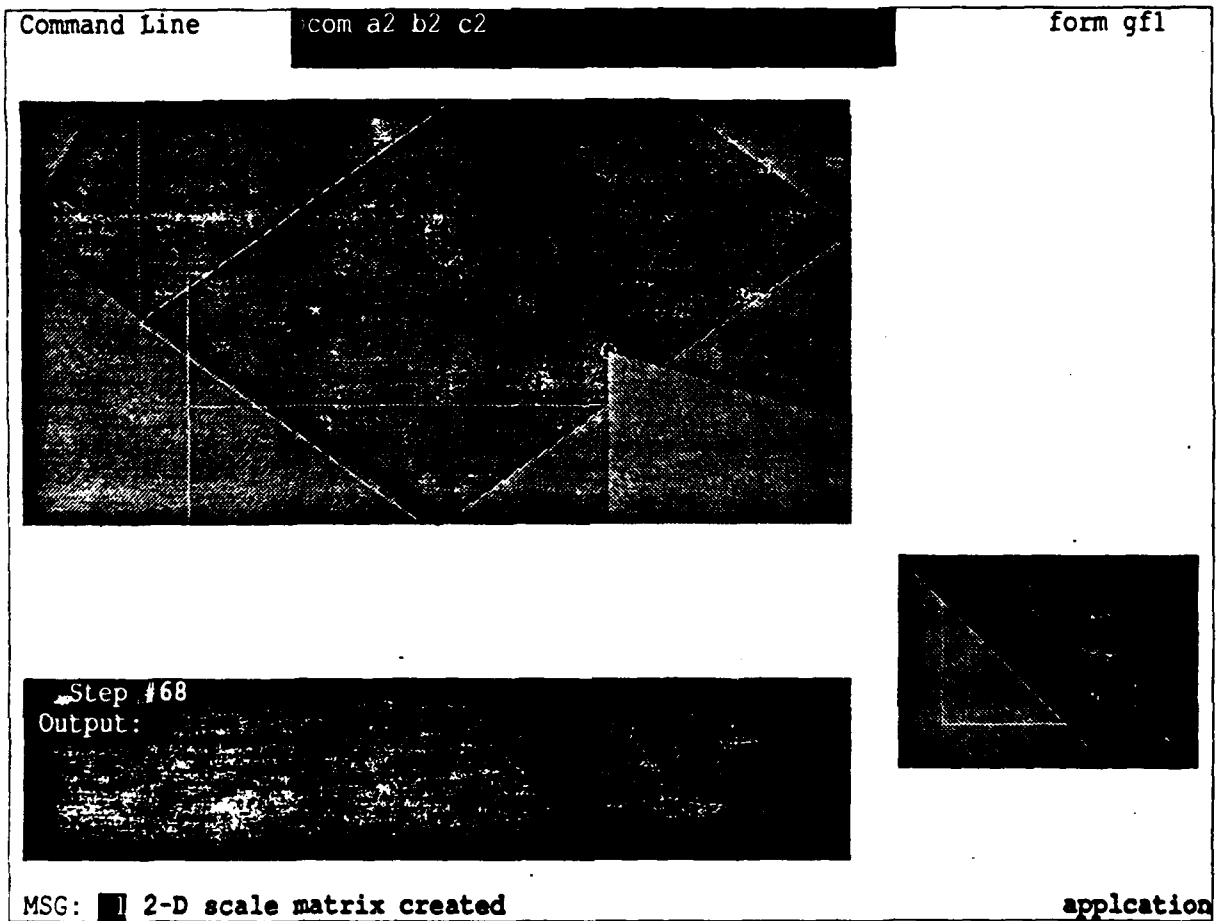


Figure 5-70a (BEFORE)

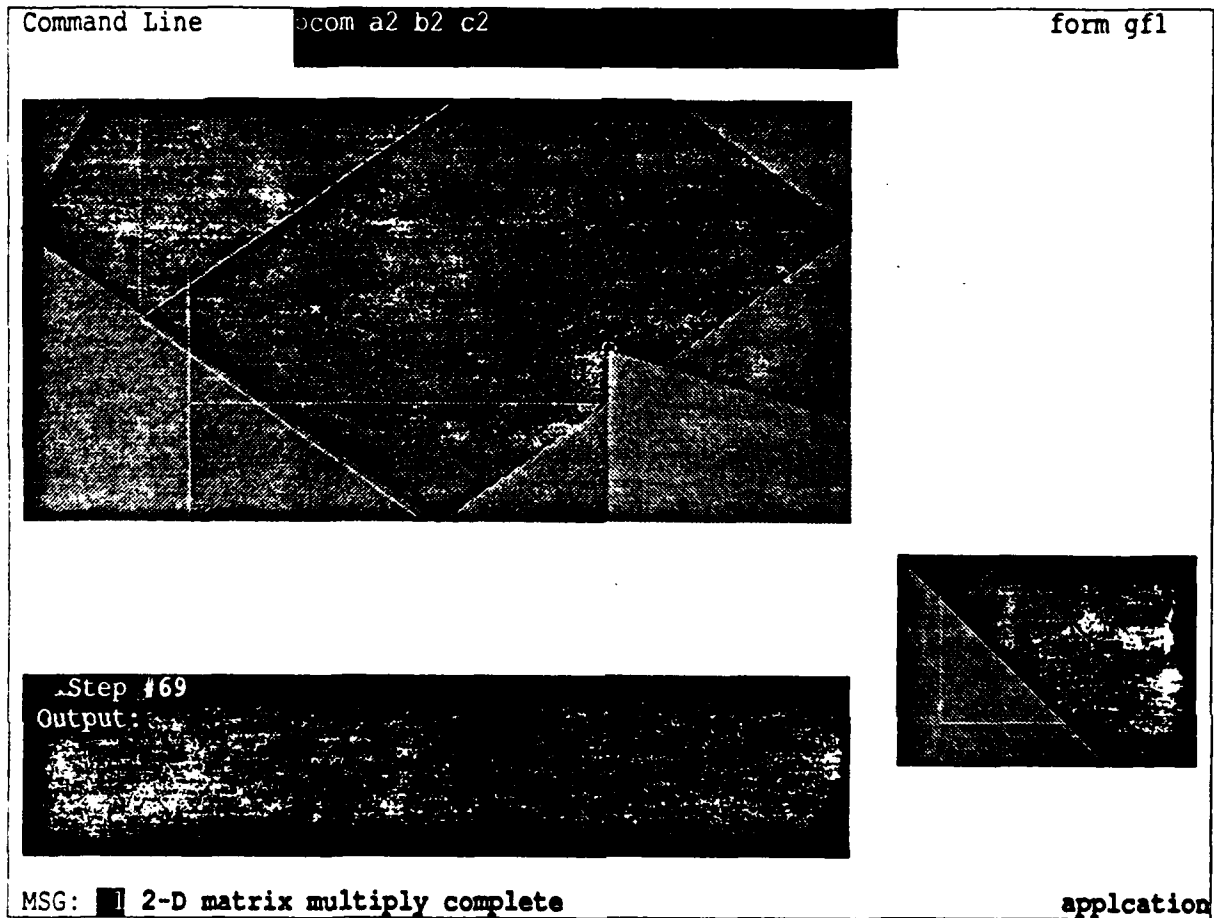


Figure 5-70b (AFTER)

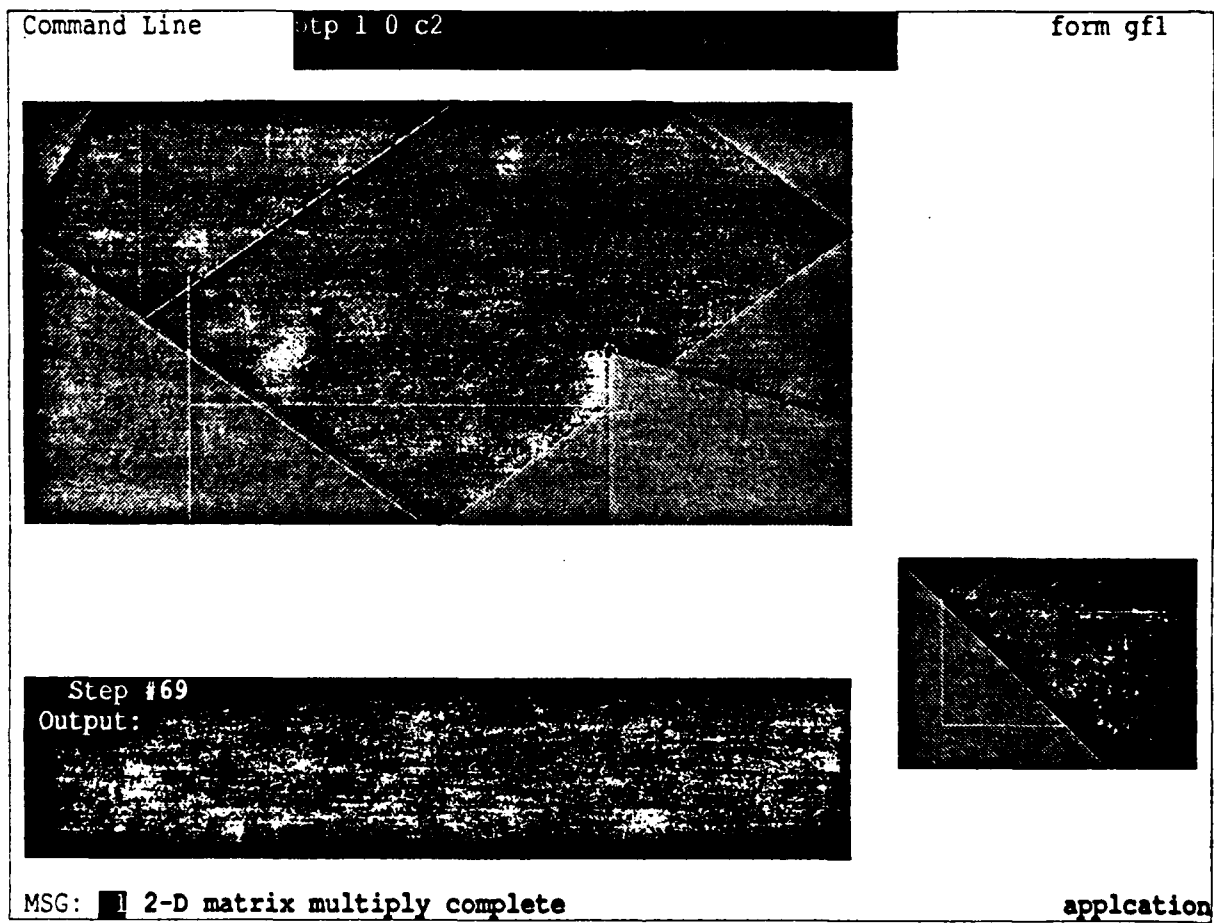


Figure 5-71a (BEFORE)

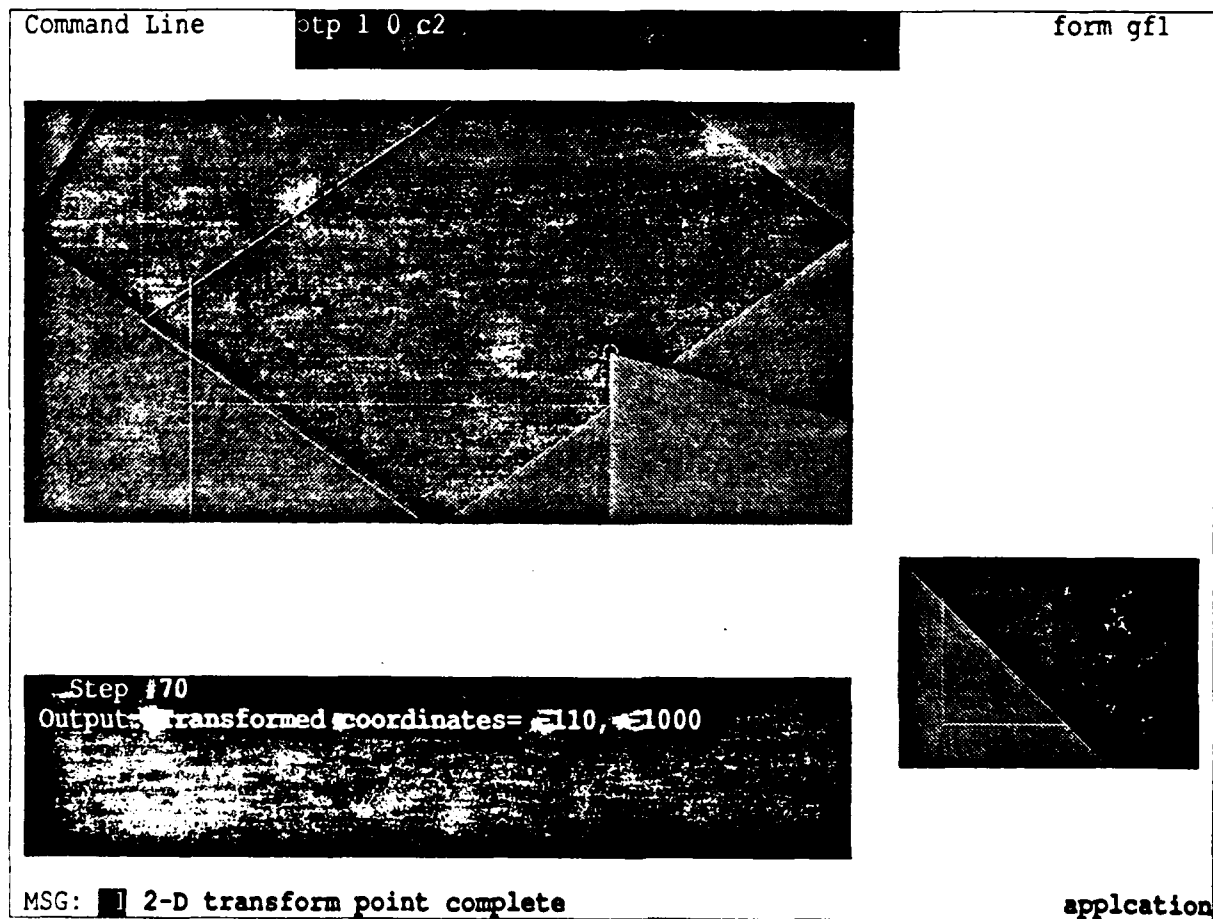


Figure 5-71b (AFTER)

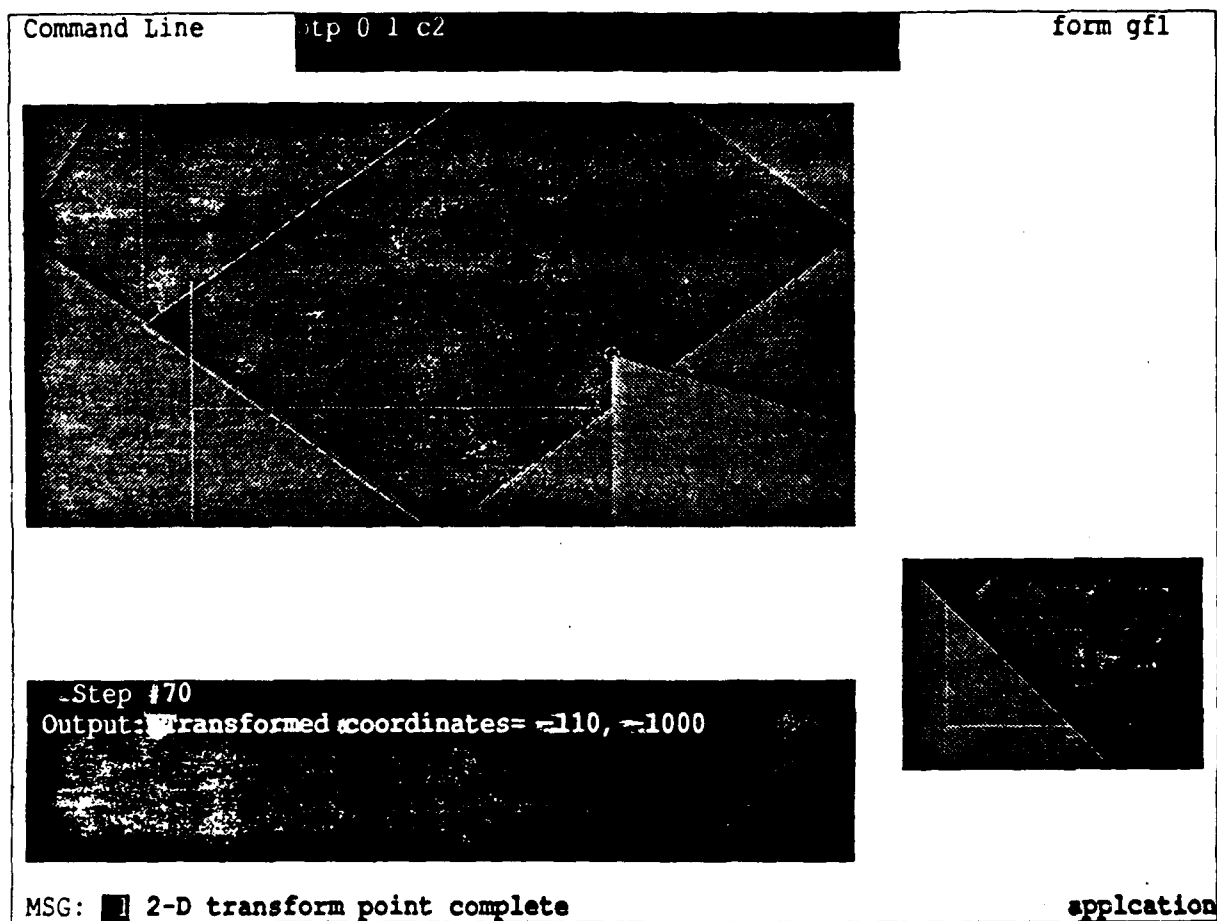


Figure 5-72a (BEFORE)

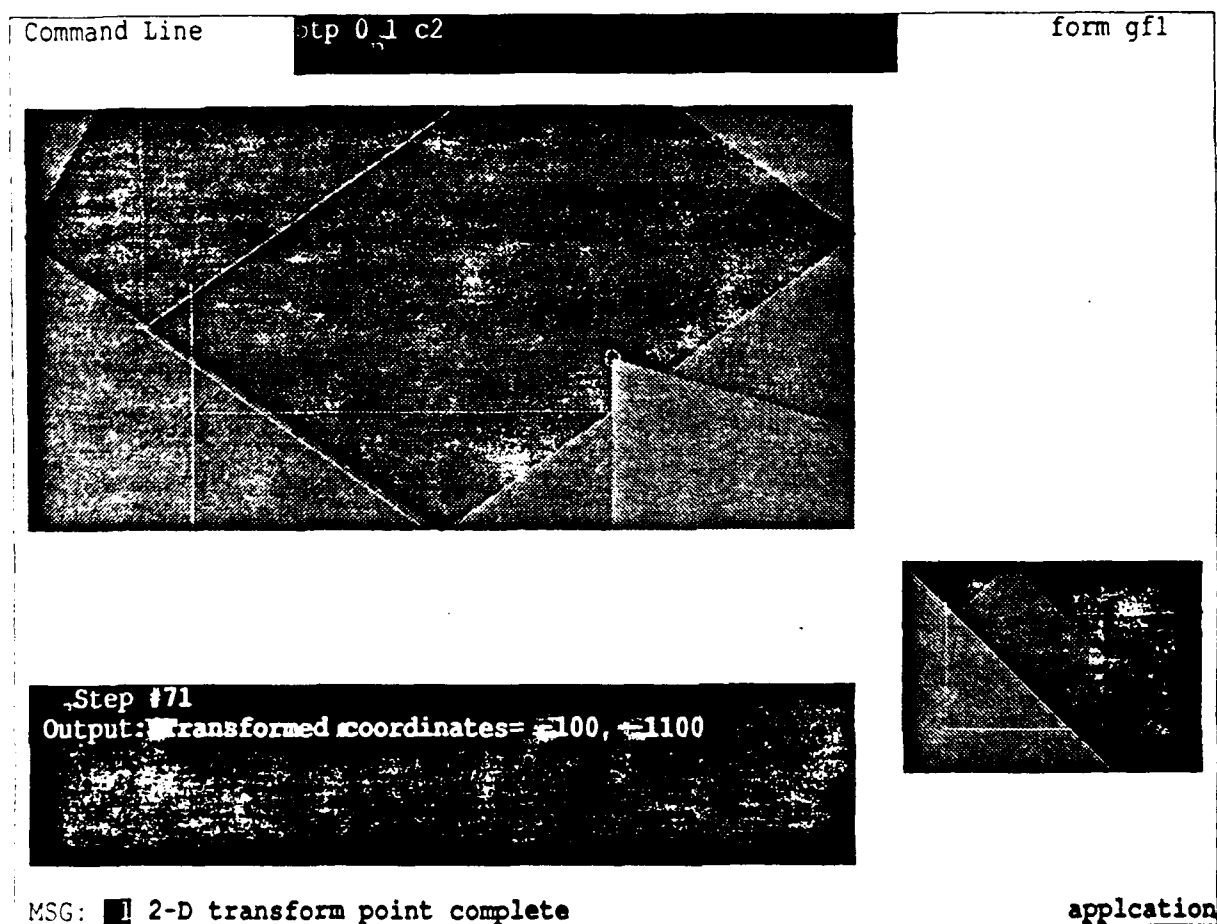


Figure 5-72b (AFTER)

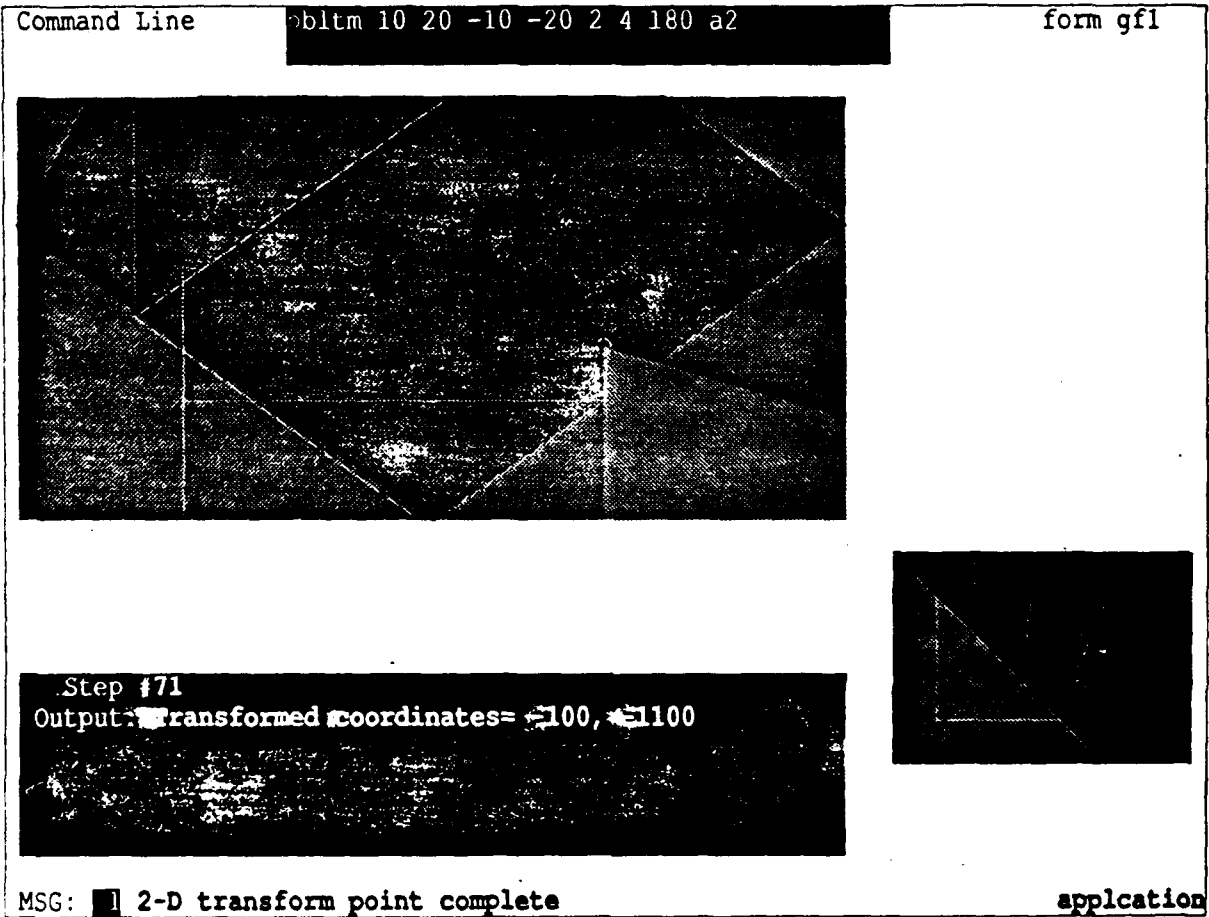


Figure 5-73a (BEFORE)

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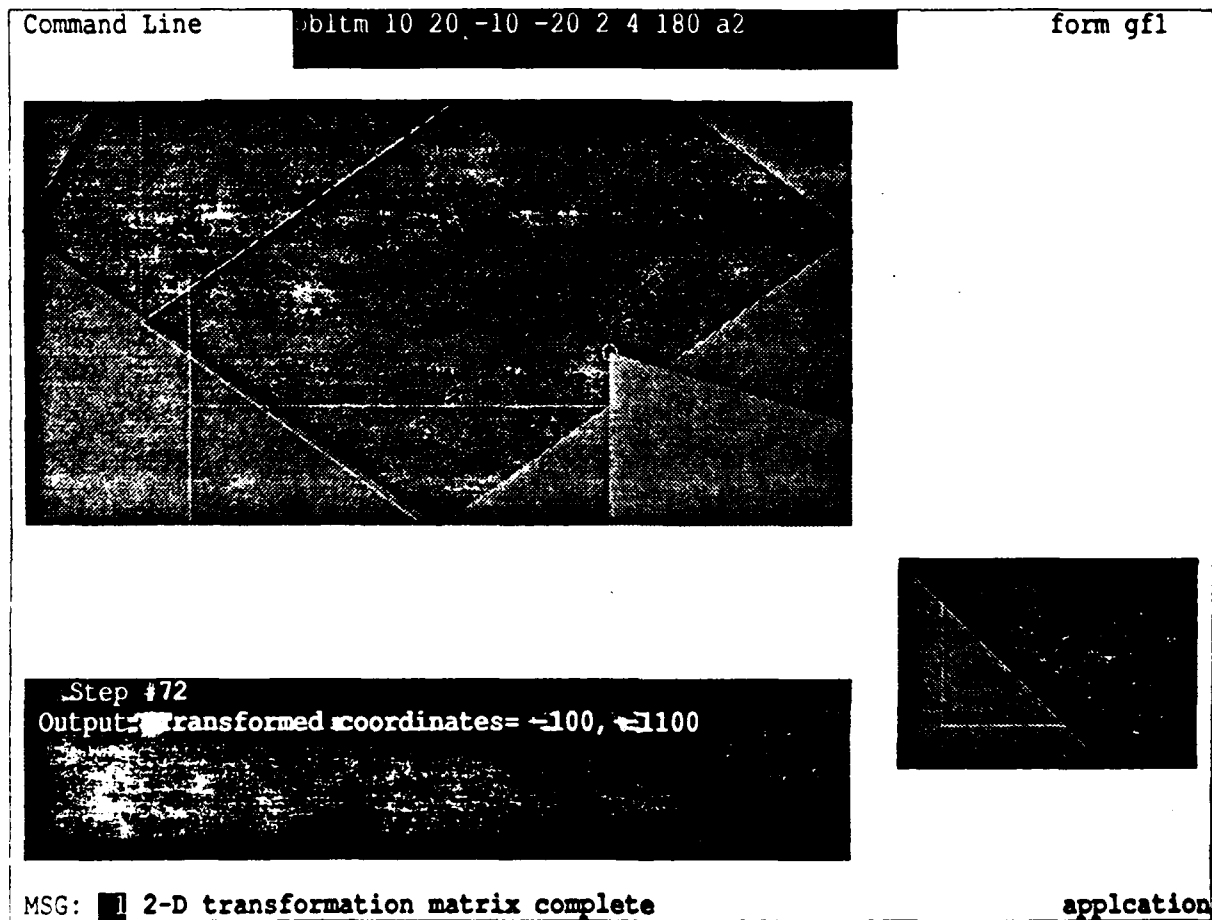


Figure 5-73b (AFTER)

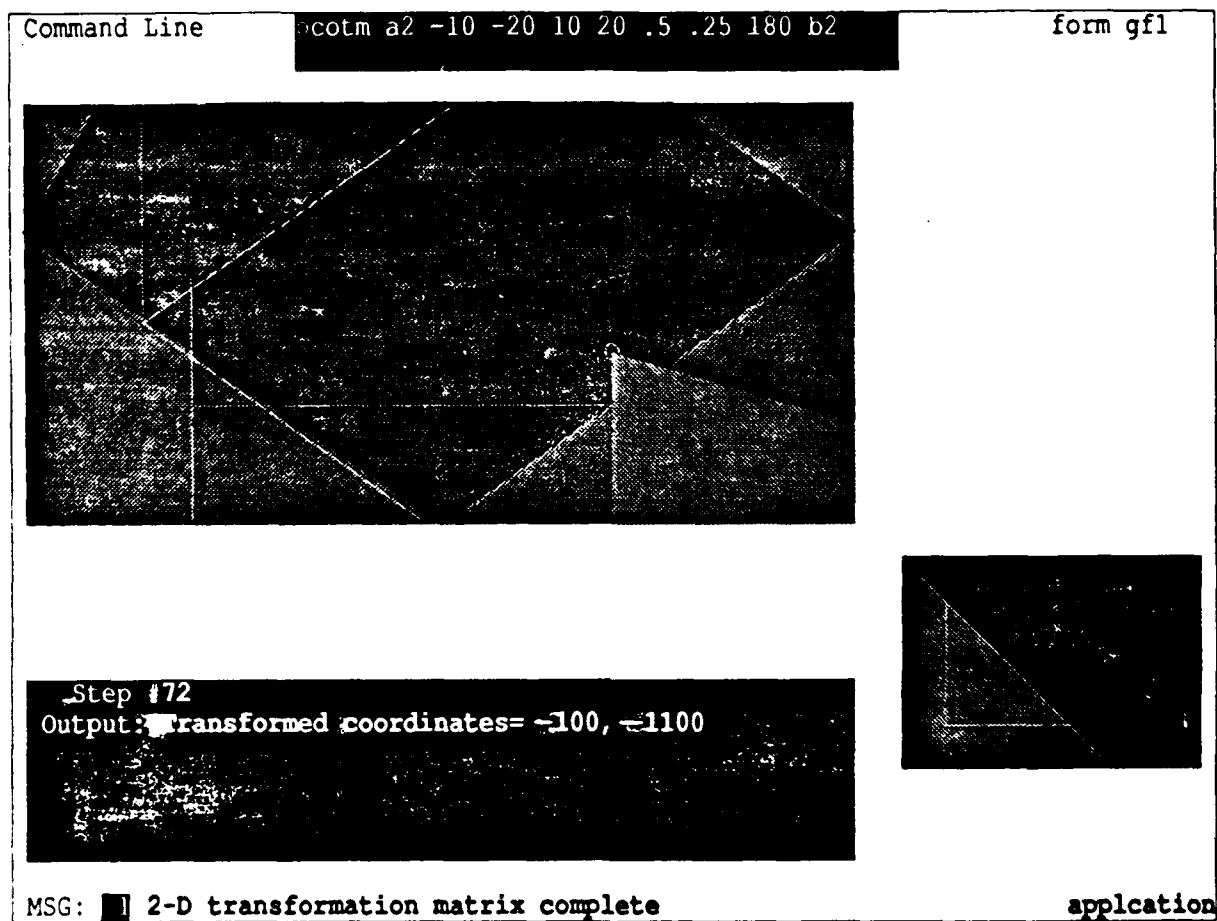


Figure 5-74a (BEFORE)

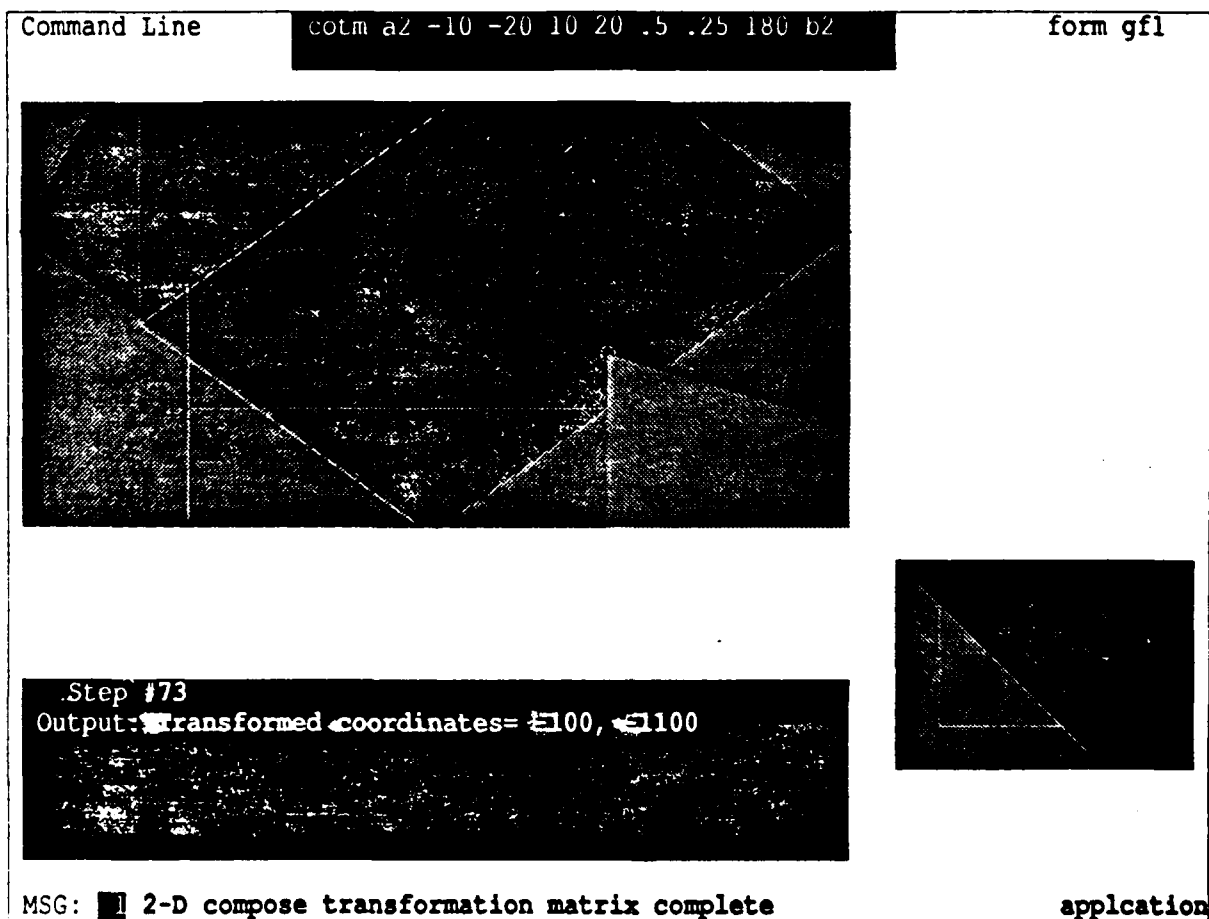


Figure 5-74b (AFTER)

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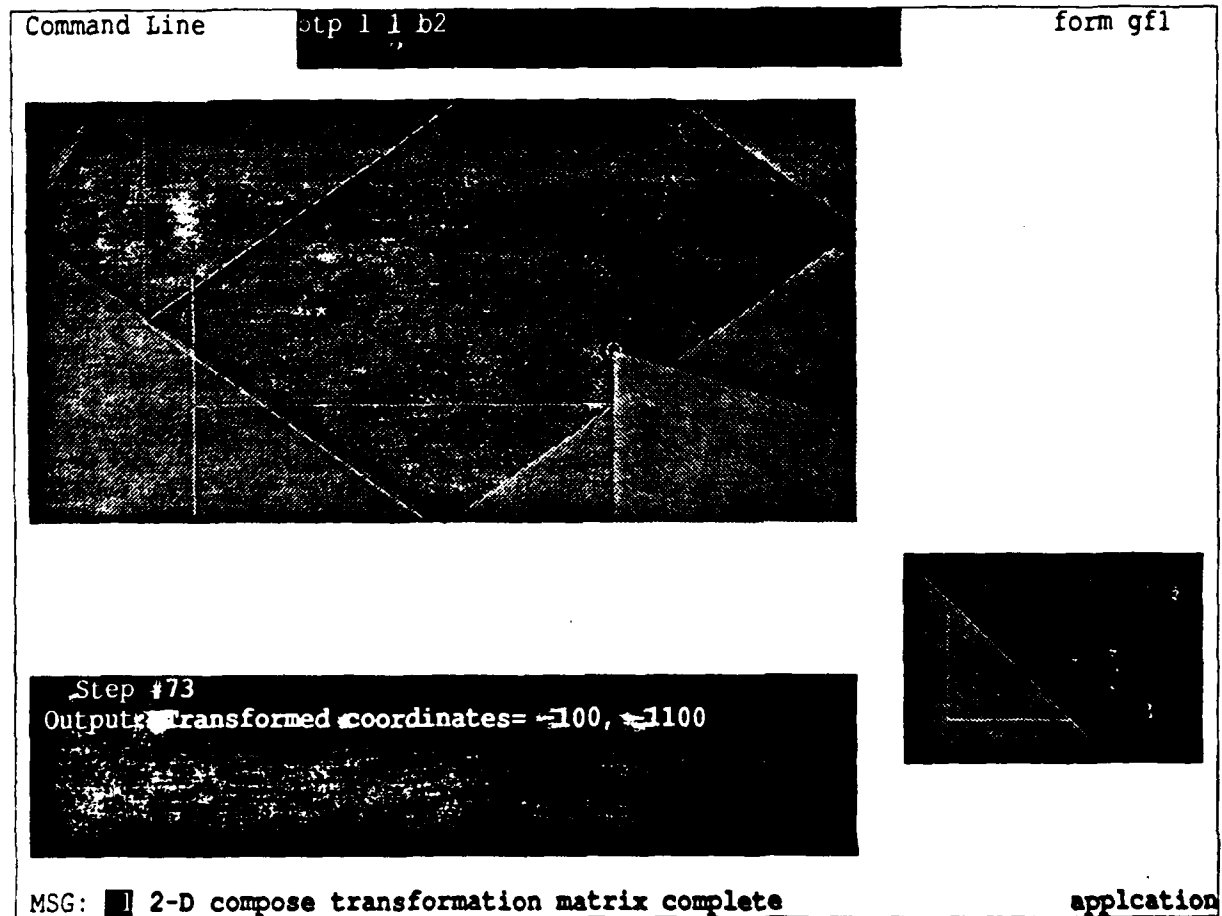


Figure 5-/75a (BEFORE)

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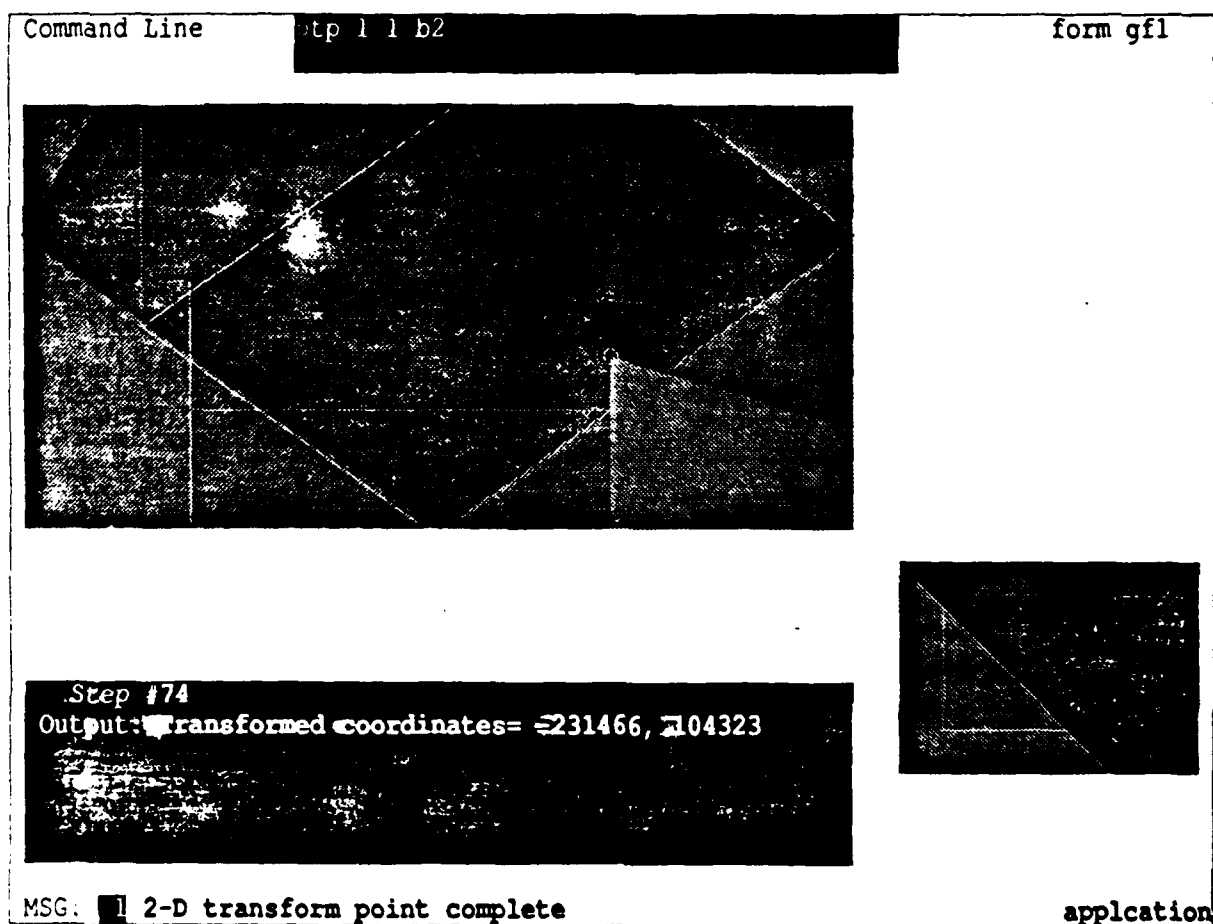


Figure 5-75b (AFTER)

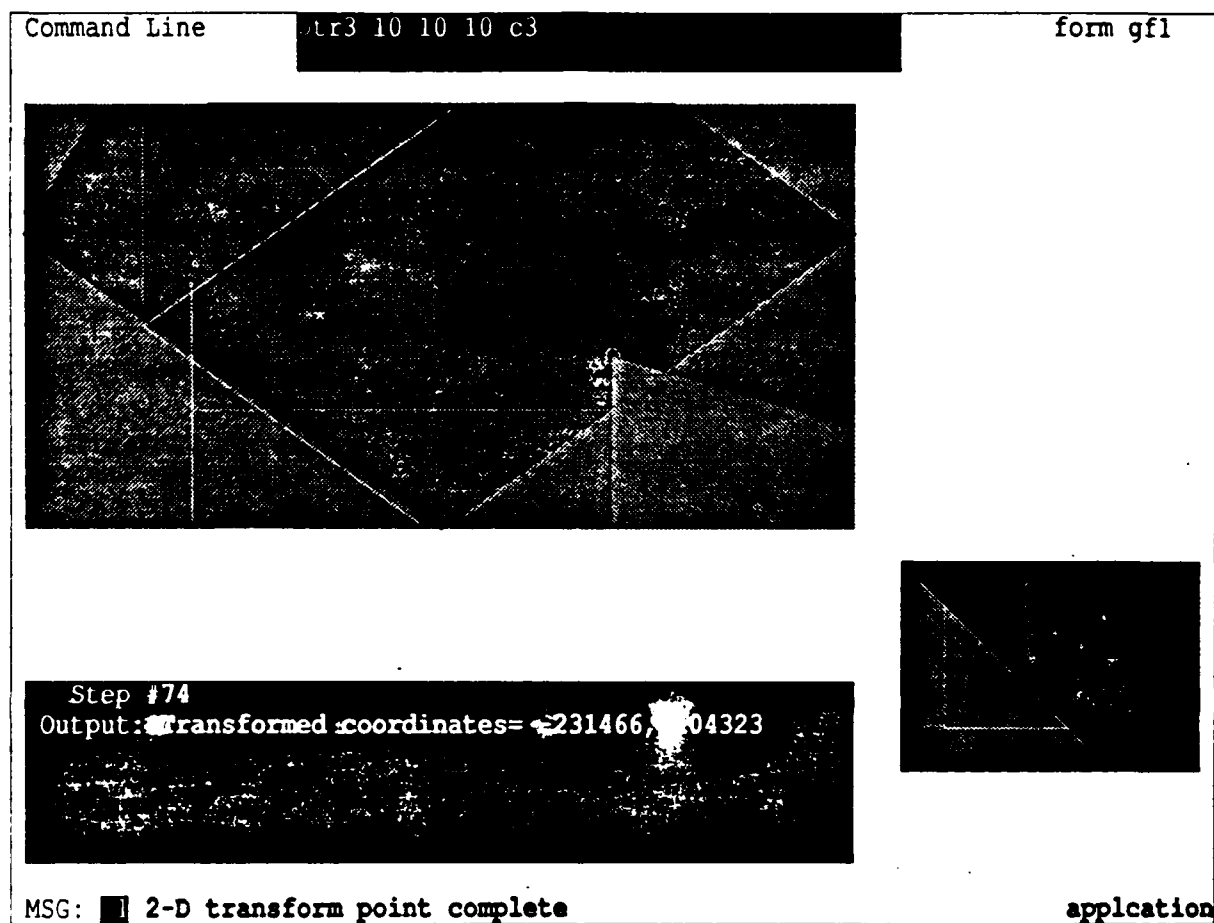


Figure 5-76a (BEFORE)

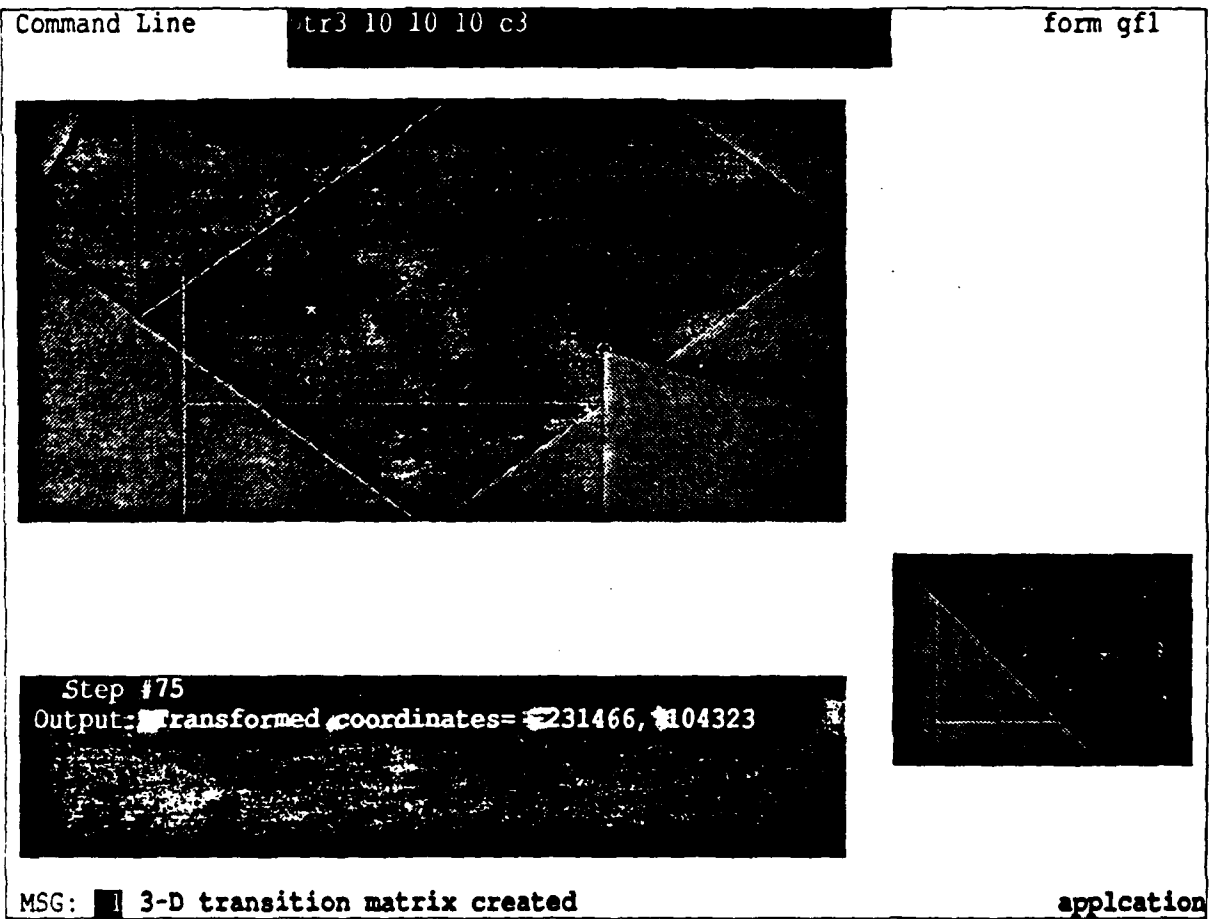


Figure 5-76b (AFTER)

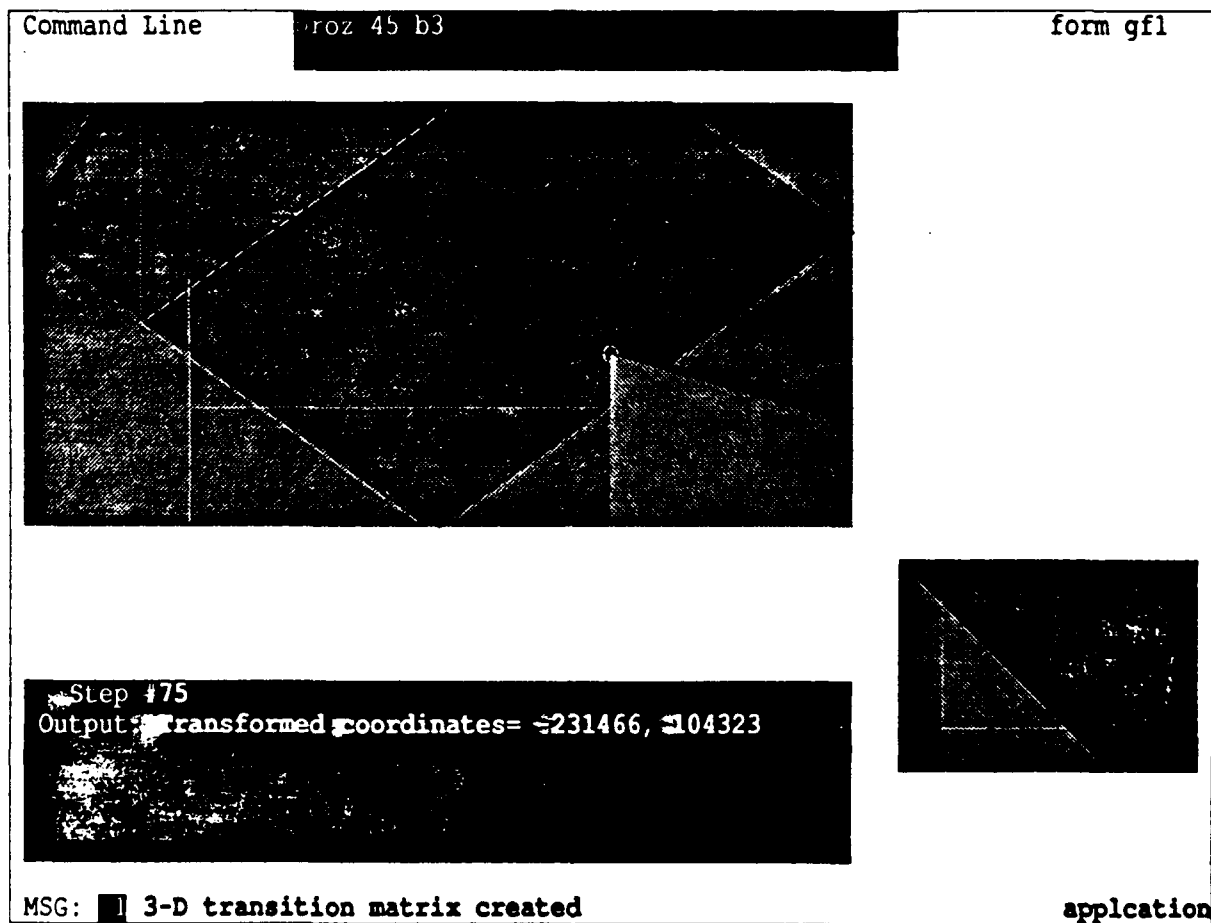


Figure 5-77a (BEFORE)

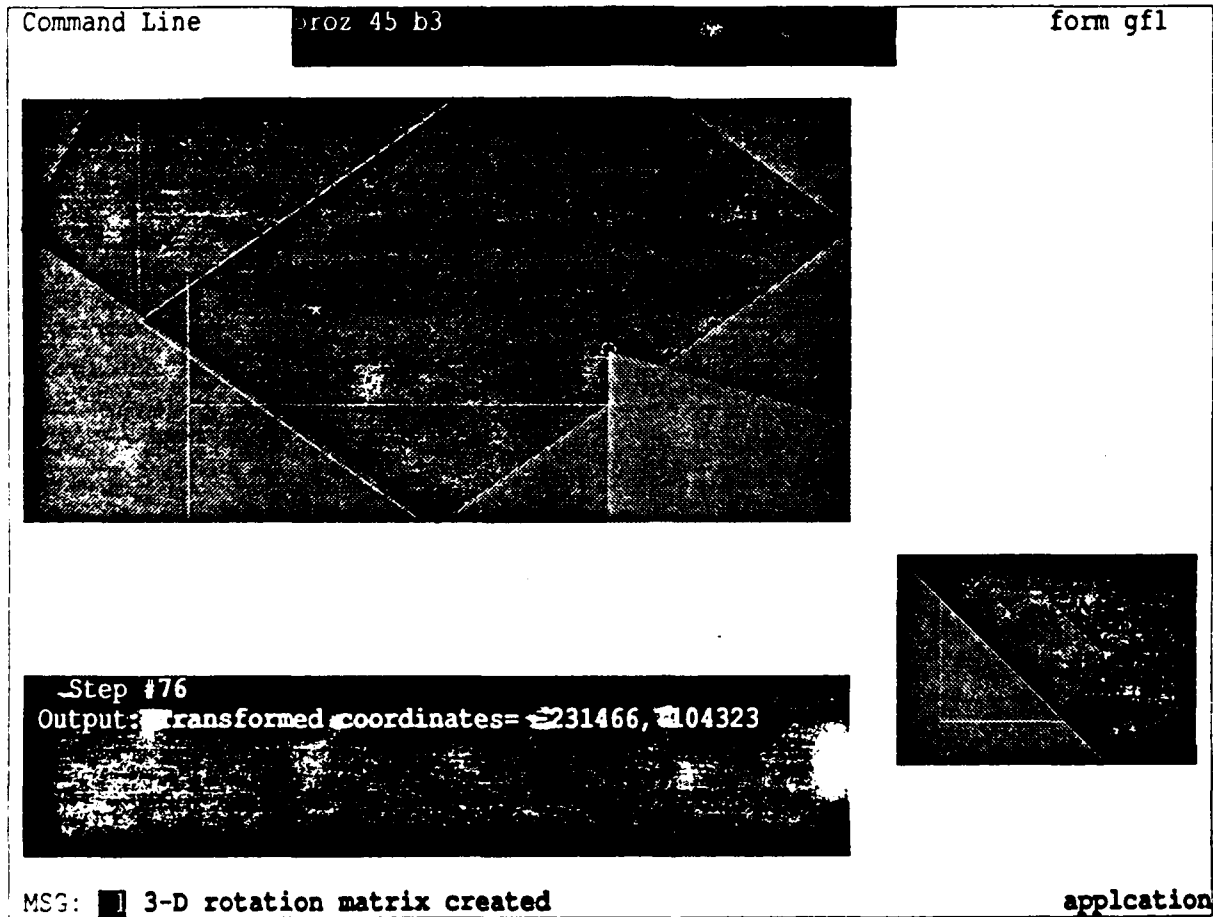


Figure 5-77b (AFTER)

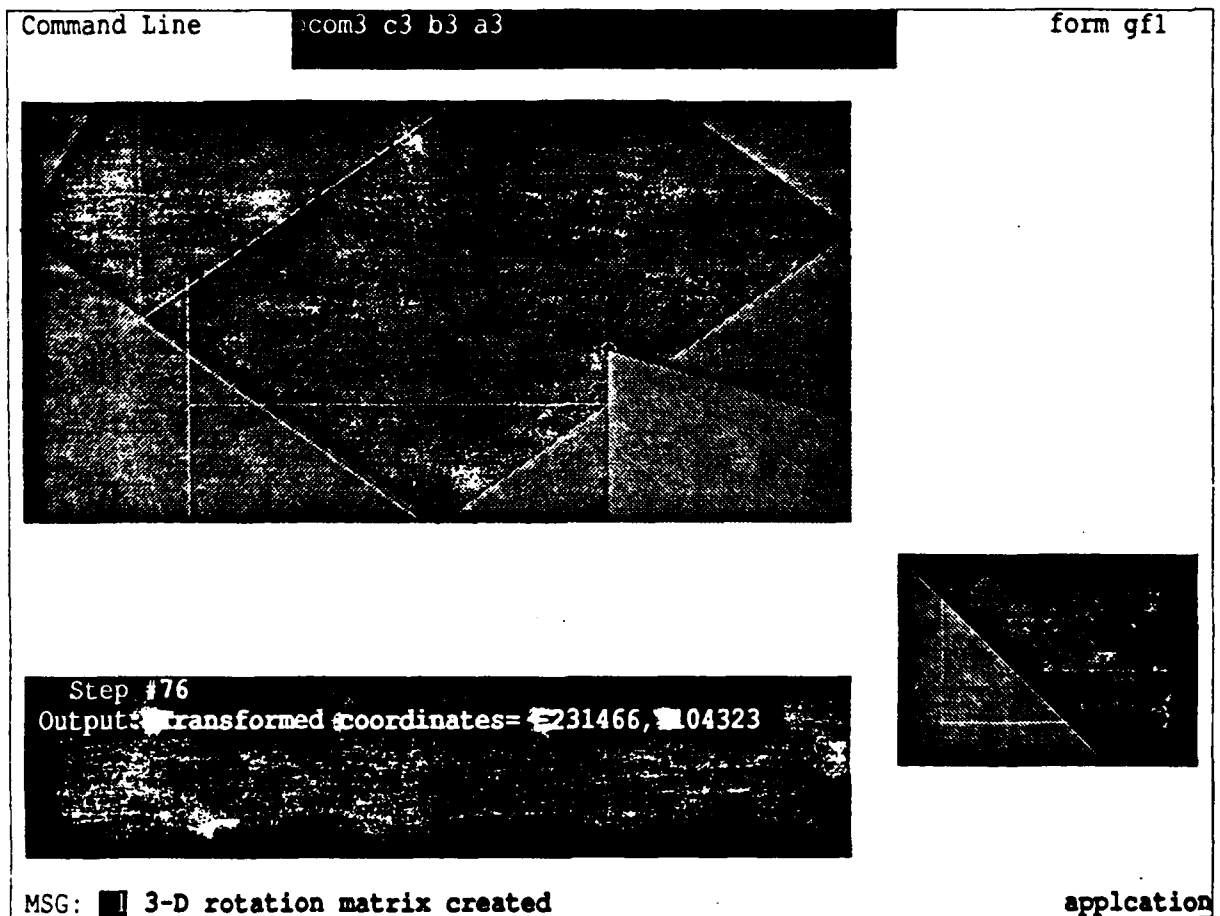


Figure 5-78a (BEFORE)

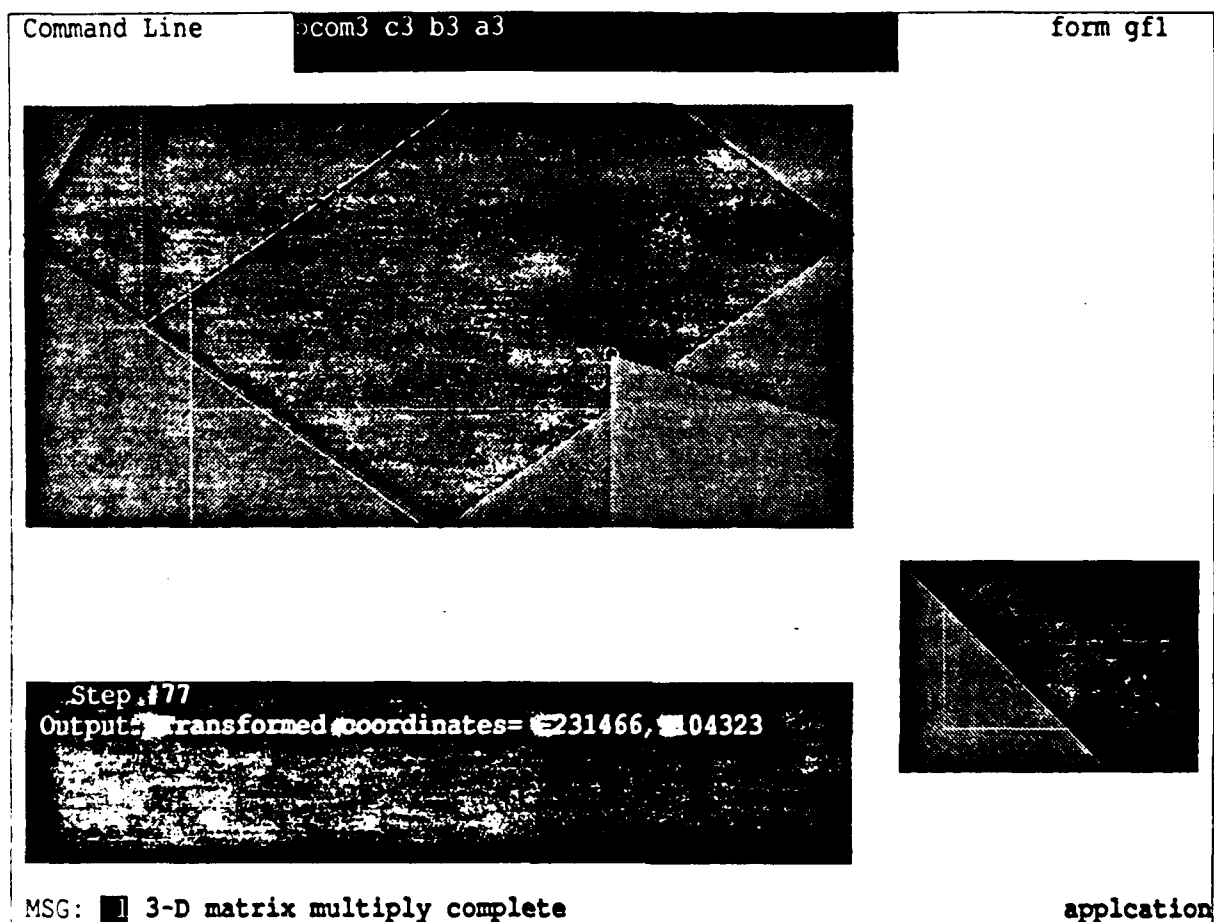


Figure 5-78b (AFTER)

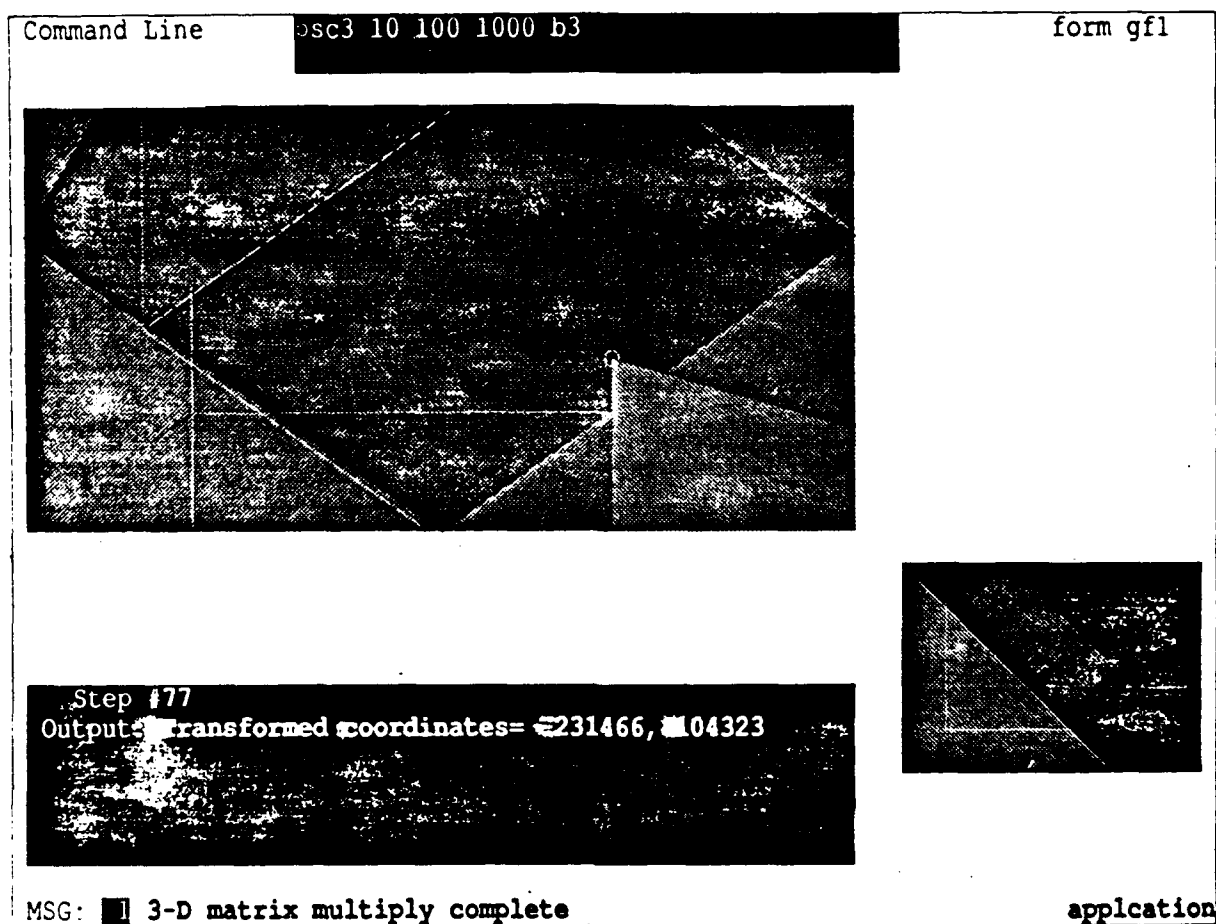


Figure 5-79a (BEFORE)

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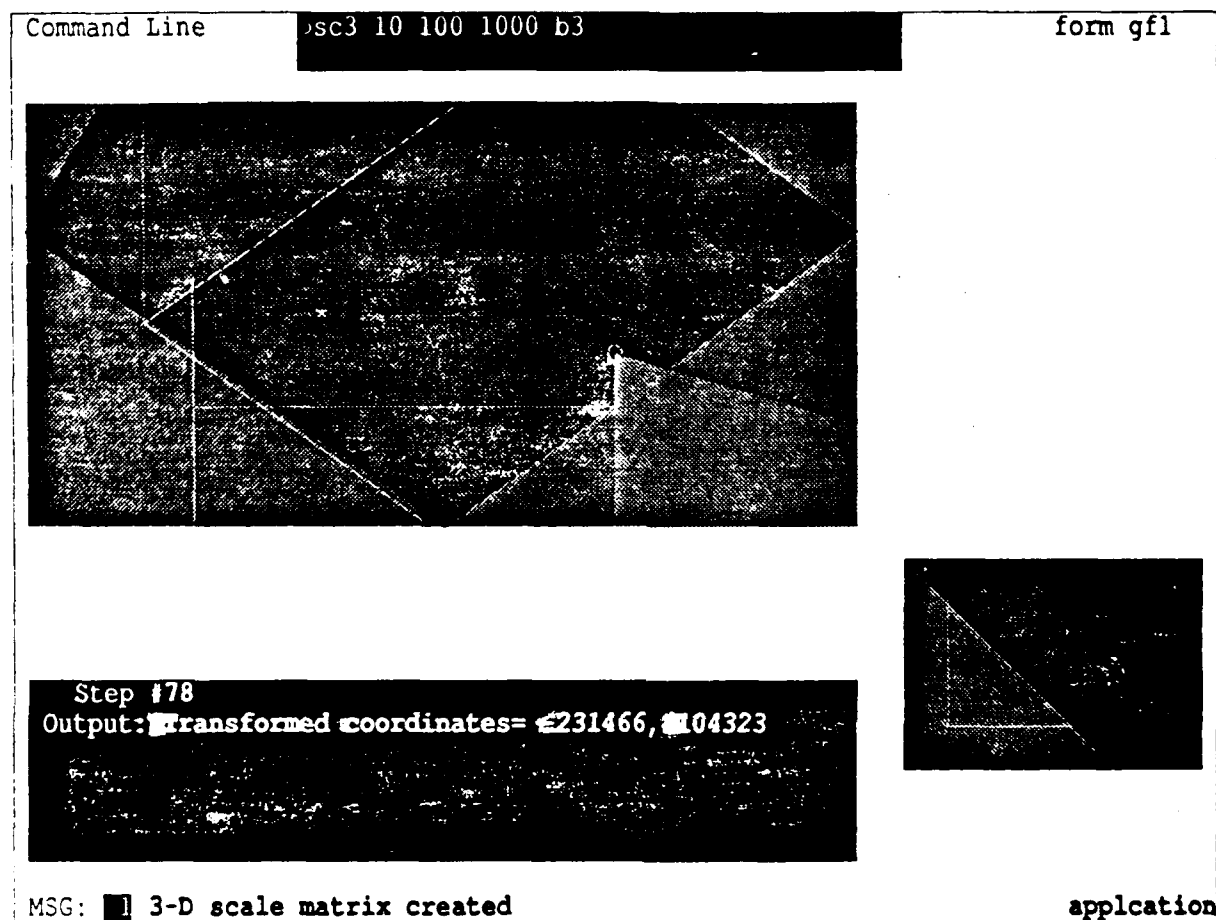


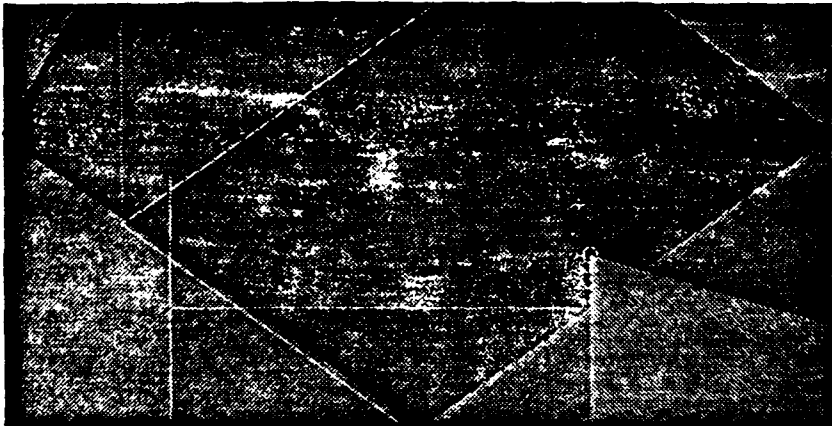
Figure 5-79b (AFTEF.)

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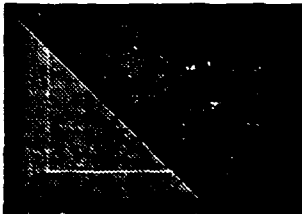
Command Line

com3 a3 b3 c3

form gfl



Step #78
Output: Transformed coordinates= 231466, 104323



MSG: 3-D scale matrix created

application

Figure 5-80a (BEFORE)

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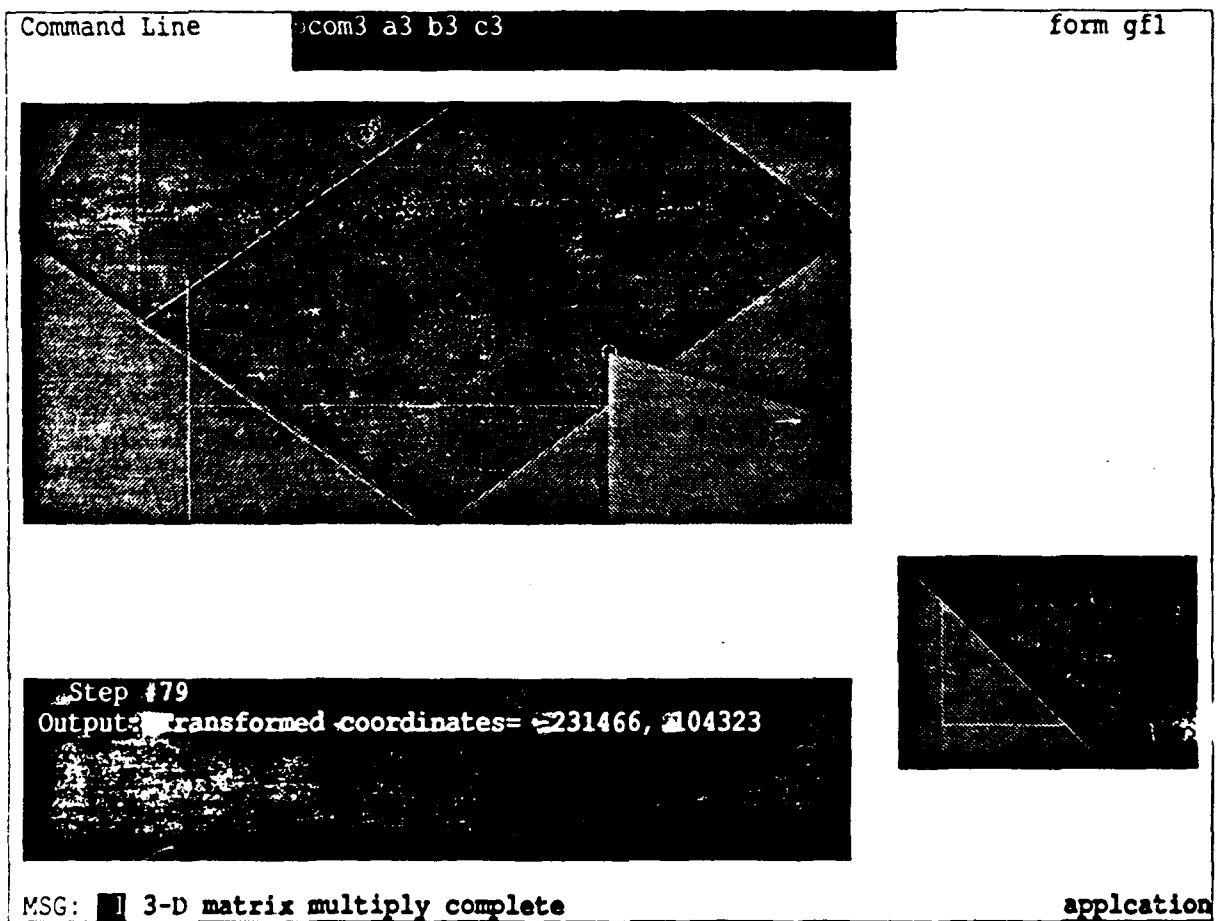


Figure 5-80b (AFTER)

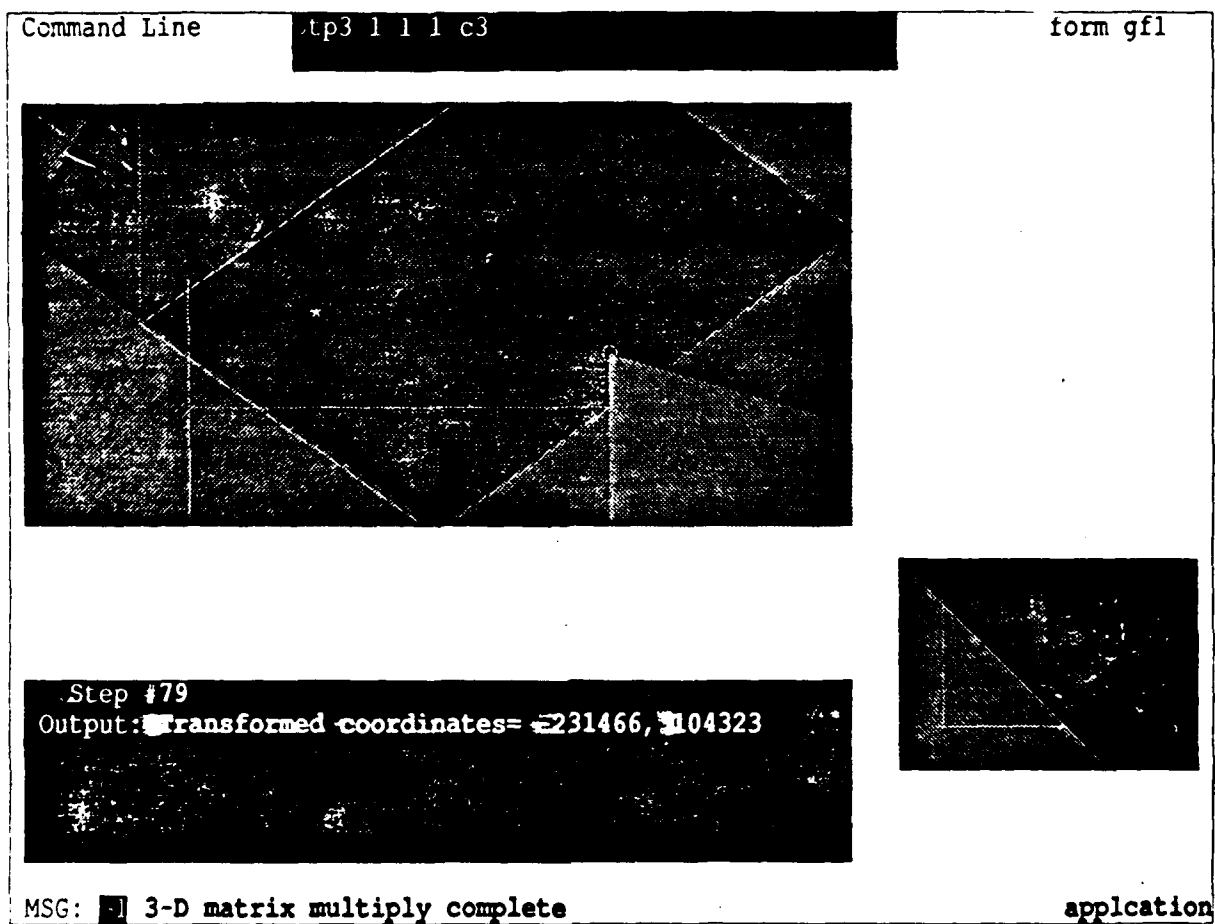


Figure 5-81a (BEFORE)

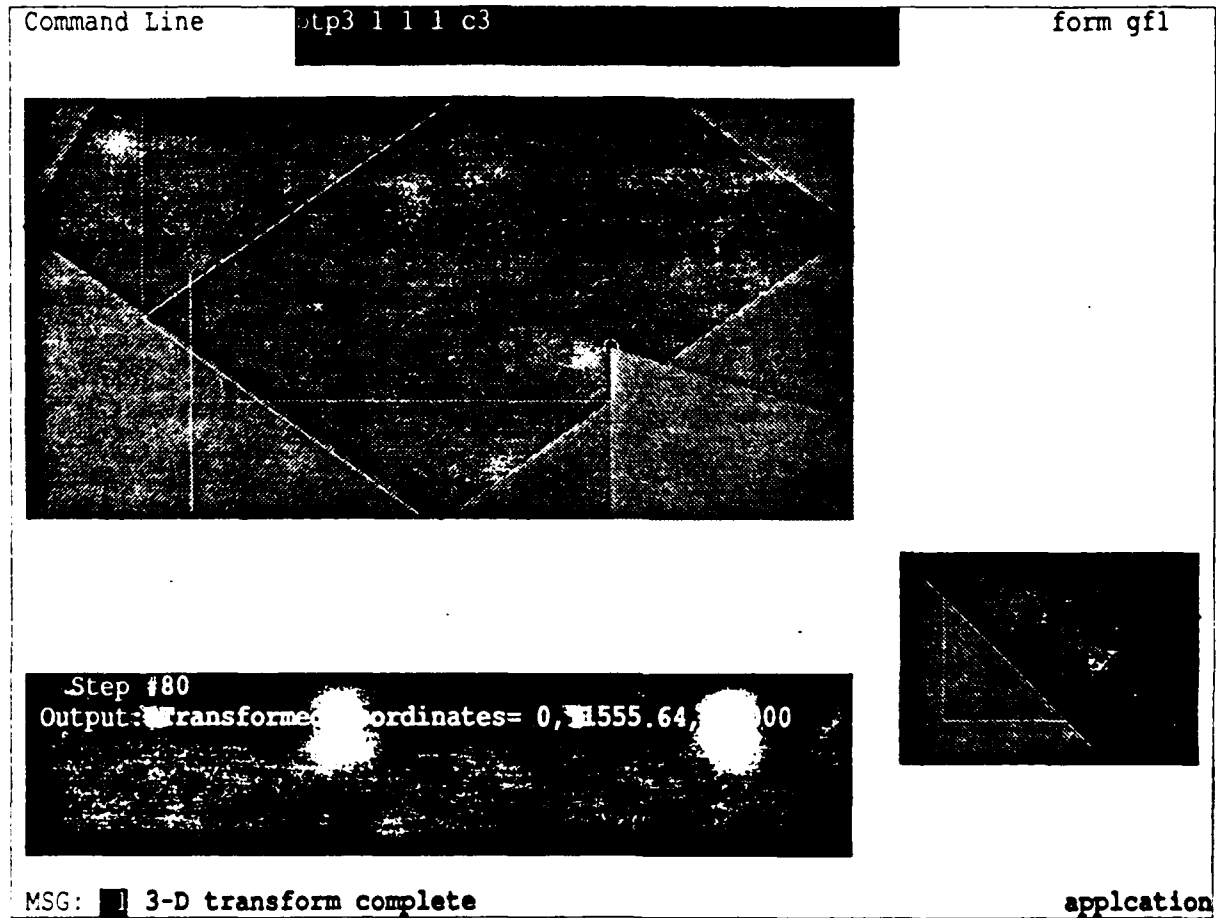


Figure 5-81b (AFTER)

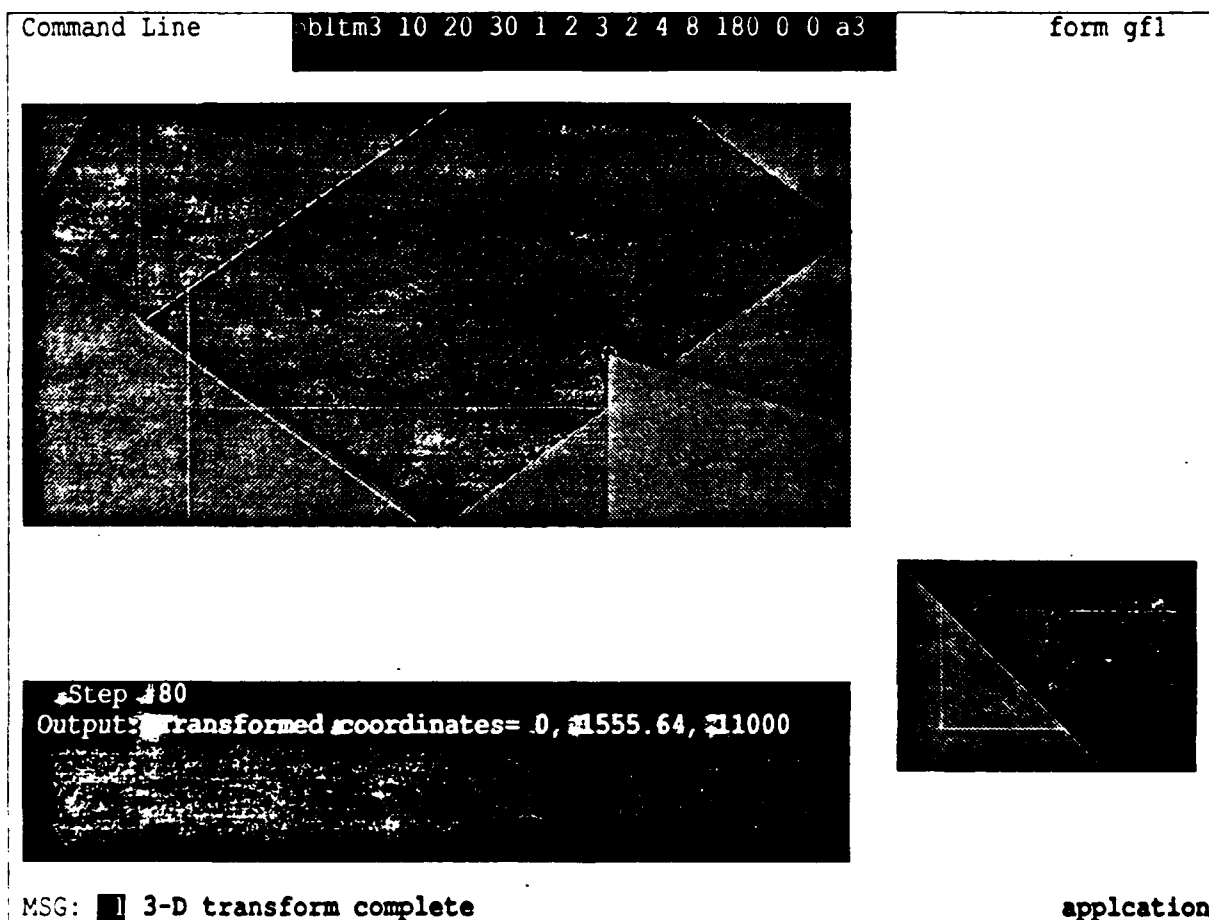


Figure 5-82a (BEFORE)

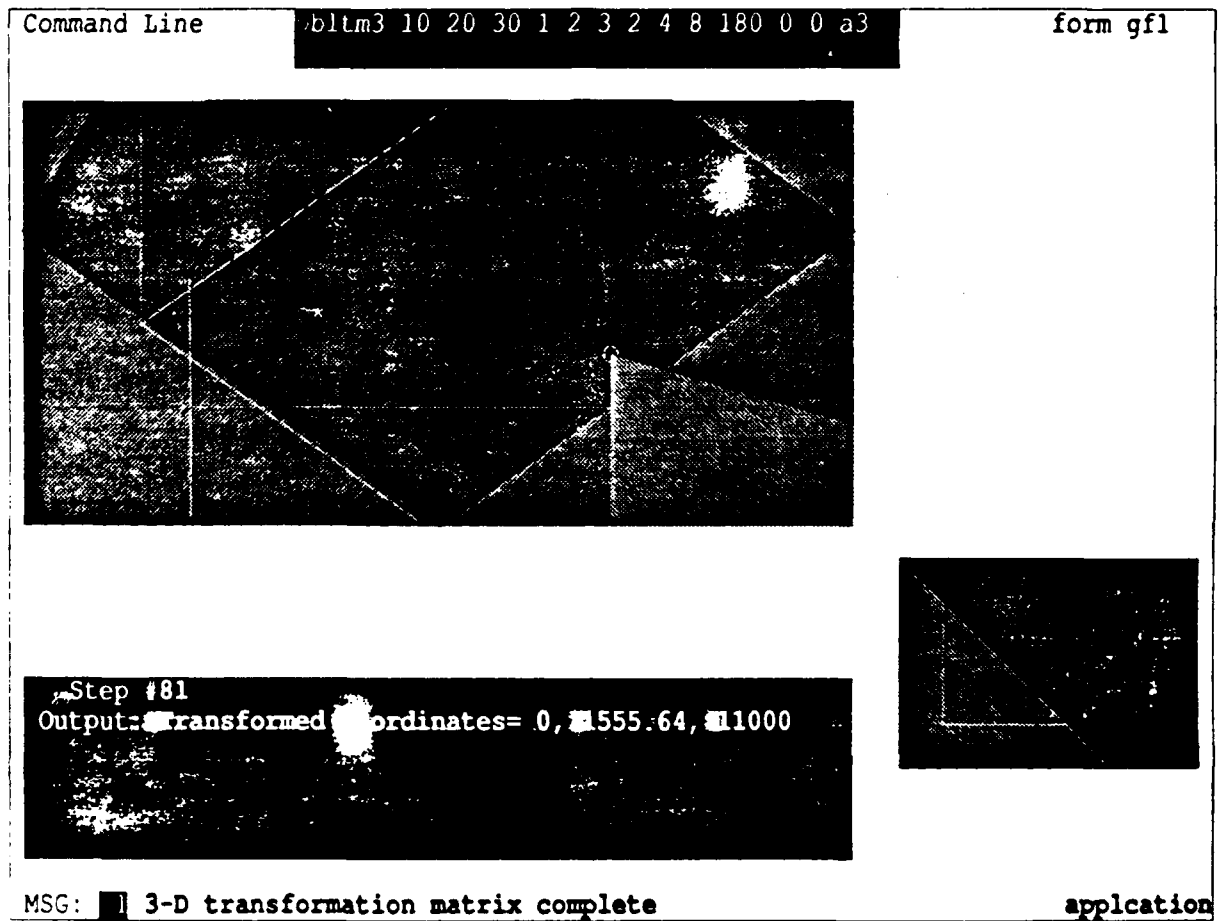


Figure 5-82b (AFTER)

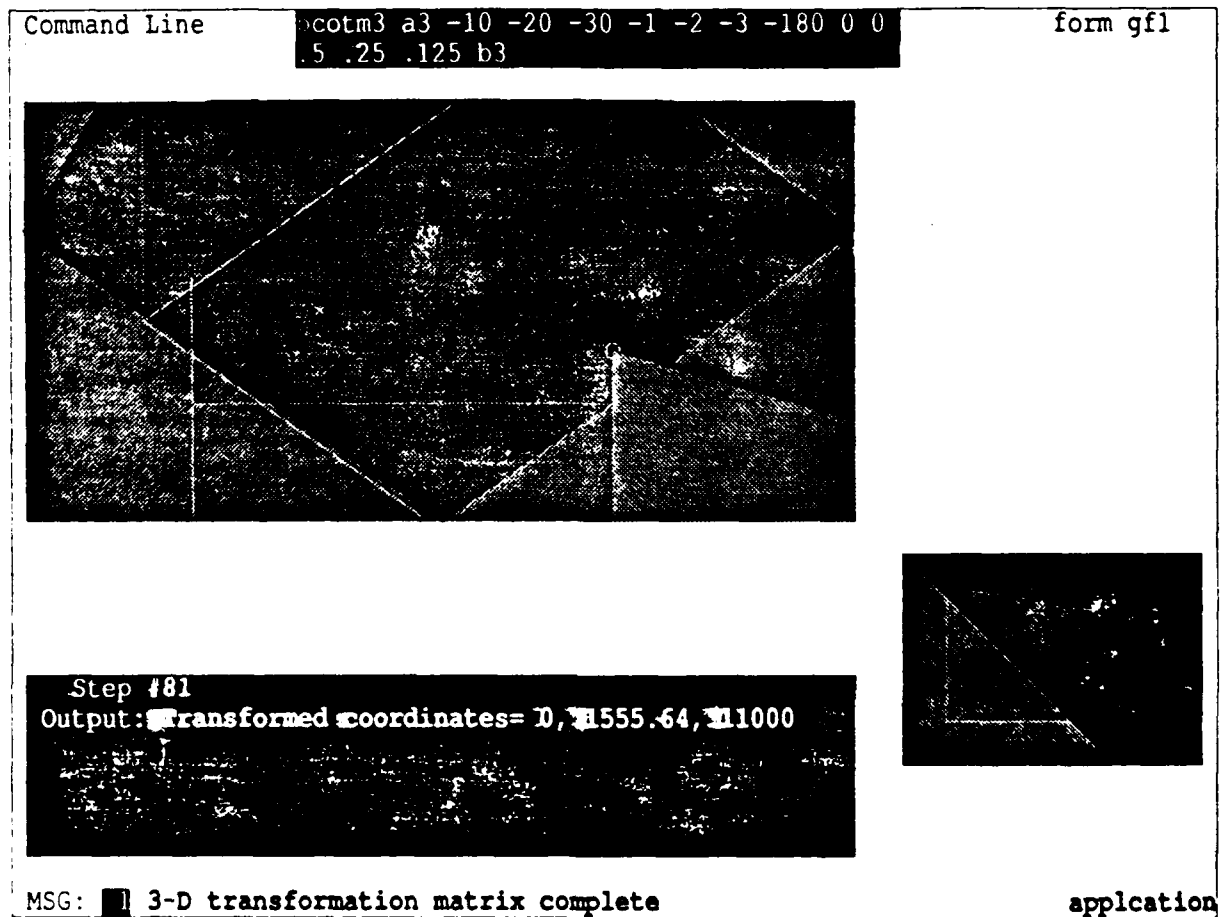


Figure 5-83a (BEFORE)

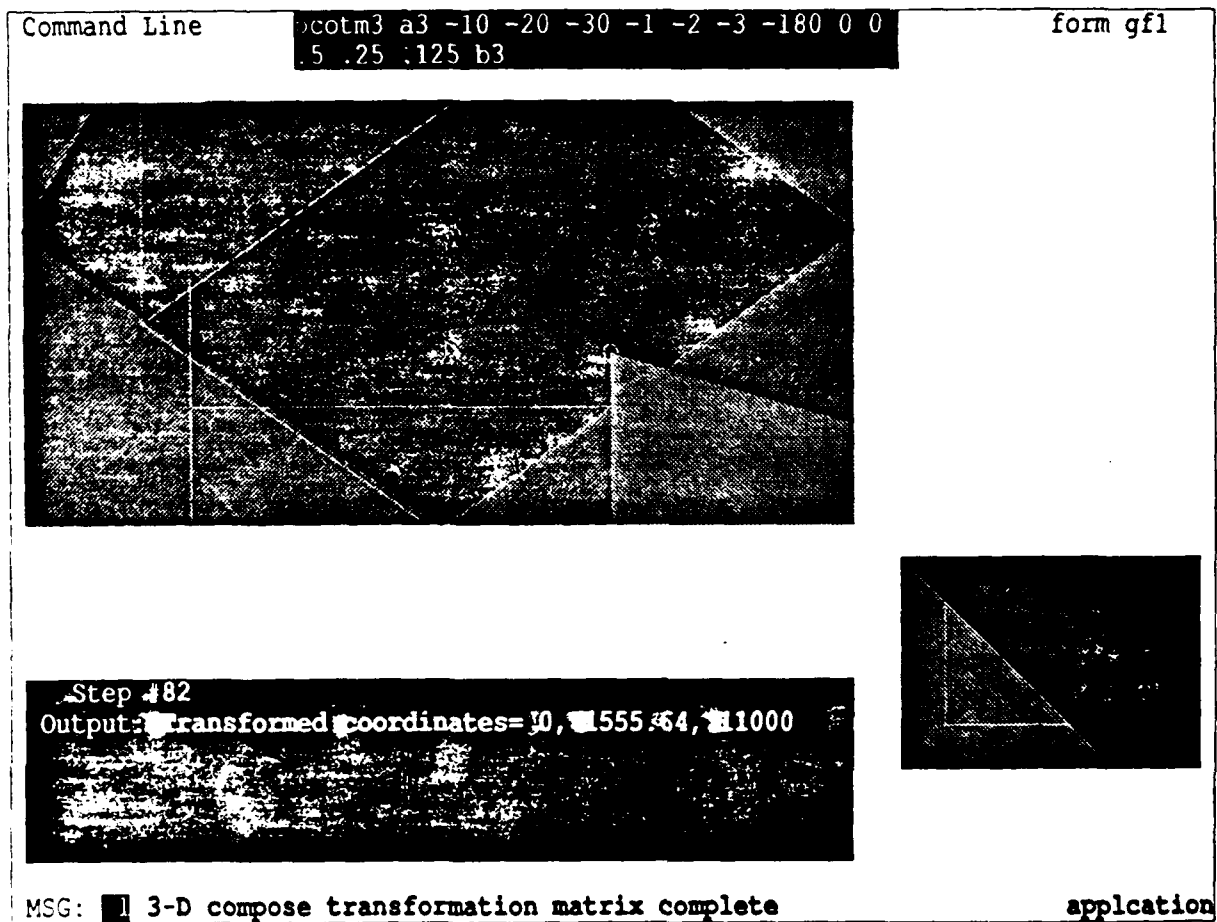


Figure 5-83b (AFTER)

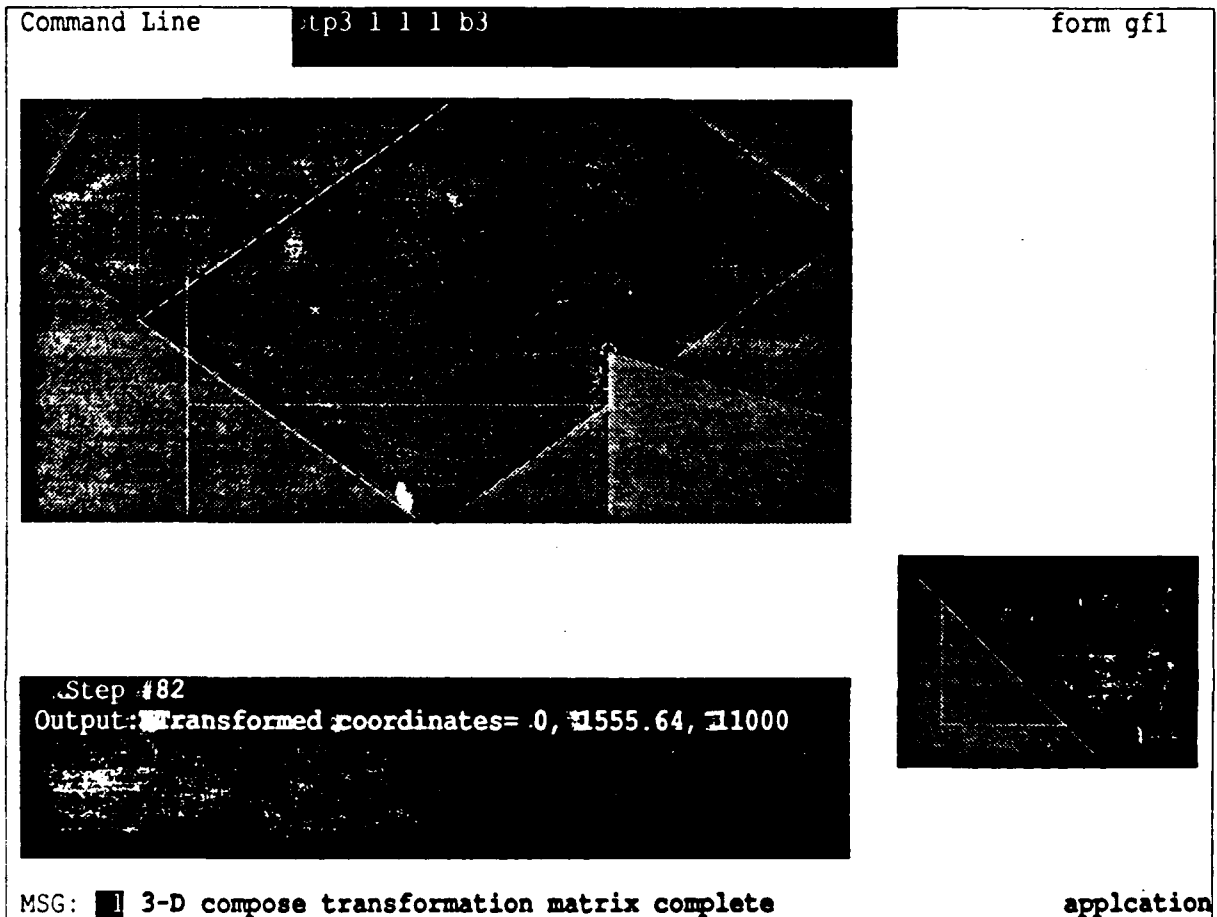


Figure 5-84a (BEFORE)

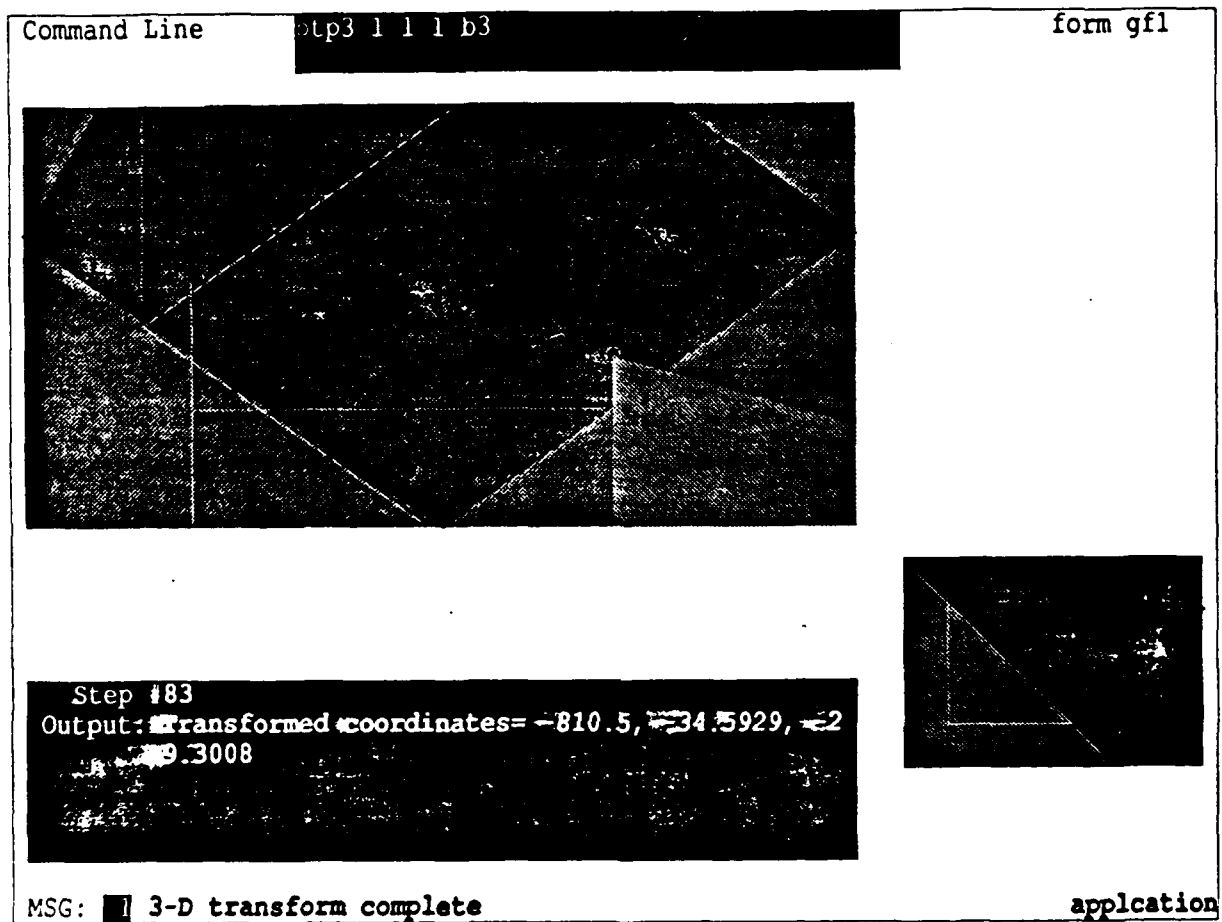


Figure 5-84b (AFTER)

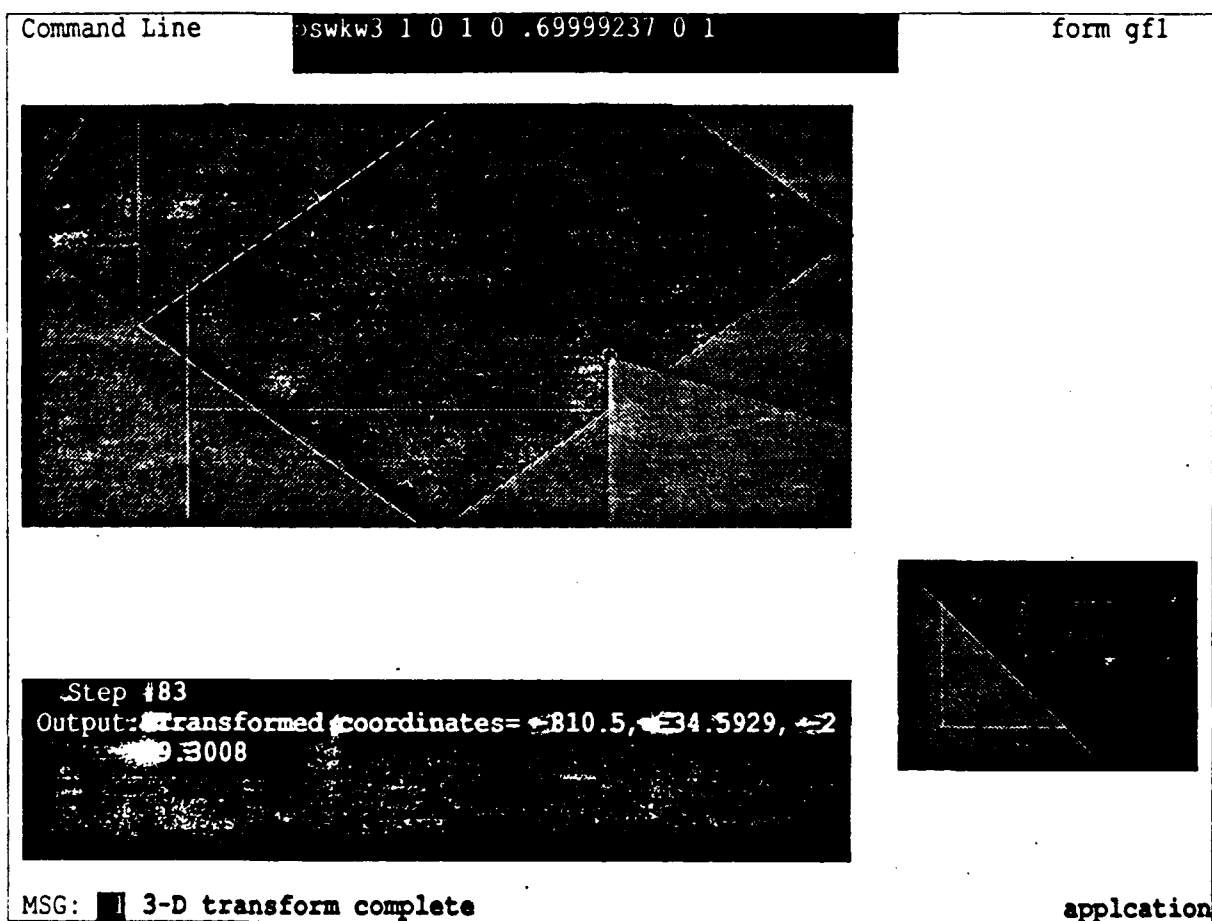


Figure 5-85a (BEFORE)

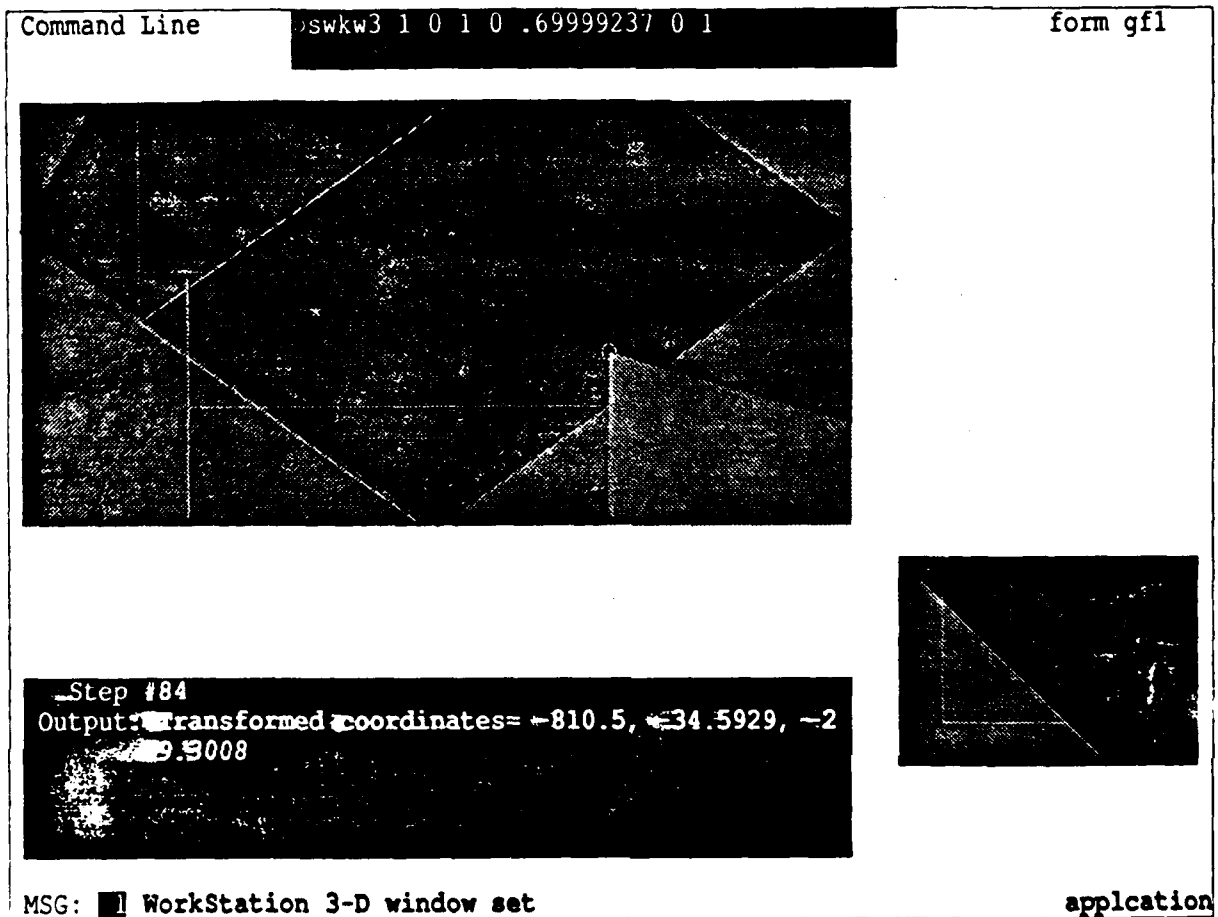


Figure 5-85b (AFTER)

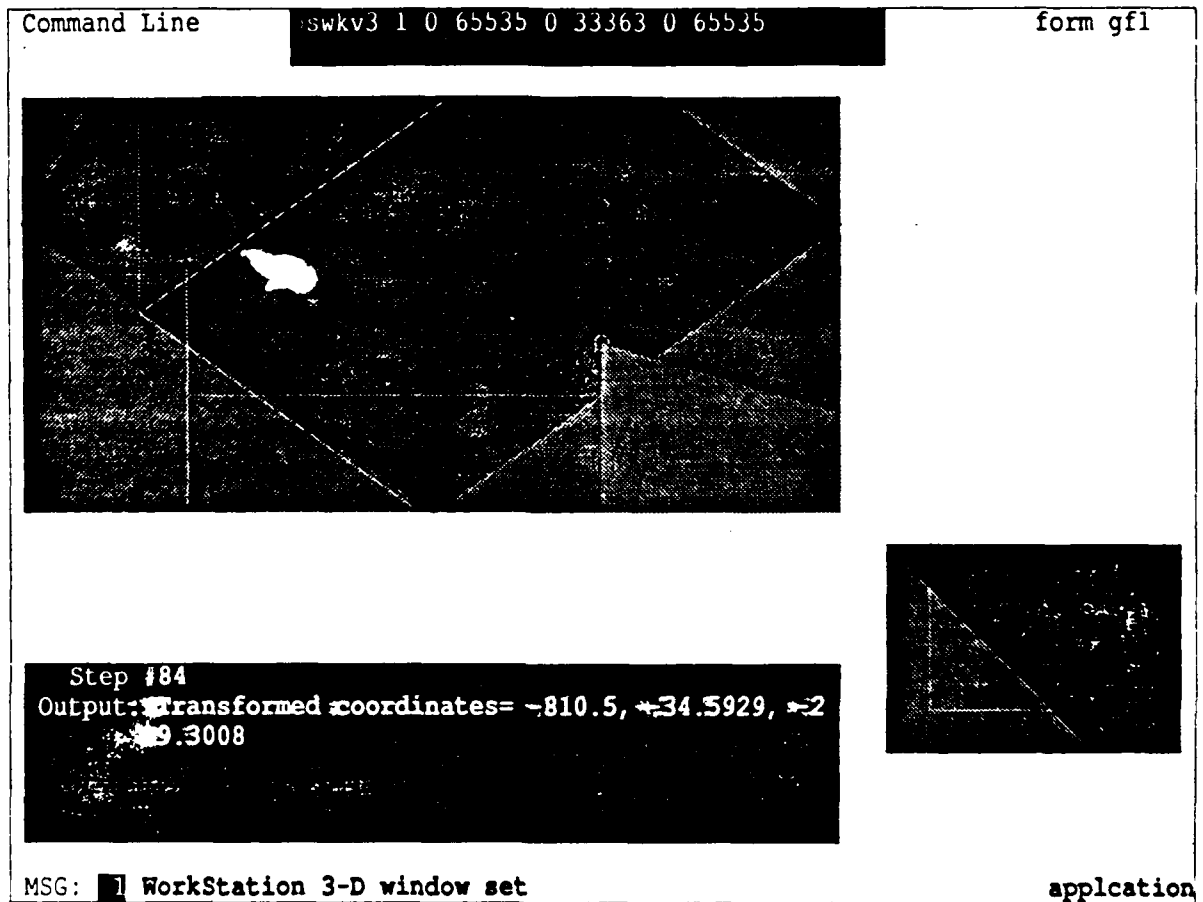


Figure 5-86a (BEFORE)

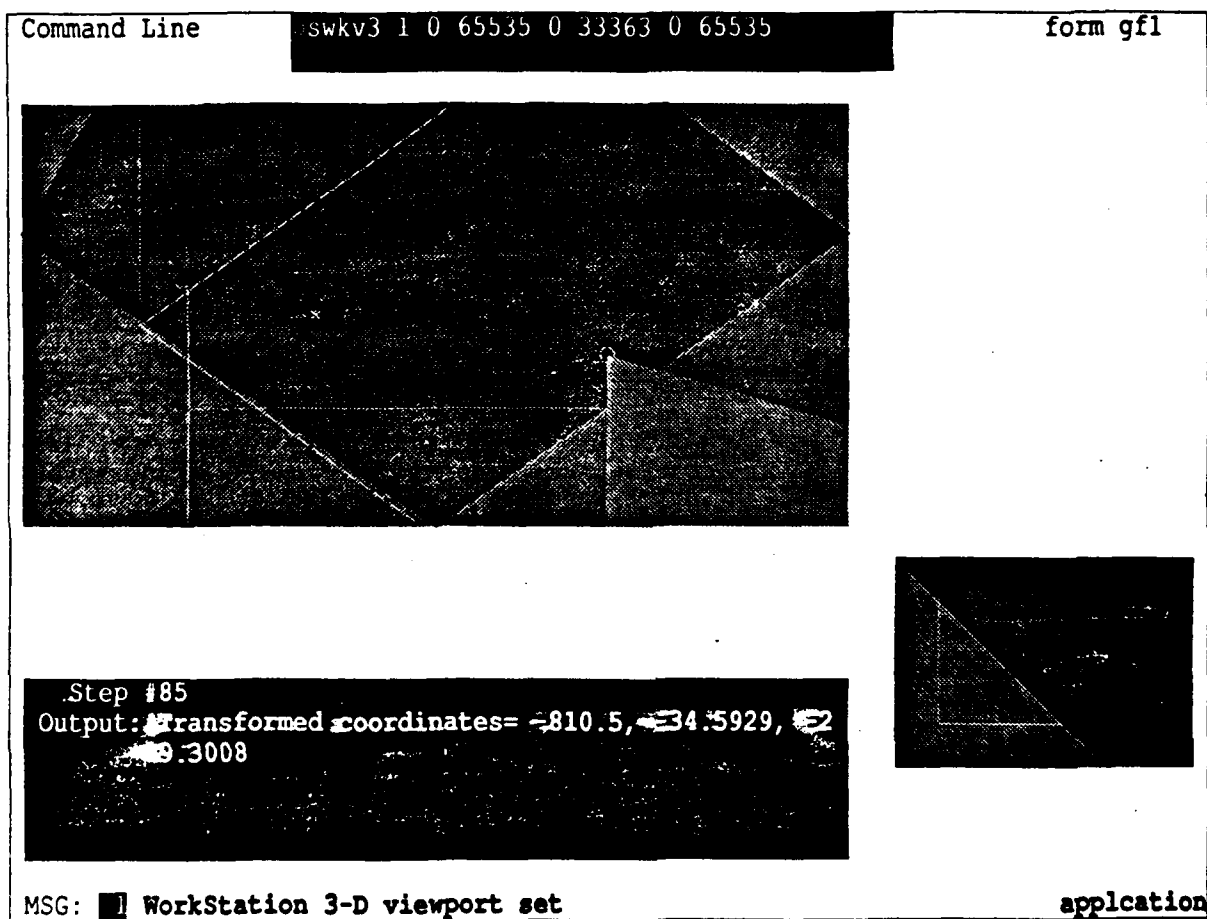


Figure 5-86b (AFTER)

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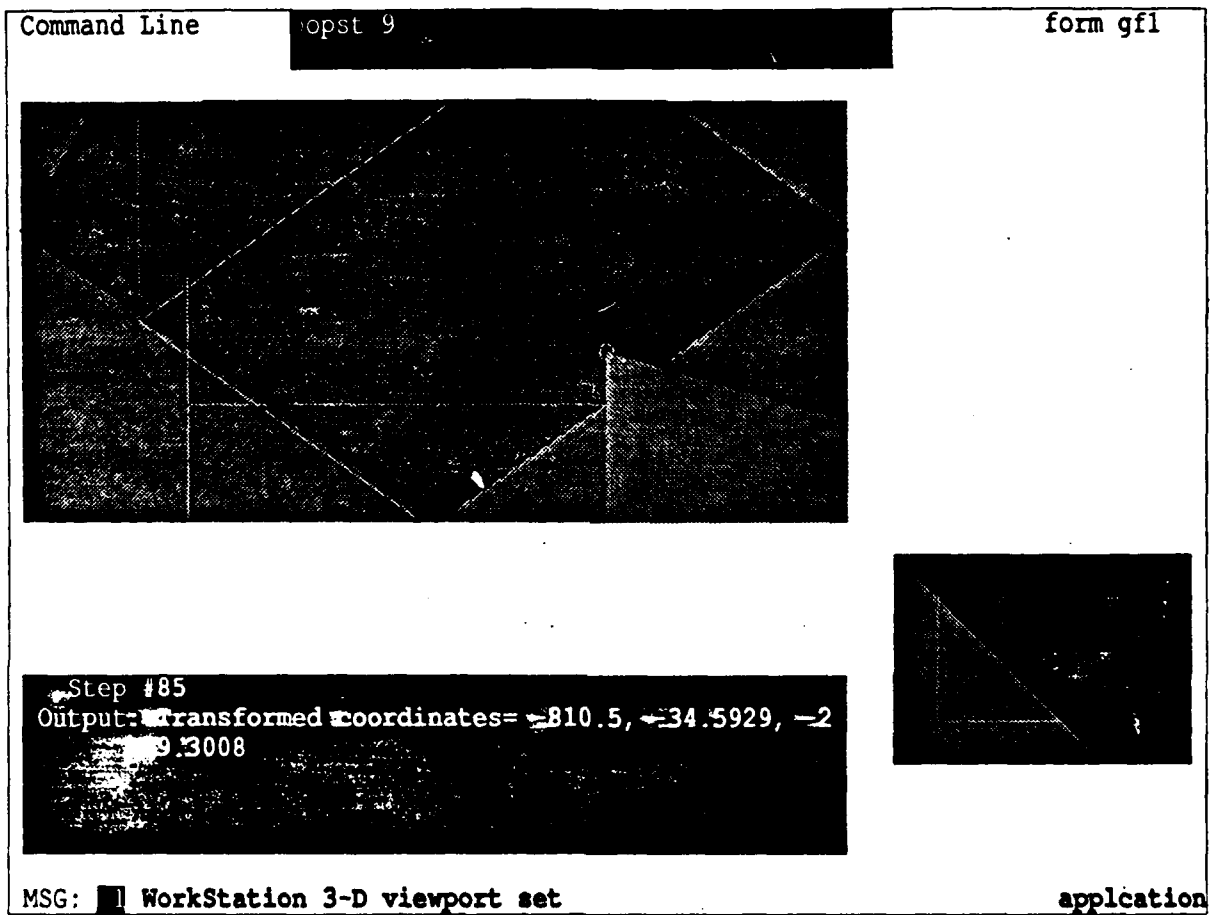


Figure 5-87a (BEFORE)

UTP 620344220
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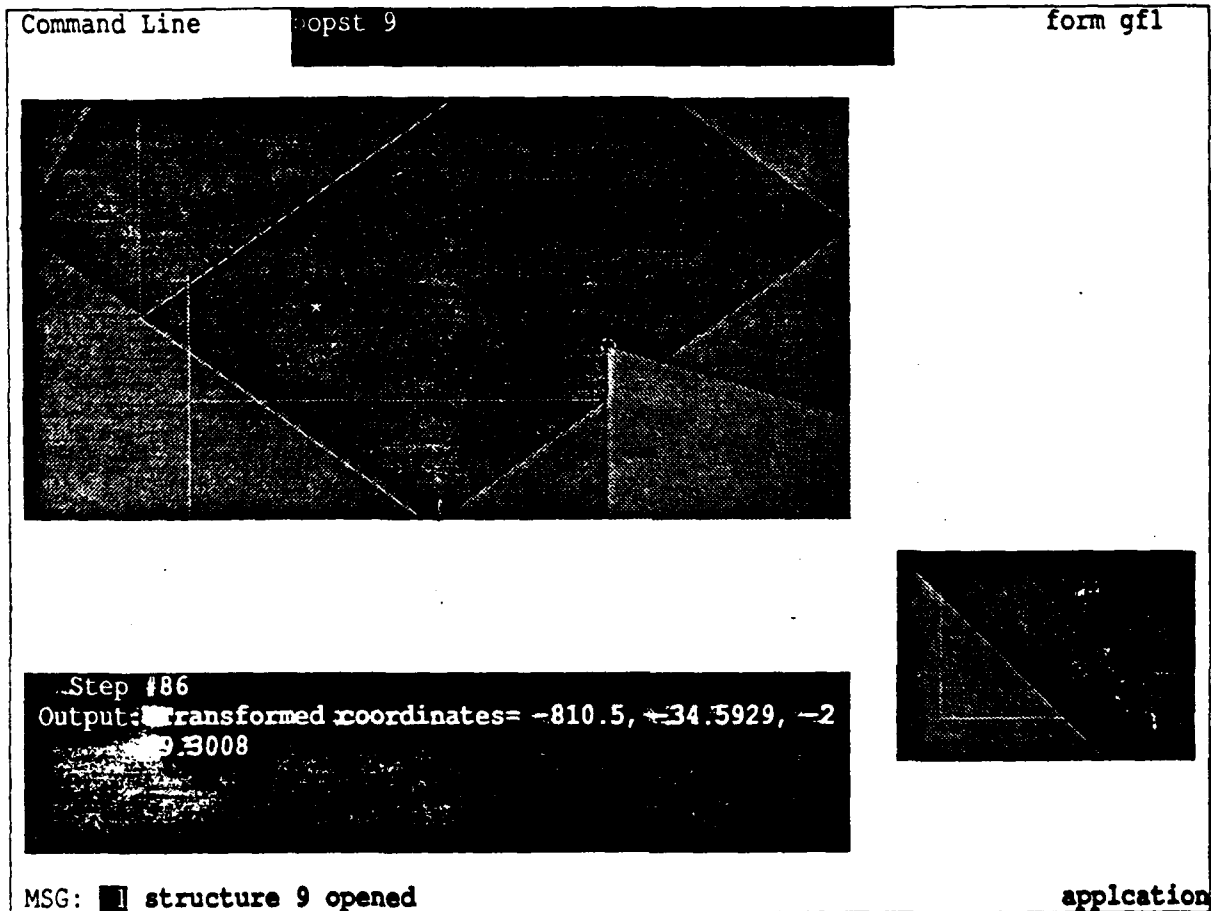


Figure 5-87b (AFTER)

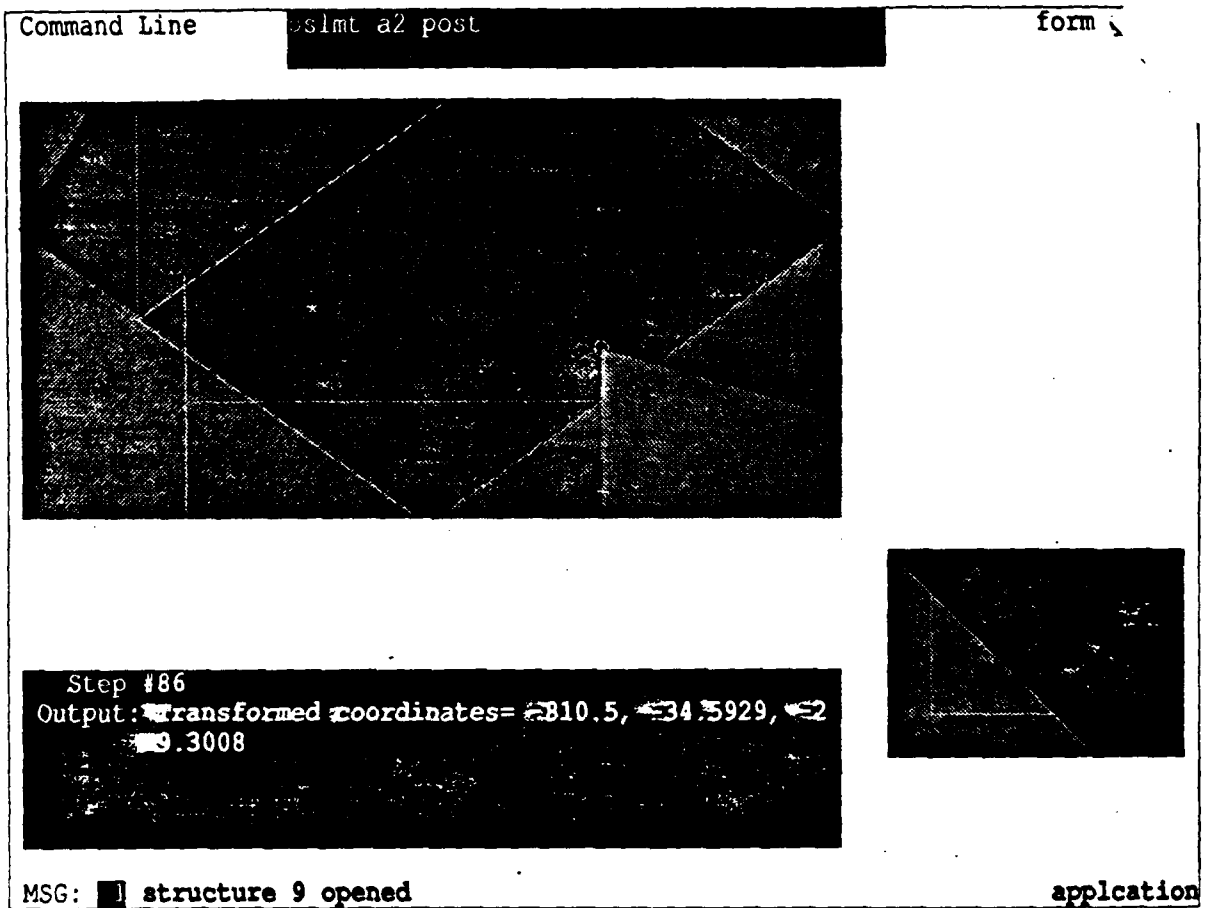


Figure 5-88a (BEFORE)

UTP 620344220
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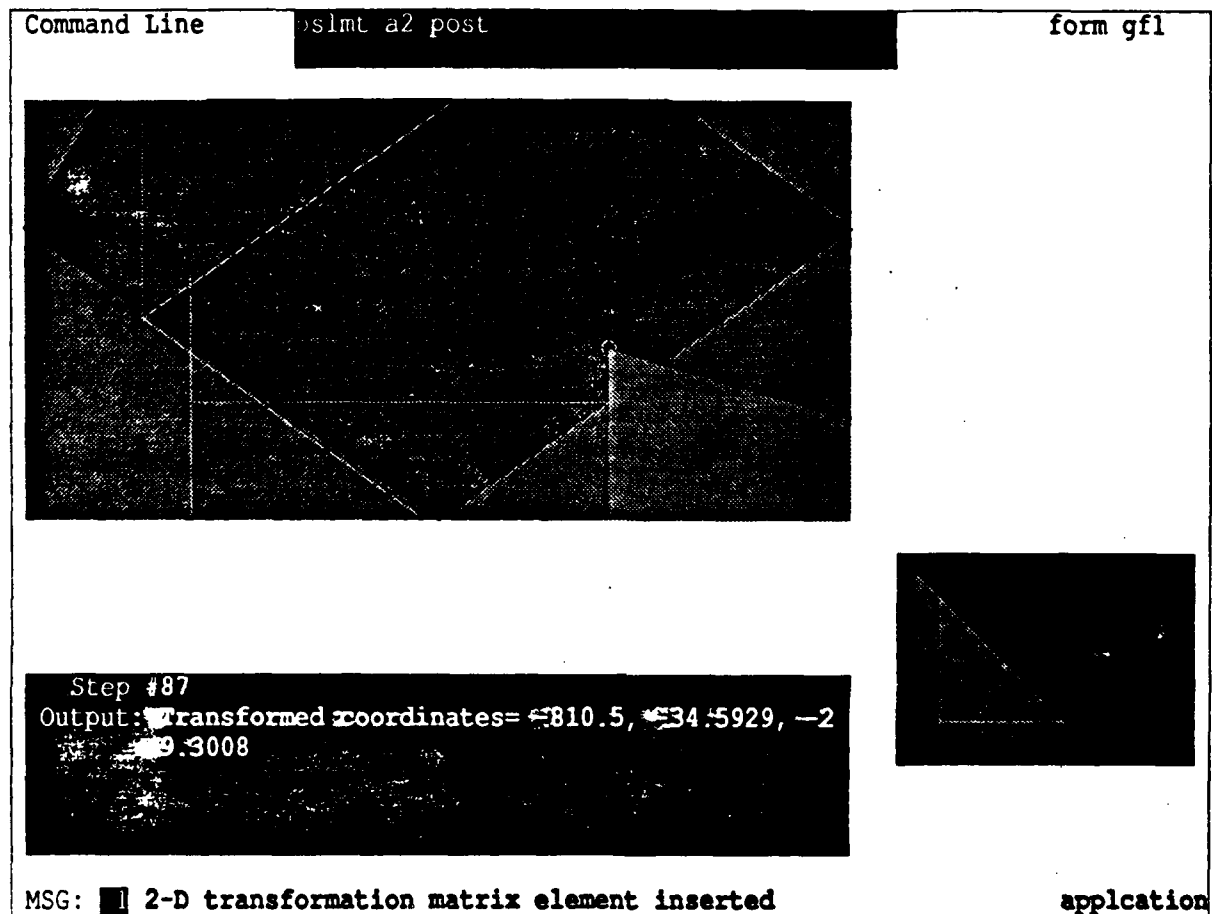


Figure 5-88b (AFTER)

UTP 620344220
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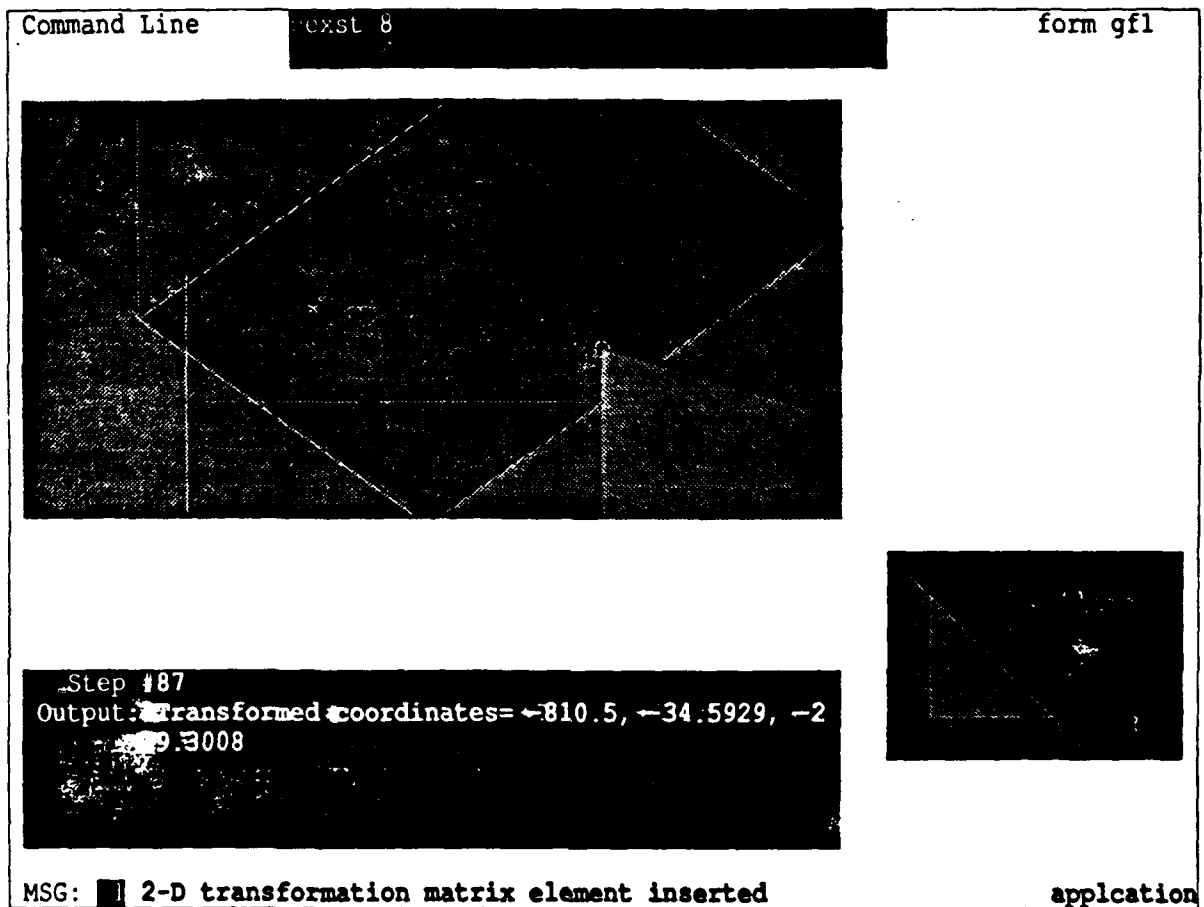


Figure 5-89a (BEFORE)

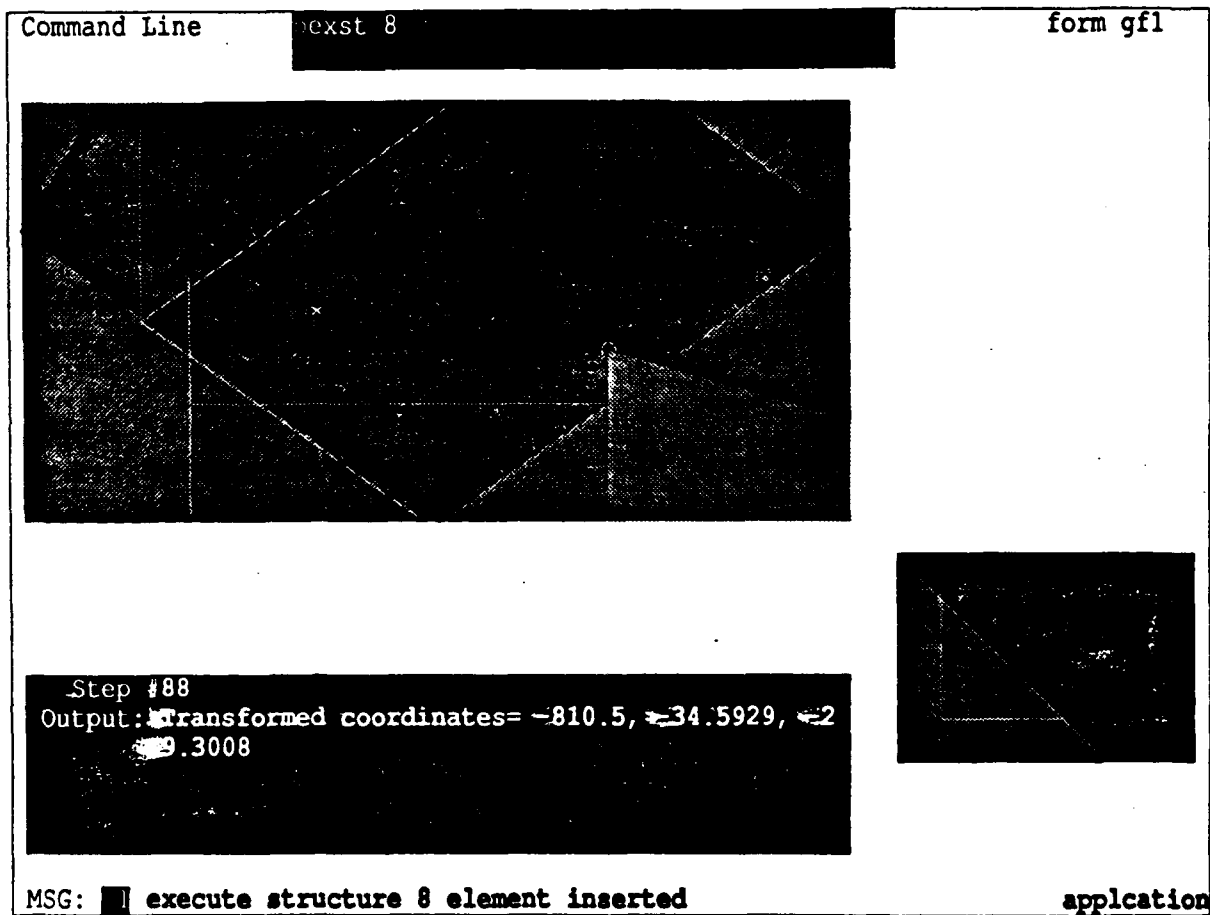


Figure 5-89b (AFTER)

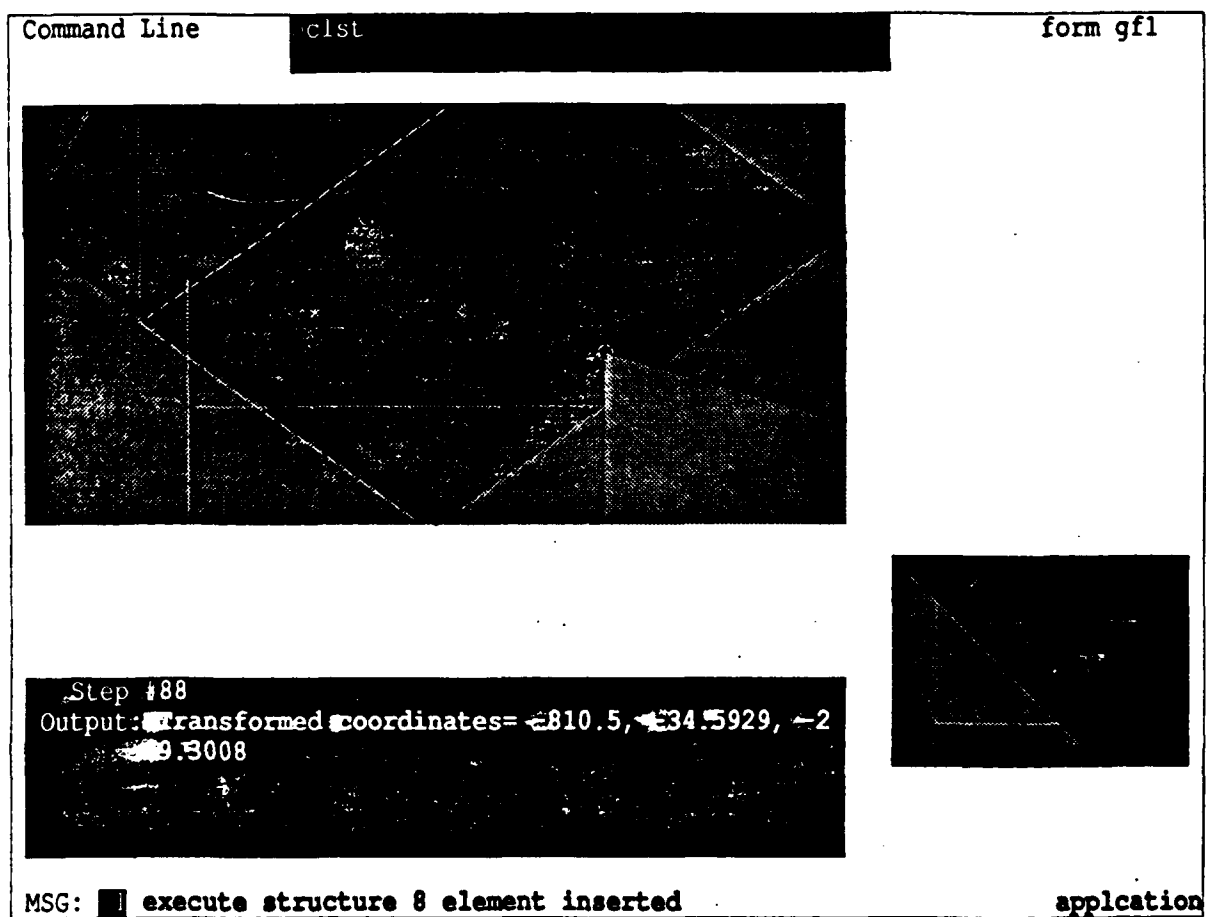


Figure 5-90a (BEFORE)

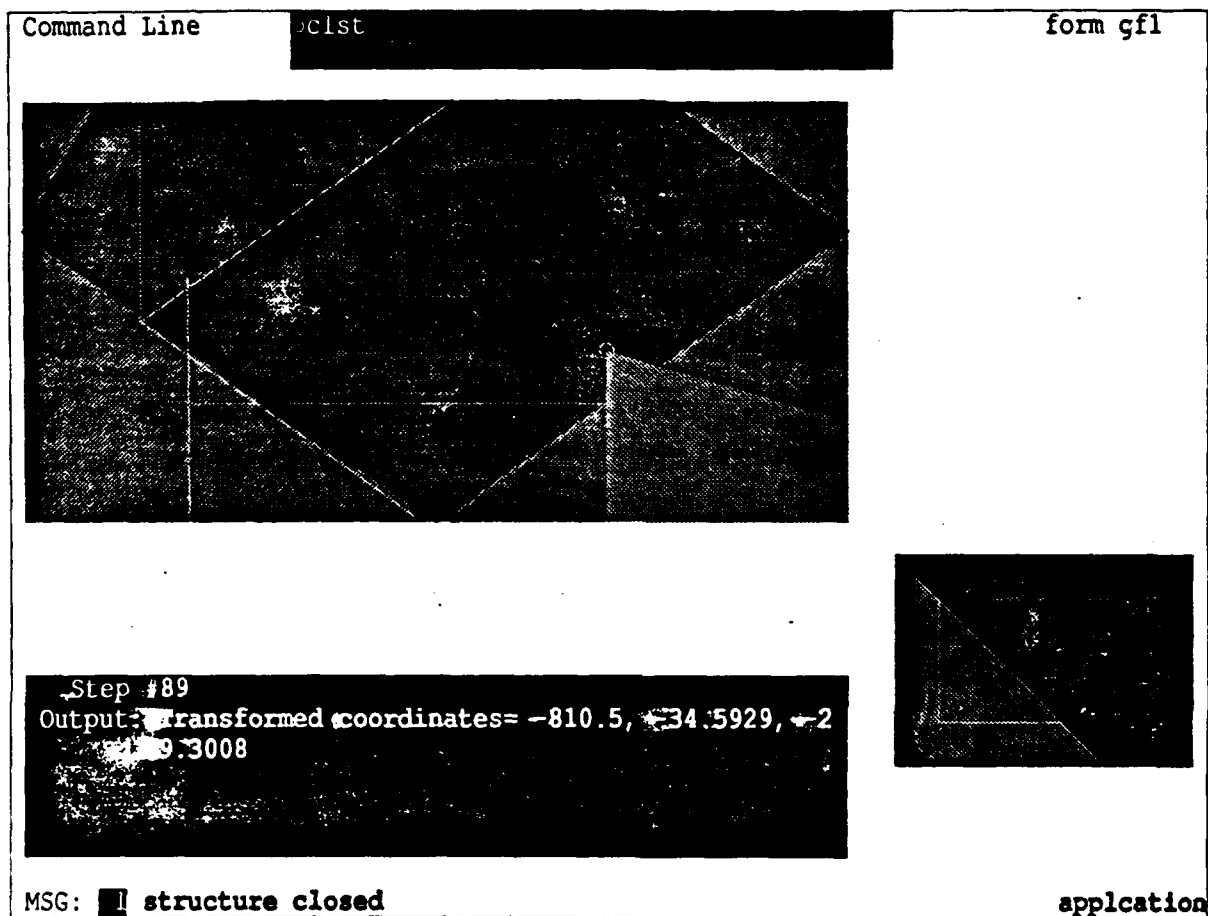


Figure 5-90b (AFTER)

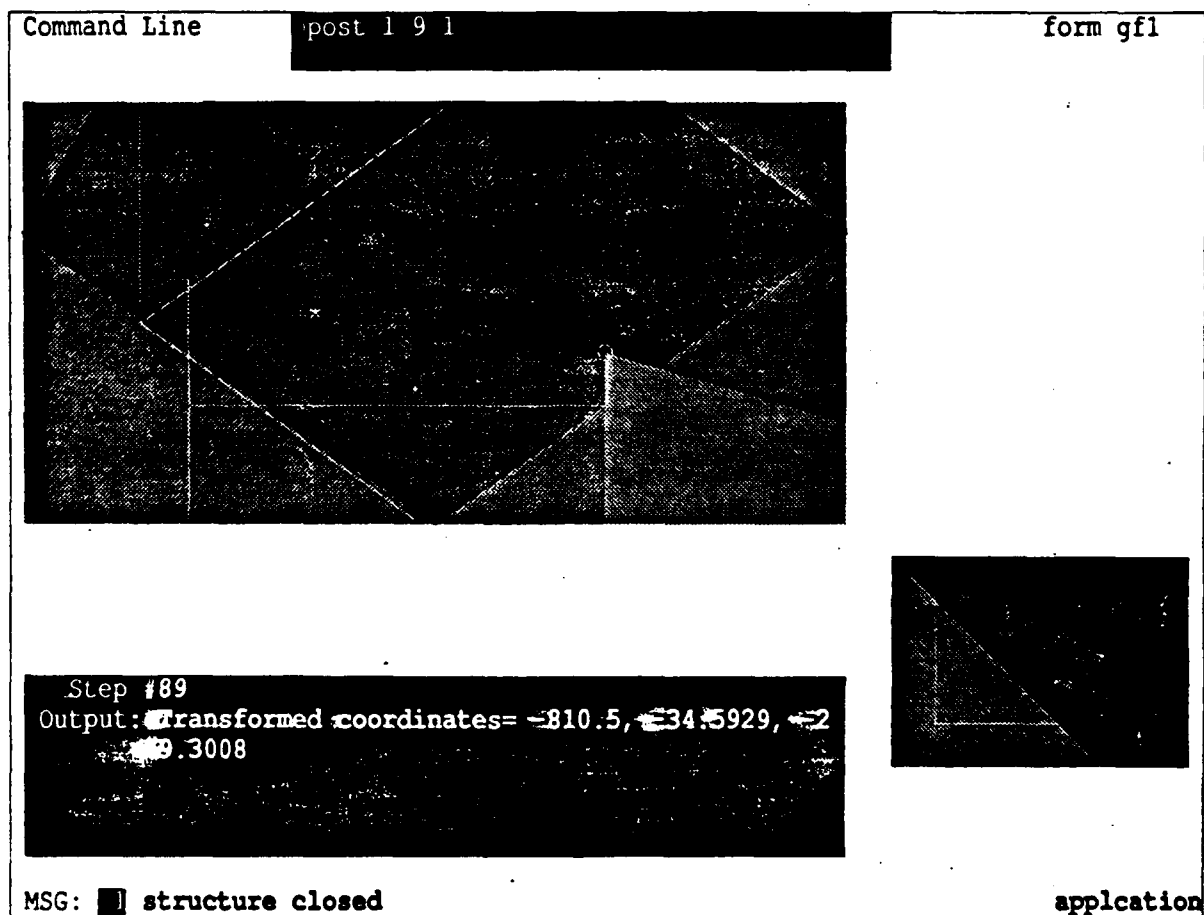


Figure 5-91a (BEFORE)

UTP 620344220
30 September 1990

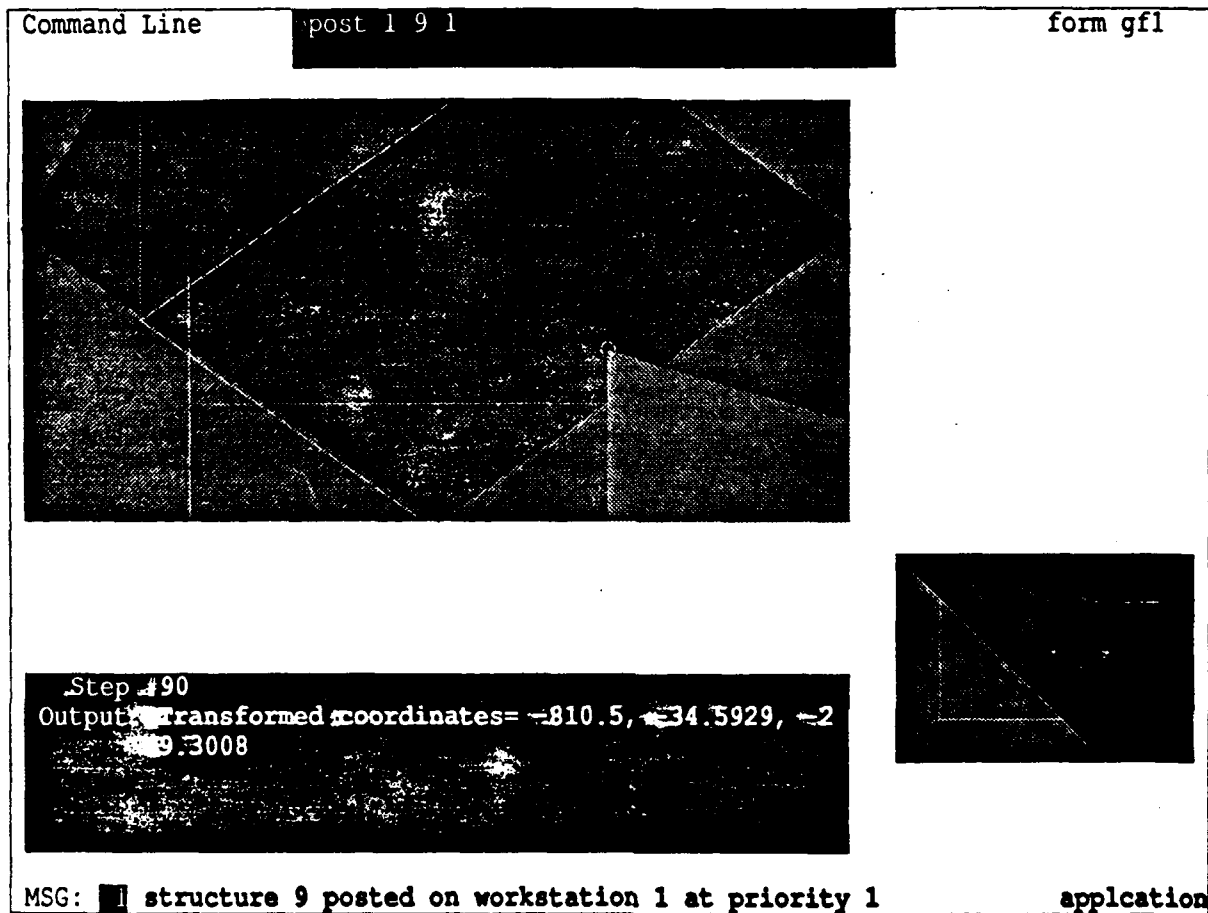


Figure 5-91b (AFTER)

UTP 620344220
30 September 1990

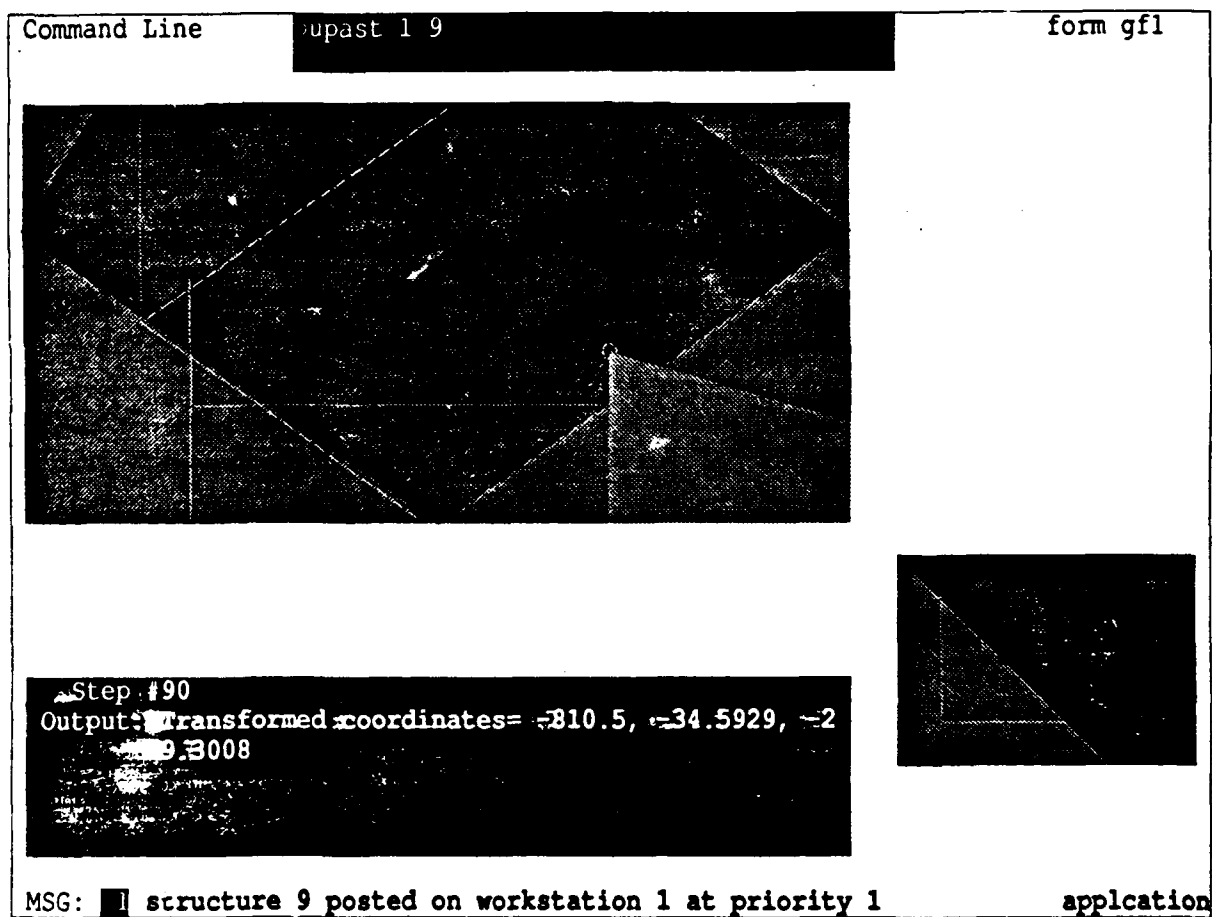


Figure 5-92a (BEFORE)

UTP 620344220
30 September 1990

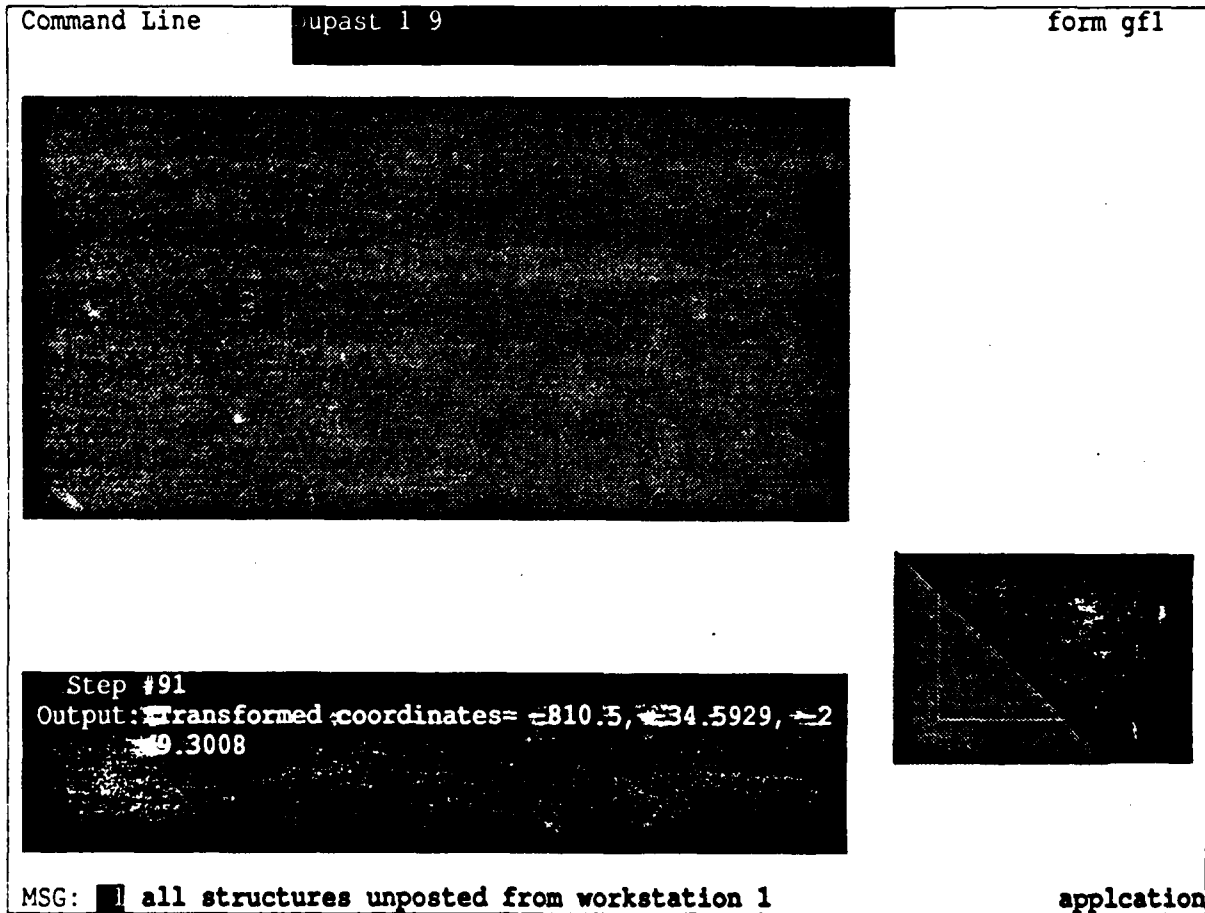


Figure 5-92b (AFTER)

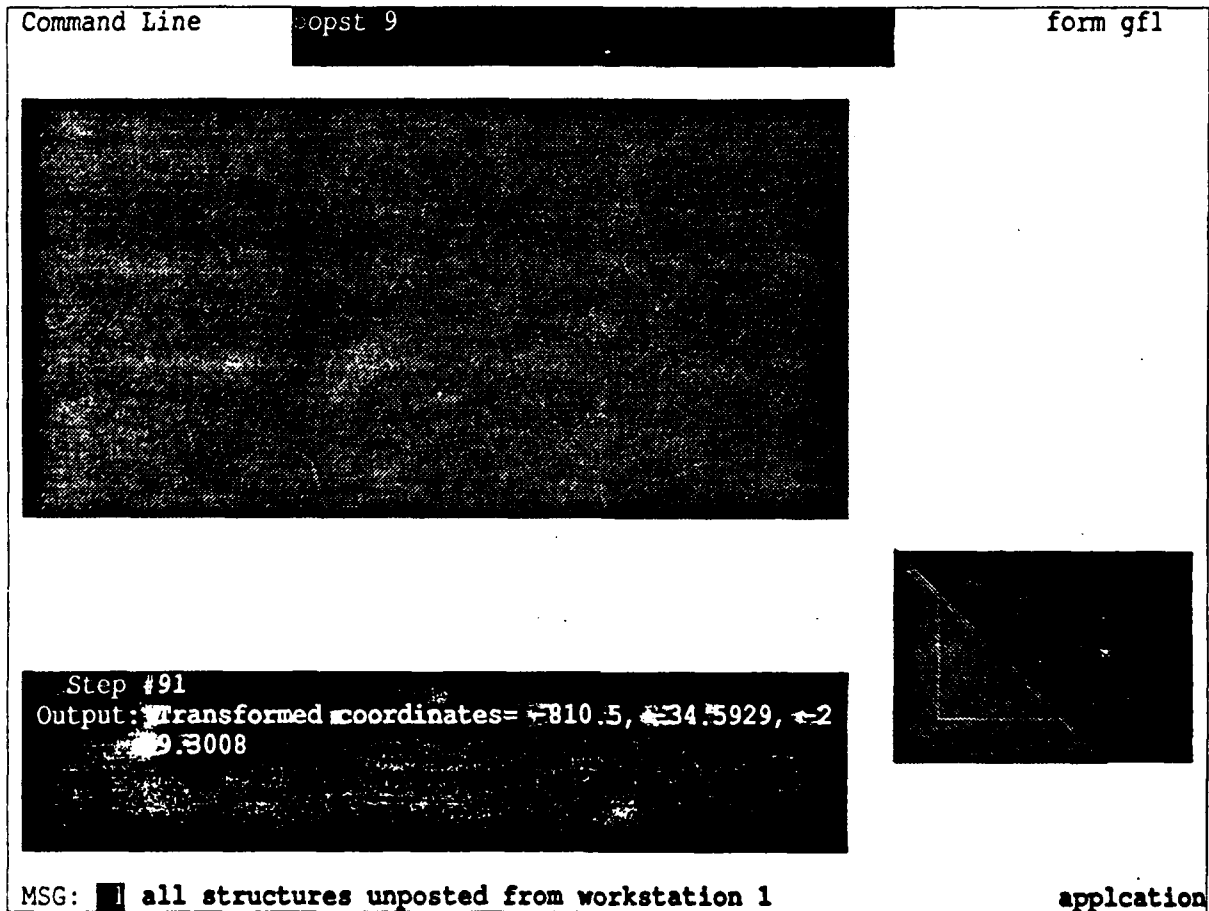


Figure 5-93a (BEFORE)

UTP 620344220
30 September 1990

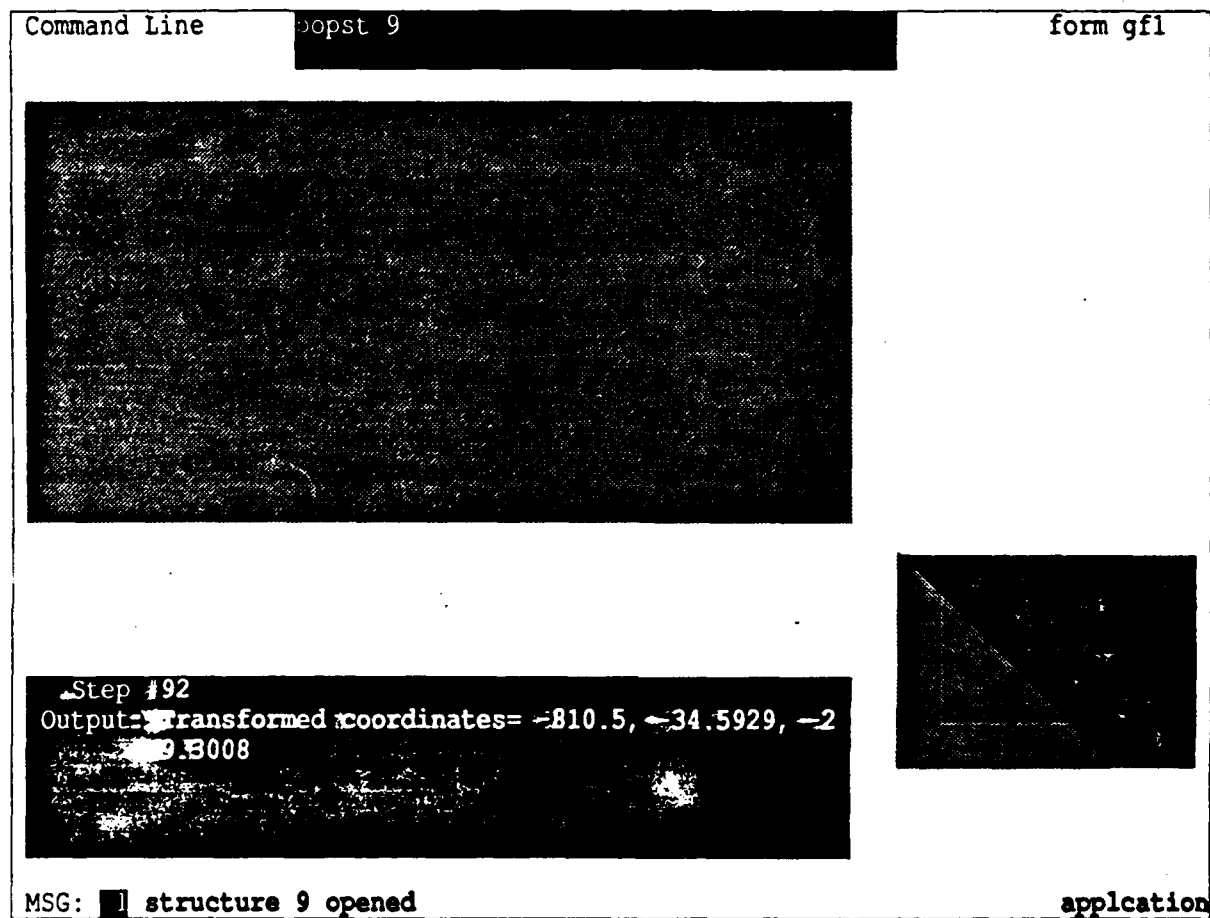


Figure 5-93b (AFTER)

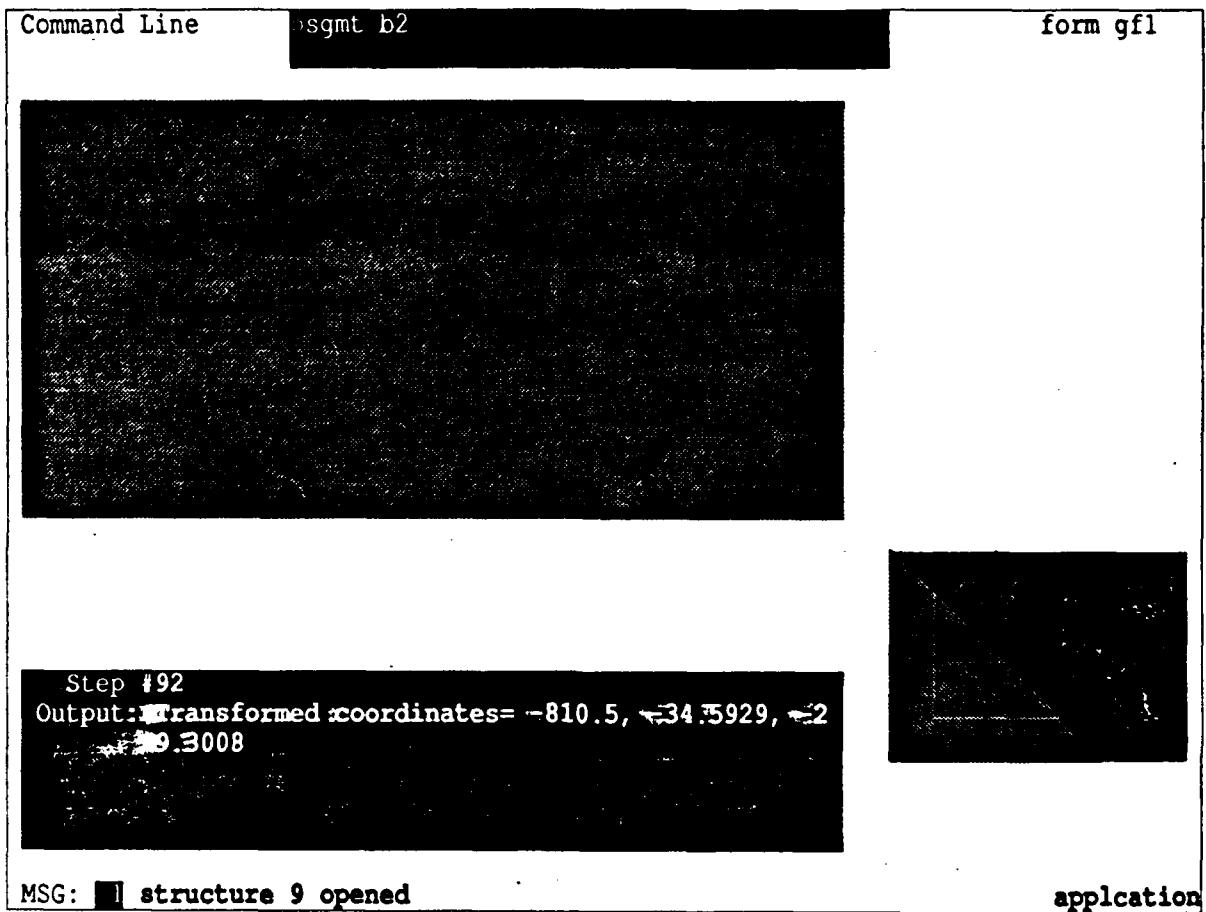


Figure 5-94a (BEFORE)

UTP 620344220
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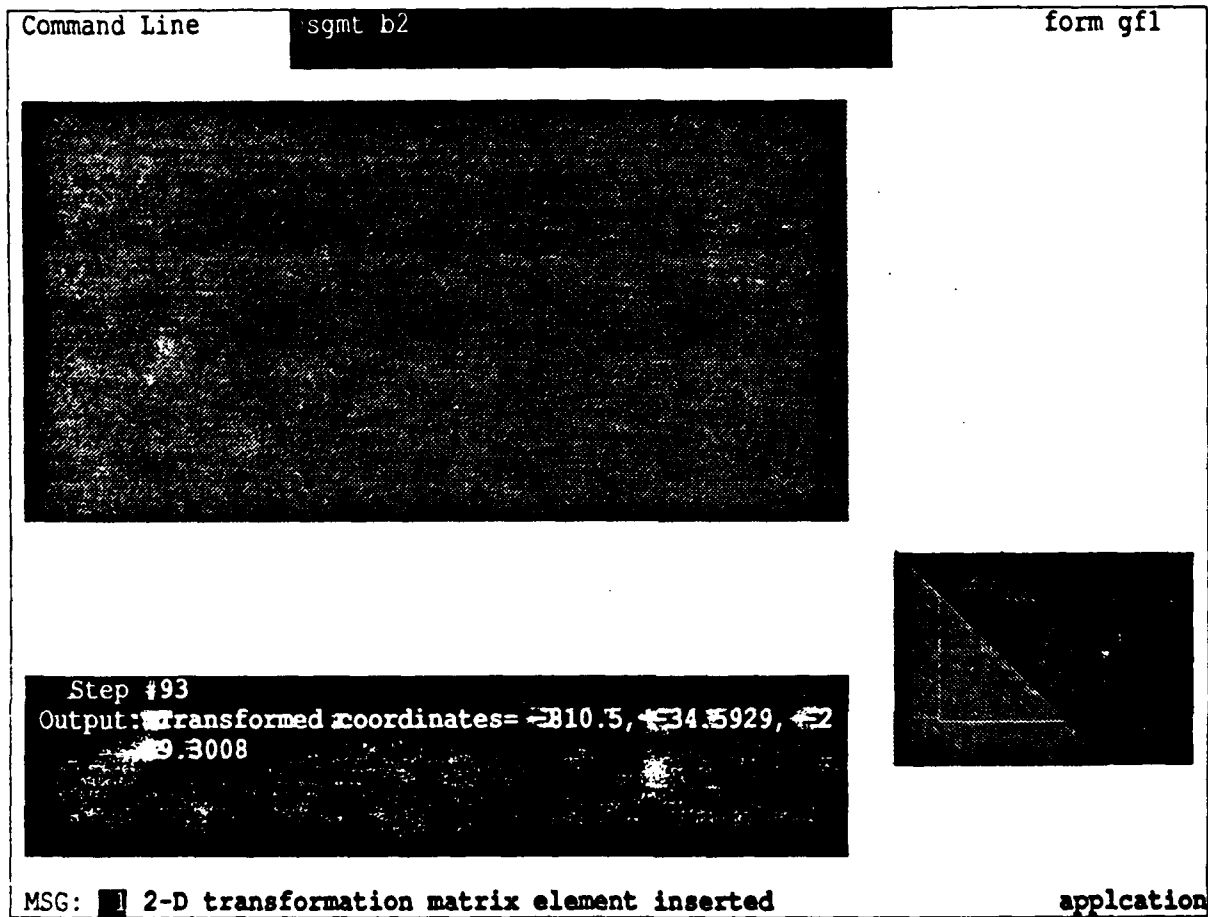


Figure 5-94b (AFTER)

UTP 620344220
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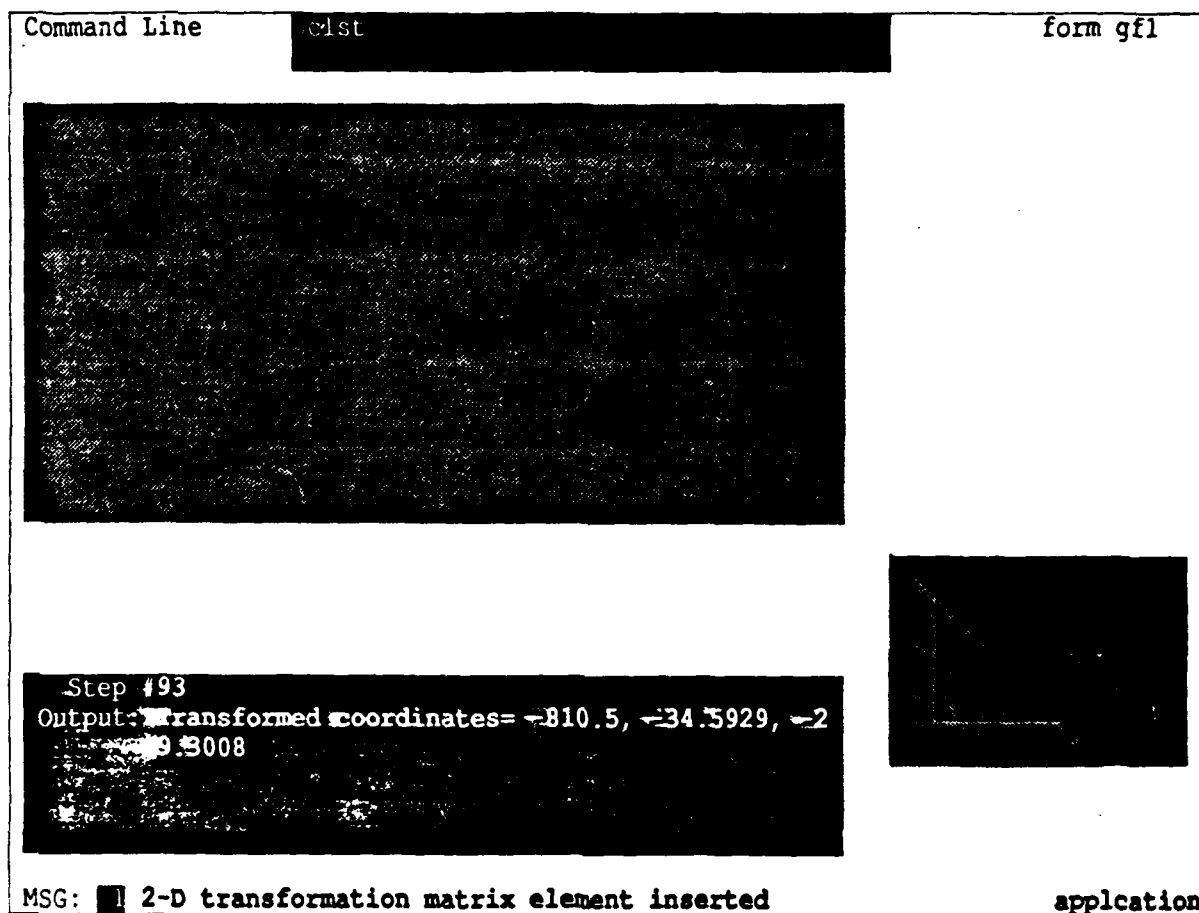


Figure 5-95a (BEFORE)

UTP 620344220
30 September 1990

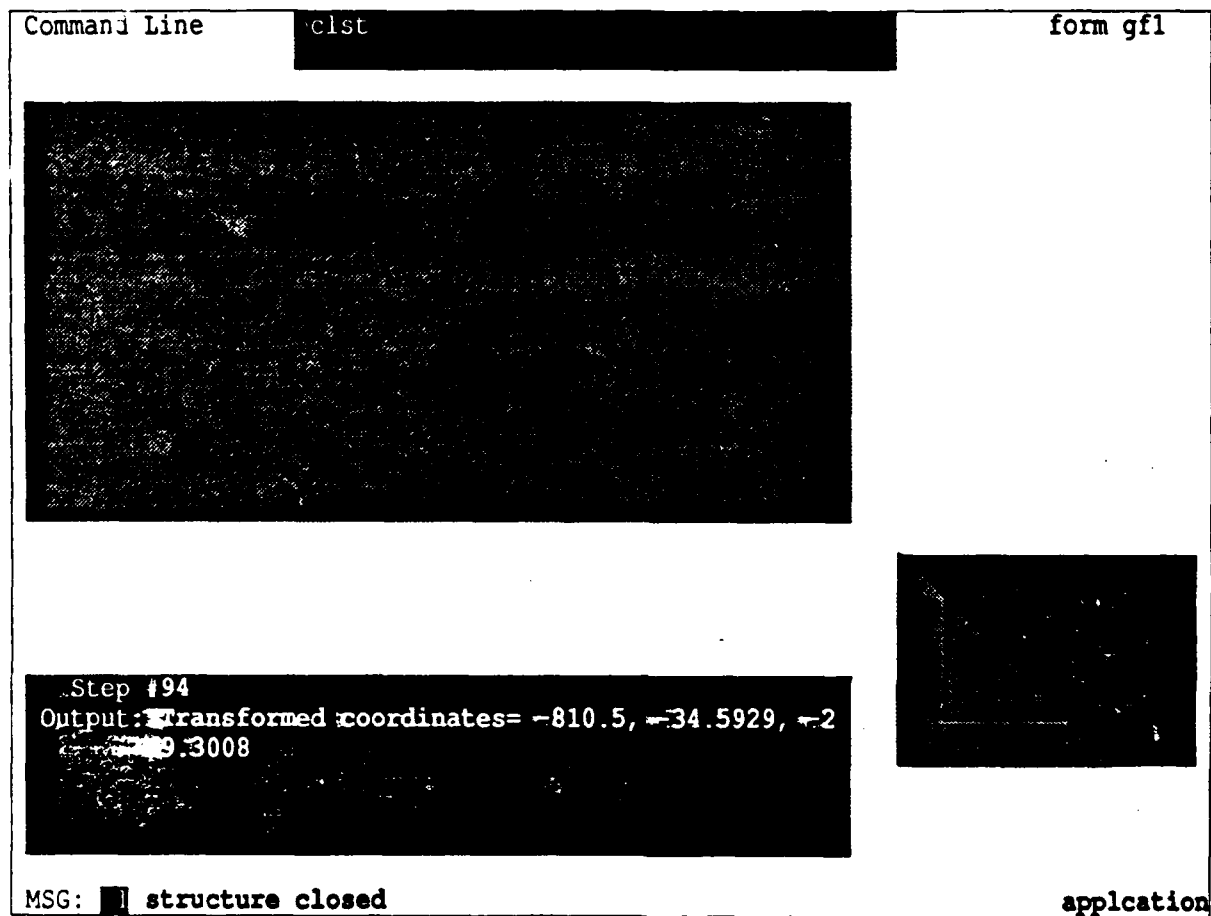


Figure 5-95b (AFTER)

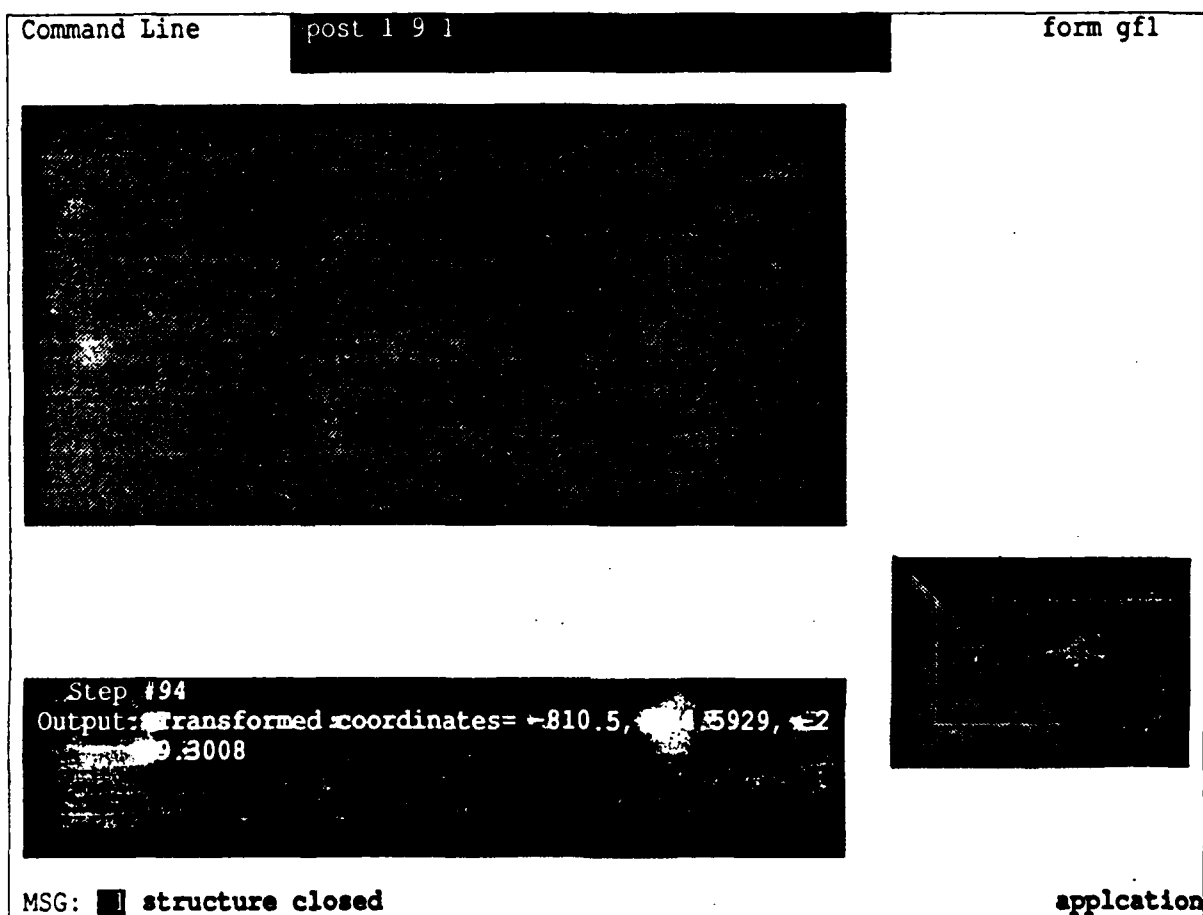


Figure 5-96a (BEFORE)

UTP 620344220
30 September 1990

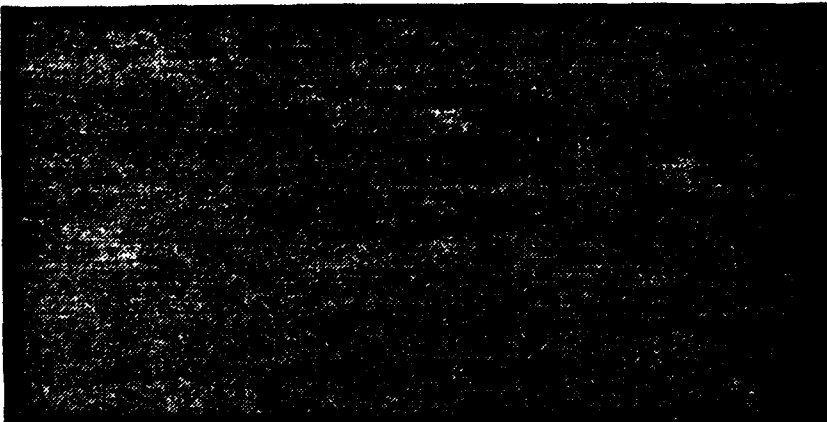
Command Line	post 1 9 1	form gfl
		
Step #95 Output: Transformed coordinates= -810.5, -34.5929, -2 -9.3008		
MSG: 1 structure 9 posted on workstation 1 at priority 1		application

Figure 5-96b (AFTER)

UTP 620344220
30 September 1990

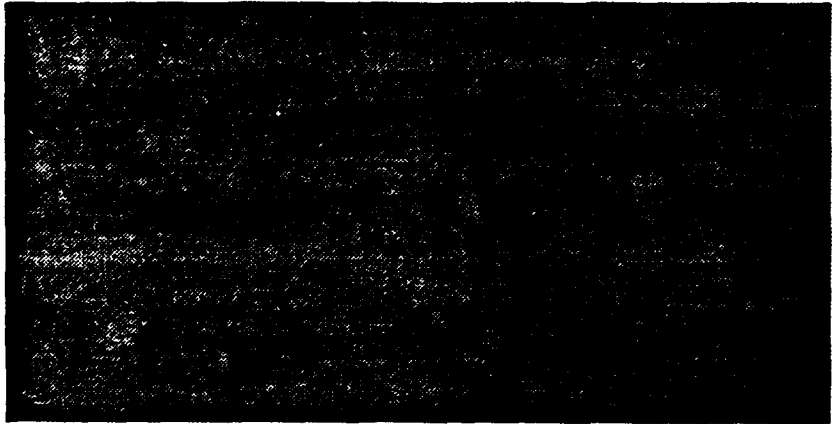
Command Line	opst 9	form gfl
		
Step #95 Output: transformed coordinates= -810.5, -34.5929, -2 -23008		
MSG: structure 9 posted on workstation 1 at priority 1		application

Figure 5-97a (BEFORE)

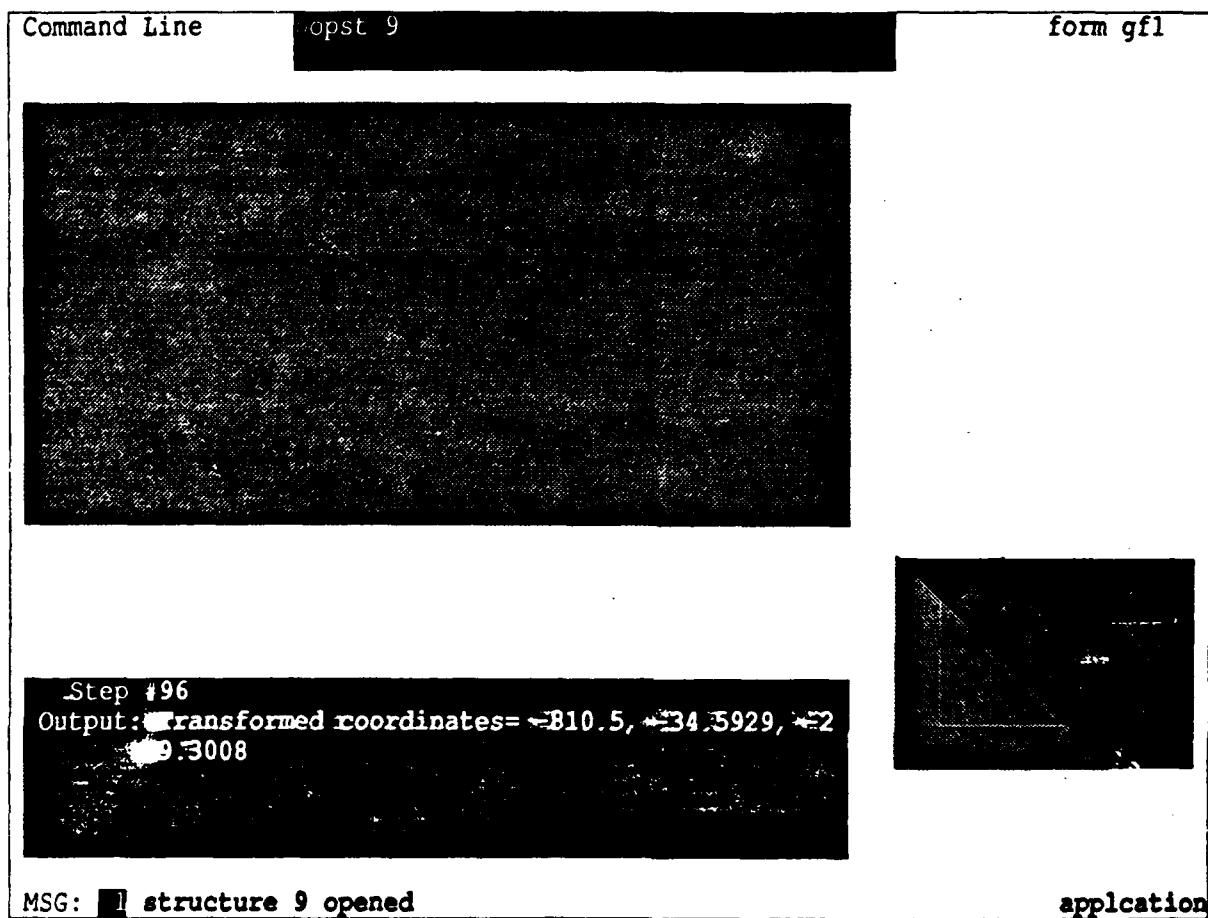


Figure 5-97b (AFTER)

UTP 620344220
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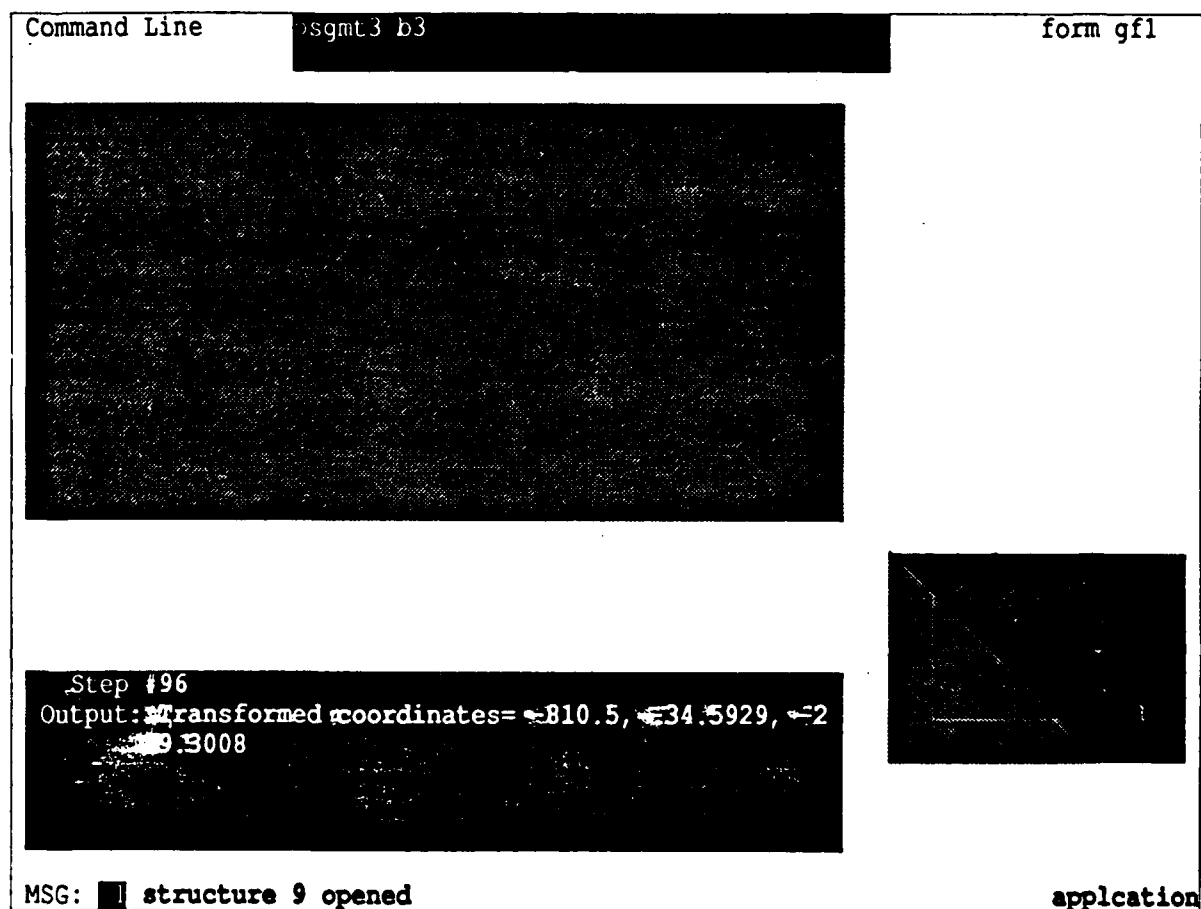


Figure 5-98a (BEFORE)

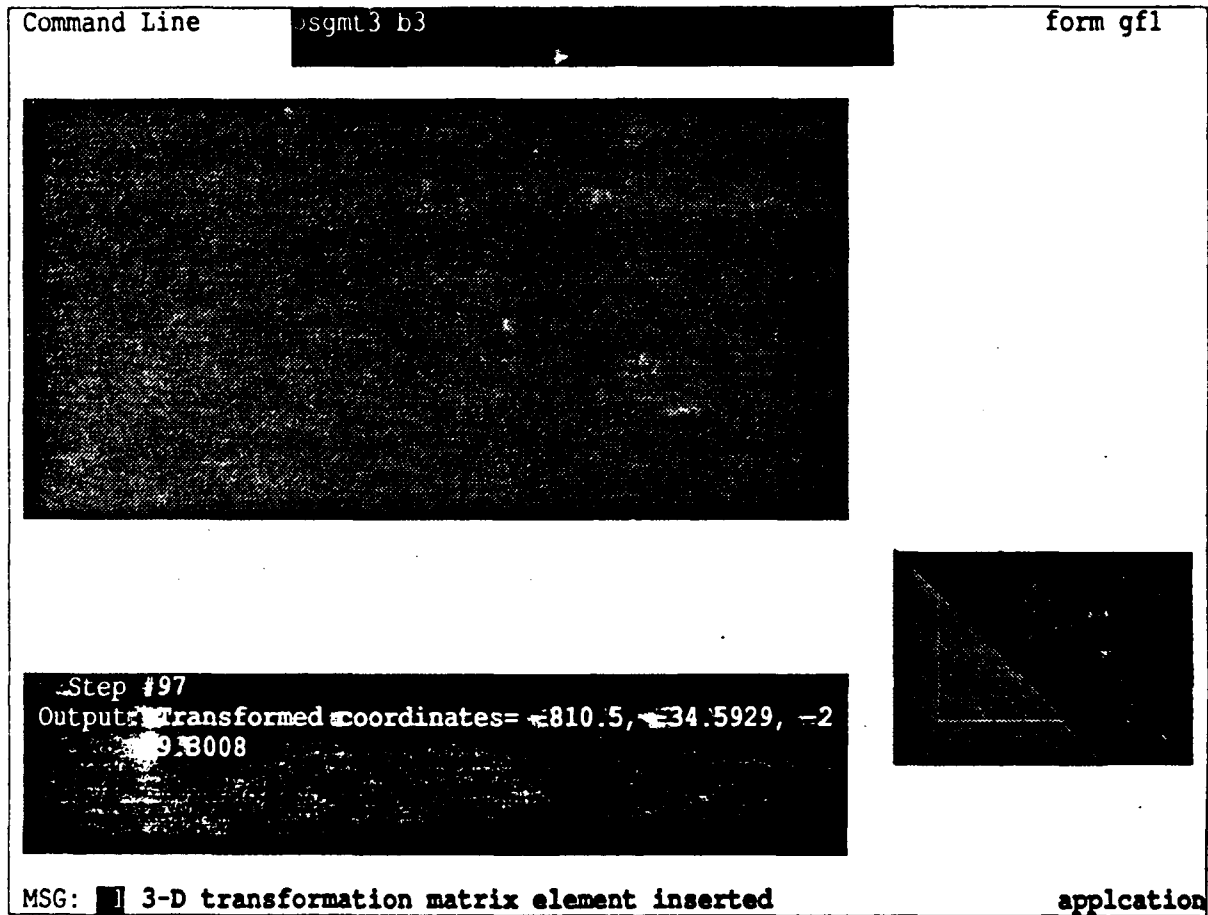


Figure 5-98b (AFTER)

UTP 620344220
30 September 1990

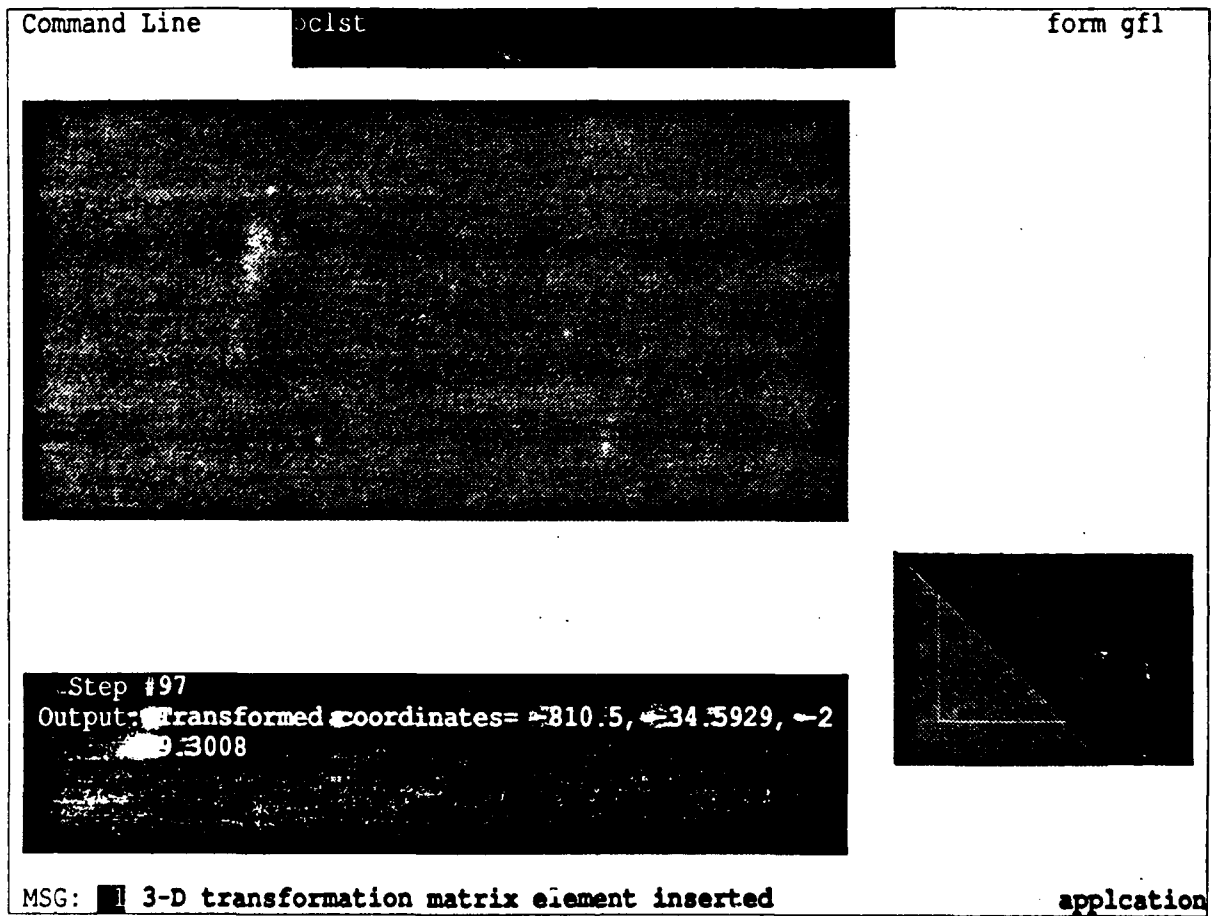


Figure 5-99a (BEFORE)

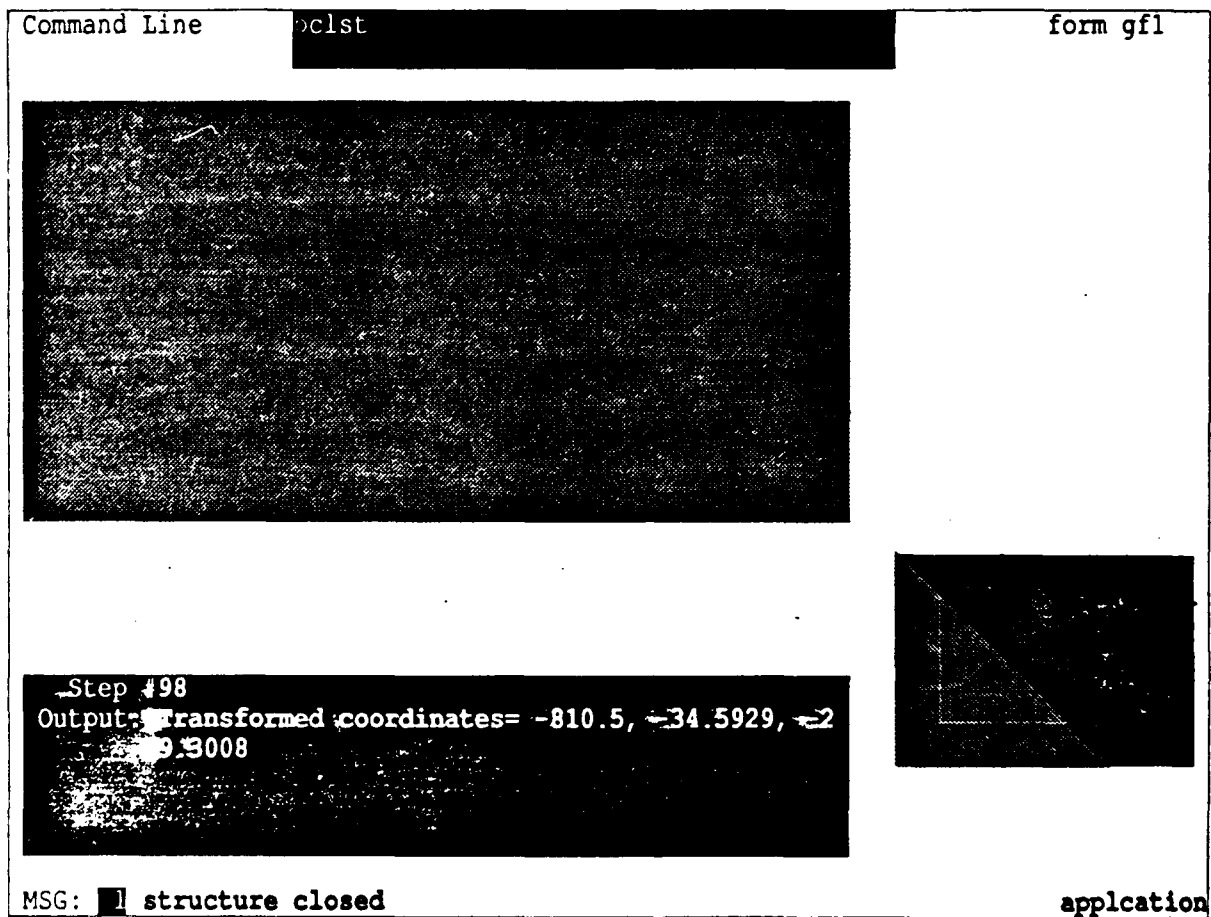


Figure 5-99b (AFTER)

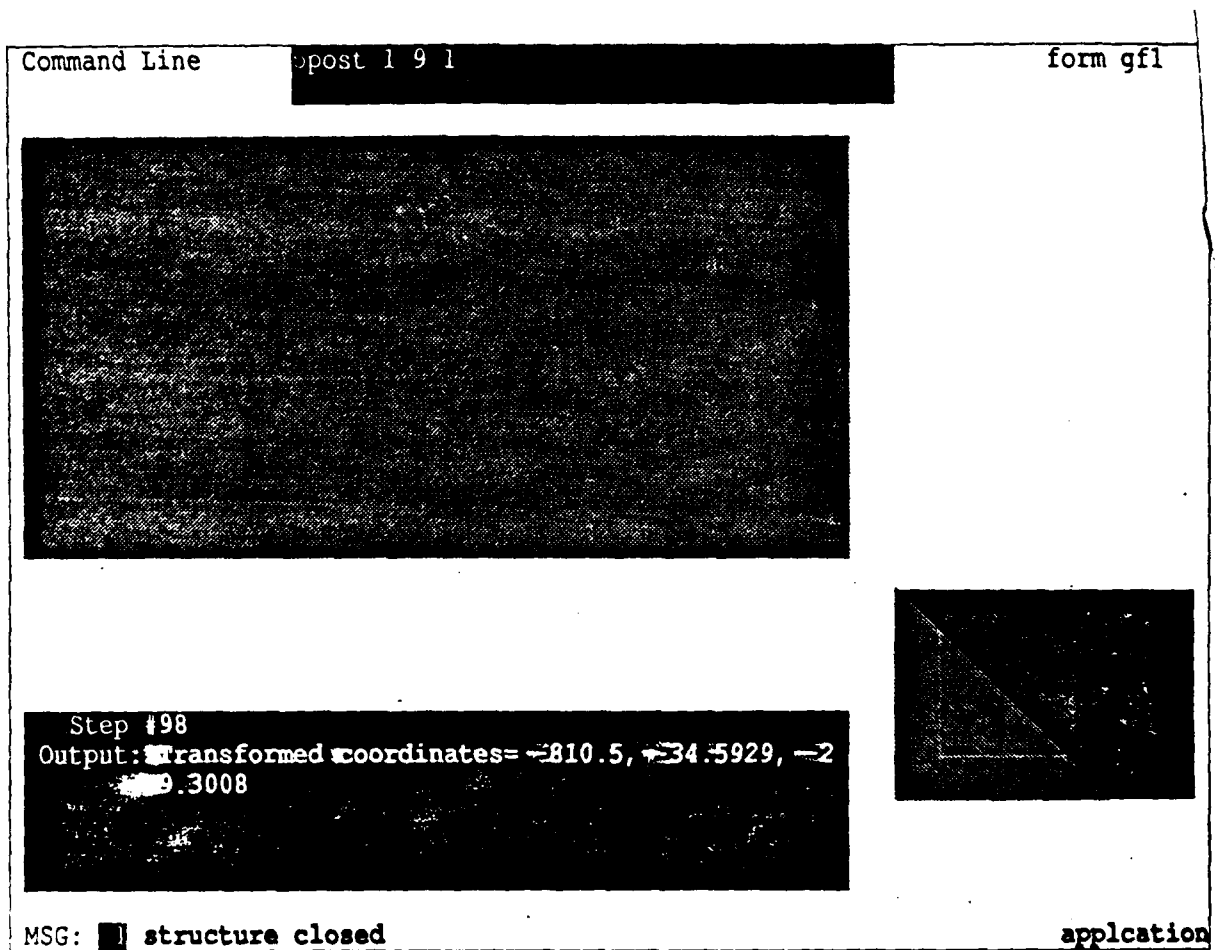


Figure 5-100a (BEFORE)

UTP 620344220
30 September 1990

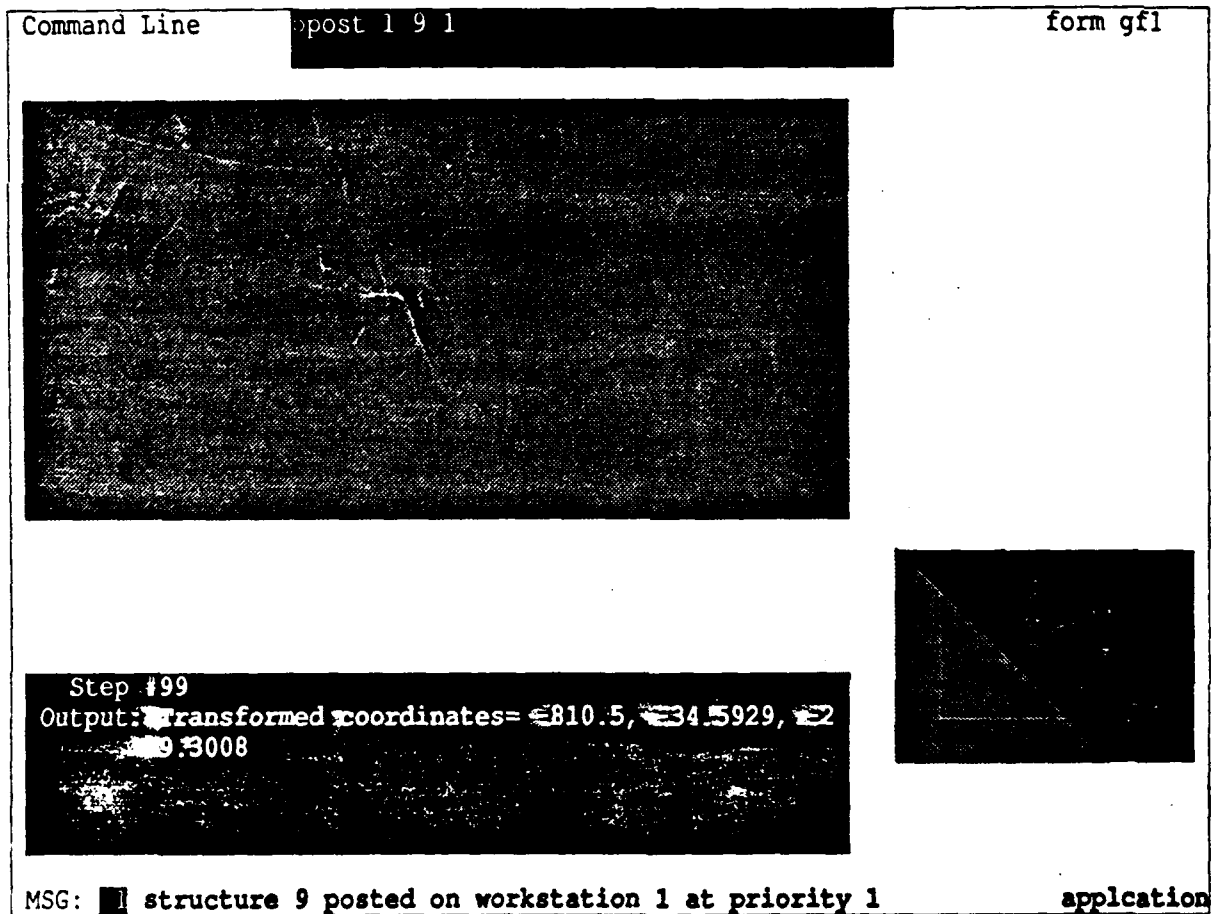


Figure 5-100b (AFTER)

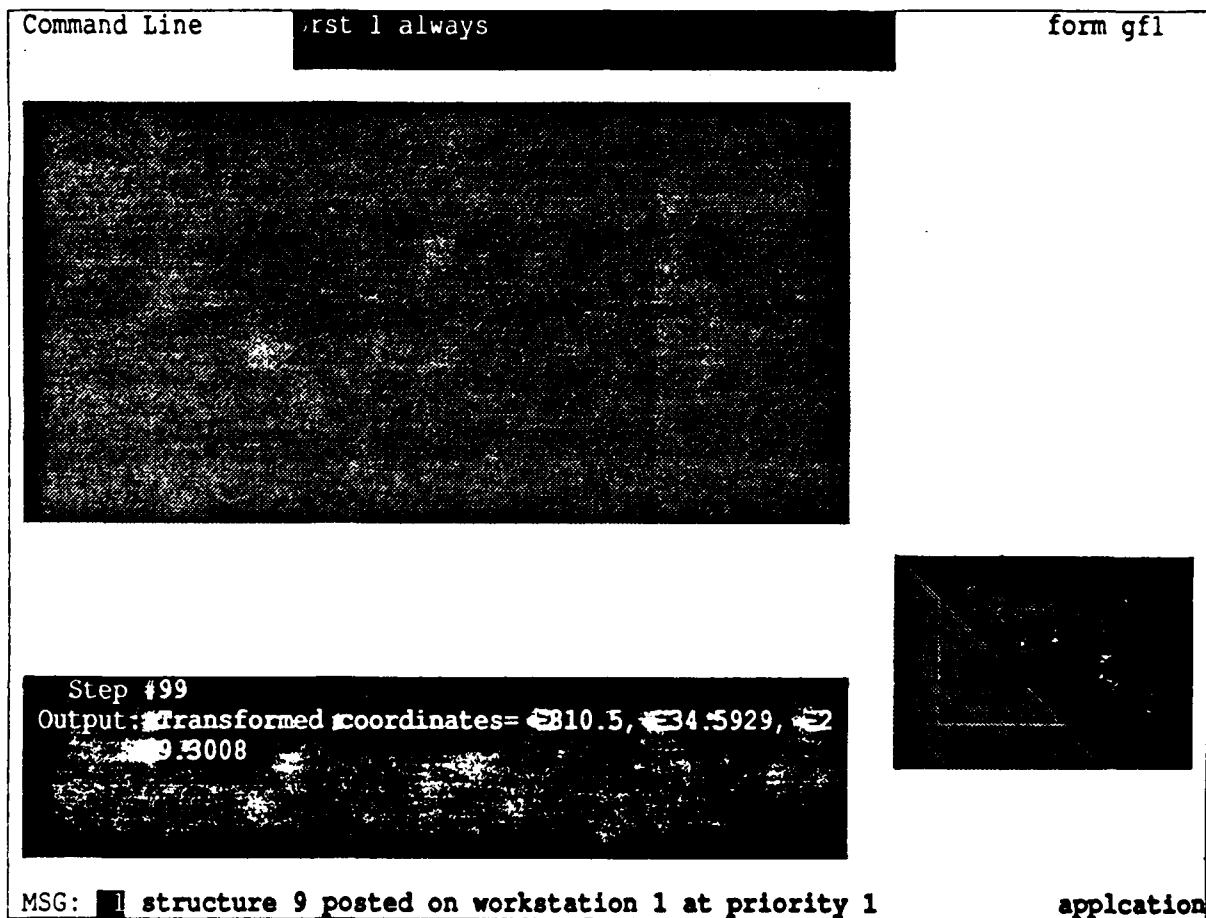


Figure 5-101a (BEFORE)

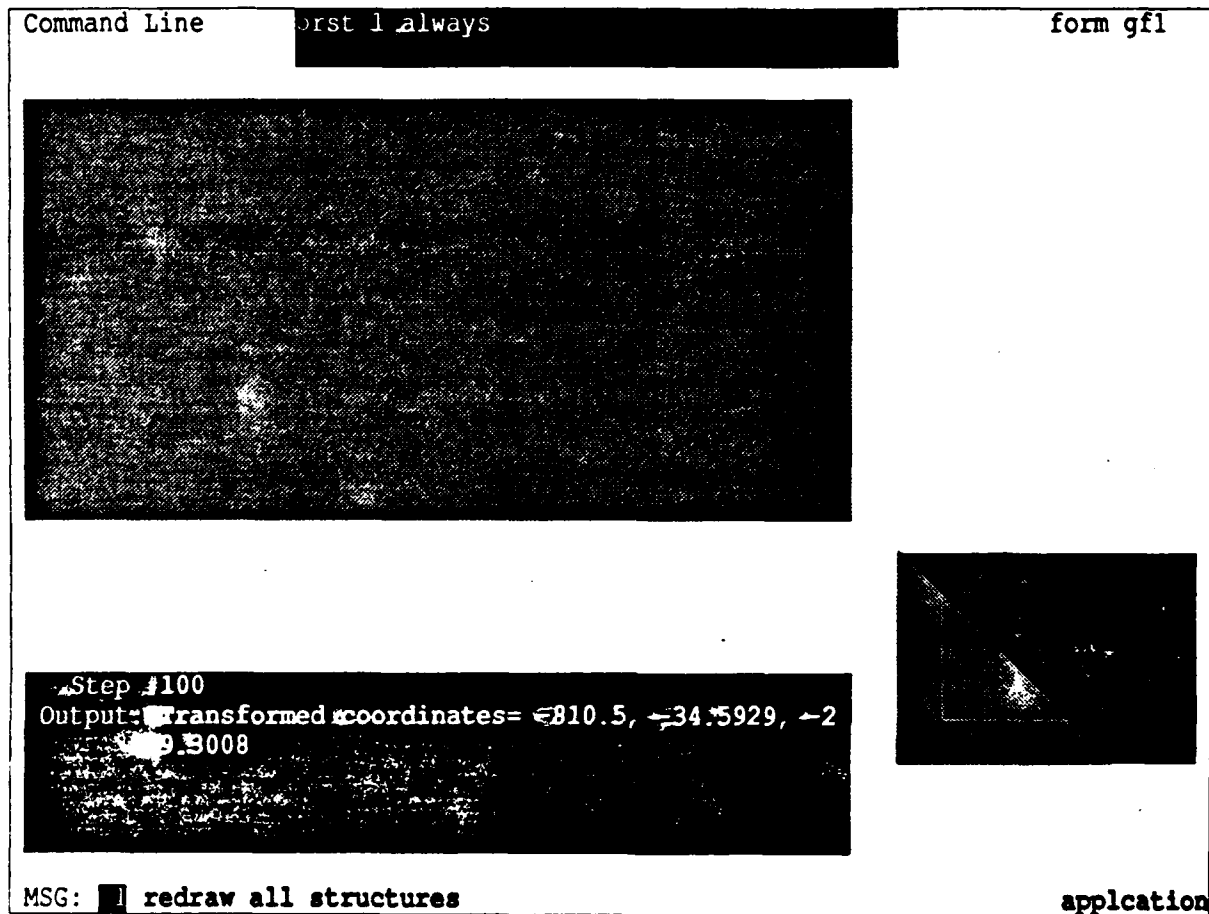


Figure 5-101b (AFTER)

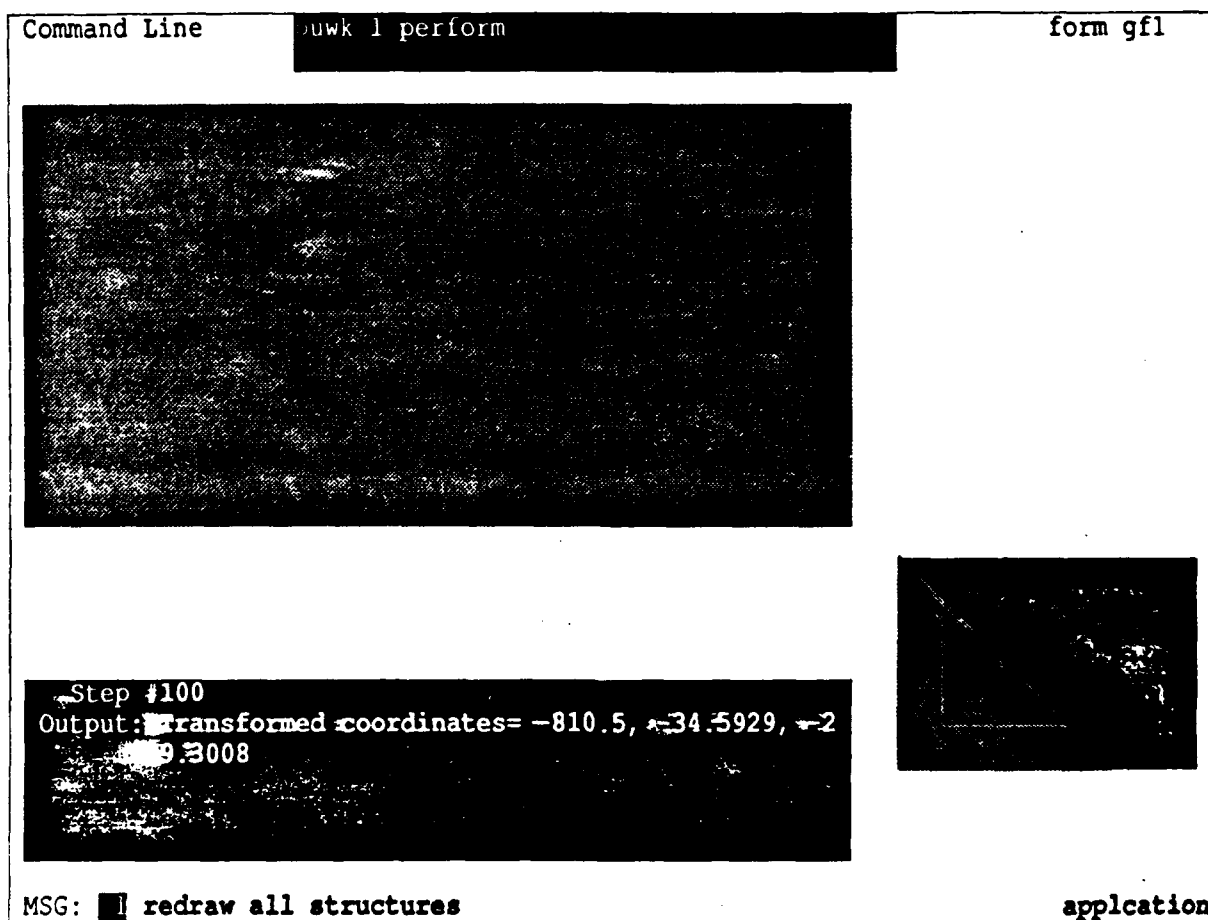


Figure 5-102a (BEFORE)

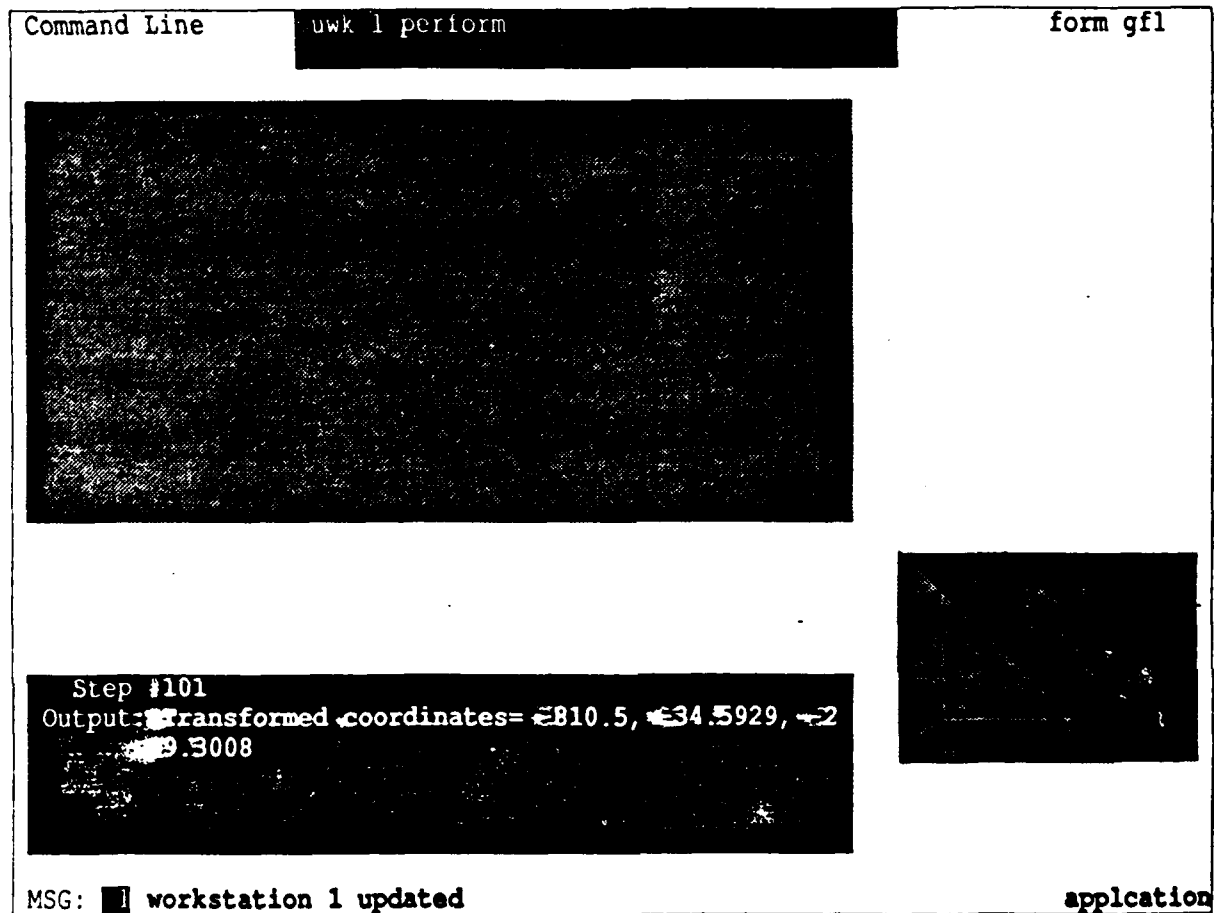


Figure 5-102b (AFTER)

UTP 620344220
30 September 1990

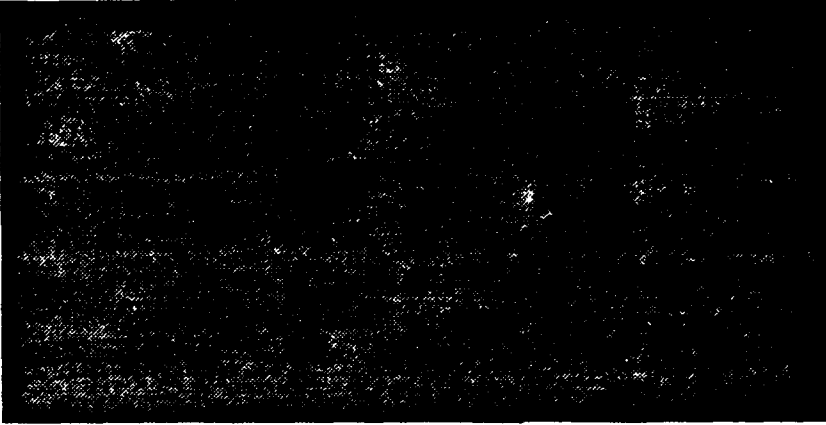
Command Line	msg "GSS UTP output is complete"	form gfl
		
Step #101 Output: transformed coordinates= 810.5, 34.3929, 2 9.3008		
		
MSG: workstation 1 updated	application	

Figure 5-103a (BEFORE)

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Command Line	msg "GSS UTP output is complete"	form gfl
		
Step #101 Output: transformed coordinates= -810.5, -34.5929, -2 9.3008		
		
MSG: 1 GSS UTP output is complete	application	

Figure 5-103b (AFTER)

UTP 620344220
30 September 1990

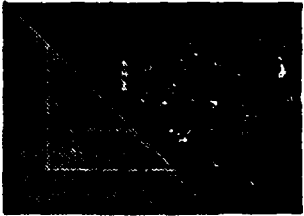
Command Line	dsn 6 delete	form gfl
		
Step #101 Output: transformed coordinates= -810.5, 84.3929, -2 9.3008		
MSG:  GSS UTP output is complete		application

Figure 5-104a (BEFORE)

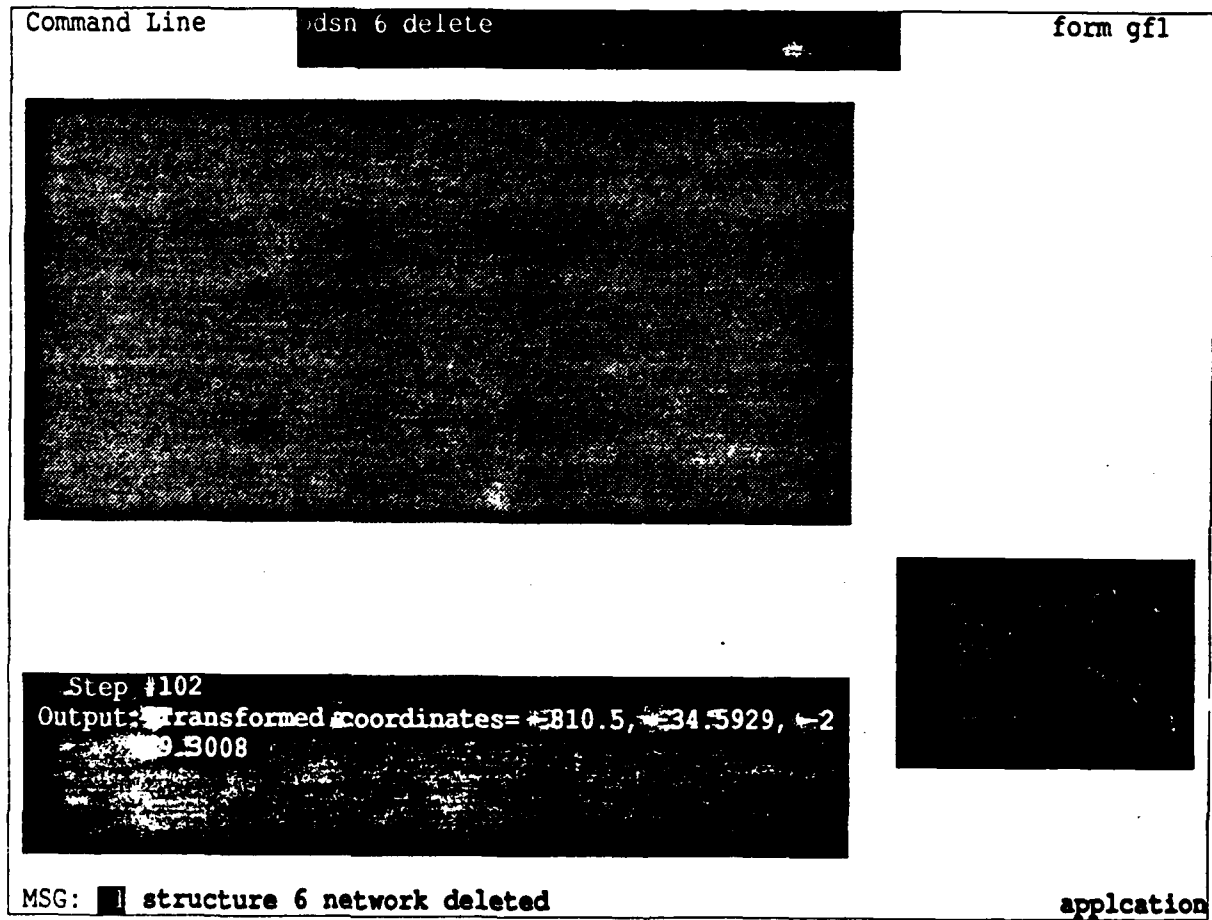


Figure 5-104b (AFTER)

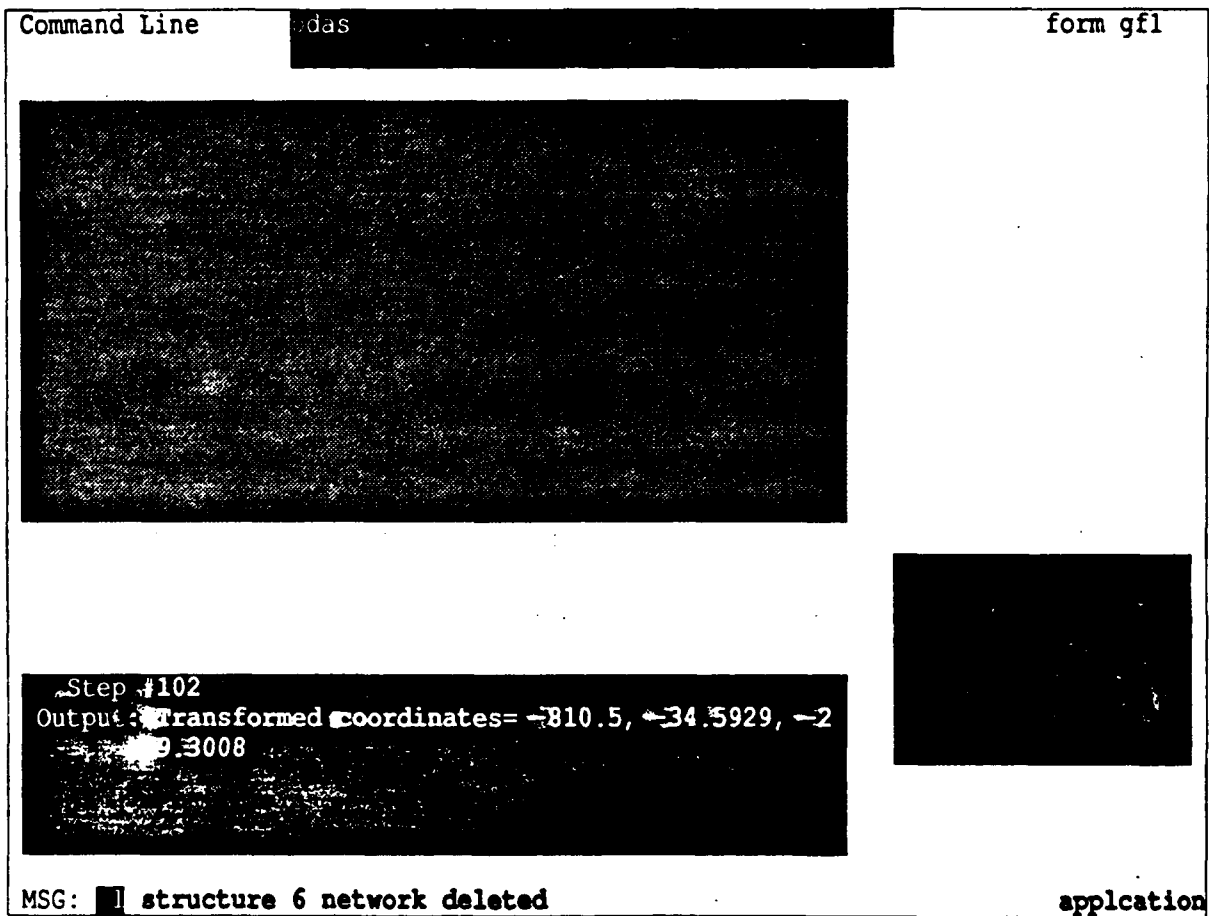


Figure 5-105a (BEFORE)

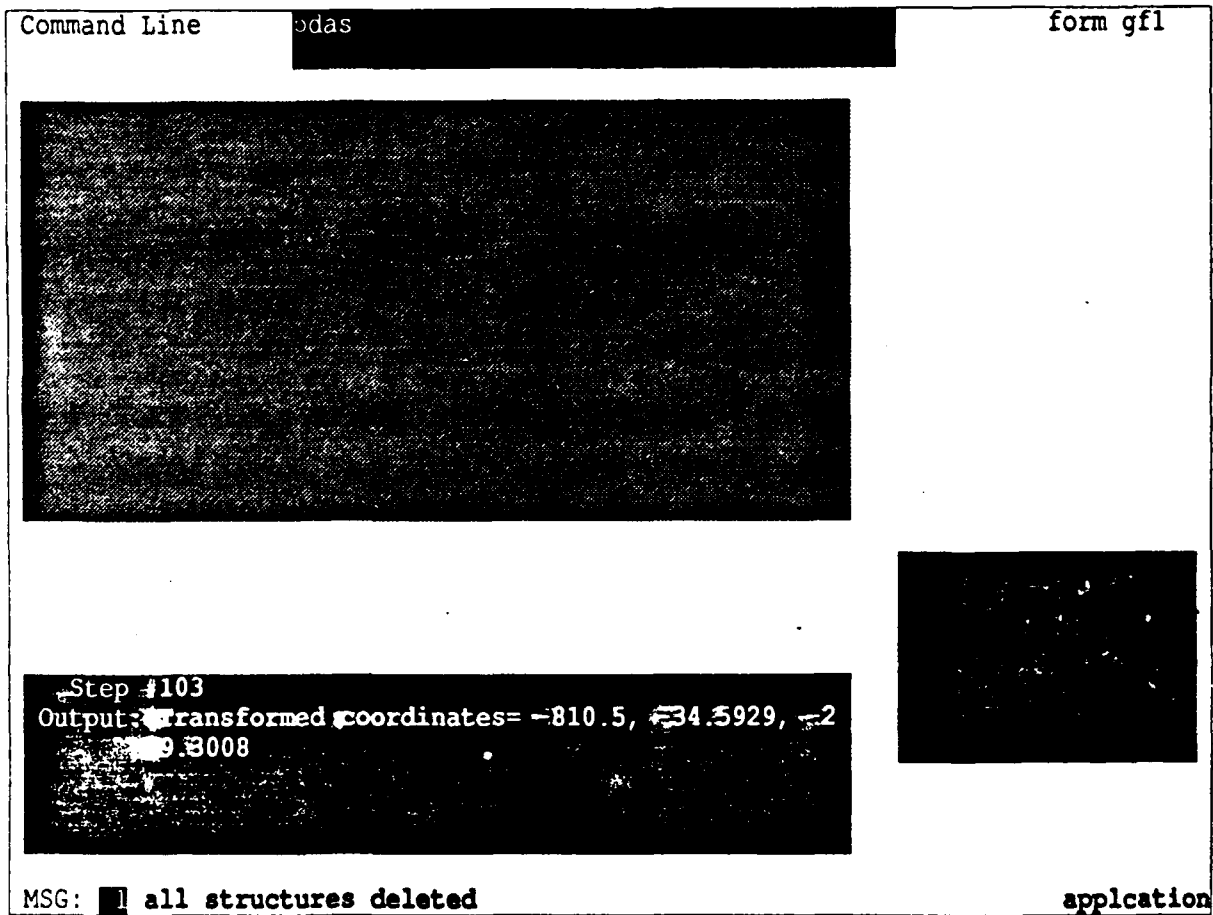


Figure 5-105b (AFTER)

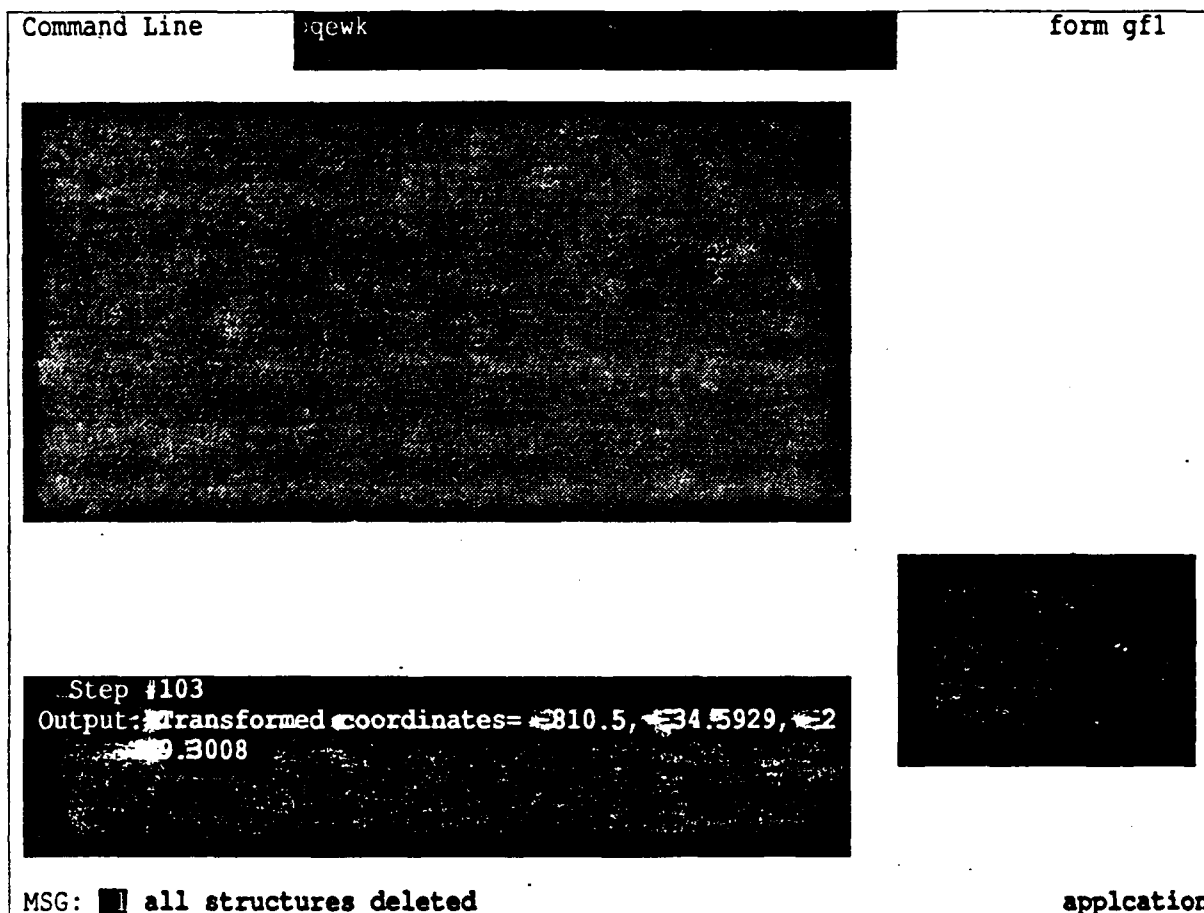


Figure 5-106a (BEFORE)

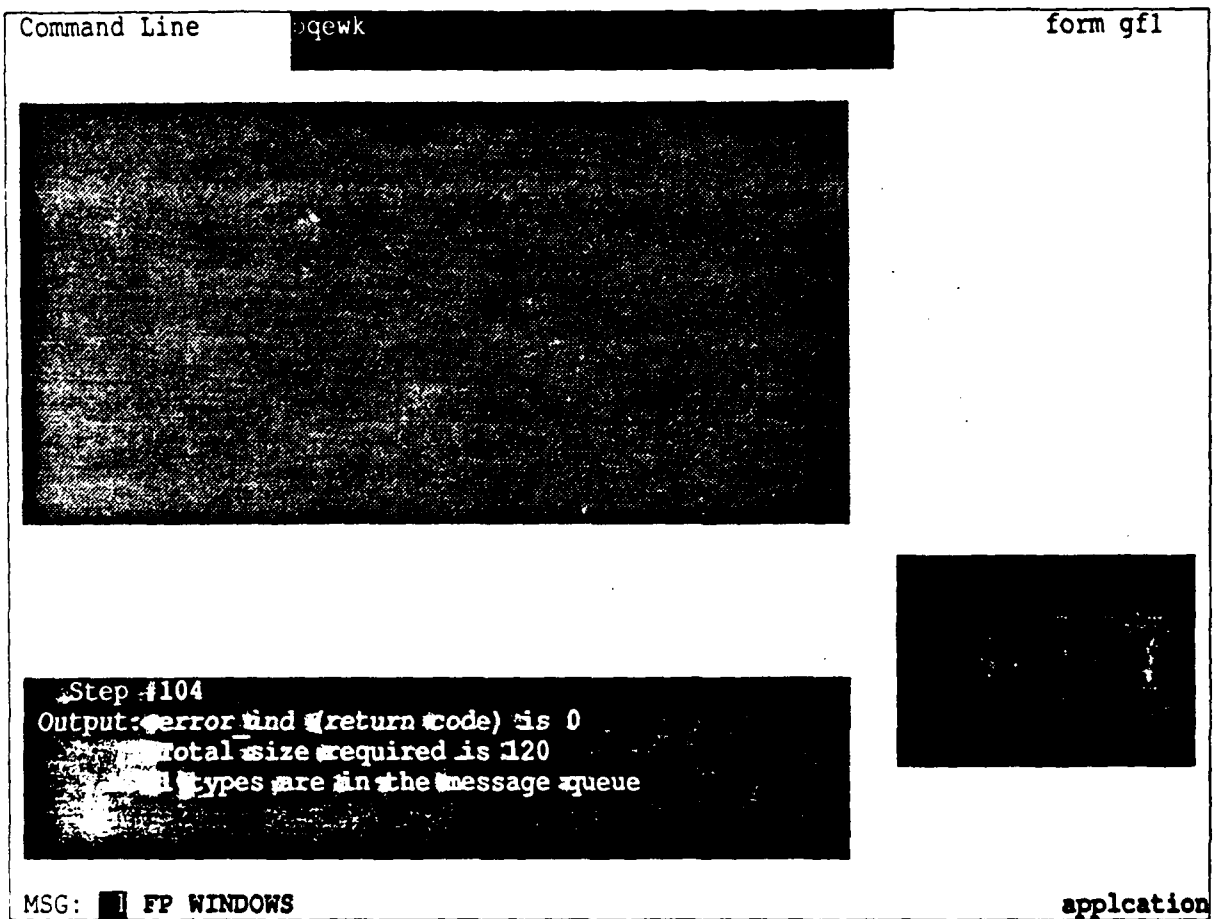


Figure 5-106b (AFTER)

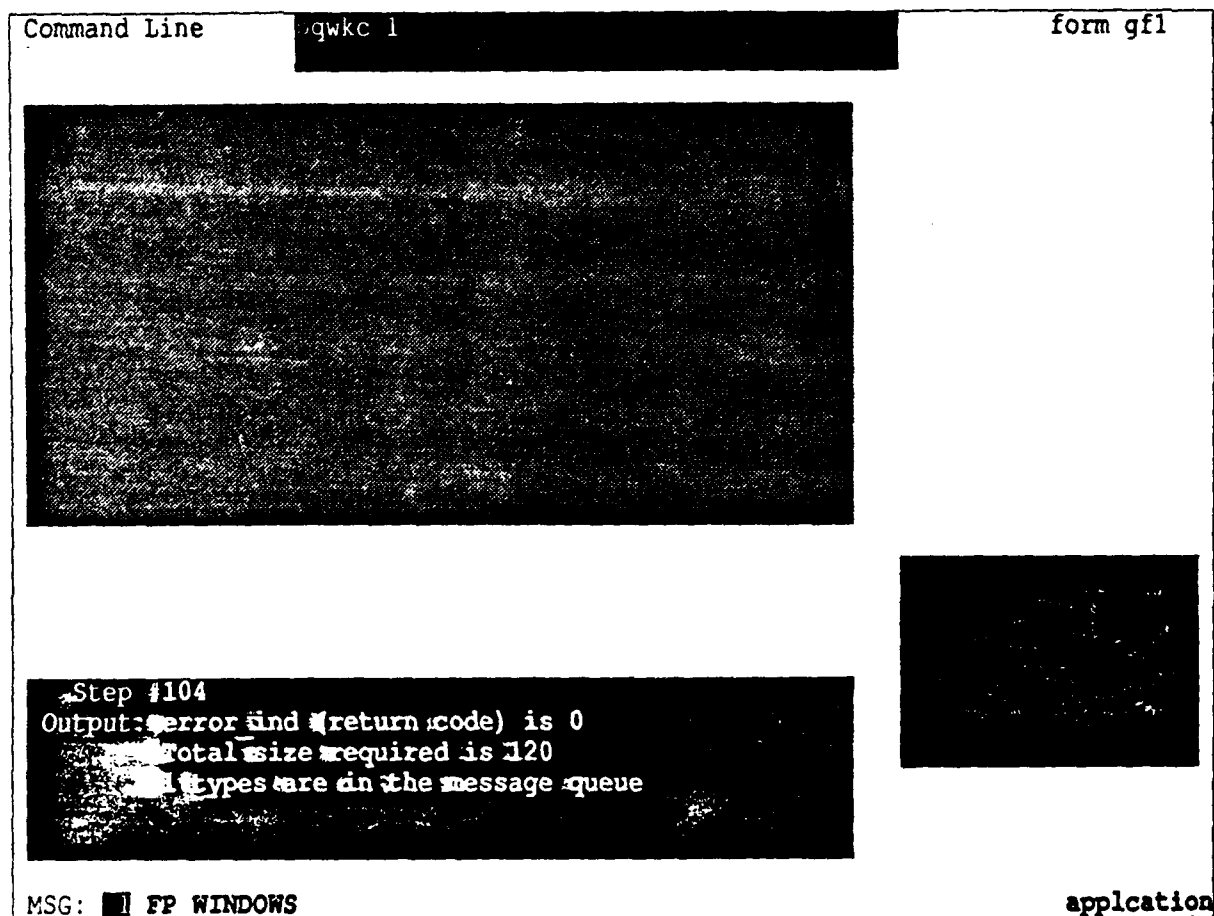


Figure 5-107a (BEFORE)

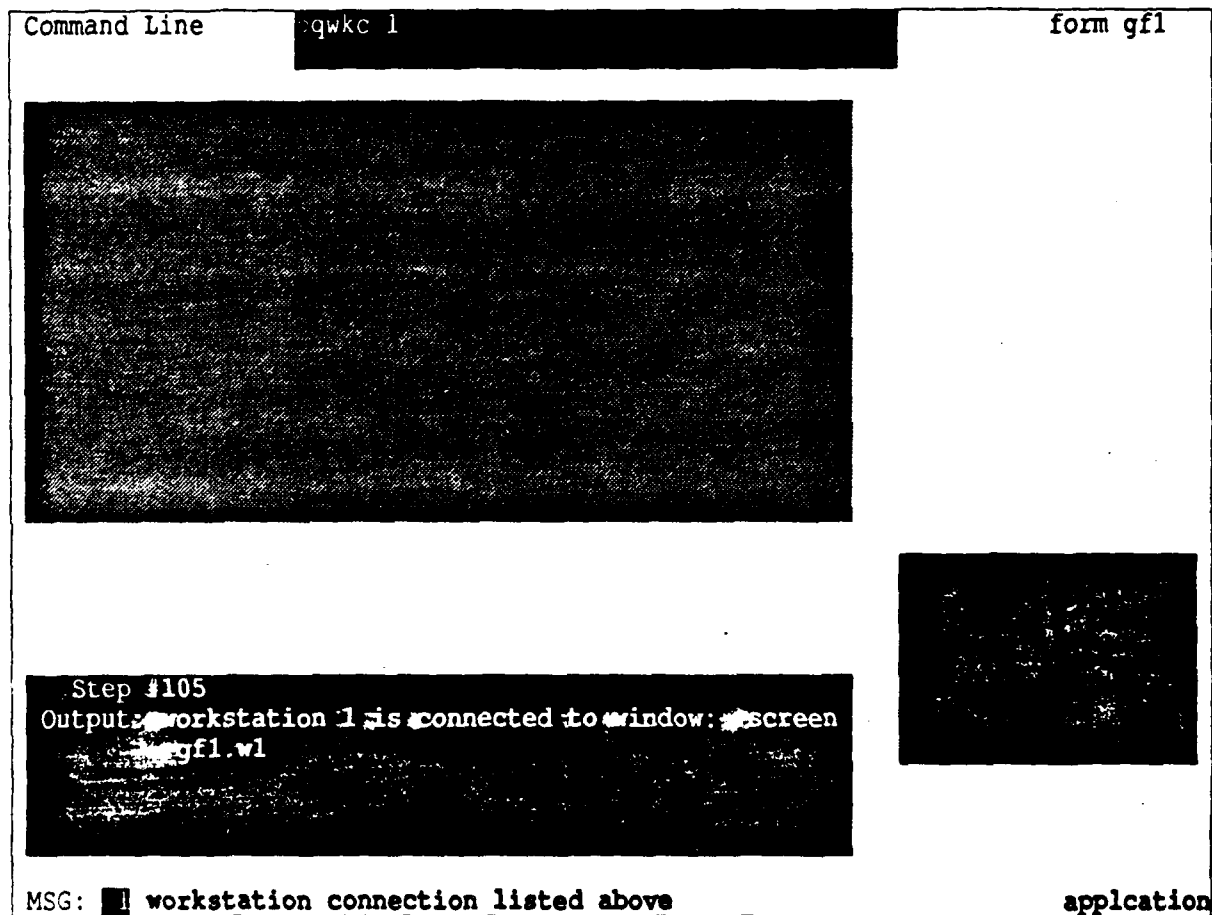


Figure 5-107b (AFTER)

UTP 620344220
30 September 1990

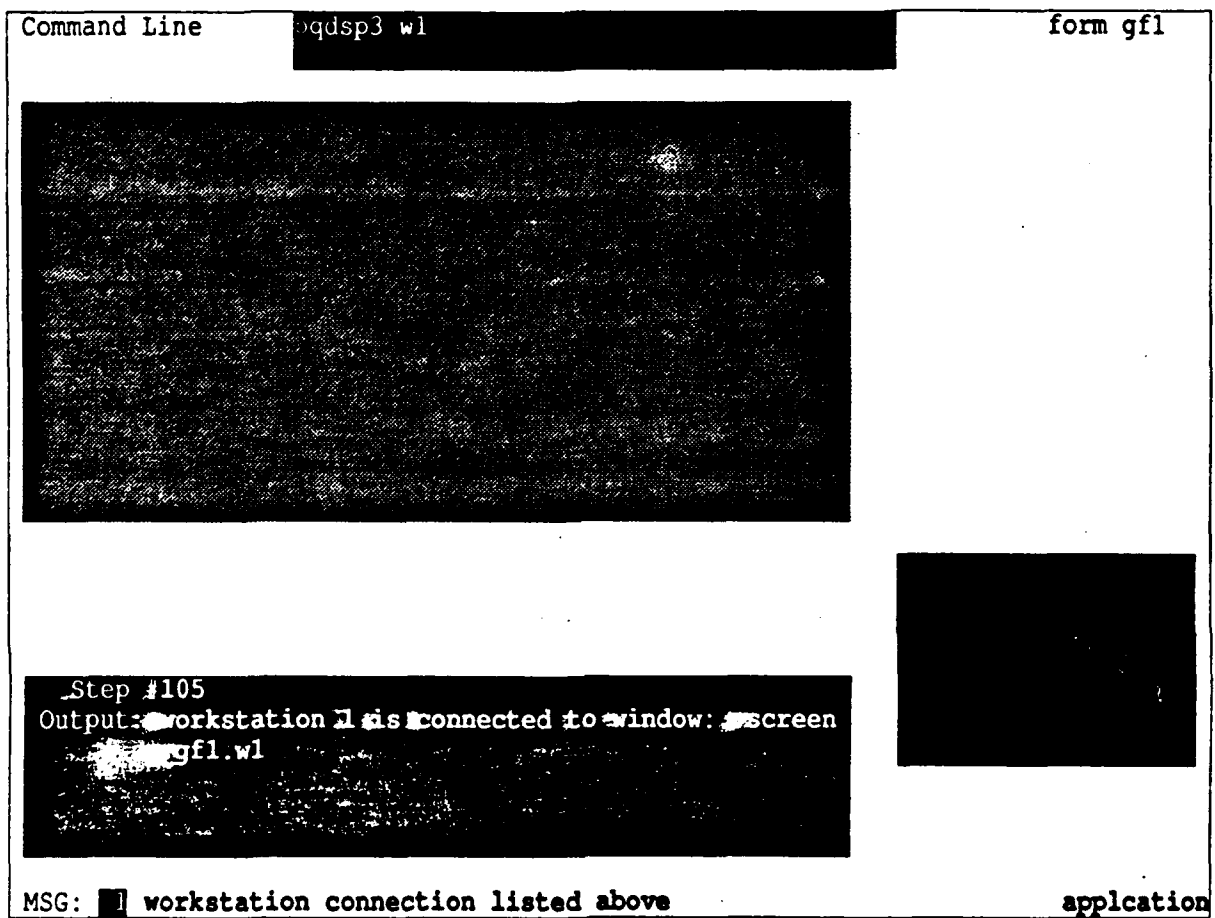


Figure 5-108a (BEFORE)

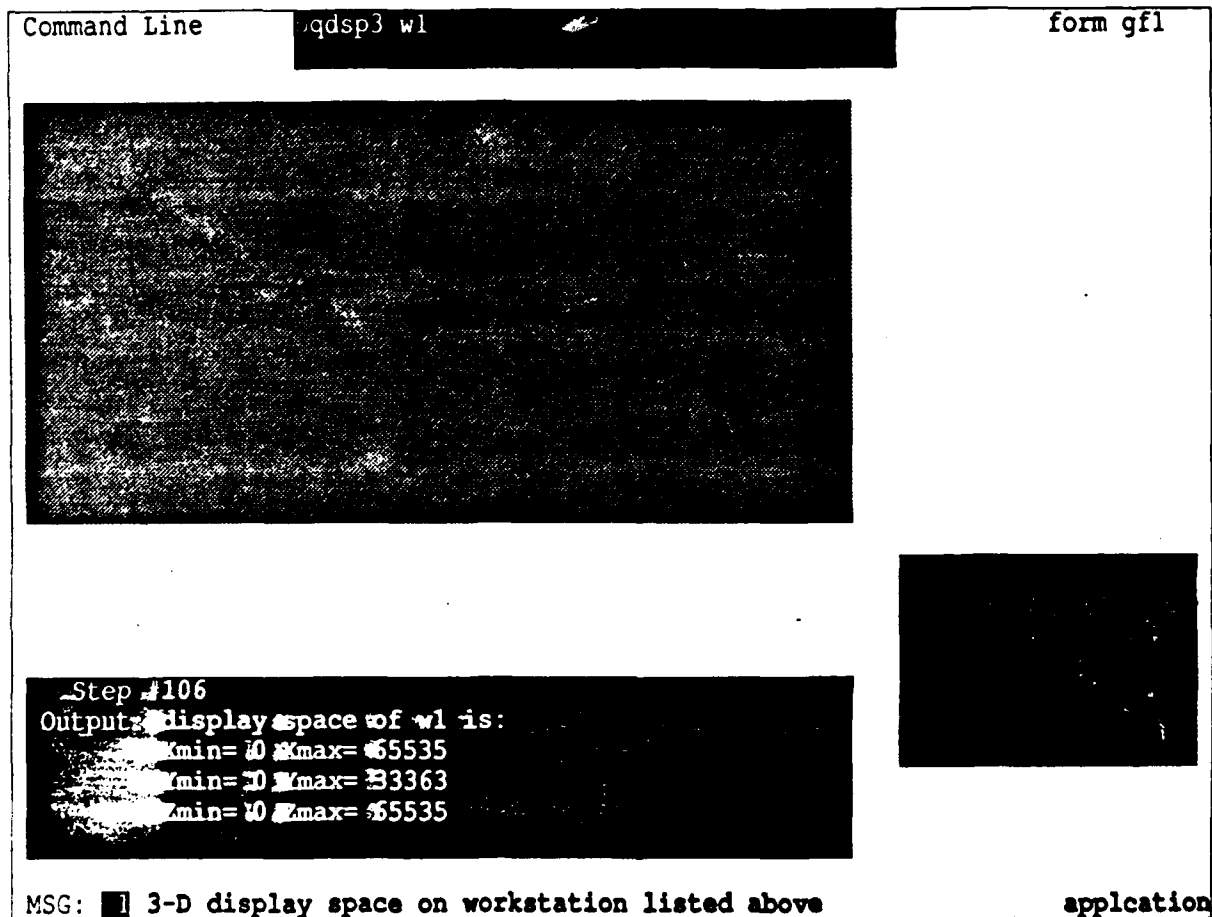


Figure 5-108b (AFTER)

UTP 620344220
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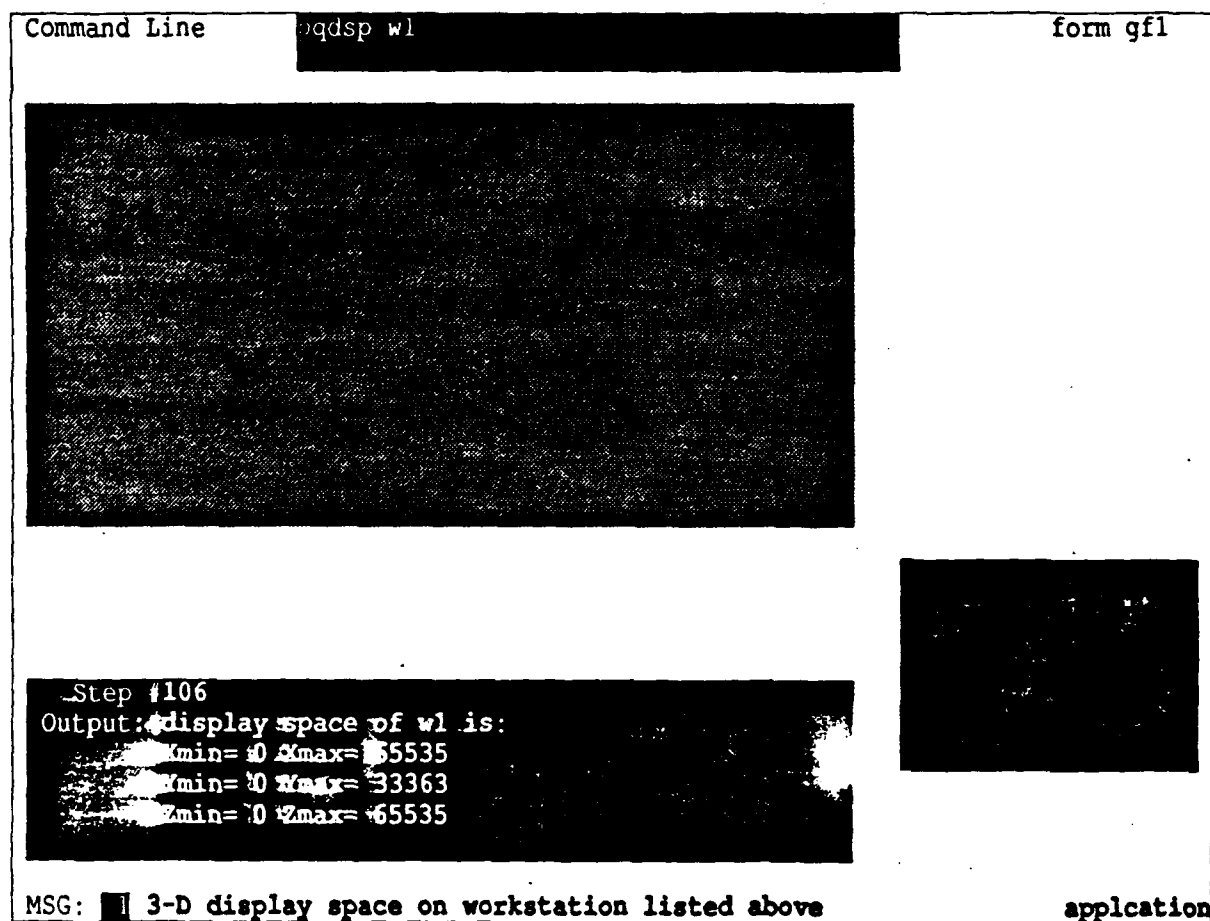


Figure 5-109a (BEFORE)

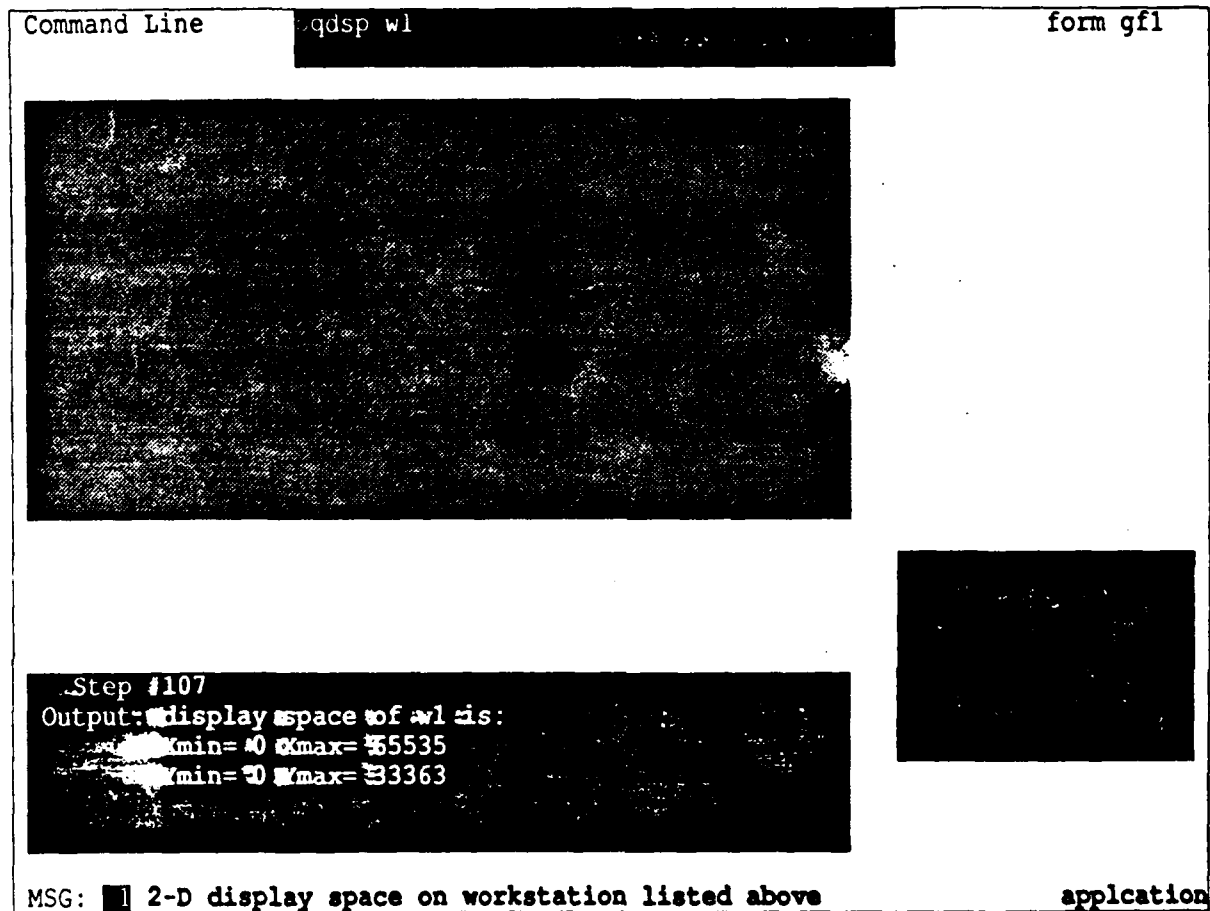


Figure 5-109b (AFTER)

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Command Line	berhnd 0 0	form gfl
		
Step #107 Output: display space of w1 is: xmin= 0 xmax= 65535 ymin= 0 ymax= 33363		
MSG: 2-D display space on workstation listed above		application

Figure 5-109c (Message Queue, AFTER)

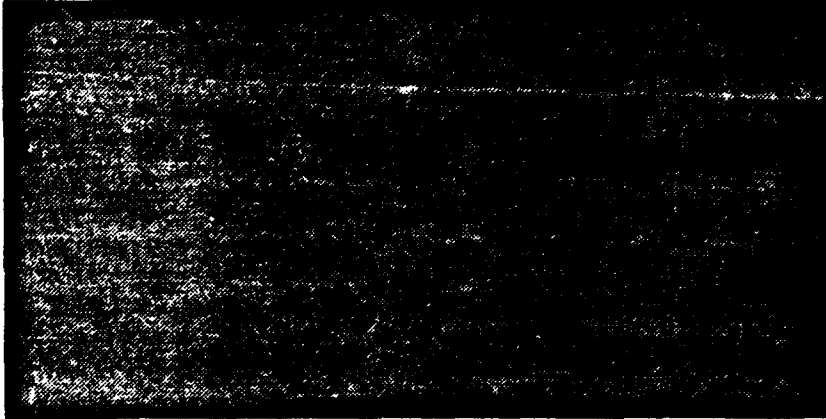
Command Line	erhnd 0 0	form gfl
		
Step #108 Output: display space of w1 is: min= max= 365535 min= max= 33363		
MSG: 4 no error		application

Figure 5-110a (BEFORE)

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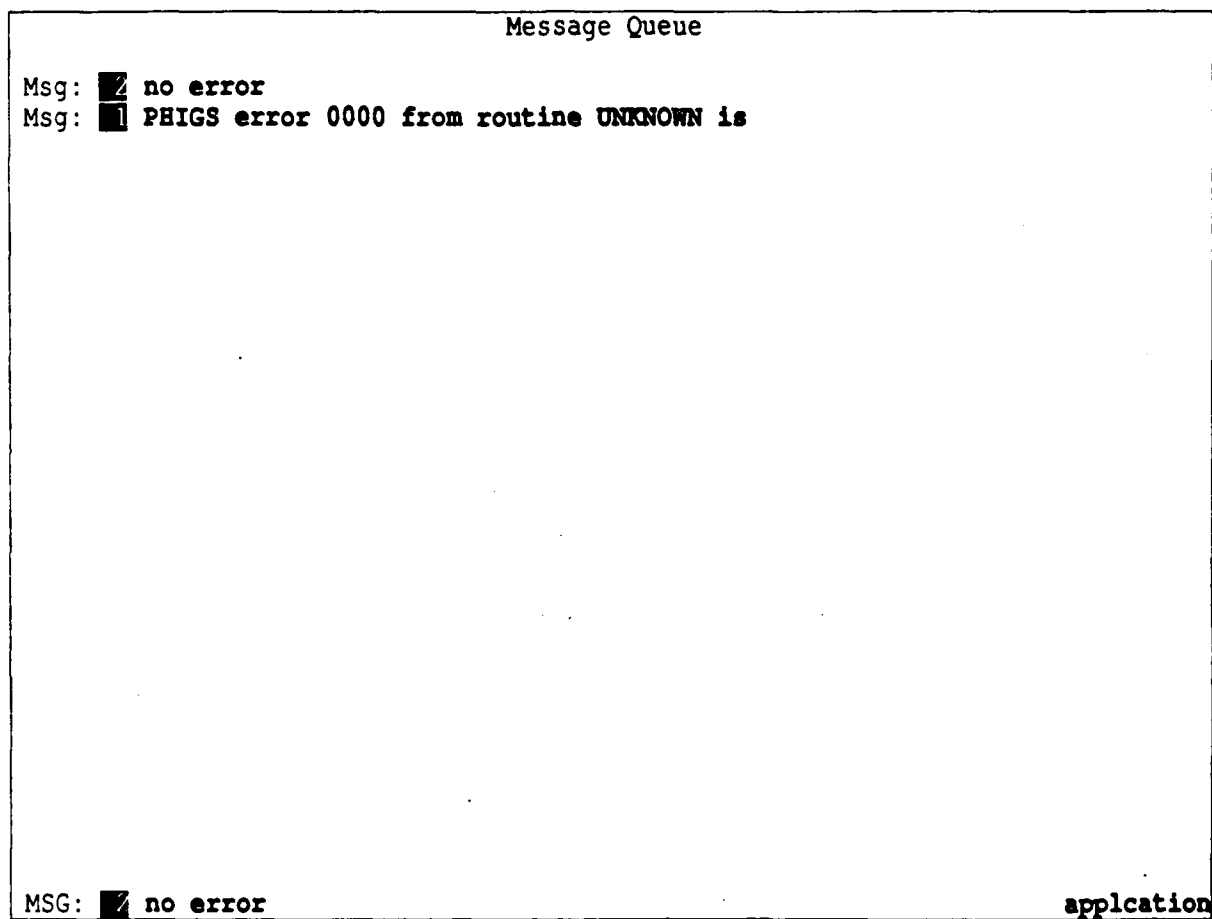


Figure 5-110b (AFTER)

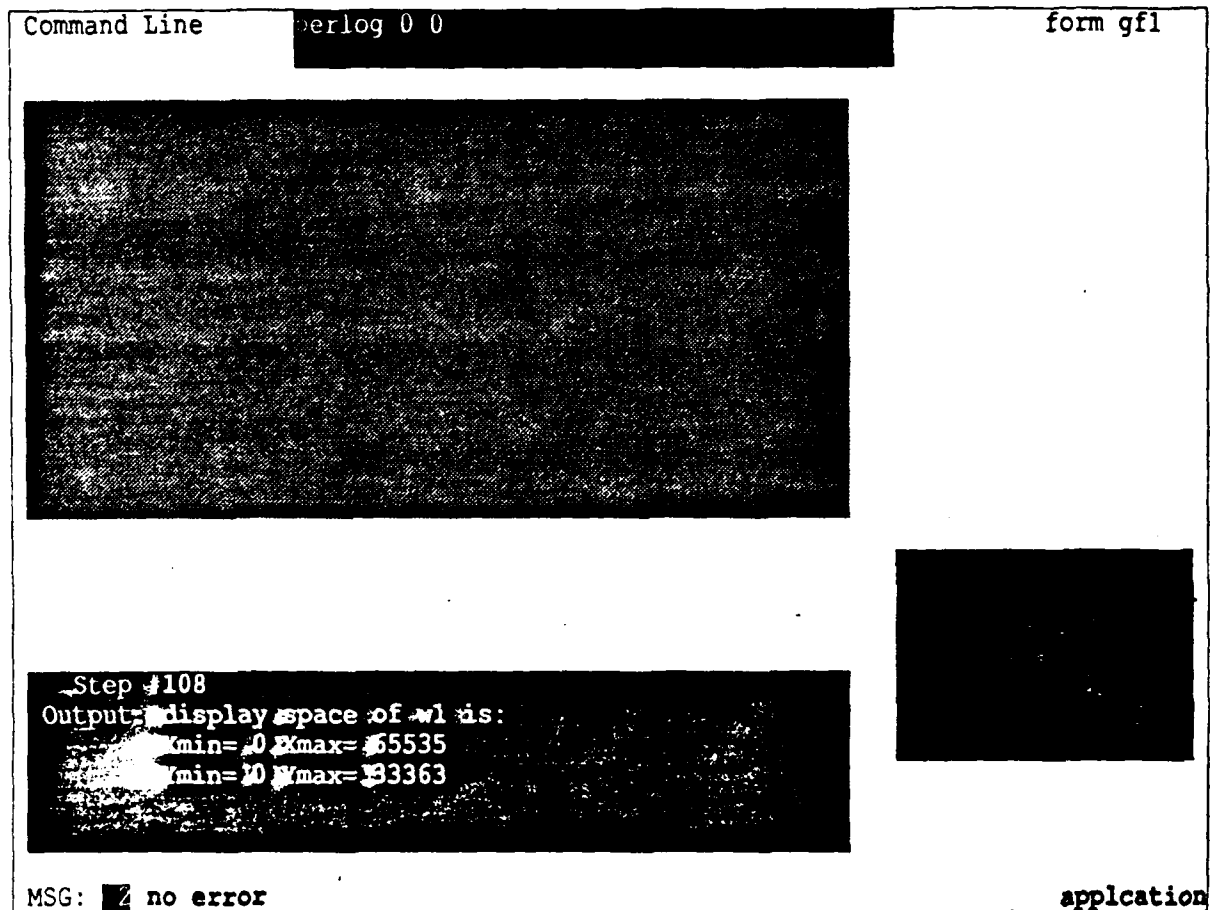


Figure 5-110c (Message Queue, AFTER)

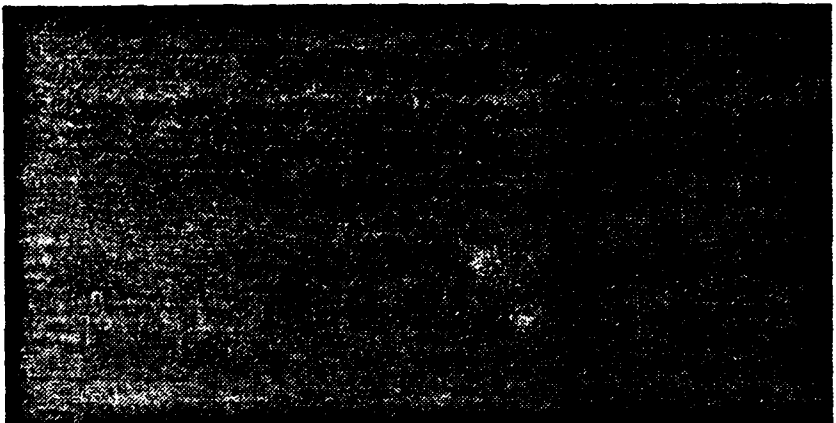
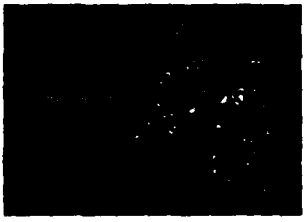
Command Line	erlog 0 0	form gfl
		
Step #109 Output: display space of w1 is: Xmin= 0 Xmax= 65535 Ymin= 0 Ymax= 33363		
MSG:	no error	application

Figure 5-111a (BEFORE)

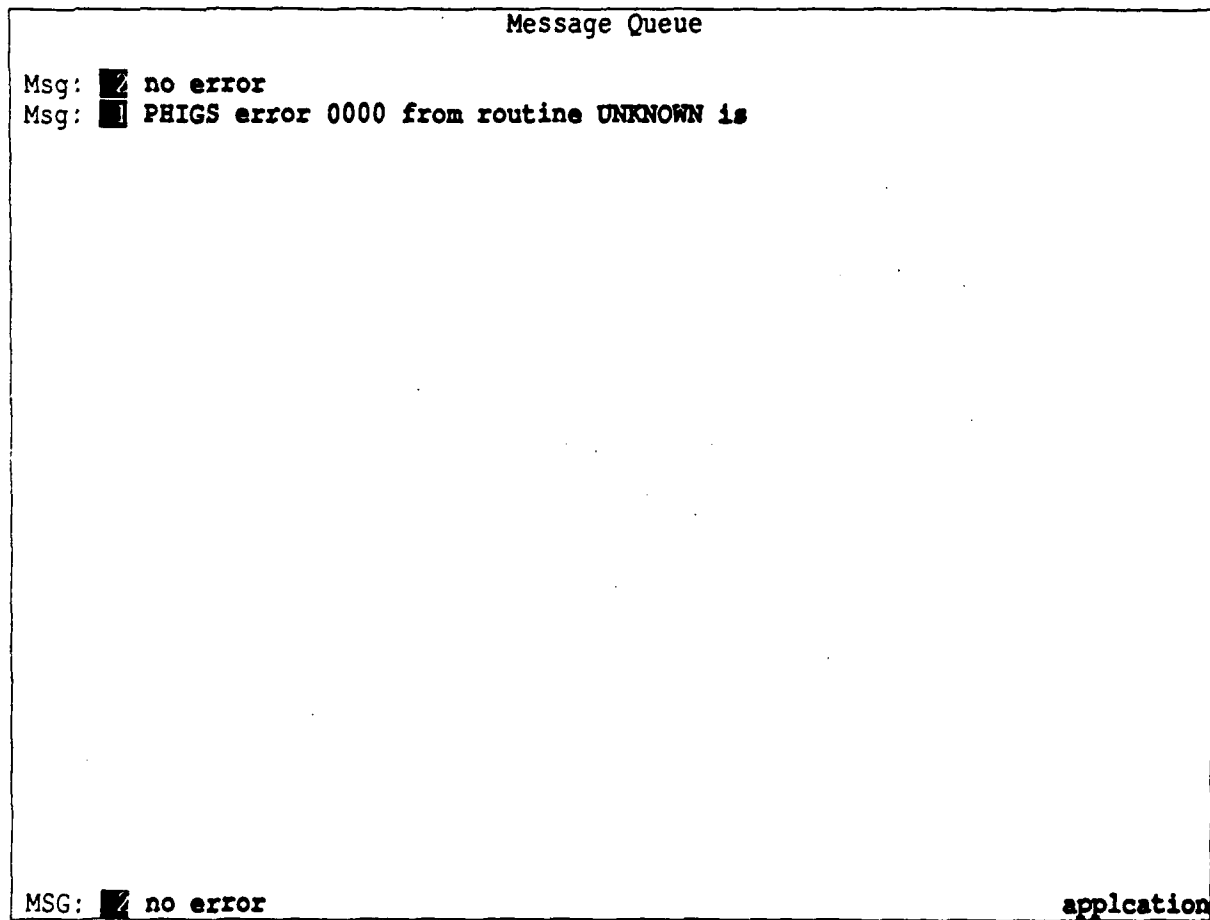


Figure 5-111b (AFTER)

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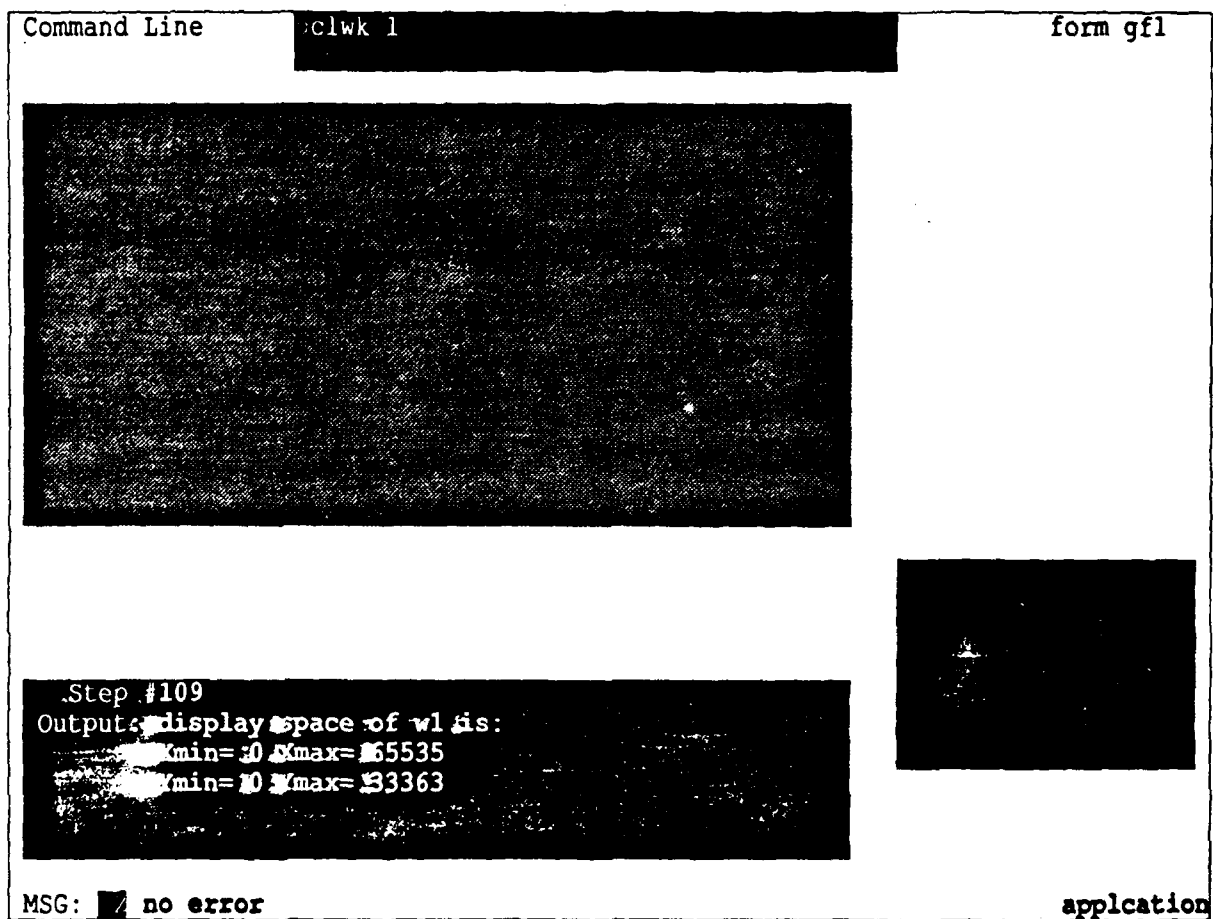


Figure 5-112a (BEFORE)

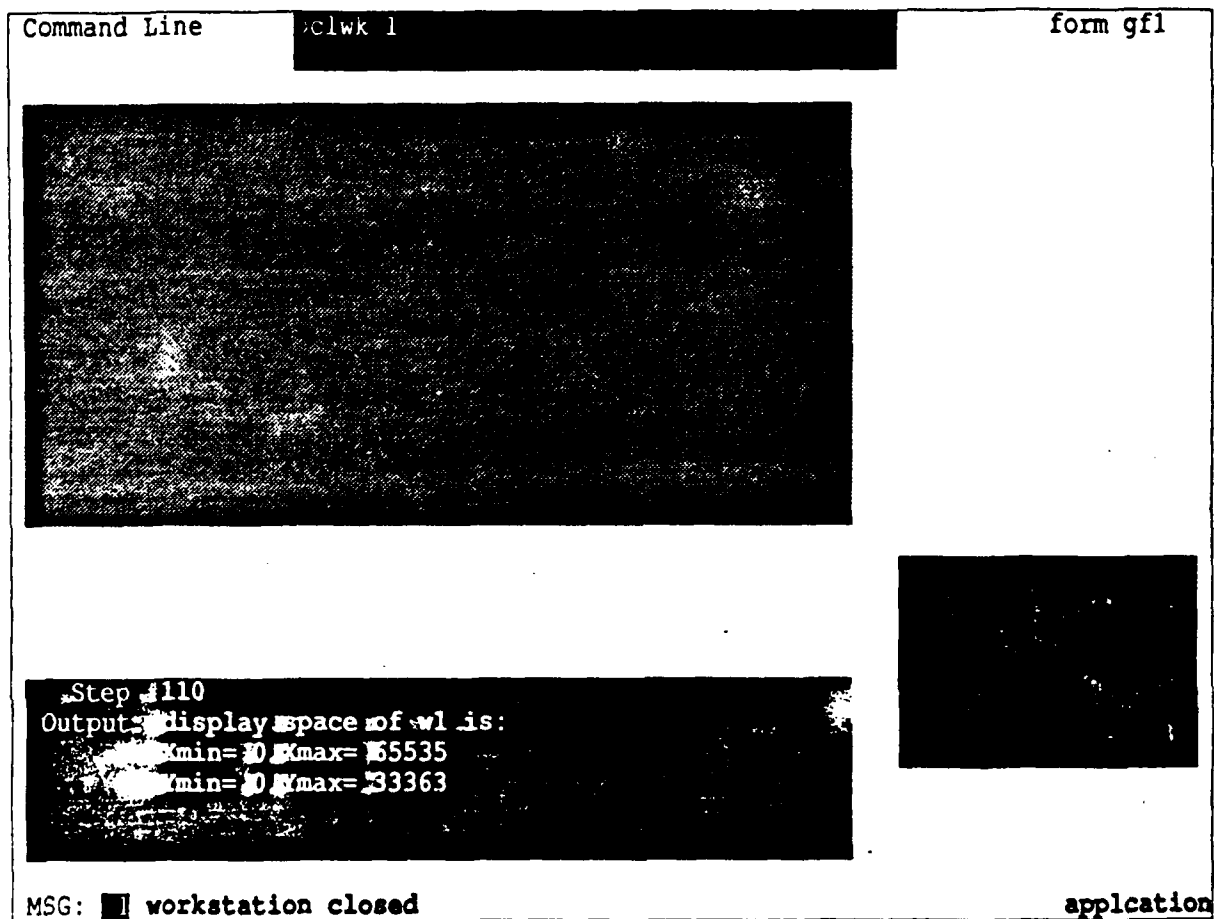


Figure 5-112b (AFTER)

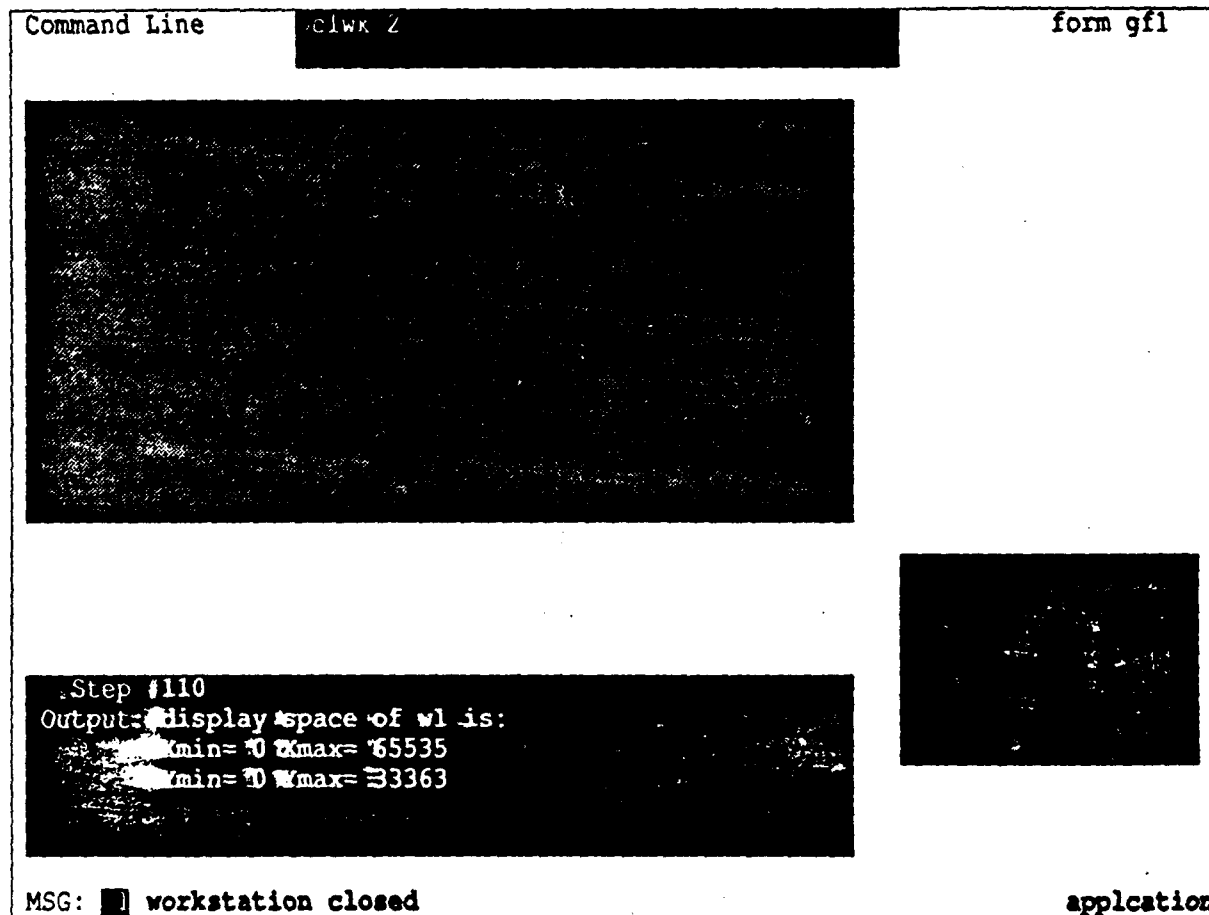


Figure 5-113a (BEFORE)

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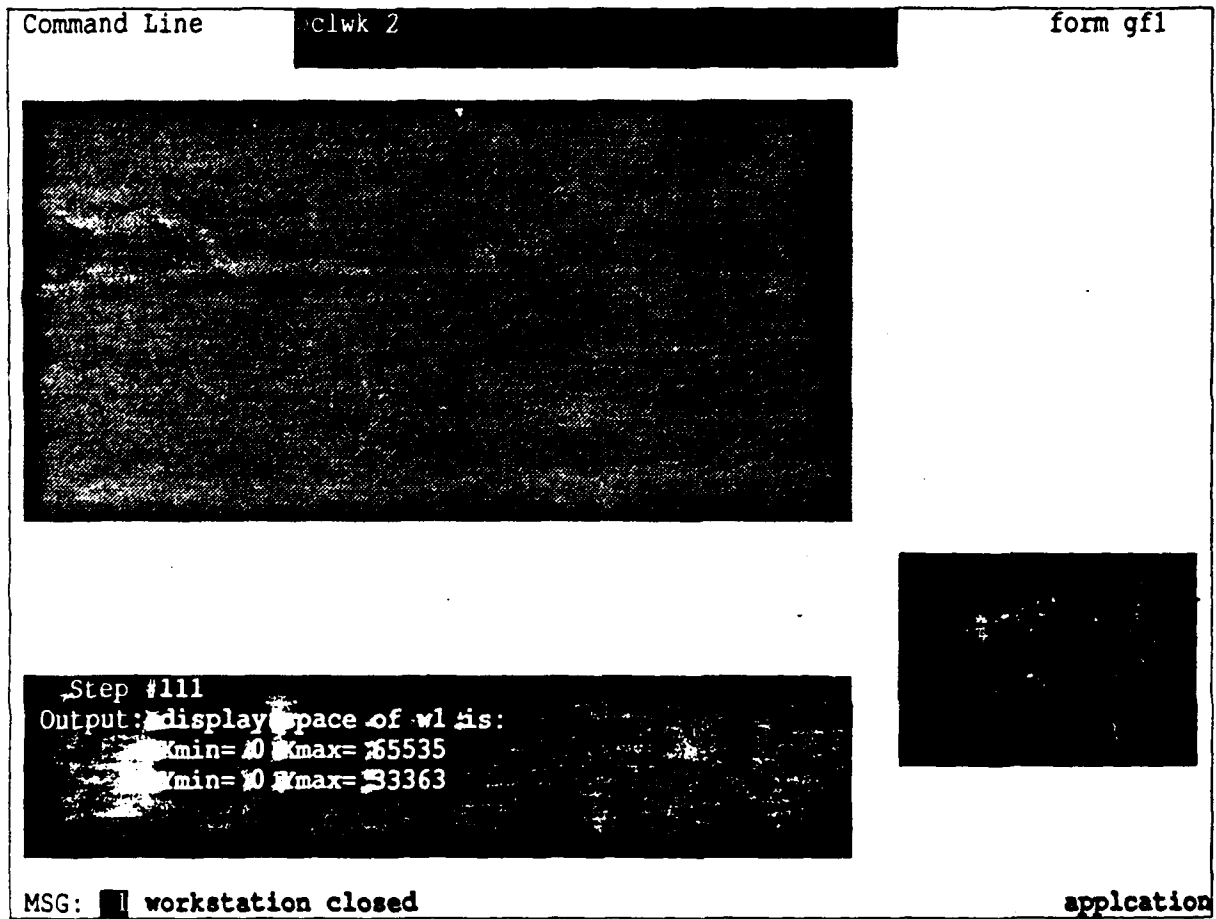


Figure 5-113b (AFTER)

APPENDIX A

Commands for ARTEST

Commands are of the following form:

<command> <arg1> <arg2> <argn>

where the angle brackets are not actually entered.
<command> refers to the actual procedure call
<arg1> refers to argument 1, <arg2> to argument 2, etc.
arguments are separated by blank(s), and arguments which
contain blanks are enclosed in double quotes.

To allow communication of transformation data, six
predefined matrices have been supplied. These are referred to
as 'matrix ID' in the calling argument string. It is the user's
responsibility to maintain the data in each. The names of
these are:

2-dimensional: A2, B2, C2
3-dimensional: A3, B3, C3

The results from inquire functions and point transforms
will be shown in the "Display" output region, thus avoiding the
need for extra local variables.

The available commands will be the short form as described
by the PHIGS C language binding. A description of these calls
follows:

1. open PHIGS
 <popph>
2. close PHIGS
 <pclph>
3. open workstation
 <popwk> <WS ID number> <path to window>
 <device name> <parent window ID> <page in window>
4. close workstation
 <pclwk> <WS ID number>
5. set workstation window 2-D
 <pswk2> <WS ID number> <min X> <max X> <min Y> <max Y>
6. set workstation window 3-D
 <pswk3> <WS ID number> <min X> <max X>
 <min Y> <max Y> <min Z> <max Z>
7. set workstation viewport 2-D
 <pswkv2> <WS ID number> <min X> <max X> <min Y> <max Y>
8. set workstation viewport 3-D
 <pswkv3> <WS ID number> <min X> <max X>
 <min Y> <max Y> <min Z> <max Z>
9. scale 2-D
 <psc2> <scale X> <scale Y> <matrix ID>
10. scale 3-D
 <psc3> <scale X> <scale Y> <scale Z> <matrix ID>
11. translate 2-D

- <ptr> <delta X> <delta Y> <predefined matrix ID>
- 12. translate 3-D
 - <ptr3> <delta X> <delta Y> <delta Z> <matrix ID>
- 13. rotate about X axis
 - <prox> <angle (degrees)> <matrix ID>
- 14. rotate about Y axis
 - <proy> <angle> <matrix ID>
- 15. rotate about Z axis
 - <proz> <angle> <matrix ID>
- 16. rotate 2-D
 - <pro> <angle> <matrix ID>
- 17. compose matrix 2-D
 - <pcom> <matrix ID 'A'> <matrix ID 'B'> <matrix ID (=AxB)>
- 18. compose matrix 3-D
 - <pcom3> <matrix ID 'A'> <matrix ID 'B'> <matrix ID (AxB)>
- 19. transform point 2-D
 - <ptp> <input X> <input Y> <matrix ID>
- 20. transform point 3-D
 - <ptp3> <input X> <input Y> <input Z> <matrix ID>
- 21. build transformation matrix 2-D
 - <pbltm> <ref X> <ref Y> <delta X> <delta Y>
<scale X> <scale Y> <rotate angle> <matrix ID>
- 22. build transformation matrix 3-D
 - <pbltm3> <ref X> <ref Y> <ref Z> <delta X> <delta Y>
<delta Z> <scale X> <scale Y> <scale Z> <rotate X>
<rotate Y> <rotate Z> <result matrix ID>
- 23. compose transformation matrix 2-D
 - <pcotm> <matrix ID> <ref X> <ref Y> <delta X> <delta Y>
<scale X> <scale Y> <rotate angle> <resulting matrix ID>
- 24. compose transformation matrix 3-D
 - <pcotm3> <matrix ID> <ref X> <ref Y> <ref Z> <delta X>
<delta Y> <delta Z> <scale X> <scale Y> <scale Z>
<rotate X> <rotate Y> <rotate Z>
<resulting matrix ID>
- 25. message
 - <pmsg> <message string>
- 26. error handler
 - <perhnd> <error number> <function number>
- 27. error log
 - <perlog> <error number> <function number>
- 28. set error handler mode
 - <pserhm> <new mode (=ON, OFF)>
- 29. inquire error handler mode
 - <pqerhm>
- 30. redraw all structures
 - <prst> <workstation ID> <control (=CONDITIONALLY, ALWAYS)>
- 31. update workstation
 - <puwk> <workstation ID> <regen flag (=PERFORM, POSTPONE)>
- 32. post structure
 - <ppost> <workstation ID> <structure ID> <priority level>
- 33. unpost structure
 - <pupost> <workstation ID> <structure ID>
- 34. unpost all structures
 - <pupast> <workstation ID>

35. open structure
 <popst> <structure ID>
36. close structure
 <pclst>
37. delete structure
 <pdst> <structure ID>
38. delete structure network
 <pdsn> <structure ID> <ref flag (=DELETE, KEEP)>
39. delete all structures
 <pdas>
40. polyline 2-D
 <ppl> <num points> <X1> <Y1> <X2> <Y2> ... <Xn> <Yn>
41. polyline 3-D
 <ppl3> <num points> <X1> <Y1> <Z1> <X2> <Y2> <Z2>
 ... <Xn> <Yn> <Zn>
42. polymarker 2-D
 <ppm> <num points> <X1> <Y1> <X2> <Y2> ... <Xn> <Yn>
43. polymarker 3-D
 <ppm3> <num points> <X1> <Y1> <Z1> <X2> <Y2> <Z2>
 ... <Xn> <Yn> <Zn>
44. text 2-D
 <ptx> <X coord> <Y coord> <text string>
45. text 3-D
 <ptx3> <X> <Y> <Z> <Vec X-x> <Vec X-y> <Vec X-z>
 <Vec Y-x> <Vec Y-y> <Vec Y-z> <text string>
46. fill area 2-D
 <pfa> <num points> <X1> <Y1> <X2> <Y2> ... <Xn> <Yn>
47. fill area 3-D
 <pfa3> <num points> <X1> <Y1> <Z1> <X2> <Y2> <Z2> ...
 ... <Xn> <Yn> <Zn>
48. set local transform 2-D
 <pslmt> <matrix ID> <type (=PRE, POST, REPLACE)>
49. set local transform 3-D
 <pslmt3> <matrix ID> <type (=PRE, POST, REPLACE)>
50. set global transform 2-D
 <psgmt> <matrix ID>
51. set global transform 3-D
 <psgmt3> <matrix ID>
52. execute structure
 <pexst> <structure ID>
53. set polyline type
 <psln> <linetype (SOLID, DASH, DOT, DOTDASH)>
54. set polyline color index
 <psplci> <line color index (RED, WHITE, GREEN, etc.)>
55. set polymarker type
 <psmk> <marker type (POINT, PLUS, STAR, O, X)>
56. set polymarker color index
 <pspmci> <marker color index (RED, WHITE, GREEN, etc.)>
57. set character height
 <pschh> <character height>
58. set text color index
 <pstxci> <text color index (RED, WHITE, GREEN, etc.)>
59. set interior style

- <psis> <interior style (=HOLLOW, FILLED)>
60. set interior color index
 <psici> <color index (RED, WHITE, GREEN, etc.)>

61. inquire list of available workstation
 <pgewk>
62. inquire workstation connection and type
 <pqwkc> <workstation ID>
63. inquire display space size 2-D
 <pqdsp> <device name> <>window ID> <page>
64. inquire display space size 3-D
 <pqdsp3> <device name> <>window ID> <page>

65. in addition, the command "GRAPHICS" will be used to
initialize the screen specifically designed for 3-D graphics.
The command "FORM" may be used to return to the initial ARTEST
setup screen.

<graphics>