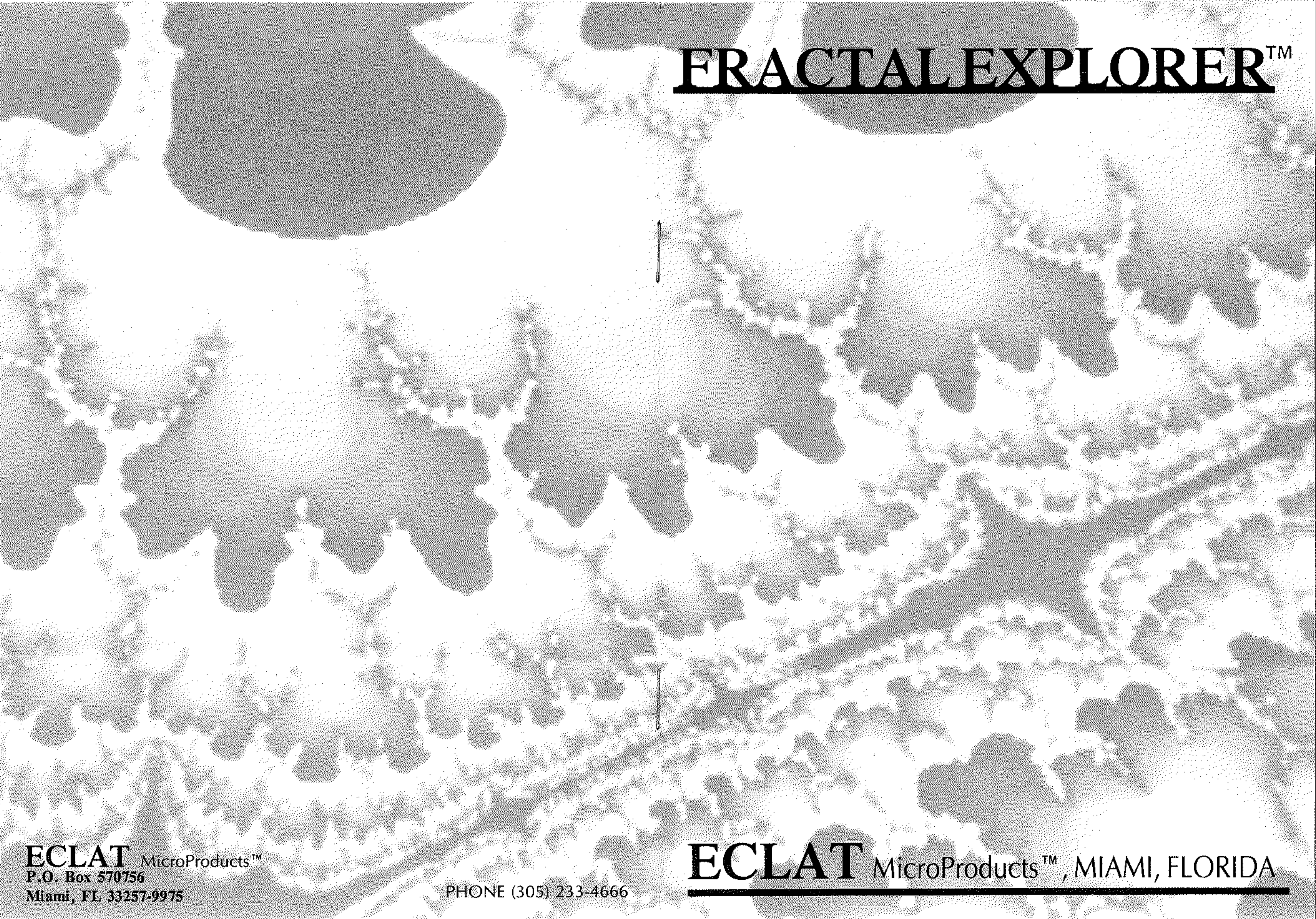

FRACTAL EXPLORER™

ECLAT MicroProducts™, MIAMI, FLORIDA

ECLAT MicroProducts™
P.O. Box 570756
Miami, FL 33257-9975

PHONE (305) 233-4666

Recd UPS 01 MAY 89

PICTURES GENERATED WITH **FRACTAL EXPLORER** MAY BE FREELY DISTRIBUTED.

NO OTHER FILES OR OPERATING CODE; BASIC, OR ASSEMBLY LANGUAGE MAY BE DISTRIBUTED. **ONLY THE PICTURES CREATED BY FRACTAL EXPLORER MAY BE DISTRIBUTED.**

APPLE COMPUTER, INC. MAKES NO WARRANTIES, EITHER EXPRESSED OR IMPLIED, REGARDING THE ENCLOSED COMPUTER SOFTWARE PACKAGE, ITS MERCHANTABILITY OR ITS FITNESS FOR ANY PARTICULAR PURPOSE. THE EXCLUSION OF IMPLIED WARRANTIES IS NOT PERMITTED BY SOME STATES. THE ABOVE EXCLUSION MAY NOT APPLY TO YOU. THIS WARRANTY PROVIDES YOU WITH SPECIFIC LEGAL RIGHTS. THERE MAY BE OTHER RIGHTS THAT YOU MAY HAVE WHICH VARY FROM STATE TO STATE.

PRODOS 8 and PRODOS 16 are copyrighted programs of Apple Computer, Inc. licensed to ECLAT MICROPRODUCTS to distribute for use only in combination with **FRACTAL EXPLORER**. Apple Software shall not be copied onto another diskette (except for archive purposes) or into memory unless as part of the execution of **FRACTAL EXPLORER**. When **FRACTAL EXPLORER** has completed execution Apple Software shall not be used by any other program.

IIGS version

TABLE OF CONTENTS

FRACTAL EXPLORER

FRACTAL EXPLORER will allow you to create your own series of Fractal images and to display them in a slide show with pre-programmed color effects. No programming knowledge is required. There are no numbers to enter. All instructions needed are presented in menu form and prompts will guide you along the way.

Apple IIGS generated Pictures are $C1 filetypes which are compatible with Paintworks(TM) and other Apple IIGS paint programs.

FRACTAL EXPLORER is also available in A 4 color Single Hires version for the Apple II,II+, and a 16 color Double Hires version for the Apple IIe,IIc and compatibles on one 5 1/4 in disk.

GETTING STARTED

Make a Back-up copy of the **FRACTAL EXPLORER** master disk. Put the original away for safekeeping and use your back-up as your new master.

FRACTAL EXPLORER comes with some Super Hires Fractal pictures already on the disk. These can be left on the disk or deleted, as the user desires.

Since **FRACTAL EXPLORER** is unprotected and Prodos compatible, use any Prodos disk copy program for making working copies, such as the System Utilities. It is wise to make an additional back-up for making user disks and to put the original master away as an Archival copy. Do not distribute copies of the **FRACTAL EXPLORER** disk or ANY of the programs on the

THE SLIDE SHOW

To view the slide show of the pictures already on the disk, simply insert the disk into DRIVE 1 in your computer and turn on the power.

The disk will boot and show you an introductory page. Press any key (or simply wait a minute) and the main menu will appear.

Select RUN SLIDE SHOW from the menu. You will now see the Super Hires Pictures on the disk. You can use the following commands during the slide show.

C	- Color Complement Picture
X	- Exclusive or the Palette
>	- Cycle up the Palette
<	- Cycle down the Palette
+	- Select Next Palette
-	- Select Previous Palette
F	- Color Fill Mode On
SPACE BAR	- Pause (any key to re-start)
-> RT ARROW	- next picture in sequence
<- LT ARROW	- last picture in sequence
ESCAPE	- Exit Slideshow

The user can set the slide show parameters by selecting menu item, SLIDE SHOW OPTIONS. This will allow the user to set the time each slide is displayed, pre-programmed Color Effects, and the number of times to repeat the slide show. Again, the user is guided by prompts and menu selections.

CREATING YOUR OWN FRACTALS

By selecting CREATE FRACTAL PICS from the main menu, users can create their own original fractal pictures.

If the disk is full, The user cannot create a new fractal image until some are deleted from the disk.

MAKE USER DISK selection will delete all pictures except picture number 1, the first fractal image (do not do this to your original disk unless you want to lose the pictures provided).

ZOOM NEW PICTURE selection will create a new picture from one of the pictures selected in the PICTURE AVAILABLE list. After selecting the Zoom option and a picture, Move the zoom box around with the arrow keys, I,J,K,M keys or the mouse. When over the area of interest, press the RETURN key to begin the drawing of the area in the ZOOM BOX. The screen will slowly start to fill with the new Fractal picture. The image will take about 2-4 hours to fill. Since the number of calculations increase with the number of times the picture is zoomed, pictures Zoomed 10 times may take 10 to 20 hours to generate. So this will give your computer something to do overnight. Partially completed pictures can be stored at any time, by pressing the ESC key and then following the menu instructions - "Press S to Save Pic". The Picture can then be continued at a later time. This feature is also useful for a picture that takes many hours to generate. Partially completed pictures can be saved and continued to insure against their loss due to power outages or other calamities.

While the picture is being generated, the user can press the following Color Effects keys

C	- Complement screen Pixels
X	- Exclusive Or Palette Values
F	- Fill Mode On
+	- Select Next Palette Available
-	- Select Last Palette Available

The user can save the picture with the colors desired. Remember, the slide show can also be programmed to do these color effects plus palette cycling.

When the create program has finished drawing the new fractal picture, a menu will appear that will allow the user to (S)ave the picture or (Q)uit the CREATE program. The (S)ave option will assign the next available picture number to the new picture and save it to disk. The SLIDE SHOW will automatically find all Pictures on the disk. If the user does not make a choice within a minute or so, the program will automatically save the completed picture to the disk, and add it to the slide show directory.

CREATE JULIA SET FROM PICTURE allows the user to create a picture using the same mathematical expression as the Mandelbrot set, but the points are initialized in a different manner. The constants for the Julia set are first chosen by the user from any Mandelbrot Set Picture, by moving the " Julia Point " to a desired area. The resulting Julia set Picture will render a shape (or a set of shapes) which is dependent on where the user set the Julia Point. Much like the Zoom box, the user moves the Julia Point with the ARROW KEYS or I,J,K,M keys (or mouse) to the desired point and then presses the RETURN Key (or mouse button). The screen will then begin filling in with a picture of the Julia Set for the chosen set of constants.

Interestingly, Julia Set Pictures can be generated from Zoomed Mandelbrot Set Pictures.

Trying to generate Julia Set Pictures from Julia Set Pictures or Zoomed Mandelbrot Set pictures from Julia Set Pictures will give unpredictable results.

VIEW A PICTURE allows the user to view the selected picture. Also the Color effects keys can be pressed during viewing.

CONTINUE A PICTURE , as mentioned above, allows the user to continue a picture that was previously stored but not completed. The save and continue feature is useful for pictures that cannot be completed in one session.

DELETE A PICTURE allows a user to selectively delete any of the listed pictures. If all of the pictures are deleted, see DRAW INITIAL PICTURE option.

DRAW INITIAL PICTURE will create the exact same Picture as FRAC.PICGS1, which encompasses the entire Mandelbrot Set. This is useful if FRAC.PICGS1 is erased from the disk.
Some users may also want to erase all pics from the disk and start from "scratch", and see the first picture of a series being drawn.

WHAT IS FRACTAL GEOMETRY

The type of geometry to which most people have been exposed is Euclidian Geometry, which uses X and Y co-ordinates to describe shapes such as circles or straight lines, but is very poor in describing many familiar shapes, such as a tree or the shape of a cloud.

Many objects such as trees indeed do have a shape to them. A fractal shape. A fractal shape is a geometric shape that is fragmented, from the latin word "fractus" as described by Benoit Mandelbrot in his book " The Fractal Geometry of Nature" (see Acknowledgments).

There are more than one type of fractals. There are "Regular Fractals" and the "Domains of Attraction Fractal."

"Regular fractals",such as the Snowflake Curve or the Dragon Curve, are generated by following a set of rules.

A typical set of rules may be:
Draw a jagged line with 3 straight line segments. Now replace each of those 3 line segments with a smaller copy of the original jagged line and so on, replacing each straight line segment with a smaller copy of the jagged segment.

A rendering of a tree can be made by drawing two branches coming from a trunk. Now replace each branch with a smaller branch which sprouts two smaller branches. Repeat this process, again and again, until a tree is formed.

The fractal pictures from FRACTAL EXPLORER are the "Domains of Attraction" type of fractals. FRACTAL EXPLORER will create fractal geometric shapes using Complex Polynomial Iterative Functions to generate and explore the Mandelbrot Set and the Julia Set (see Acknowledgments for further reading).

HOW FRACTAL EXPLORER WORKS

The program begins by displaying an image of the entire Mandelbot Set and using this image as the "Parent" or base picture for zooming and creating additional images which can be further "blown up".

This first image is created by implementing the expression

$$Z_{n+1} = Z_n^2 + C$$

where Z and C are complex numbers (see Appendix A for a brief discussion of complex numbers). Each number has two components, a real and an imaginary part. By thinking of each number's real part as being on the X-axis and the imaginary part as being on the Y-axis, and using the operator i to keep the two components separate, the expression can be written as:

$$(Zx + iZy) \Leftarrow (Zx + iZy)^2 + (Cx + iCy)$$

Multiplied out gives;

$$(Zx + iZy) \Leftarrow Zx^2 + i2*Zx*Zy + (iZy)^2 + (Cx + iCy)$$

where, as in computer code notation, the new value of Z replaces the old value. If the real (X part) and the imaginary (Y part) are grouped, (note: i times i = -1)

$$Zx + iZy \Leftarrow (Zx^2 - Zy^2 + Cx) + i(2* Zx * Zy + Cy)$$

So now each new real and imaginary part replaces Zx and Zy respectively.

ow does this become a colorful picture on the Apple II screen ?

he process is begun by starting with Zx and Zy equal to zero and an rbitrary value is picked for Cx and Cy.

is calculated as described and then the absolute magnitude of Z is alculated to see if it is growing large.

lagnitude of Z is calculated by squaring Zx and squaring Zy and adding hem, then take the square root, the same as a vector magnitude.

he resultant Z is then calculated iteratively letting the new value eplace the old. The Z value will tend to either converge to zero, or grow o some positive value.

ertain values of Cx and Cy will cause the Z value to converge to zero, ertain values of Cx and Cy will cause the Z value to grow to some positive alue, and some values will make Z grow very quickly. It is how fast that his Z value grows which is given a color representation for the fractal mage. If the expression can be iterated many, many times and the esultant Z value approaches 0, then black is plotted (the point is "within he set").

If The Z value starts growing, it will generally become very large after a few more iterations. An arbitrary value of 2 is picked as the magnitude where Z is "blowing up". If the abolute value of Z goes beyond 2 then on the next few iteration it will become very, very large and go "sky High". The number of iterations called COUNT are then translated into a color to be plotted at that point. COUNT ranges from 0 up to 255
so the 16 colors of the present palette are cycled through repeatedly.

Scanning the values from Cx= -2 to +2 and Cy = -1.2 to +1.2 will encompass the values of interest to us and will render the familiar Mandelbrot fractal, which we call the parent or base picture.

The program plots each of the 64,000 points (320 x 200) on the Super Hires Screen one at a time.

For the initial Mandelbrot Set Picture, The program starts off by scanning, beginning at top left, for 320 values of Cx between -2 and +2 while holding Cy at -1.2. this will generate the first row of points across the top of the screen.

The Cy value is incremented by 1/200 to the next Cy value for the next row, and the same Cx values are scanned again. This is repeated until the screen is full. The Cy value is scanned from +1.2 to -1.2.

The pictures are a "Top View" and give a feeling of the "activity" of the function at the locations plotted. The black area in the center is a quiet area where the function converges on zero. As we progress outward from zero the function will cross some value where it will "come to life" and show activity. As we go further from the center, the function "blows up", that is, the magnitude of Z will go "sky high" heading toward infinity. With the Zoom box, we can explore the regions where the function shows the most interesting activity.

e Julia Set Pictures use the same expression,

$$Z_{n+1} = Z_n^2 + C$$

t instead of always starting with Z = 0 and scanning C across all of the ints of interest in Cx and Cy, the Julia set calculation starts with C ual to some pre-chosen point on the Mandelbrot Set (some Cx and Cy osen by the user with the Julia Point), and then scans Z across some lues of interest mapping each point to the screen.

o create a JULIA SET picture, first, the user choses a point from a ANDELBROT SET picture, even a zoomed MANDELBROT SET picture, by oving the Julia point around with the mouse or arrow keys. When a point chosen, the values of Cx and Cy at that point on the Mandelbrot set are tomatically extracted from the MANDELBROT SET and used for the Julia et calculations for Cx and Cy.

COUNT MAX is passed to the assembly language calculation routine and is the maximum number of iterations that will be made at that point. In FRACTAL EXPLORER it is adaptive, that is , it is increased by 16 on every picture Zoom. COUNT MAX starts at 32 for PIC1 (the base pic) and is increased by 16 on every Zoom up to the limit of 255.

MAX Z is arbitrarily set equal to 2. If the Magnitude of Z reaches this number before COUNT MAX iterations, then the calculation is stopped and the number COUNT (which is the number of iterations performed to reach Z MAX) is returned from the calculation routine.
It is this number COUNT which is translated into a color numbered 1 through 15 (0 is black and reserved for points within the set) by performing modulo 16 division of COUNT.

If Z magnitude does not reach Z MAX, after COUNT MAX iterations, then the calculation is exited.
The point is within the set and a black "quiet" point is plotted.

The number of multiplication places is also adaptive and is increased with the Zoom number. It begins with 24 bit signed binary arithmetic. 8 bit integer and 16 bit fractional part, and is increased by 3 bits (to correspond to the times 8 Zoom - 2x2x2 8) until 64 bits are reached.

This is why pictures that have a higher Zoom number take longer to calculate.

All math calculations and graphics plotting are done in assembly language

HINTS, TIPS AND OTHER INFO:

The Volume name of the Apple IIGS version of FRACTAL EXPLORER is;

/FRACGS

Pictures have the pathname, for ex.

/FRACGS/FRAC.PICGS1

When the user exits FRACTAL EXPLORER, the user is in the BASIC.SYSTEM with all PRODOS commands available.

More than one picture can be stored at any Zoom number. For example, multiple pictures can be stored at Zoom 5. Also, previously generated pictures can be deleted.
The Parent (Base) Picture can also be deleted after the first picture is generated from it, if desired.

Any picture can be renamed with the ProDos RENAME command so that they will be displayed in any desired order with the slideshow.

The User can create a "Best of" Slide Show of Pictures from different disks using any PRODOS file copy type of utility. Be sure to arrange them FRAC.PICGS1 thru FRAC.PICGS18

If the parent picture FRAC.PICGS1 is deleted, it can be generated again by going into the create menu and chosing DRAW INITIAL PICTURE.

Of course, another working disk can be made from the Master Disk.

Apple IIGS generated Pictures are $C1 filetypes which are compatible with Paintworks(TM) and other Apple IIGS paint programs. Using one of these programs is the suggested way to print out the pictures.

For Paint Programs, An example of a Super Hires Picture's pathname is;

/FRACGS/FRAC.PICGS1

(NOTE: after pictures have been altered with paint programs, the constants stored in palette locations may also have been altered. These pictures then can be used in FRACTAL EXPLORER SLIDESHOW, but can no longer be zoomed from, since the constants have been altered. Therefore, only do this to copies of your FRACTAL EXPLORER pictures.)

The FRACTAL EXPLORER pictures are compatible with any APPLE GS slide show which will show $C1 type files.

DO NOT DISTRIBUTE THE FRACTAL EXPLORER SLIDESHOW WITH THE FRACTAL EXPLORER PICTURES. IT IS A VIOLATION OF COPYRIGHT LAWS TO DO SO.

The flexible, programmable slideshow included with FRACTAL EXPLORER is a significant part of the FRACTAL EXPLORER program. If a user wants to use this slideshow, then purchase of FRACTAL EXPLORER is required.

Since the Zoom box is 1/8 of the screen Height and 1/8 of the screen Width, each Zoom Magnifies the area in the box 64 times (8 * 8). After ten Zooms the final screen is 1/ 64 to the 10 th power, or 1/64 times 1/64 ten times, or blown up approximately 1,000,000,000,000,000,000 times, area wise. Or 1,000,000,000 times in width and 1,000,000,000 in height.

This means that if the first picture were a map of the world, and you created 11 pictures (Zooming 11 times), the final picture would be an actual size picture of the earth's surface.

Even though the precision from using 64 bit numbers is as good as or better than used in most computers, due to the finite precision of the numbers, zooming beyond 16 times may yield an unexpected picture.

APPENDIX A

COMPLEX NUMBERS

A complex number will have the form

$$Z = X + iY$$

where X and Y are real numbers and i is the so-called imaginary unit which has the definition

$$i^2 = -1$$

The real number X is the real component of Z. The iY part is called the imaginary component of Z. The actual number Y is a real quantity.

Addition, subtraction and multiplication of complex numbers follow the familiar rules for real quantities. Real quantities are only added to or subtracted from other real quantites and imaginary quantites are only added to and subtracted from other imaginary quantities.

For multiplication, as mentioned, i times i = -1 ,So

$$(X + iY)^2 = X^2 + i2XY + i^2Y^2$$

$$(X + iY)^2 = X^2 - Y^2 + i2XY$$

A complex number can be represented geometrically by plotting the real component on the X axis and the imaginary part on the Y axis.
Another property of a complex number is it's length, or absolute magnitude |Z|, which can be found by

$$|Z| = (X^2 + Y^2)$$

which is the same as calculating a vector magnitude.
There are other properties and operations of complex numbers that need not be covered here, but can be found in many Algebra books.

ACKNOWLEDGEMENTS

For further reading on the subject of The Mandelbrot set, the Julia Set, and other fractals that may interest the reader, the following book, which inspired the program **FRACTAL EXPLORER**, is suggested:

The Fractal Geometry of Nature
by Benoit Mandelbrot
W.H. Freeman and Co.

also suggested reading

The Beauty of Fractals
by Heinz-Otto Pietgen
Springer-Verlag

CHAOS Making a New Science
by James Gleick
Viking Press