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How Far Can a Cantilevered "Hightower" Project?

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This program allows us to see what various "hightowers" would actually look like. In looking at the figures generated, keep in mind the effect of scale changes that become necessary as the number of rods increases. (The pictures are of course made using digital approximations of continuous data, which in some cases results in visual irregularities or "jumps" in the pictures.) The "greatest distance" values reported on the screen are in terms of orange rods, that is to say, in terms of decimeters.

The rod program is designed to run on most IBM PC's and compatibles with either BASICA or GWBASIC. The program used to produce the reprinted displays was slightly modified to run on a less common but higher resolution 400-line machine. In the program, lines 10 through 30 set the screen to graphic mode and clear it of any previous display. Line 40 asks the user for the number of rods to be displayed. Line 50 clears the screen again and line 60 draws a square border around it. Line 70 initializes the variable TABLE to 255, the horizontal position of the edge of the table. Line 80 draws the shaded rectangle which represents the table. Lines 90 and 100 set the height and width of the rods, scaling them if the stack will otherwise be too tall to display. The variable X, the running total of the horizontal distance of the Nth rod from the table, is then set to zero. Lines 120 through 150 plot the rods on the screen. The variable N loops from the bottom rod to the top rod, the top rod being number one. Line 130 adds 1/(2N), the formula derived in class, to X. Line 140 draws each specific rod, using the appropriate scaling constants to taylor the values onto the screen. The ",B" at the end of the line tells the computer to draw a horizontal box defined by the two corner coordinates which are specified. Line 150 then loops back to draw the next rod. The lines 160 through 200 draw various gauge lines and hash marks indicating the center of gravity of the stack and how far out the top rod lies in relation to its length. Lines 210 through 230 print out how many rods are displayed and how far out the top rod lies, in terms of rod lengths. Line 240 then waits for the user to press a key before the program clears the screen and ends execution.

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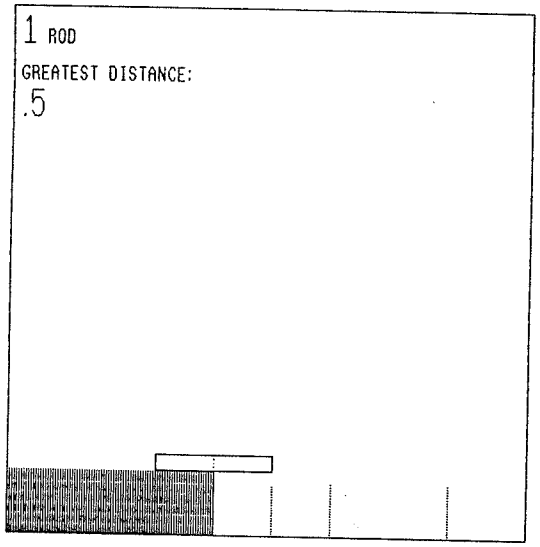
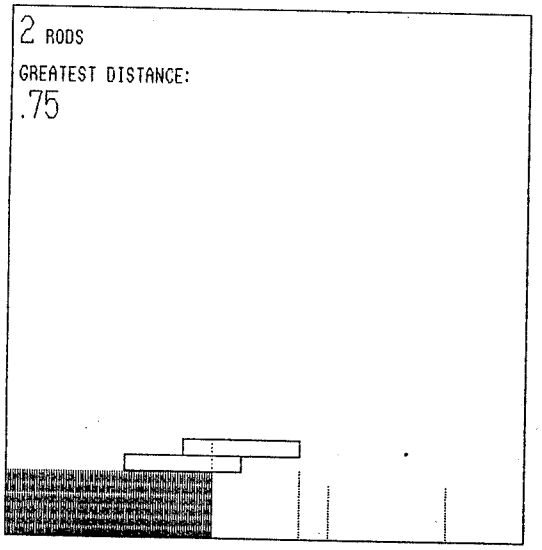
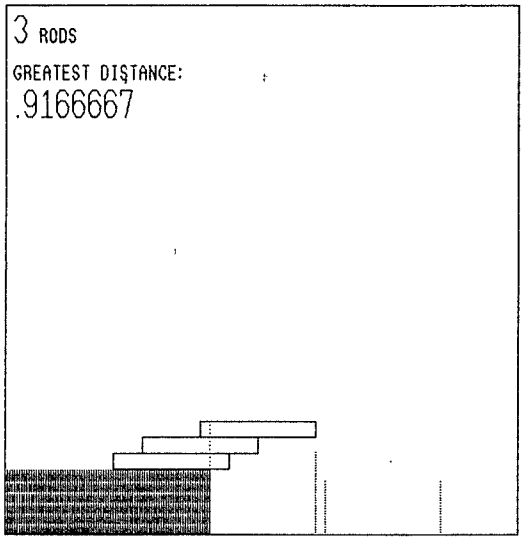
The program itself is:

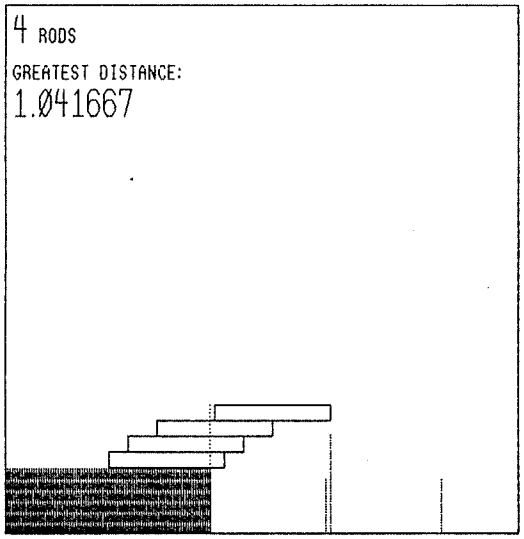
```
5 REM  Program RODS
10 SCREEN 2
20 KEY OFF
30 CLS
40 INPUT " How Many Rods";NR
50 CLS
60 LINE (0,0)-(639,199),1,B
70 TABLE = 255
80 FOR T = 0 TO TABLE STEP 3 : LINE (T,176)-(T,200) : NEXT T
90 H = 6 : IF H*NR > 170 THEN H = 165/NR
100 W = H*24
110 X = 0
120 FOR N=NR TO 1 STEP -1
130 X = X + 1/(2*N)
140 LINE (W*(X-1)+TABLE,H*(N-NR)+175) - (W*X+TABLE,H*(N-NR-1)+175),1,B
150 NEXT N
160 FOR T = H*(N-NR-1)+181 TO 200 STEP 2 : PSET (W*X+TABLE,T) : NEXT T
170 FOR T = TABLE TO 639 STEP W
180 FOR Y = 180 TO 200 STEP 2 : PSET (T,Y) : NEXT Y
190 NEXT T
200 FOR T = H*(N-NR)+175 TO 175 STEP 3 : PSET (TABLE,T) : NEXT T
210 LOCATE 2,2 : PRINT NR;"Rods"
220 LOCATE 3,2 : PRINT " Greatest Distance:"
230 LOCATE 4,2 : PRINT X
240 X$ = INKEY$ : IF X$="" THEN 240
250 CLS
260 END
```


The first few pictures show us how a few rods can in fact project much further than one might expect. (The resulting pictures look rather unstable, as of course they actually would be—but small shifts in each rod could produce greater stability.)

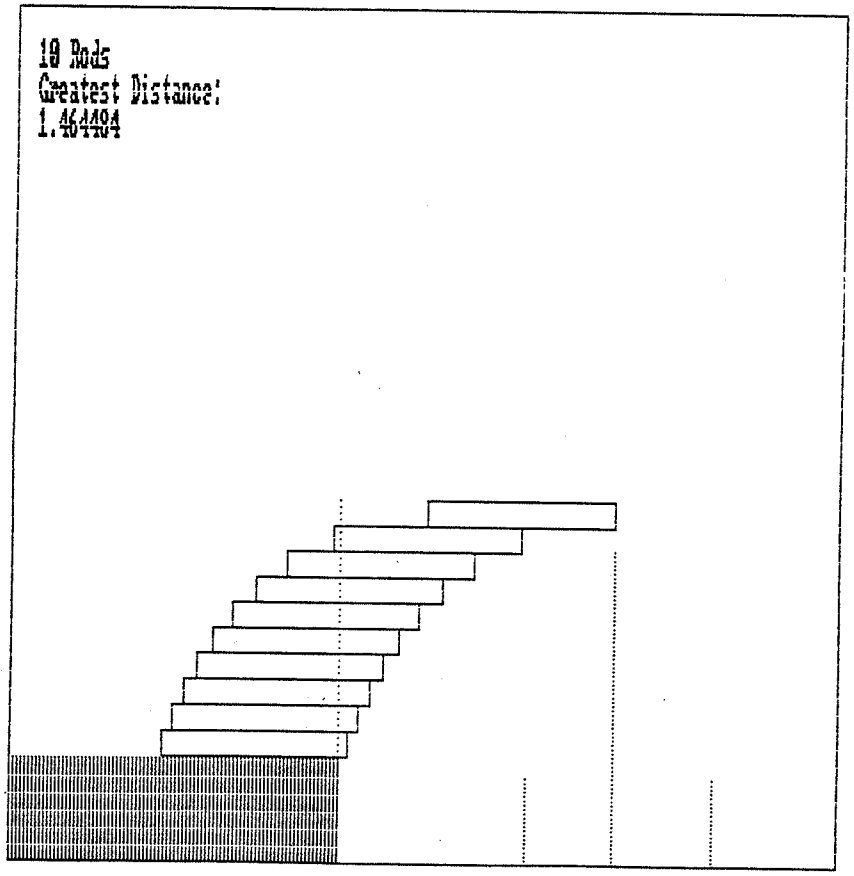


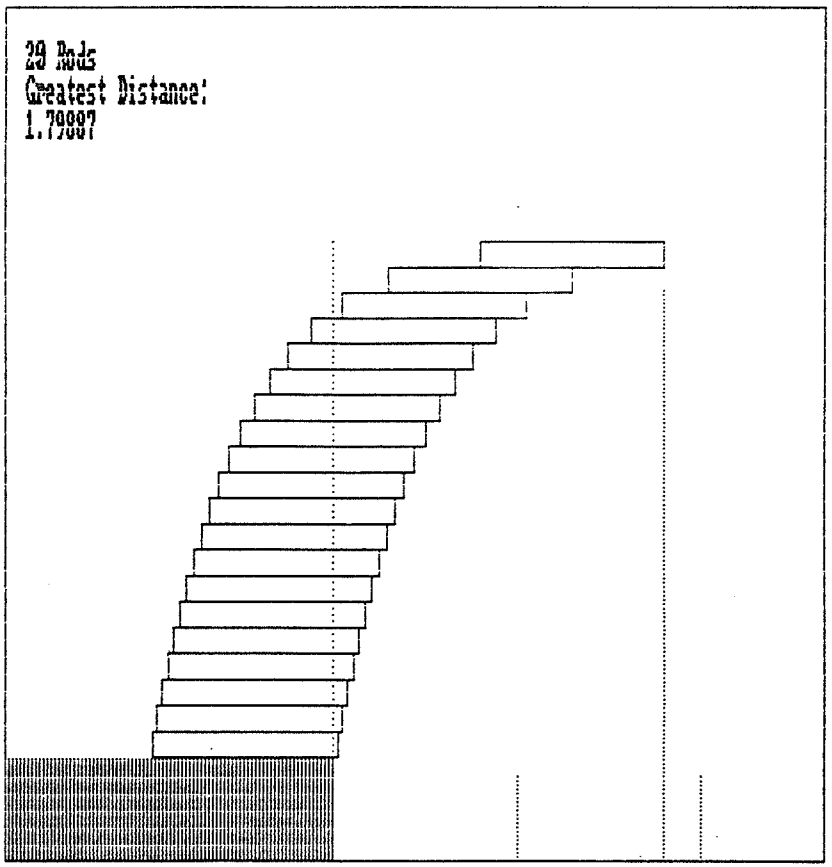


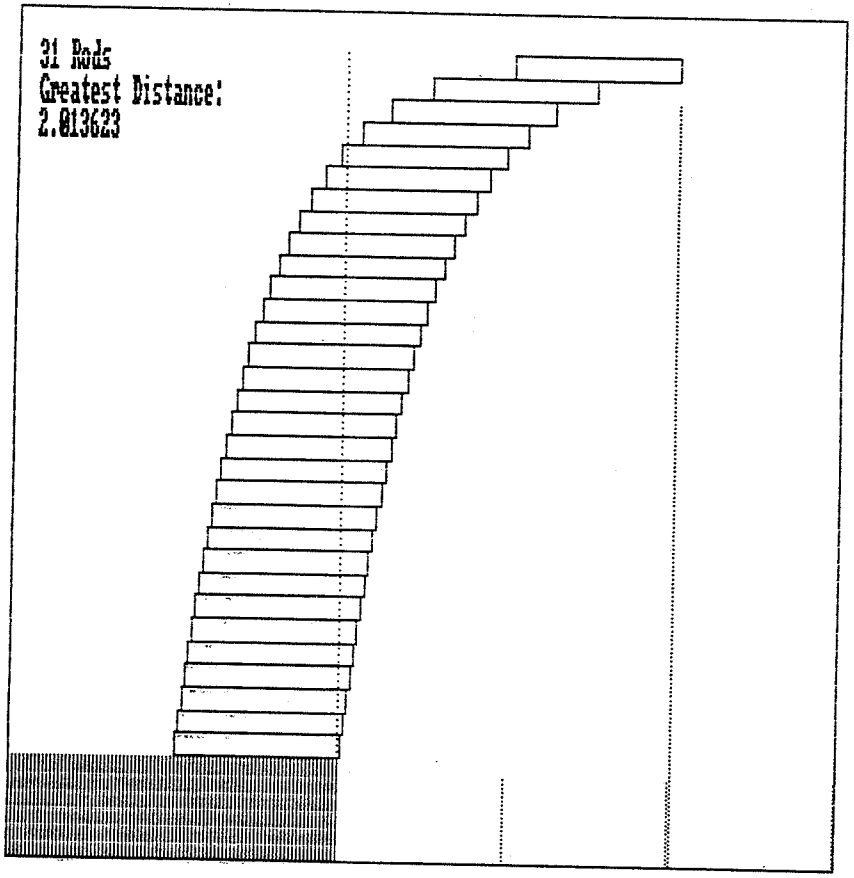


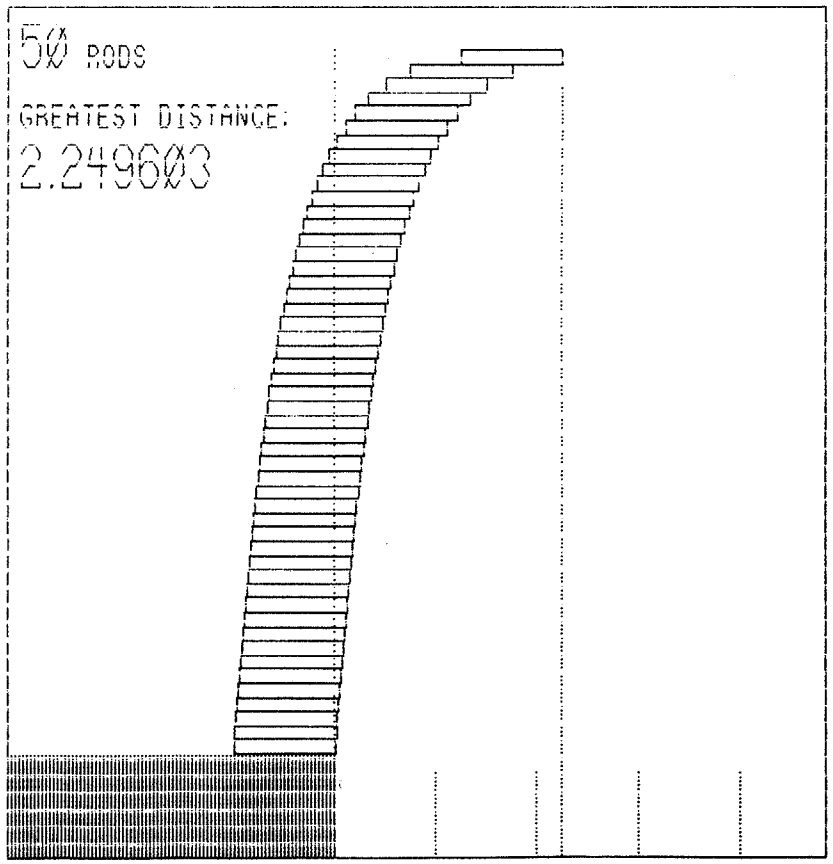


I made a number of pictures to get an idea of what can happen when one uses larger numbers of rods. A few of these pictures are shown next:

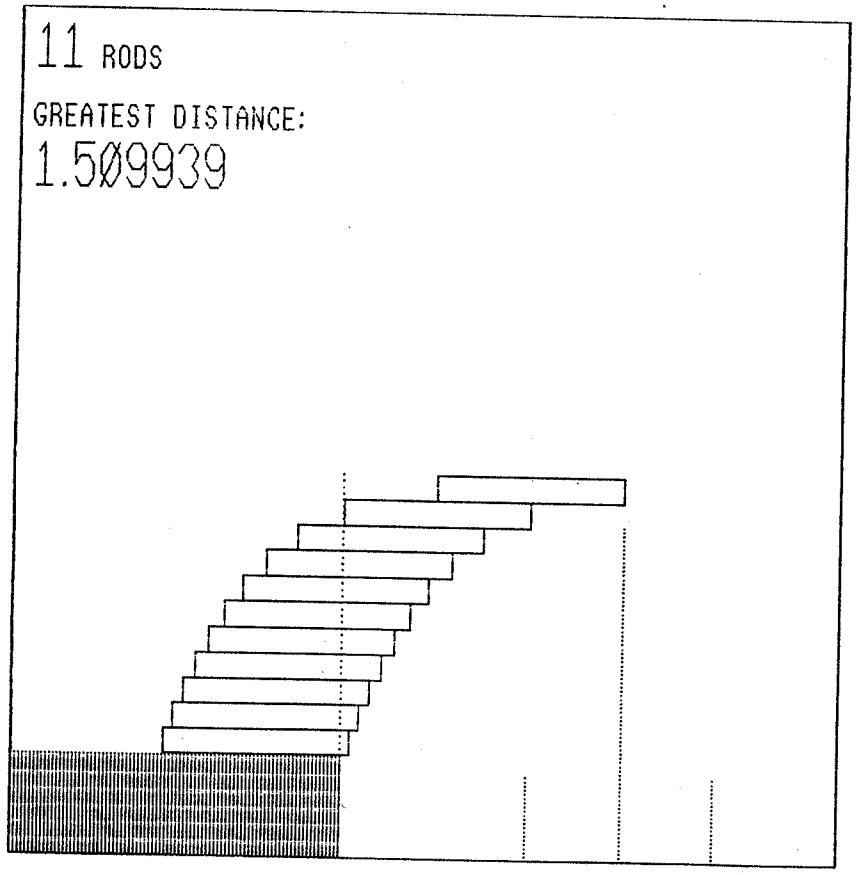


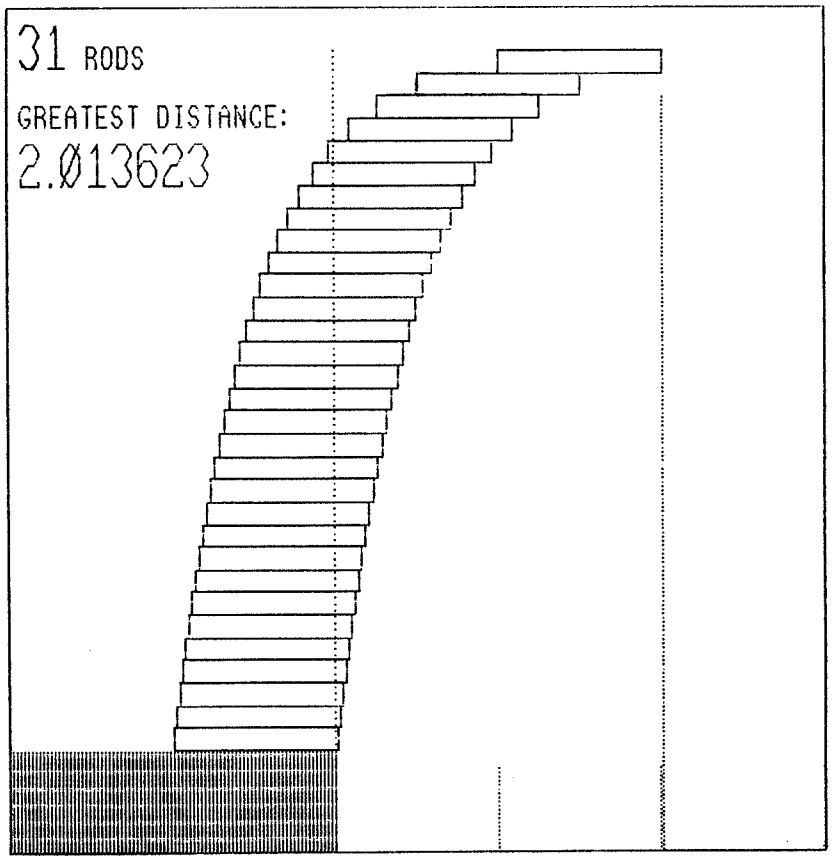

29 Rods
Greatest Distance:
1.79887

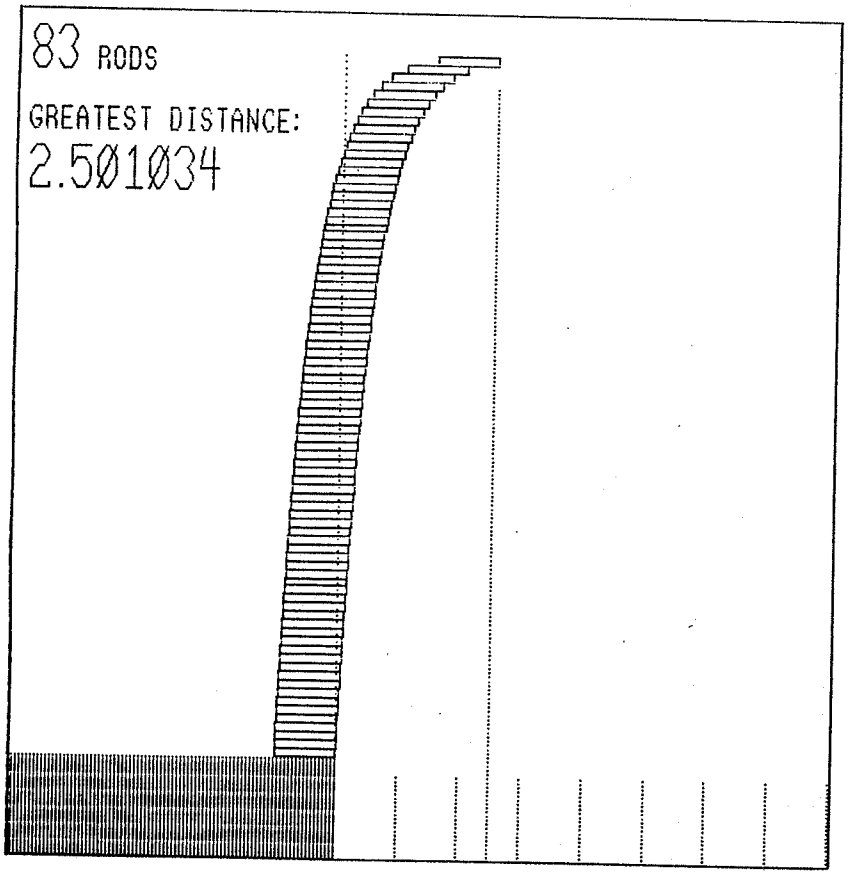

31 Rods
Greatest Distance:
2.013623

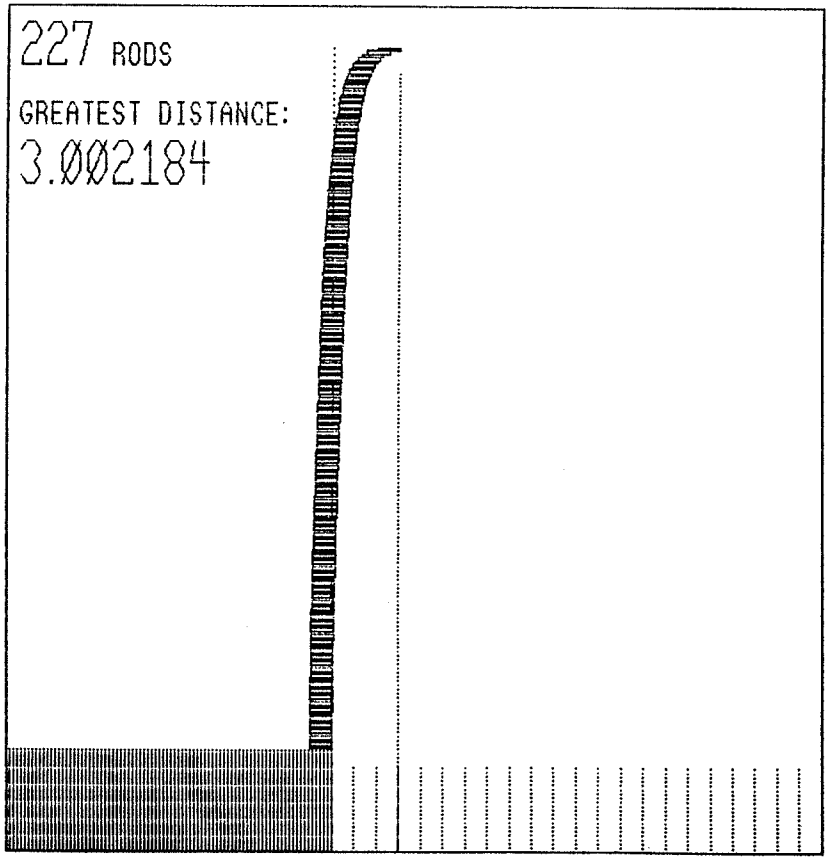


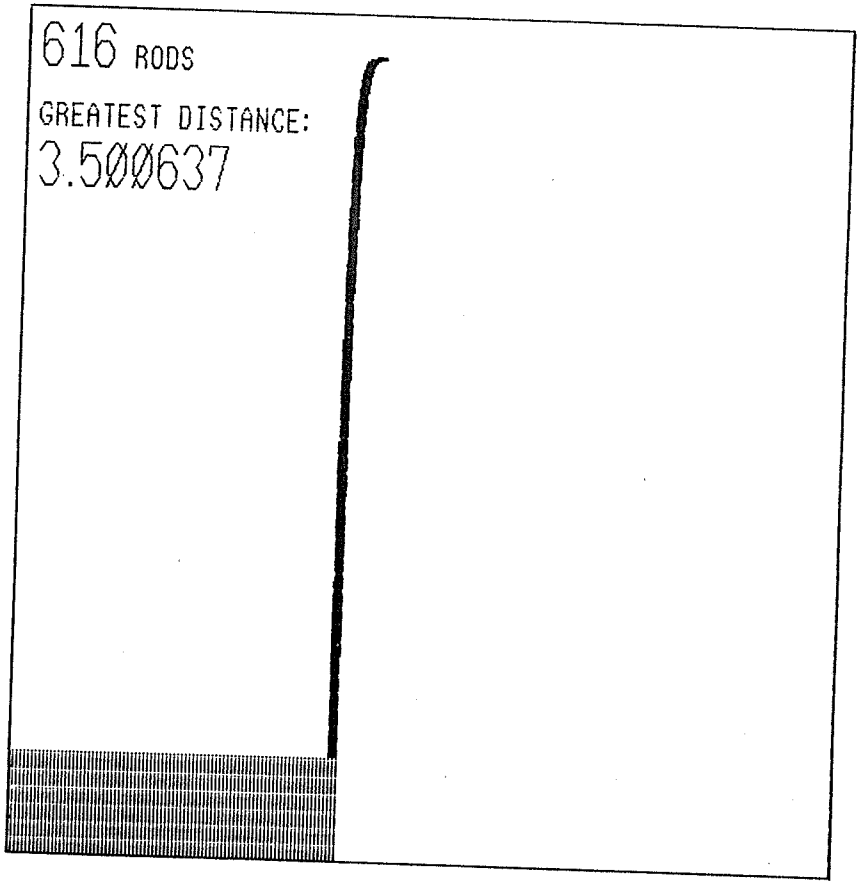
At this point I decided it might make more sense to alter the computer program so as to have it print out the pictures of the smallest number of rods that would project more than 1.5 decimeters, then more than 2.0 decimeters, then at least 2.5 decimeters, and so on.

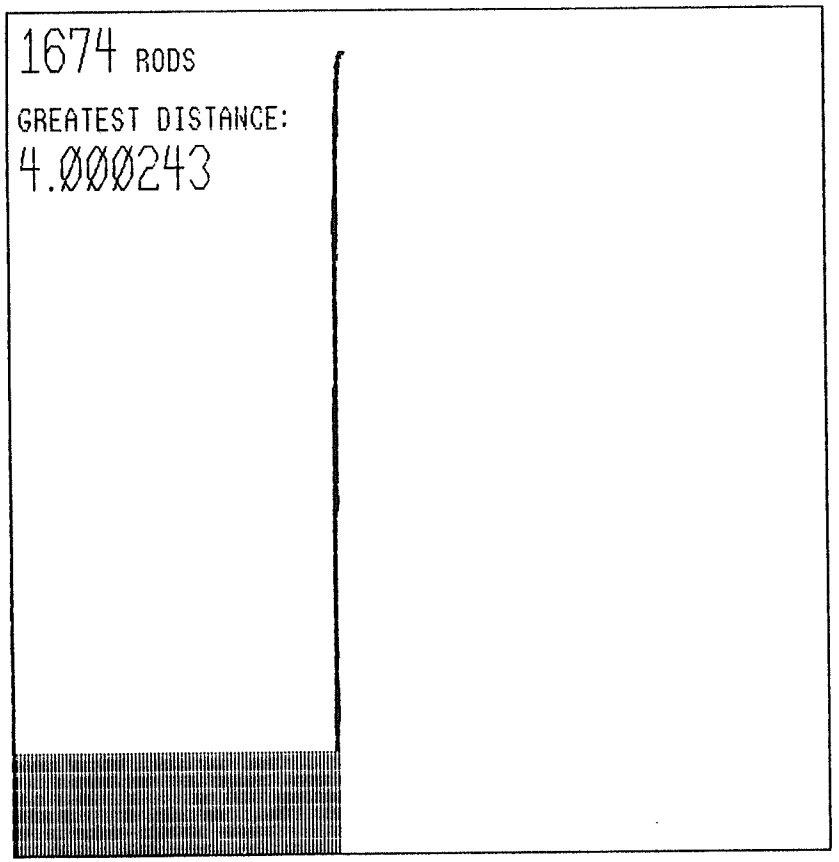



31 RODS
GREATEST DISTANCE:
2.Ø13623


83 RODS
GREATEST DISTANCE:
2.5Ø1Ø34


227 RODS
GREATEST DISTANCE:
3.002184


616 RODS
GREATEST DISTANCE:
3.500637



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