

Magic Camera

COLLABORATORS

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Contents

1	Magic Camera	1
1.1	Magic Camera User’s Guide	1
1.2	About the Author	1
1.3	About Magic Camera	1
1.4	About Raytracers	2
1.5	Writing Scripts	3
1.6	Scripts Writing Basics	4
1.7	Data Types	5
1.8	Integer	6
1.9	Real	6
1.10	Point	7
1.11	Vector	7
1.12	Color	7
1.13	Identifier	8
1.14	Filename	8
1.15	Text Strings	8
1.16	Using Variables and Expressions	8
1.17	Declaring Reals	11
1.18	Declaring Ints	11
1.19	Declaring Vectorss	11
1.20	Declaring Arrays	12
1.21	Declaring Slices	13
1.22	Declaring Paths	13
1.23	Built-in Functions	14
1.24	Global Scripts Elements	15
1.25	Setting Up the Camera	15
1.26	camera.location	16
1.27	camera.target	16
1.28	camera.up	16
1.29	camera.resolution	17

1.30	camera.aspect	17
1.31	camera.hfov	18
1.32	camera.vfov	18
1.33	The Sky	18
1.34	sky.zenith	19
1.35	sky.horizon	19
1.36	sky.up	19
1.37	sky.numstars	20
1.38	sky.starcolor	20
1.39	Changing the Atmosphere	21
1.40	fog.color	21
1.41	fog.thinness	21
1.42	fog.distance	22
1.43	fog.power	22
1.44	Smoothing Polygons	22
1.45	ws_g_antialias	23
1.46	Controlling the Octree	24
1.47	Declaring Bitmaps	24
1.48	ws_g_note	25
1.49	ws_g_flags	26
1.50	Lighting	26
1.51	lamp.location	27
1.52	lamp.color	27
1.53	lamp.spread	28
1.54	lamp.power	28
1.55	lamp.radius	28
1.56	lamp.distance	29
1.57	lamp.numrays	29
1.58	lamp.pointat	30
1.59	lamp.noshad	30
1.60	lamp.direct	30
1.61	Vertices	31
1.62	Surface Characteristics	31
1.63	Patterns	31
1.64	Pattern Name	33
1.65	color	33
1.66	color.diffuse	33
1.67	color.ambient	33
1.68	color.reflect	34

1.69	color.filter	34
1.70	color.transmit	35
1.71	color.index	35
1.72	color.specrefl	36
1.73	color.speccoef	36
1.74	check	37
1.75	check.pattern1, check.pattern2	37
1.76	check.xsize, check.ysize, check.zsize	37
1.77	brick	38
1.78	brick.brick, brick.mortar	38
1.79	brick.xsize, brick.ysize, brick.zsize	38
1.80	brick.msize	39
1.81	brick.yoffset, brick.zoffset	39
1.82	marble	39
1.83	marble.pattern, marble.grain	40
1.84	marble.scale	40
1.85	marble.power	40
1.86	wood	41
1.87	wood.pattern, wood.grain	41
1.88	wood.scale	41
1.89	clouds	42
1.90	clouds.sky, clouds.clouds	42
1.91	clouds.scale	42
1.92	clouds.power	43
1.93	clouds.perturb	43
1.94	clouds.xphase, clouds.yphase, clouds.zphase	44
1.95	wrapsphere	44
1.96	wrapsphere.bitmap, wrapcylinder.bitmap, wrapflat.bitmap	44
1.97	wrapsphere.pattern, wrapcylinder.pattern, wrapflat.pattern	45
1.98	wrapsphere.substitute, wrapcylinder.substitute, wrapflat.substitute	45
1.99	wrapsphere.dodiffuse, wrapsphere.dotransmit, wrapsphere.dorefect	46
1.100	wrapsphere.xrepeat, wrapsphere.yrepeat	46
1.101	wrapsphere.filter	47
1.102	wrapflat	47
1.103	wrapflat.location	48
1.104	wrapflat.xaxis, wrapflat.yaxis	48
1.105	wrapflat.xlength, wrapflat.ylength	49
1.106	wrapflat.repeatx, wrapflat.repeaty	49
1.107	wrapcylinder	49

1.108wrapcylinder.xrepeat	50
1.109wrapcylinder.height	50
1.110blotch	50
1.111blotch.scale	51
1.112blotch.pattern	51
1.113Textures	51
1.114Texture Name	52
1.115Waves	52
1.116waves.ncenters	52
1.117waves.scale	53
1.118waves.phase	53
1.119waves.size	53
1.120Spherical Bump Maps	54
1.121bumpsphere.xrepeat, bumpsphere.yrepeat	54
1.122bumpsphere.bitmap, bumpcylinder.bitmap, bumpflat.bitmap	54
1.123bumpsphere.size, bumpcylinder.size, bumpflat.size	55
1.124Cylindrical Bump Maps	55
1.125bumpcylinder.xrepeat	56
1.126wrapcylinder.height	56
1.127Flat Bump Maps	56
1.128bumpflat.location	57
1.129bumpflat.xaxis, bumpflat.yaxis	57
1.130bumpflat.xlength, bumpflat.ylength	57
1.131bumpflat.repeatx, bumpflat.repeaty	58
1.132Primitive Object Types	58
1.133pattern	58
1.134texture	59
1.135origin	59
1.136offtree	60
1.137Triangles	60
1.138triangle.location	61
1.139triangle.v1, triangle.v2	61
1.140triangle.p1, triangle.p2, triangle.p3	62
1.141Parallelograms	62
1.142parallelogram.location	62
1.143parallelogram.v1, parallelogram.v2	63
1.144Planes	63
1.145plane.location	64
1.146plane.v1, plane.v2	64

1.147Spheres	65
1.148sphere.location	65
1.149sphere.radius	65
1.150Rings	66
1.151ring.location	66
1.152ring.v1, ring.v2	67
1.153ring.in, ring.out	67
1.154Primitive Constructions	67
1.155Smoothing Constructions	68
1.156Height Fields	68
1.157hfield.location	69
1.158hfield.v1, hfield.v2	69
1.159hfield.up	69
1.160hfield.height	70
1.161hfield.floor	70
1.162hfield.file	71
1.163Rotational Solids (Spins)	71
1.164spin.location	72
1.165spin.segments	72
1.166spin.slice	73
1.167spin.start, spin.end	73
1.168spin.rise	73
1.169spin.fillfirst, spin.filllast	74
1.170Boxes	74
1.171box.location	74
1.172box.v1, box.v2, box.v3	75
1.173Filled Slices	75
1.174fill.location	76
1.175fill.slice	76
1.176fill.hole	77
1.177fill.xaxis, fill.yaxis	77
1.178Skinned Polygon Frames	77
1.179skin.slice	78
1.180skin.fillfirst, skin.filllast	78
1.181Extrusions	78
1.182extrude.location	79
1.183extrude.xaxis, extrude.yaxis	79
1.184extrude.slice	80
1.185extrude.direct	80

1.186	extrude.length	80
1.187	extrude.fillfirst, extrude.filllast	81
1.188	Spheres	81
1.189	psphere.location	81
1.190	psphere.radius	82
1.191	psphere.hsegments, psphere.vsegments	82
1.192	Named Objects and Instancing	83
1.193	'Undocumented' Features	85
1.194	Technical Description	85
1.195	The Magic Camera Color Model	86
1.196	Anti-Aliasing	88
1.197	The Octree	89
1.198	Run-time Options	90
1.199	ToolType Options	90
1.200	Command Line Options	92
1.201	Options Window	94
1.202	RGB	96
1.203	IFF Files	96
1.204	misc_raw24	96

Chapter 1

Magic Camera

1.1 Magic Camera User's Guide

Table of Contents

- About Magic Camera
- About Ray Tracers
- Writing Scripts
- Run Time Options
- Technical Description
- Contacting the Author

1.2 About the Author

To contact the author for registration/bug reports:

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One final note...

Please do not call me on the phone. I work full time, do freelance computer work, and still have to take care of a house and yard. I can't afford to give telephone support at the prices I'm charging. Please contact me ONLY through the means listed above. Thank you.

1.3 About Magic Camera

Magic Camera © 1990-1994 Dan Wesnor

This project is huge. It took thousands of hours of programming, researching, and testing. I stopped counting lines of code at 12,000, and that was a long time ago.

Many thanks to the people at the SAS Institute for the best compiler I've ever used. If you program your Amiga (and I hope you do), buy it.

I hate having to do this, but having worked so hard, I feel I deserve some recognition, and if you feel the effort was good and the product useful to you, I also feel I deserve some compensation for the work I've done. So read the following to avoid any legal problems.

The rights to profit from this program belong completely to the sole author, Dan Wesnor. Remember, only the demo version is freely distributable. The registered version may only be used by the person to whom it is registered. Registration is traceable, and any "loose" copies of the registered version found on bulletin boards and so forth will be considered illegal. The registree, not the sysop, will be considered responsible for all illegally distributed copies registered under his/her name. Prosecution is always an option. Copies which cross state lines become a federal case. (The version you are using will inform you as to whether it is a demo or registered version, and who the registree is.)

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USE THIS SOFTWARE AT YOUR OWN RISK. The author assumes no liability for damages resulting from the use of this program. Period. Using this software constitutes waiver for any damages which you might incur in the process.

About This Documentation

This documentation is intended for use with AmigaGuide and compatible document readers. You can try one of the programs which converts Guide files to readable text. I've never used one, so good luck.

In short, I hate writing documentation. I'm also no good at it. I feel I made a good effort, and I detested every minute of it. Unfortunately, it shows in the text. I'll probably make several cuts at the documentation and release new versions with each new version of the code.

If you notice any bugs in the documentation, send them to me, just as you would a program bug. Hopefully, you'll find neither.

1.4 About Raytracers

A ray tracer is a program which creates highly realistic three dimensional scenes. Although a ray tracer is slow compared to other forms of 3D rendering, the basic algorithm used is simple, elegant, powerful, and quite easy

to modify to produce highly realistic results. For instance, the same basic subroutines solve the problems of object visibility, local lighting (shadows), reflections, and transparency with refraction. This would explain why ray tracers are popular programs for many interested in 3D computer graphics - they are simple to write.

It seems as if the ray tracing algorithm has everything going for it: power, elegance, expandability. But there's a down side to everything. Ray tracing's primary down side is speed. A ray tracer must perform many calculations, called ray-object intersection tests. Each of these tests can involve from twenty to one hundred floating point calculations (when optimized). If a moderately detailed scene (5,000 objects) is rendered at a resolution of 640x480 pixels, then as many as 150 BILLION floating point calculations can be performed. And this doesn't include the calculations for shadows, reflections, transparency, anti-aliasing (getting the "jaggies" out), and pattern and texture mapping. Add it all up, and your computer ends up doing a lot of thinking.

So, what can't a ray tracer do. Well, in computer graphics, there is a problem that's referred to as "global lighting". Put simply, global lighting takes into account all the light in the scene. Light in a scene comes not only from sources like the lamps, but it is also reflected from every point on every object in the scene (the term "global" means just that - everything, everywhere). A ray tracer does not take this reflected light into account when computing shadows and shading. There are just too many possible light sources in a global solution. Some programmers have tried, using an algorithm called "ray bouncing", but even mediocre results slow rendering by a factor of 100 or more.

The current "great hope" of solving the global lighting problem is an algorithm called "radiosity". You may have heard this buzzword once or twice. If you've ever seen pictures generated using radiosity (especially indoor scenes), they're incredible. I would love to implement this algorithm, but unfortunately, it's just too slow, requires too much memory, and requires that the person building the scene know quite a bit about the internals of the algorithm. I have some ideas about finding some middle ground, but this is way down on my "to do" list.

If you'd like to know more about how Magic Camera implements the ray tracing algorithm, see the Technical Description section.

1.5 Writing Scripts

Magic Camera takes its input in the form of script files. Scripts describe the scene which is to be rendered, including the shape and location of objects in the scene and the surface characteristics of those objects.

- Script Basics
- Data Types
- Using Variables and Expressions
- Built-in Functions
- Global Elements
- Surface Characteristics
- Primitive Elements
- Constructed Elements

Named Objects/Instances

1.6 Scripts Writing Basics

Scripts consist of descriptions of objects, the surface characteristics of those objects, scene lighting, the arrangement of the camera, and general instructions to Magic Camera as to how the scene is to be rendered.

Scripts are stored in ASCII files, so they may be written using any text editor, or any word processor which allows files to be saved in ASCII. Scripts may also be generated by another program, such as programs which convert objects from other popular renderers into Magic Camera format.

Although scripts follow a free-format, it is always a good idea to follow a basic format so you know where everything is when you have to change the script. I usually put control statements such as `maxobcube` or `maxaadepth` at the beginning of the file. These are followed by the camera, then the lamps, and then the sky. After this, patterns and textures are declared, and finally, the objects themselves. More important objects, such as those that are animated or those which serve as a focal point for the scene usually come first, and the background objects last. Of course, you can organize your scripts any way you want.

It's easier to keep track of what your script is doing by using comments. Two types of comments are allowed, C-style, and line comments. C-style comments are enclosed between `/*` and `*/`, and may continue over many lines. Example:

```
/* this is a comment */
```

Line comments are initiated by a semicolon, and continue until the end of the line. They may start anywhere on the line. They may not extend past the end of the line, but more than one may be used in a row:

```
; this is a line comment  
; and this is another
```

Use comments to write notes to yourself, so you can remember how a script works months from now. It prevents a lot of confusion.

Sometimes, scripts get too long to manage. In this case, you may want to break the script down into several files. To rejoin them, use the include statement:

```
include "filename"
```

Typically, I put objects in separate files, and include them into the main file. This keeps scripts uncluttered, and allows objects to be easily shared by more than one script.

Scripts consist of keywords and elements. Keywords are usually followed by a value, such as:

```
maxobcube 3
```

The value of "maxobcube" would be set to 3. Elements are more complex, and consist of a keyword followed by a list of subelements in braces ('{' and '}'). Some subelements are mandatory and must be included. Some are optional, and have default values. If you forget a mandatory subelement, the parser will tell you. Subelements, like keywords, consist of a keyword followed by a value. An example of an element declaration (this one's a sphere) is given below:

```
sphere {
  loc    <0, 5, 0>
  radius 3
  patt   red
}
```

This sphere element uses three subelements, 'loc', 'radius', and 'patt'. The subelements 'loc' and 'patt' are actually shorthand for 'location' and 'pattern'. Any time a subelement has a shorthand listed, feel free to use it to save typing. If you want, you can also use the longhand term.

In reading the descriptions of elements below, note that some subelements are surrounded by brackets ('[' and ']'). This indicates that these subelements are optional. DO NOT INCLUDE THE BRACKETS IN THE SCRIPT. You'll get a syntax error if you do.

When subelements are referred to in context with their elements, a notation like "sphere.radius" is used. This indicates the "radius" subelement of the "sphere" element. This notation is used only by the documentation and cannot be used in scripts.

While on the subject of errors, if Magic Camera detects an error in a script, it will inform you and try to continue reading the script. Sometimes it will not be able to continue after the error. Correct the errors and run the script again.

Included in the Magic Camera package, you should have received three files, called "scan.l", "parse.y", and "defaults.c". These are the definitive definitions of the scripting language. They are also difficult to read. Scan.l contains a list of keywords that the parser recognizes, and also the regular expressions for things like Real numbers. Parse.y contains the grammar of the language, and will show the organization of the language, and which subelements are acceptable with which elements. Defaults.c is a definitive list of the default values for all subelements; use it as a reference. If it disagrees with other documentation you received, let me know. Defaults.c is always correct (as are all three of these files). If you learn to read these files, you may find some interesting things. Experimental features show up here, but may not be documented if they are not ready for use. If you try to use these experimental features, do so with caution. They may not work properly. That's why they're not documented.

1.7 Data Types

This section lists the various types of values that Magic Camera will accept. It describes exactly how the types are formed. The data types accepted are:

Int
Real
Point
Vector
Color
Identifier
Filename
Text

1.8 Integer

Int denotes an integer number. For those who can read such things, the regular expression for an integer is:

```
[0-9]+
```

In English, this translates to a string of one or more digits (0-9).

Examples:

```
52      Valid.  
52.0    Not Valid - Integers may not contain decimal points.
```

1.9 Real

Real denotes a real number. The regular expression is:

```
[0-9]*"."[0-9]+
```

Which means zero or more optional digits, followed by a decimal point, followed by one or more digits.

Real numbers using exponential notation may also be used:

```
[0-9]*"."[0-9]+[eE][+-]?[0-9]+
```

This more confusing regular expression simply means that any Real number may end with an "e" notation.

Also, an Int may be substituted anywhere a Real is used.

Examples:

```
11.45      Valid.  
1.145e1    Valid.  Same as 11.45 above.  
1.145e+1   Valid.  Same as 11.45 above.  
11.45e-10  Valid.  
.1145     Valid.  No leading zero required.  
1145.     Invalid. Decimal point must be followed by  
           digits.  
1145      Valid.  Ints may be used in  
           place of Reals.
```

11.4.5 Invalid. Only one decimal point allowed.

1.10 Point

Point denotes a three dimensional point. A Point consists of three legal Real numbers contained in less-than/greater-than signs ('<' and '>') and separated by commas. The numbers are in X, Y, Z order.

Examples:

```
<1.5, -7.0, 0.3> Valid.
<1.5,-7.0,0.3> Valid. Spaces not required.
<1.5, -7, .3> Valid. '-7' and '.3' are legal
Real numbers.
```

1.11 Vector

Vector denotes a three dimensional vector. The basic definition of Vector is the same as for Point, with the exception that at least one dimension of the Vector must be non-zero.

Examples:

```
<1.5, -7, .3> Valid.
<0, 0, 0> Invalid. Must have one non-zero dimension.
<0, 1.0, 0> Valid.
```

1.12 Color

Color denotes a set of RGB values. Its basic definition is the same as for Point, except that all three values must be between 0.0 and 1.0, inclusive. The values are in red, green, blue order. Zero denotes no color, one denotes full color.

Examples:

```
<0, 0, 0> Valid. This would be black.
<1, 1, 1> Valid. White.
<1, 0, 0> Valid. Red.
<1, 1, 0> Valid. Yellow
<0, 0, .5> Valid. A darkish blue.
<.6, 1, .6> Valid. A pastel green
<.5, -.1, .6> Invalid. No negative numbers.
<.5, 1.1, .6> Invalid. No numbers greater than 1.0.
```

Hint: Play with a color requester (like the one found in Preferences) to find the colors you want to use.

1.13 Identifier

Identifiers (IDs) are used to name patterns, objects, and just about anything else that can be named. Once an element has been named, it is referenced by that name. The regular expression for an Identifier is:

```
[_]*[a-zA-Z]+[_.a-zA-Z0-9]*
```

This means that an Identifier consists of any number of optional leading underscores, followed by any alphabetic character, followed by any number of alphanumerics, underscores, or periods.

Examples:

horse	Valid.
_horse	Valid.
__horse	Valid. Any number of leading underscores may be used.
hor5se	Valid.
hor_se	Valid.
5horse	Invalid. First non-underscore character must be alphabetic.
_5horse	Invalid. First non-underscore character must be alphabetic.

1.14 Filename

Filenames are used when a file (such as a bitmap) must be loaded. The regular expression for a filename is:

```
"[a-zA-Z0-9/\'._\\]+"
```

This means any string of one or more alphanumeric characters, slashes (either forward or backwards), single quotes, periods, or underscores. Note that your operating system may allow more different characters in filenames than Magic Camera will currently parse.

1.15 Text Strings

The Text data type is used primarily by the note element. Text consists of any characters between double quotes ("). However, Text may not carry over from one line to the next.

Example:

```
"Boy, have we got some text here!" Valid
```

1.16 Using Variables and Expressions

Magic Camera scripts support the use of variables. Variables are used to make managing related values easier and to allow simple animation.

Variables make managing related values easier by allowing the value to be specified once in the file, then used many times. If the value changes, then the file only needs to be changed in one place. For example:

```
real sphere_radius = 5.0

sphere {
    ...
    radius    sphere_radius
    ...
}

sphere {
    ...
    radius    sphere_radius*2
    ...
}
```

This example creates two spheres, one twice as big as the other. If the writer decides that the spheres should be larger, then he only changes the statement

```
real sphere_radius = 5.0

to

real sphere_radius = 7.5
```

causing all spheres which use `sphere_radius` to control their size to change.

Variables can facilitate animation by using the built-in variables "FRAME", "FIRSTFRAME", and "LASTFRAME". These variables can be changed each time the program is run (see Run Time Options). They may be used in calculations involving the location or size of objects. For example:

```
int numframes = 20

sphere {
    loc    <0, FRAME*10.0/numframes, 0>
    ...
}
```

In this example, the Y coordinate of the sphere is dependent on the value of FRAME. All that the user needs to do is change the value of FRAME, or FIRSTFRAME and LASTFRAME each time Magic Camera is run, and several frames will be produced in which the sphere appears to move vertically. See the demo script "balls.a" for a more complex example of using variables for animation.

Declaring Variables

There are 6 different variable types: real, int, vector, array, slice, and path. They are described below.

Type	Description
real	same as Real
int	same as Integer
vector	a three dimensional vector
array	a one dimensional array of Reals
slice	a one dimensional array of 2D points
path	a two dimensional array of 3D points

Variables of type "real", "int", and vector are declared by:

```
type var_name = value
```

where type is either "real", "int", or "vector", var_name is an Identifier, and value is an appropriate Real, Integer, or Vector value. All variables MUST be initialized.

Variables of type "array", "int", and "path" are defined by:

```
type var_name = { value1, value2, value3, ..., valueN }
```

See the details on each type for examples.

Pre-defined Variables

Variable	Value
PI	3.1415...
E	2.718281828...
TINY	An extremely small, positive value
HUGE	An extremely large, positive value
FRAME	Determined by run-time options
FIRSTFRAME	Determined by run-time options
LASTFRAME	Determined by run-time options

Expressions

As you may have noticed in some examples, expressions may be used. They follow the standard order of operation for most programming languages, and should be familiar to many. For the rest of you the order is as follows:

1. Any value or expression in parenthesis is evaluated first.
2. Expressions are evaluated left to right.
3. Multiplication ("*") and division ("/") are evaluated next.
4. Addition ("+") and subtraction ("-") are evaluated last.

A built-in function or variable name may be used in any appropriate place in an expression. Expressions may freely mix real and integer values.

However, any expression which contains a real value ANYWHERE within it is considered a real expression, and may not be used in place of an integer.

The expression may be used anywhere a value is accepted. An expression may be assigned to a variable by using:

```
var_name = expression
```

For example:

```
x = 4*y
```

which assigns the value of $4*y$ to the (previously declared) variable x . Expressions may be embedded in complex types such as vectors or points...

```
sphere {  
    ...  
    loc    <5*cos(angle), 0, 5*sin(angle)>  
    ...  
}
```

1.17 Declaring Reals

A variable of type real can be used anywhere a real number may be used. Before using a real variable, it must be declared and initialized:

```
real variable_name = initial_value
```

where "variable_name" is an Identifier by which the variable will be referenced in the future and "initial value" is an expression of type Real.

Example:

```
real foo = 5.2
```

1.18 Declaring Ints

A variable of type int can be used anywhere a integer number may be used. Before using a int variable, it must be declared and initialized:

```
int variable_name = initial_value
```

where "variable_name" is an Identifier by which the variable will be referenced in the future and "initial value" is an expression of type Integer.

Example:

```
int foo = 5
```

1.19 Declaring Vectorss

A variable of type vector can be used anywhere a vector, point, or color may be used. Before using a vector variable, it must be declared and initialized:

```
int variable_name = initial_value
```

where "variable_name" is an Identifier by which the variable will be referenced in the future and "initial value" is a 3D value.

Example:

```
vector foo = <5, 4, -1>
```

NOTE: Unlike the vector type, the vector variable may have a value of all zeros (<0,0,0>). However, when used in place of a vector type or color type, the vector variable must have an acceptable value.

1.20 Declaring Arrays

An array is a list of Real values which can be referenced by an "index" which specifies which value in the list is to be used. To declare an array:

```
array array_name = { value0, value1, ..., valueN }
```

where "variable_name" is an Identifier by which the array will be referenced in the future and "value0" through "valueN" are expressions of type Real. Optionally, the keyword "closed" may be used as the last element to indicate that the array is closed (see below).

To reference the values stored in an array, use:

```
array_name[integer_expression]
```

where "integer expression" is any expression of type Integer. Note that the first value in an array has an index of zero, so it would be referenced by:

```
array_name[0]
```

If the array was declared using "closed", then referencing an element beyond the last element of the array is allowed, and the index will "roll over" to the beginning of the array. For example, if an array is declared with 10 values, then:

```
array_name[15]
```

is the same as

```
array_name[5]
```

Example of a closed array:

```
array foo = {  
    1, 2, 3, 4, 5
```

```

    closed
}

```

NOTE: Currently, an array may hold only 100 values.

1.21 Declaring Slices

Slices are primarily used to describe cross sections of objects to be built using certain constructed primitives, such as spins and extrusions.

A slice is a list of 2D vectors. To declare a slice:

```

slice slice_name = {
    <Xvalue0, Yvalue0>,
    <Xvalue1, Yvalue1>,
    ...,
    <XvalueN, YvalueN>
}

```

where "variable_name" is an Identifier by which the slice will be referenced in the future and "value0" through "valueN" are expressions of type Real. Optionally, the keyword "closed" may be used as the last element to indicate that the slice is closed (see below). The vectors need not be put on separate lines. The example does so only for clarity.

Example of a closed slice:

```

slice foo = {
    <1, 1>,
    <1, 0>,
    <0, 0>,
    <0, 1>
    closed
}

```

NOTE: Currently, a slice may hold only 100 points.

1.22 Declaring Paths

A path is a list of 3D Points which can be referenced by an "index" which specifies which point in the list is to be used. To declare a path:

```

path path_name = {
    point0,
    point1,
    ...
    pointN
}

```

where "variable_name" is an Identifier by which the path will be

referenced in the future and "point0" through "pointN" are expressions of type Point. Optionally, the keyword "closed" may be used as the last element to indicate that the path is closed (see below). The points need not be put on separate lines. The example does so only for clarity.

To reference the values stored in a path, use:

```
path_name[integer_expression]
```

where "integer expression" is any expression of type Integer. Note that the first value in a path has an index of zero, so it would be referenced by:

```
path_name[0]
```

If the path was declared using "closed", then referencing an element beyond the last element of the path is allowed, and the index will "roll over" to the beginning of the path. For example, if an path is declared with 10 values, then:

```
path_name[15]
```

is the same as

```
path_name[5]
```

A path can be used anywhere a Point or Vector can be used, for example, the location of a sphere:

```
sphere {
    loc      path_name[3]
    radius   3
    patt     red
}
```

Example of a closed path:

```
path foo = {
    <0, 0, 0>,
    <0, 1, 0>,
    <0, 1, 1>,
    <1, 0, 0>
    closed
}
```

NOTE: Currently, a path may hold only 100 values.

1.23 Built-in Functions

The following built in functions may be used in expressions (note that all angular values are in degrees):

Function	Description
----------	-------------

cos(degrees)	Returns the cosine of the angle "degrees"
sin(degrees)	Returns the sine of the angle "degrees"
tan(degrees)	Returns the tangent of the angle "degrees"
acos(value)	Returns the arccosine of the "value"
asin(value)	Returns the arcsine of the "value"
atan(value)	Returns the arctangent of the "value"
cosh(degrees)	Returns the hyperbolic cosine of the angle "degrees"
sinh(degrees)	Returns the hyperbolic sine of the angle "degrees"
tanh(degrees)	Returns the hyperbolic tangent of the angle "degrees"
exp(value)	Returns "e" to the power of "value"
log(value)	Returns the natural logarithm of "value"
log10(value)	Returns the base 10 logarithm of "value"
pow(x,y)	Returns "x" to the power of "y"
power(x,y)	Same as pow(x,y) above
sqrt(x)	Returns the square root of "x"
ceil(x)	Rounds "x" upwards to the nearest integer
floor(x)	Truncates "x" downwards to the nearest integer
deg2rad(degrees)	Converts the value "degrees" to the equivalent in radians
rad2deg(radians)	Converts the value "radians" to the equivalent in degrees

1.24 Global Scripts Elements

Setting the Camera
 The Sky
 Lighting the Scene
 Changing the Atmosphere
 Vertices
 Smoothing
 Anti-aliasing
 Octree control
 Importing Bitmaps
 Annotating Scripts
 Miscellaneous Flags

1.25 Setting Up the Camera

Definition:

```

camera {
  location Point
  target Point
  [up Vector]
  [resolution Int Int]
  [aspect Real]
  [hfov Real]
  [vfov Real]

```

```
}
```

NOTE: All scripts must contain a camera definition.

1.26 camera.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: All values legal for Point
Default value: No default.

This subelement is mandatory.

Description:

Positions the camera in three dimensional space.

See Also: camera

1.27 camera.target

Subelement: target
Shorthand: None
Data type: Point
Legal values: All values legal for Point
Default value: No default

This subelement is mandatory.

Description:

Defines the point in space which the camera looks at. Currently, no depth-of-field information is derived from the target, but may be in the future.

See Also: camera

1.28 camera.up

Subelement: up
Shorthand: None
Data type: Vector
Legal values: All values legal for Vector.

However, the "up" vector must be distinct from the direction the camera is pointing.

Default value: <0, 1, 0>

This subelement is optional.

Description:

Defines the direction which will be considered up for camera pointing purposes only. The "up" vector must not be parallel to the direction the camera is pointing.

See Also: camera

1.29 camera.resolution

Subelement: resolution
Shorthand: res
Data type: Int Int
Legal values: Both Ints must be greater than or equal to one.
Default values: 320 400

This subelement is optional.

Description:

Determines the resolution of the output image. The first value indicates the horizontal resolution, the second vertical. Values of up to 65535 are supported, but this would cause extremely time and disk space consuming renderings.

See Also: camera

1.30 camera.aspect

Subelement: aspect
Shorthand: None
Data type: Real
Legal values: All positive Reals greater than zero
Default value: 0.56

This subelement is optional.

Description:

Determines pixel aspect ratio. Pixel aspect is defined as the vertical pixel size divided by the horizontal pixel size. The default value is the standard for 320x400 Amiga displays. Here are some other values:

320x200 Amiga: 1.12
640x400 Amiga: 1.12
640x200 Amiga: 2.24
Square Pixel (320x240, 640x480, 800x600, etc.): 1.0

Note: If aspect is not specified and hfov and vfov are, the default value for aspect is computed from those two values and the image resolution.

See Also: camera

1.31 camera.hfov

Subelement: hfov
Shorthand: None
Data type: Real
Legal values: 1.0 to 179.0, inclusive
Default value: 45.0

This subelement is optional.

Description:

Specifies the horizontal field-of-view, in degrees. Larger numbers indicate wider camera shots. Smaller numbers give a zoom effect.

Note: If vfov is specified, hfov is computed from aspect and vfov and the image resolution.

See Also: camera

1.32 camera.vfov

Subelement: vfov
Shorthand: None
Data type: Real
Legal values: 1.0 to 180.0, inclusive
Default value: Computed

This subelement is optional.

Description:

Specifies the vertical field-of-view, in degrees. Larger numbers indicate wider camera shots. Smaller numbers give a zoom effect.

Note: If vfov is not specified, the default value for vfov is computed from camera.hfov and camera.aspect and the image resolution.

See Also: camera

1.33 The Sky

Definition:

```
sky {  
    [zenith Color]  
    [horizon Color]  
    [up Vector]
```

```
[numstars Int]
[starcolor Color]
}
```

NOTE: Although all subelements are optional, there must be at least one in the sky definition.

1.34 sky.zenith

Subelement: zenith
Shorthand: None
Data type: Color
Legal values: All legal Color values
Default value: <0.5, 0.0, 0.5> (deep magenta)

This subelement is optional.

Description:

Specifies the color of the sky at the zenith. Normally the zenith is directly overhead, but can be changed using the up subelement of sky.

See Also: sky.horizon

1.35 sky.horizon

Subelement: horizon
Shorthand: None
Data type: Color
Legal values: All legal Color values
Default value: <0.0, 0.0, 0.5> (deep blue)

This subelement is optional.

Description:

Specifies the color of the sky at the horizon. The horizon is defined to be the plane passing through <0, 0, 0> and perpendicular to the up vector of sky

.

See Also: sky.zenith

1.36 sky.up

Subelement: up
Shorthand: None
Data type: Vector
Legal values: All legal Vector values
Default value: <0, 1, 0>

This subelement is optional.

Description:

Specifies the direction towards the zenith. Note that this "up" vector is different from camera.up. This "up" vector is used only in computing sky color.

See Also: sky
 sky.horizon

1.37 sky.numstars

Subelement: numstars
Shorthand: nstars
Data type: Int
Legal values: Positive integers
Default value: 0

This subelement is optional.

Description:

Specifies the total number of stars which should appear in the picture.

Note: Because of the way the stars algorithm works, stars tend to disappear when several levels of anti-aliasing are used. I hope to get this cleared up soon.

See Also: sky
 sky.starcolor

1.38 sky.starcolor

Subelement: starcolor
Shorthand: scolor
Data type: Color
Legal values: All legal Color values
Default value: <1, 1, 1>

This subelement is optional.

Description:

Specifies the brightest color which will be used for stars. The stars algorithm will "dim" this color to lesser values to simulate stars of different intensities.

Note: Because of the way the stars algorithm works, stars tend to disappear when several levels of anti-aliasing are used. I hope to get this cleared up soon.

See Also: sky
sky.numstars

1.39 Changing the Atmosphere

Definition:

```
fog {  
  [color Color]  
  [thinness Real]  
  [distance Real]  
  [power Real]  
}
```

NOTE: Although all subelements are optional, at least one must be included in the definition.

1.40 fog.color

Subelement: color
Shorthand: None
Data type: Color
Legal values: All legal Color values
Default value: <0.5, 0.5, 0.5>

This subelement is optional.

Description:

Specifies the color of fog in the picture. The more something is obscured by fog, the closer to this color it will become.

See Also: fog

1.41 fog.thinness

Subelement: thinness
Shorthand: thin
Data type: Real
Legal values: Greater than zero
Default value: 1.0

This subelement is optional.

Description:

Specifies how thick the fog will be. Higher values decrease visibility. Lower values increase visibility.

See Also: fog

1.42 fog.distance

Subelement: distance
Shorthand: dist
Data type: Real
Legal values: Greater than zero
Default value: 10.0

This subelement is optional.

Description:

Specifies how far away the fog begins to take effect. The fog will not obscure any objects within this many units of the camera.

See Also: fog

1.43 fog.power

Subelement: power
Shorthand: pow
Data type: Real
Legal values: Greater than zero
Default value: 2.0

This subelement is optional.

Description:

Specifies how linear the fog thickness will be. A value of 1.0 indicates that the fog will be uniformly thick over any distance, i.e. the obscuring effect of the fog will be proportional to the distance from the camera. Higher values cause the fog to thicken as objects move away from the camera.

See Also: fog

1.44 Smoothing Polygons

Objects made of polygons (triangles and parallelograms) tend to have a flat look to them. Magic Camera is capable of using a shading technique (called "Phong shading") to give these polygons the appearance of being rounded (they are not actually rounded, they just appear to be through optical trickery). This gives the objects the appearance of being smooth instead of faceted.

Enclose groups of polygons to be smoothed in between "smoothon" and "smoothoff" statements. There may be more than one "smoothon"/"smoothoff" pair, but pairs may not be nested. The "smoothon" and "smoothoff" statements take no

arguments.

Example:

```
smoothon

/* Polygon definitions here... */

smoothoff

smoothon

/* More polygons here ... */

smoothoff
```

All types of statements may be put between "smoothon" and "smoothoff". However, only triangles, parallelograms, and compound objects will be affected. Polygons in one "smoothon"/"smoothoff" pair will be handled separately from those in other pairs.

1.45 ws_g_antialias

"Jaggies" on the edges of polygons may be smoothed by invoking the anti-aliasing routines. Magic Camera uses an adaptive anti-aliasing algorithm which traces additional rays only when necessary. When the corners of a pixel are found to have different colors, the pixel is subdivided, and more rays are traced. If the difference can still not be resolved, the pixel is subdivided again, and so on, until either the difference is resolved or a pre-determined limit is reached.

The maximum number of subdivisions per pixel allowed is determined by the "maxaadept" statement. The "maxaadept" statement takes one argument, an Int. The value given for "maxaadept" must be greater than zero. The default value is one, and a value of three gives excellent anti-aliasing (at the expense of rendering time). Larger values of "maxaadept" cause extremely time consuming ray traces without producing noticeably better results.

The difference in color which the algorithm considers to be significant is controlled by the "maxaadiff" statement. This statement takes a Color as its only argument. The default value is <0.1, 0.1, 0.1>, and rarely needs to be changed.

Examples:

```
maxaadept 3          /* go deep... */
maxaadiff <0.3, 0.3, 0.3> /* but only when necessary */
```

For more information on anti-aliasing, see Anti-Aliasing in the Technical Description section.

1.46 Controlling the Octree

Magic Camera uses a data structure called an "octree" to reduce the number of intersection tests the ray tracer needs to perform. An octree subdivides the three-dimensional world until either there are fewer than "maxobcube" cubes in each division of the world, or each octant of the world has been subdivided "maxoctdepth" times.

The "maxoctdepth" statement takes a single Int as its argument. The default value is five. Larger numbers increase the size of the octree by as much as eight times for each one added to the value.

The "maxobcube" statement has one argument, a single Int. Its default value is two. Larger values will build a smaller octree.

Larger octrees may speed up ray tracing, but for some scenes, they can actually slow processing down. Larger octrees always use more memory.

If the ray tracer runs out of memory while building the octree, it will not abort. However, an "unbalanced" octree will be built, which may cause longer trace times. Also, the ray tracer may need more memory after the octree has been built. If the octree has used all the available memory, and the ray tracer needs more later on, the ray tracer will quit before finishing the scene.

It's always a good idea to specify an octree which leaves at least some memory free.

Examples:

```
maxobcube 5      /* good settings for low memory */
maxoctdepth 3
```

For more information on octrees, see How an Octree Works in the Technical Description section.

1.47 Declaring Bitmaps

When using bitmapped patterns and bitmapped textures, it is necessary to declare bitmaps before using them. Bitmaps are stored in files on disk, and loaded into memory when declared. Two types of file formats are recognized, IFF and raw 24 bit data.

To declare a bitmap using an IFF file:

```
iff filename bitmapname
```

To declare a bitmap using raw 24 bit data:

```
raw24 filename bitmapname
```

In both cases, the argument "filename" is of type Filename and the argument "bitmapname" is of type Identifier. Data is loaded from a file called "filename" and stored in a bitmap called "bitmapname". When the bitmap is referenced in other parts of the script, it will be referenced by "bitmapname".

If the same bitmap file is used several times, it needs to be declared only once. Using the same file in several bitmap declarations wastes memory.

Example:

```
/* load an image from the file "mapfiles/duffslabel.iff" and use it in a
spherical wrap */

iff mapfiles/duffslabel.iff duffslabel

wrapsphere foo {
    bitmap    duffslabel
    /* other wrapsphere subelements here */
}
```

See also: wrapsphere
 wrapcylinder
 wrapflat
 bumpsphere
 bumpcylinder
 bumpflat

NOTE: Bitmap are memory hungry. The approximate amount of memory needed by a bitmap can be computed as follows:

For 24 bit images:

$$\text{memory (bytes)} = (\text{X image size}) \times (\text{Y image size}) \times 3$$

For images which are 8 bits or less deep:

$$\text{memory (bytes)} = (\text{X size}) \times (\text{Y size}) \times (\text{depth}) / 8$$

Examples:

A 640 by 480 24 bit image uses:

$$\text{memory} = 640 \times 480 \times 3 = 921,600 \text{ bytes}$$

A 320 by 400 HAM image uses:

$$\text{memory} = 320 \times 400 \times 6 / 8 = 96,000 \text{ bytes}$$

(HAM images are 6 bits deep)

1.48 ws_g_note

Sometimes you may want to include notes in a script and have those notes printed out as that script is executed. A good use of this is displaying the author's name or any copyright information. To include notes in a script, use:

note Text

For example:

```
note "This script by The Imagination Guys"
```

The message between quotes would be displayed as the script is executed.

1.49 ws_g_flags

Magic Camera scripts may contain flags which cause certain features of the ray tracer to either be disabled or altered. Flags are made up of a single word and take no arguments. The following table lists Magic Camera's script flags and their functions.

noshadows	Causes shadows to not be computed
noshad	" " " " " "
nottransparent	Causes no transparencies to be computed
notrans	" " " " " "
noreflect	Causes no reflections to be computed
norefl	" " " " " "
illuminate	Causes all objects to be fully lit
illum	" " " " " "

1.50 Lighting

There are two types of lamps in Magic camera, local lamps and directional lamps. Local lamps exist at a fixed location in space. Directional lamps have no fixed location. Light from directional lamps appears to have come from a source placed an infinite distance away in a given direction.

Local lamps are more powerful and offer a wider range of options. Directional lamps are "quick and dirty", allowing simple light sources to be quickly defined.

Local lamps can further be divided into three groups: simple, extended, and spotlight. Simple local lamps have no outstanding features. Extended lamps can be used to create more realistic shadows at the expense of increased trace time, and spotlights create an effect similar to that of a theater spotlight. It is possible, but not terribly useful, to create an "extended spotlight" lamp.

The definition of a local lamp is:

```
lamp {
  location Point
  [color Color]
  [distance Real]
  [radius Real] /* for extended lamps */
  [numrays Int] /* for extended lamps */
  [pointat Point] /* for spotlights */
  [spread Real] /* for spotlights */
```

```
[power Real]    /* for spotlights */  
[noshad]  
}
```

The definition of a directional lamp is:

```
lamp {  
    direction    Vector  
    [color      Color]  
    [noshad]  
}
```

Unless indicated above, you may not mix the definitions for local and directional lamps. In particular, the "direction" and "location" elements may not exist within the same lamp definition.

1.51 lamp.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: All values legal for Point.
Default value: None

This subelement is mandatory for local lamps and illegal for directional lamps.

Description:

Defines the position in three dimensional space at which the lamp is to be located.

See Also: lamp

1.52 lamp.color

Subelement: color
Shorthand: None
Data type: Color
Legal values: All values legal for Color.
Default value: <1, 1, 1>

This subelement is optional for all lamps.

Description:

Indicates the color of light emitted by the lamp. A value of <0, 0, 0> (black) is pointless since it essentially turns off the lamp.

See Also: lamp

1.53 lamp.spread

Subelement: spread
Shorthand: None
Data type: Real
Legal values: greater than zero
Default value: 15.0

This subelement is optional for local lamps and ineffective for directional lamps.

Description:

For "spotlight" type lamps, defines the spread angle of the spotlight in degrees. For a value of 45.0, the lamp will emit a cone of light which is 45 degrees in angle.

The pointat subelement must be defined in order for "spread" to be effective.

See Also: lamp
power

1.54 lamp.power

Subelement: power
Shorthand: pow
Data type: Real
Legal values: Greater than zero
Default value: HUGE

This subelement is optional for local lamps and ineffective for directional lamps.

Description:

For "spotlight" type lamps, defines how sharp the edges of the spotlight circle will be. Higher values increase sharpness.

See Also: lamp
spread

1.55 lamp.radius

Subelement: radius
Shorthand: None
Data type: Real
Legal values: Greater than or equal to zero
Default value: 0.0

This subelement is optional for local lamps and ineffective for directional lamps.

Description:

Causes the lamp to be a spherical extended light source with a radius of the given value. If a radius other than 0.0 is specified, than numrays controls the number of shadow rays cast to this lamp.

Using extended light sources will causes shadows to "soften", making them more realistic. However, trace time increases dramatically, just as if several lamps were added to the scene. This subelement is recommended for use in final images only.

See Also: lamp

1.56 lamp.distance

Subelement: distance

Shorthand: dist

Data type: Real

Legal values: Greater than or equal to zero

Default value: HUGE

This subelement is optional for local lamps and ineffective for directional lamps.

Description:

Specifies the distance from the lamp at which the light fades away. Objects farther away from the source than the indicated value will not be lit by the lamp. Objects closer to the lamp will be more brightly lit. The default value of HUGE is sufficiently large to cause all objects to be fully lit in most scenes.

See Also: lamp

1.57 lamp.numrays

Subelement: numrays

Shorthand: nrays

Data type: Int

Legal values: Greater than zero

Default value: 1

This subelement is optional for local lamps and ineffective for directional lamps.

Description:

Indicates how many rays will be traced to the lamp in order to compute shadows. The actual number of shadow rays per lamp is the square of the value given; i.e., a value of 3 causes 9 rays to be cast in shadow computation for this lamp. The default value of one essentially cause the lamp to be a point,

rather than extended, source.

See Also: lamp
 radius

1.58 lamp.pointat

Subelement: pointat
Shorthand: None
Data type: Point
Legal values: All values legal for Point.
Default value: <0, 0, 0>

This subelement is optional for local lamps and ineffective for directional lamps.

Description:

For "spotlight" type lamps, defines the location in three dimensional space at which the spotlight should point.

See Also: lamp
 spread
 power

1.59 lamp.noshad

Subelement: noshad
Shorthand: None
Data type: None
Legal values: None
Default value: None

This subelement is optional for all lamps.

Description:

Causes no shadow computation to be done for this lamp. Full shading computations are still done, but no shadows will be cast by the lamp. (Great for rendering vampires.)

See Also: lamp

1.60 lamp.direct

Subelement: direction
Shorthand: direct
Data type: Vector
Legal values: All values legal for Vector.
Default value: None

This subelement is mandatory for directional lamps and illegal for local lamps.

Description:

Indicates the direction in which light travels from a directional lamp.

See Also: lamp

1.61 Vertices

Some primitives, namely triangles can be described by using named vertices. This form of declaration is useful in creating polygon meshes and is most commonly used by programs which translate other object formats into Magic Camera scripts.

To declare a named vertex:

```
vertex Identifier Point
```

Example:

```
vertex vert1 <13, 2, 6>
```

This will create a vertex named "vert1" at the point <13, 2, 6>.

Once a group of vertices is no longer needed, the "flushverts" command should be used. This frees up the memory used by all the named vertices which have been declared. The "flushverts" command takes no arguments.

1.62 Surface Characteristics

Obviously, there must be some way to control the appearance of objects which are in the scene. Magic Camera provides two basic ways in which an object's characteristics can be altered: surface color, and surface texture.

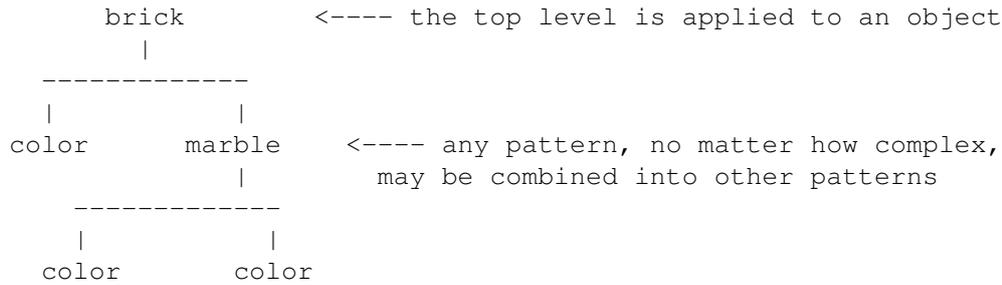
The color of a surface is controlled by pattern elements. Pattern elements can range from simple colors to procedural textures to bitmapped patterns created using your favorite paint program or scanner.

Normally, all objects appear smooth. However, this produces unrealistic images, since objects in the real world have different textures. Magic camera allows texture definitions to be attached to objects. Textures may be either procedural or bump-mapped.

1.63 Patterns

Magic Camera has very powerful pattern generation features. Patterns can be defined in heirarchical trees. This means that one pattern can be used to define how other patterns are applied. For example, a marble pattern may be used to combine two color patterns to produce a marble surface. The brick pattern may then be used to combine the resulting marble surface with another color pattern, generating a wall made up of marble bricks.

Hopefully, this diagram will help explain:



By carefully combining patterns, you can create extremely complex patterns. Use your imagination!!

There are three types of patterns used by Magic Camera: simple, procedural, and bitmapped.

Simple patterns are always on the lowest levels of pattern trees. They are the building blocks for all other pattern types. Simple patterns are define using color.

Procedural patterns use some type of built-in algorithm to mix other patterns. The following are Magic Camera's pre-defined procedural patterns:

- check
- brick
- marble
- wood
- clouds
- blotch

The last four procedural patterns can often be used to create some very interesting patterns. Remember, clouds need not be white on a blue sky (they don't even need to be on the sky!!), and wood can be so mangled as to not look even remotely like wood, if that's what you want. Play with these, and you'll find you can do some creative things with them.

Bitmapped patterns are also very useful. They can be used to put pictures on wall, create street signs, or even put labels on soda bottles. The various bit-mapped patterns all use information loaded by the bitmap command. However, they differ in how the bitmap is applied to the object. The bitmap may be "stamped" onto the object using the wrapflat pattern. The wrapsphere and wrapcylinder patterns have more of a "shrink wrap" effect, as if a spherical or cylindrical picture were placed around the object and shrunk onto it until it fit tightly.

1.64 Pattern Name

This field is of type identifier, and "names" the pattern. When the pattern is attached to objects, it will be referenced by this identifier.

1.65 color

The color pattern is the simplest of all pattern definitions, and is used as a basis for defining all other patterns. The format of a color definition is:

```
color patt_name {
  [diffuse color]
  [ambient color]
  [reflect color]
  [filter color]
  [transmit color]
  [index real]
  [speccoef real]
  [specrefl real]
}
```

Please note that although no subelements are mandatory, there must be at least one subelement within the definition.

1.66 color.diffuse

Subelement: diffuse
Shorthand: diff
Data type: Color
Legal values: All legal values for Color
Default value: <1, 1, 1>

This subelement is optional.

Description:

Defines the diffuse color of the pattern. The diffuse color is the color which the pattern appears to be when fully lit.

See also: color
The Magic Camera Color Model

1.67 color.ambient

Subelement: ambient
Shorthand: amb
Data type: Color
Legal values: All legal values for Color

Default value: <.5, .5, .5>

This subelement is optional.

Description:

Defines the amount of ambient light falling on the pattern. Ambient light is light that does not appear to come from any particular light source. This represents the minimum amount of light which will fall on objects with this pattern, even if no lamps are present in the scene.

A good trick for glowing objects, such as neon signs or car tail lights, is to raise the ambient value to <1, 1, 1>, causing the pattern to glow in the dark.

See also: color
 The Magic Camera Color Model

1.68 color.reflect

Subelement: reflect
Shorthand: refl
Data type: Color
Legal values: All legal values for Color
Default value: <0, 0, 0>

This subelement is optional.

Description:

Defines the amount of reflection in the pattern. The default (black) causes no reflections to appear on this pattern. Changing the value causes reflections to be computed, which heightens realism but also increases trace time.

See also: color
 The Magic Camera Color Model

1.69 color.filter

Subelement: filter
Shorthand: filt
Data type: Color
Legal values: All legal values for Color
Default value: <1, 1, 1>

This subelement is optional.

Description:

Defines the filter color of the pattern. For transparent objects, this defines how much light will be filtered as rays pass through the object on a per

unit length basis. The default value (white) causes all light passing through the object to be filtered if the ray travels one or more unit length inside the object.

If a pattern with a filter value of $\langle 0.5, 0, 0 \rangle$ is applied to a sphere of radius 1.0, then rays traveling through the center of the sphere will have all red light filtered out, since the ray travels 2.0 units through the center (radius*2) and half (0.5) of the light is filtered per unit. Rays traveling through the sphere near its edges will have less red light filtered out. Other green and blue light will not be affected.

This subelement is primarily used to create more convincing shadows of transparent objects.

See also: color
 color.transmit
 The Magic Camera Color Model

1.70 color.transmit

Subelement: transmit
Shorthand: trans
Data type: Color
Legal values: All legal values for Color
Default value: $\langle 0, 0, 0 \rangle$

This subelement is optional.

Description:

Defines the color of light transmitted by the pattern. A pattern with a transmit value of $\langle 0, 0, 1 \rangle$ will appear as blue glass. The default value (black) makes the pattern opaque. Changing the value will increase trace time.

Note that, unlike filter, there is no dependence on the length of a ray passing through the object.

See also: color
 color.filter
 The Magic Camera Color Model

1.71 color.index

Subelement: index
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: 1.0

This subelement is optional.

Description:

For transparent patterns, defines the index of refraction. The default value causes no refraction to occur. Larger values increase the amount of refraction.

Refraction, put simply, is the bending of light as it passes through a transparent object.

See also: `color`

1.72 `color.specrefl`

Subelement: `specrefl`

Shorthand: `srefl`

Data type: Real

Legal values: Between zero and one, inclusive

Default value: 0.5

This subelement is optional.

Description:

This is the percentage of light reflected by "specular" reflection. Higher values produce brighter "hot spots" on the pattern.

For the purposes of Magic Camera, specular reflection means reflection of the light source on the pattern. This makes a pattern appear to be shiny.

See also: `color`
`color.speccoef`
The Magic Camera Color Model

1.73 `color.speccoef`

Subelement: `speccoef`

Shorthand: `scoef`

Data type: Real

Legal values: Greater than zero

Default value: 50

This subelement is optional.

Description:

This element controls the "tightness" of the pattern's specular reflection. Higher values produce tighter "hot spots" on the pattern.

For the purposes of Magic Camera, specular reflection means reflection of the light source on the pattern. This makes a pattern appear to be shiny.

See also: `color`
`color.specrefl`

The Magic Camera Color Model

1.74 check

This pattern produces a checkerboard type pattern, with alternating squares of two different surfaces. The format is:

```
check patt_name {  
  pattern1 Identifier  
  pattern2 Identifier  
  [xsize Real]  
  [ysize Real]  
  [zsize Real]  
}
```

1.75 check.pattern1, check.pattern2

Subelement: pattern1, pattern2
Shorthand: patt1, patt2
Data type: Identifier
Legal values: The name of any previously defined pattern
Default value: None

These subelements are mandatory.

Description:

These subelements specify the alternating patterns used in the checkerboard.

See also: check

1.76 check.xsize, check.ysize, check.zsize

Subelement: xsize, ysize, zsize
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: 1.0 for each

These subelements are optional.

Description:

These subelements specify the size of the alternating blocks in the X, Y, and Z dimensions.

See also: check

1.77 brick

This pattern simulates a brick surface. The format is:

```
brick patt_name {
  brick Identifier
  mortar Identifier
  [xsize Real]
  [ysize Real]
  [zsize Real]
  [msize Real]
  [yoffset Real]
  [zoffset Real]
}
```

1.78 brick.brick, brick.mortar

Subelement: brick, mortar
Shorthand: None
Data type: Identifier
Legal values: The name of any previously defined pattern
Default value: None

These subelements are mandatory.

Description:

These subelements specify the patterns used for the "bricks" and the "mortar" in the pattern.

See also: brick

1.79 brick.xsize, brick.ysize, brick.zsize

Subelement: xsize, ysize, zsize
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: xsize = 1.0, ysize = 0.5, zsize = 0.5

These subelements are optional.

Description:

These subelements specify the size of the bricks in the X, Y, and Z dimensions.

See also: brick

1.80 brick.msize

Subelement: msize
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: 0.2

This subelement is optional.

Description:

This subelement specifies the thickness of the mortar between the bricks.

See also: brick

1.81 brick.yoffset, brick.zoffset

Subelement: yoffset, zoffset
Shorthand: None
Data type: Real
Legal values: Any valid Real
Default value: yoffset = 0.5, zoffset = 0.5

These subelements are optional.

Description:

These subelements specify the offset between rows of bricks. As bricks are "stacked" in the Y dimension, each successive row is displaced in the X dimension by "yoffset". As bricks are "stacked" in the Z dimension, each successive row is displaced in the X dimension by "zoffset". Note that there is currently no subelement called "xoffset".

See also: brick

1.82 marble

This pattern creates a rather realistic marble effect. The format is:

```
marble patt_name {  
    pattern Identifier  
    grain Identifier  
    [scale Real]  
    [power Real]  
}
```

1.83 marble.pattern, marble.grain

Subelement: pattern, grain
Shorthand: patt, None
Data type: Identifier
Legal values: The name of any previously defined pattern
Default value: None

These subelements are mandatory.

Description:

These subelements specify the patterns used. The pattern named by "pattern" is the primary pattern of the marble, while the pattern named by "grain" is used for the grain running through the marble.

See also: marble

1.84 marble.scale

Subelement: scale
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: 1.0

This subelement is optional.

Description:

This subelement changes the apparent size of the pattern on the surface of the object. Increasing values cause the pattern to become smaller on the object, while decreasing values cause the pattern to become larger on the object.

See also: marble

1.85 marble.power

Subelement: power
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: 1.0

This subelement is optional.

Description:

This subelement changes the sharpness of the transition between the

"pattern" and "grain" patterns of the marble. It also influences the thickness of the "grain". Increasing values cause sharper transitions, and more "grain". Decreasing values cause transitions to be less sharp, and less "grain" will appear.

See also: marble

1.86 wood

Creates a simulated wood pattern. The format is:

```
wood patt_name {
  pattern Identifier
  grain    Identifier
  [scale Real]
}
```

1.87 wood.pattern, wood.grain

Subelement: pattern, grain

Shorthand: patt, None

Data type: Identifier

Legal values: The name on any previously defined pattern

Default value: None

These subelements are mandatory.

Description:

These subelements specify the patterns used. The pattern named by "pattern" is the primary pattern of the wood, while the pattern named by "grain" is used for the grain running through the wood.

See also: wood

1.88 wood.scale

Subelement: scale

Shorthand: None

Data type: Real

Legal values: Greater than zero

Default value: 1.0

This subelement is optional.

Description:

This subelement changes the apparent size of the pattern on the surface

of the object. Increasing values cause the pattern to become smaller on the object, while decreasing values cause the pattern to become larger on the object.

See also: wood

1.89 clouds

Creates a cloud pattern. The format is:

```
clouds patt_name {
  sky Identifier
  clouds Identifier
  [scale Real]
  [power Real]
  [perturb Real]
  [xphase Real]
  [yphase Real]
  [zphase Real]
}
```

1.90 clouds.sky, clouds.clouds

Subelement: sky, clouds

Shorthand: None

Data type: Identifier

Legal values: The name of any previously defined pattern

Default value: None

These subelements are mandatory.

Description:

These subelements specify the patterns used. The pattern named by "sky" is the background pattern of the sky, while the pattern named by "clouds" is used for the clouds in the sky.

See also: clouds

1.91 clouds.scale

Subelement: scale

Shorthand: None

Data type: Real

Legal values: Greater than zero

Default value: 1.0

This subelement is optional.

Description:

This subelement changes the apparent size of the pattern on the surface of the object. Increasing values cause the pattern to become smaller on the object, while decreasing values cause the pattern to become larger on the object.

See also: clouds

1.92 clouds.power

Subelement: power

Shorthand: pow

Data type: Real

Legal values: Greater than zero

Default value: 1.0

This subelement is optional.

Description:

This subelement causes the clouds to become more or less defined in the sky, and also causes more or less clouds to be present. Increasing values cause fewer, but more sharply defined, clouds. Decreasing values have the opposite effect.

See also: clouds

1.93 clouds.perturb

Subelement: perturb

Shorthand: turb

Data type: Real

Legal values: Greater than zero

Default value: 1.0

This subelement is optional.

Description:

This subelement changes the amount of turbulence in the clouds. Higher values cause more turbulence. Values above two or so give unrealistic results, but sometimes this is desired. Low values may cause too much repetition in the cloud pattern.

See also: clouds

1.94 clouds.xphase, clouds.yphase, clouds.zphase

Subelement: xphase, yphase, zphase
 Shorthand: None
 Data type: Real
 Legal values: All valid values for Real
 Default value: 0.0

These subelements are optional.

Description:

These subelements change the phase of the sine and cosine waves used to create the clouds. By cycling one or more of these values through 360 degrees, the clouds may be animated.

See also: clouds

1.95 wrapsphere

This pattern wraps a bitmapped image onto the object using a sphere as the intermediate surface. The format is:

```
wrapsphere patt_name {
  bitmap Identifier
  pattern Identifier
  [substitute Integer Identifier]
  [dodiffuse]
  [dotransmit]
  [doreflect]
  [xrepeat Real]
  [yrepeat Real]
  [filter Integer]
}
```

The shorthand "wrapsp" may be used in place of "wrapsphere".

One of [dodiffuse], [dotransmit], or [doreflect] must be included.

1.96 wrapsphere.bitmap, wrapcylinder.bitmap, wrapflat.bitmap

Subelement: bitmap
 Shorthand: None
 Data type: Identifier
 Legal values: The name of any previously defined bitmap
 Default value: None

This subelement is mandatory.

Description:

This subelement specifies the bitmap which is to be applied to the object.

See also: wrapsphere
 wrapflat
 wrapcylinder
 Declaring Bitmaps

1.97 wrapsphere.pattern, wrapcylinder.pattern, wrapflat.pattern

Subelement: pattern
Shorthand: patt
Data type: Identifier
Legal values: The name of any previously defined pattern
Default value: None

This subelement is mandatory.

Description:

This subelement specifies the pattern which is used as a basis for the new pattern. Since the bitmap will supply only the diffuse, transmit, and/or reflect values of the new pattern, all other values come from the pattern specified by this subelement.

See also: wrapsphere
 wrapflat
 wrapcylinder
 dodiffuse
 dotransmit
 dorefect

1.98 wrapsphere.substitute, wrapcylinder.substitute, wrapflat.substitute

Subelement: substitute
Shorthand: sub
Data type: Integer Identifier
Legal values: Any integer greater than or equal to zero followed by
 the name of any previously defined pattern
Default value: None

This subelement is optional.

Description:

If the bitmap uses a color look-up table (bitmaps with 256 or fewer colors), it is possible to substitute a previously defined pattern for a color in the look-up table. For example:

```
wrapsp foo {  
    ...
```

```
    sub 4 white_marble
    ...
}
```

This would cause the pattern "white_marble" to be used where ever the color specified by pen number 4 appeared in the bitmap.

See also: wrapsphere
 wrapflat
 wrapcylinder

1.99 wrapsphere.dodiffuse, wrapsphere.dotransmit, wrapsphere.dorefect

Subelement: dodiffuse, dotransmit, dorefect
Shorthand: dodiff, dotrans, dorefl
Data type: None
Legal values: None
Default value: None

At least one of these subelements must be used.

Description:

These subelements cause the color found in the bitmapped image to be used for the diffuse, transmitted, or reflected color of the pattern. These may be used in any combination, so long as at least one appears in the definition.

See also: wrapsphere
 wrapflat
 wrapcylinder

1.100 wrapsphere.xrepeat, wrapsphere.yrepeat

Subelement: xrepeat, yrepeat
Shorthand: xrep, yrep
Data type: Real
Legal values: Greater than zero
Default value: 1.0

These subelements are optional.

Description:

These subelements control how many times the bitmap is repeated around the sphere. The bitmap is repeated "xrepeat" number of times around the equator of the sphere and "yrepeat" number of times between the poles of the sphere.

See also: wrapsphere

1.101 wrapsphere.filter

Subelement: filter
 Shorthand: filt
 Data type: Integer
 Legal values: 1, 3, 5, or 7
 Default value: 3

This subelement is optional.

Description:

Controls the size of the filter used when applying the bitmap. Either no filter is used or a 3x3, 5x5, or 7x7 Gaussian filter is applied (see table). This is necessary because aliasing occurs when mapping the bitmap from object space to screen space. This aliasing manifests itself in the form of jaggies and thin lines which disappear and reappear. Changing this values may improve the quality of the bitmap's appearance.

The values given cause the following filters to be used:

value	filter
1	no filter
3	3x3 Gaussian
5	5x5 Gaussian
7	7x7 Gaussian

Since the aliasing depends on final image resolution and the possibility of magnification through reflections and transmissions by curved surfaces, the only way to find the best filter to use is by playing with the values.

See also: wrapsphere
 wrapflat
 wrapcylinder

1.102 wrapflat

This pattern wraps a bitmapped image onto the object using a plane as the intermediate surface. The format is:

```
wrapflat patt_name {
  bitmap Identifier
  pattern Identifier
  [substitute Integer Identifier]
  [dodiffuse]
  [dotransmit]
  [doreflect]
  [filter Integer]
  [repeatx]
  [repeaty]
  location Point
  xaxis Vector
  yaxis Vector
```

```
[xlength Point]
[ylength Point]
}
```

The shorthand "wrapfl" may be used in place of "wrapflat".

One of [dodiffuse], [dotransmit], or [doreflect] must be included.

1.103 wrapflat.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: All legal values for Point
Default value: None

This subelement is mandatory.

Description:

This subelement defines the location of the plane which is used as an intermediate surface for the pattern mapping. This location corresponds to the <0,0> pixel coordinate of the bitmap.

See also: wrapflat
wrapflat.xaxis
wrapflat.yaxis

1.104 wrapflat.xaxis, wrapflat.yaxis

Subelement: xaxis, yaxis
Shorthand: None
Data type: Vector
Legal values: All legal values for Vector
Default value: None

These subelements are mandatory.

Description:

These subelements define the X and Y axes for the plane which is to be used as the intermediate surface for the pattern mapping. They correspond to the X and Y axes of the bitmap used in the pattern mapping. If xlength or ylength are not given, then the length of these vectors also determine the length in object space that the bitmap extends.

See also: wrapflat
wrapflat.location

1.105 wrapflat.xlength, wrapflat.ylength

Subelement: xlength, ylength
Shorthand: xlen, ylen
Data type: Real
Legal values: Greater than zero
Default value: Computed from xaxis and yaxis

These subelements are optional.

Description:

These subelements define the length of the X and Y axis of the bitmap in object space. If these values are not specified, then they are computed from the length of the vectors specified by xaxis and yaxis. Using these subelements is usually easier than trying to compute the proper length of xaxis and yaxis by hand.

See also: wrapflat

1.106 wrapflat.repeatx, wrapflat.repeaty

Subelement: repeatx, repeaty
Shorthand: repx, repy
Data type: None
Legal values: None
Default value: None

These subelements are optional.

Description:

If either of these flags are set, then the bitmap will be caused to repeat along its X or Y axis (as in a wallpaper pattern). The default action is to not repeat the bitmap along either axis (as in a decal).

See also: wrapflat

1.107 wrapcylinder

This pattern wraps a bitmapped image onto the object using a cylinder as the intermediate surface. The format is:

```
wrapcylinder patt_name {  
    bitmap Identifier  
    pattern Identifier  
    [substitute Integer Identifier]  
    [dodiffuse]  
    [dotransmit]  
    [doreflect]
```

```
[xrepeat Real]
height Real
[filter Integer]
}
```

The shorthand "wrapcy" may be used in place of "wrapcylinder".

One of [dodiffuse], [dotransmit], or [doreflect] must be included.

1.108 wrapcylinder.xrepeat

```
Subelement: xrepeat
Shorthand: xrep
Data type: Real
Legal values: Greater than zero
Default value: 1.0
```

This subelement is optional.

Description:

This subelement controls how many times the bitmap is repeated around the circumference of the cylinder.

See also: wrapcylinder

1.109 wrapcylinder.height

```
Subelement: height
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: None
```

This subelement is mandatory.

Description:

This subelement controls how far the bitmap extends vertically.

See also: wrapcylinder

1.110 blotch

This pattern produces a "patchwork" of other patterns. It is difficult to describe, so see some of the included sample scripts and images to get an idea of what this pattern does. The format is:

```
blotch patt_name {
    scale Real
```

```
    pattern Identifier
}
```

1.111 blotch.scale

Subelement: scale
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: 1.0

This subelement is optional.

Description:

This subelement changes the apparent size of the pattern on the surface of the object. Increasing values cause the pattern to become smaller on the object, while decreasing values cause the pattern to become larger on the object.

See also: blotch

1.112 blotch.pattern

Subelement: pattern
Shorthand: patt
Data type: Identifier
Legal values: The name of any previously defined pattern.
Default value: None

This subelement must be used at least once. It may be repeated as many as 32 times.

Description:

This subelement adds a pattern to the list of those used by "blotch". As many as 32 different patterns may be used by "blotch".

See also: clouds

1.113 Textures

Like patterns, textures are used to add detail to the surfaces of objects. Unlike patterns, which essentially change the color of an object, textures control the apparent "roughness" of the object.

There are two types of textures available in Magic Camera: procedural and bump mapped. Currently, the only procedural texture available is waves.

The "waves" texture gives the appearance of an undulating, wavy surface.

Bump mapped textures are similar to bit mapped patterns. The only difference is that the intensity of the pixels is used to determine the apparent height of that area of the object, instead of the pixels determining the color of the object. The three available bump mapped textures are bumpsphere, bumpcylinder, and bumpflat.

Textures do their work by "tricking" the ray tracer's shading algorithms into believing that the surface of the object is not flat. This shading trick produces the optical illusion that the surface is not flat. However, the actual surface of the object remains flat. This is obvious if the object is viewed "edge on". Because the surface distortions caused by textures are only illusions, at times textures will appear unrealistic. This will happen when they are viewed from a shallow angle (nearly edge on), when lit from certain angles, or if you try to make them appear too extreme.

1.114 Texture Name

This field is of type identifier, and "names" the texture. When the texture is attached to objects, it will be referenced by this identifier.

1.115 Waves

This texture produces a wave-like surface. The format is:

```
waves text_name {
  [ncenters Integer]
  [scale Real]
  [phase Real]
  [size Real]
}
```

Although all subelements are optional, at least one must be present.

1.116 waves.ncenters

Subelement: ncenters
Shorthand: None
Data type: Integer
Legal values: 1 to 50
Default value: 10

This subelement is optional.

Description:

This subelement controls the complexity of the waves. Higher numbers cause more complex waves. Lower numbers cause simpler waves. Using a value of one causes a single ring of waves. Higher values increase the time required to

compute the wave shapes.

See also: waves

1.117 waves.scale

Subelement: scale
Shorthand: None
Data type: Real
Legal values: Greater than 0.0
Default value: 1.0

This subelement is optional.

Description:

This subelement controls the scale of the waves on the object. Higher numbers produce a smaller wave pattern. Lower numbers have the opposite effect.

See also: waves

1.118 waves.phase

Subelement: phase
Shorthand: None
Data type: Real
Legal values: Any value
Default value: 0.0

This subelement is optional.

Description:

This subelement controls the phase, in degrees, of the waves. By cycling this value through 360 degrees, the waves can be made to appear to "roll".

See also: waves

1.119 waves.size

Subelement: size
Shorthand: None
Data type: Real
Legal values: Greater than 0.0
Default value: 1.0

This subelement is optional.

Description:

This subelement controls the height of the waves on the object. Higher numbers produce taller waves. Lower numbers have the opposite effect.

If the is number is too far from zero, the result may become unrealistic. Typical values are between -1.0 and 1.0.

See also: waves

1.120 Spherical Bump Maps

This texture applies a bit map texture to the object using the same geometry as wrapsphere. The format is:

```
bumpsphere text_name {  
    bitmap Identifier  
    [xrepeat Real]  
    [yrepeat Real]  
    [size Real]  
}
```

The shorthand "bumpsp" is an acceptable substitution for "bumpsphere".

1.121 bumpsphere.xrepeat, bumpsphere.yrepeat

Subelement: xrepeat, yrepeat
Shorthand: xrep, yrep
Data type: Real
Legal values: Greater than zero.
Default value: 1.0

These subelements are optional.

Description:

These subelements control how many times the bitmap is repeated around the sphere. The bitmap is repeated "xrepeat" number of times around the equator of the sphere and "yrepeat" number of times between the poles of the sphere.

See also: bumpsphere

1.122 bumpsphere.bitmap, bumpcylinder.bitmap, bumpflat.bitmap

Subelement: bitmap
Shorthand: None
Data type: Identifier

Legal values: Any previously defined bitmap.
Default value: None

This subelement is mandatory.

Description:

This subelement defines which bitmap should be used to apply the texture to the object.

See also: bumpsphere
 bumpcylinder
 bumpflat

1.123 bumpsphere.size, bumpcylinder.size, bumpflat.size

Subelement: size
Shorthand: None
Data type: Real
Legal values: Greater than 0.0
Default value: 1.0

This subelement is optional.

Description:

This subelement controls the height of the texture on the object. Higher numbers produce taller bumps. Lower numbers have the opposite effect.

If the is number is too far from zero, the results may become unrealistic. Typical values are between -1.0 and 1.0.

See also: bumpsphere
 bumpcylinder
 bumpflat

1.124 Cylindrical Bump Maps

This texture applies a bit map texture to the object using the same geometry as wrapcylinder. The format is:

```
bumpcylinder text_name {  
    bitmap Identifier  
    [xrepeat Real]  
    [height Real]  
    [size Real]  
}
```

The shorthand "bumpcy" is an acceptable substitution for "bumpcylinder".

1.125 bumpcylinder.xrepeat

Subelement: xrepeat
Shorthand: xrep
Data type: Real
Legal values: Greater than zero
Default value: 1.0

This subelement is optional.

Description:

This subelement controls how many times the bitmap is repeated around the circumference of the cylinder.

See also: bumpcylinder

1.126 wrapcylinder.height

Subelement: height
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: None

This subelement is mandatory.

Description:

This subelement controls how far the bitmap extends vertically.

See also: bumpcylinder

1.127 Flat Bump Maps

This texture applies a bit map texture to the object using the same geometry as wrapflat. The format is:

```
bumpflat text_name {  
    bitmap Identifier  
    size Real  
    [repeatx]  
    [repeaty]  
    location Point  
    xaxis Vector  
    yaxis Vector  
    [xlength Point]  
    [ylength Point]  
}
```

The shorthand "bumpfl" is an acceptable substitution for "bumpflat".

1.128 bumpflat.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: All legal values for Point
Default value: None

This subelement is mandatory.

Description:

This subelement defines the location of the plane which is used as an intermediate surface for the bump mapping. This location corresponds to the $\langle 0,0 \rangle$ pixel coordinate of the bitmap.

See also: bumpflat
bumpflat.xaxis
bumpflat.yaxis

1.129 bumpflat.xaxis, bumpflat.yaxis

Subelement: xaxis, yaxis
Shorthand: None
Data type: Vector
Legal values: All legal values for Vector
Default value: None

These subelements are mandatory.

Description:

These subelements define the X and Y axes for the plane which is to be used as the intermediate surface for the bump mapping. They correspond to the X and Y axes of the bitmap used in the bump mapping. If xlength or ylength are not given, then the length of these vectors also determine the length in object space that the bitmap extends.

See also: bumpflat
bumpflat.location

1.130 bumpflat.xlength, bumpflat.ylength

Subelement: xlength, ylength
Shorthand: xlen, ylen
Data type: Real
Legal values: Greater than zero
Default value: Computed from xaxis and yaxis

These subelements are optional.

Description:

These subelements define the length of the X and Y axis of the bitmap in object space. If these values are not specified, then they are computed from the length of the vectors specified by `xaxis` and `yaxis`. Using these subelements is easier than trying to compute the proper length of `xaxis` and `yaxis` by hand.

See also: `bumpflat`

1.131 `bumpflat.repeatx`, `bumpflat.repeaty`

Subelement: `repeatx`, `repeaty`
Shorthand: `repx`, `repy`
Data type: None
Legal values: None
Default value: None

These subelements are optional.

Description:

If either of these flags are set, then the bitmap will be caused to repeat along its X or Y axis (as in a wallpaper pattern). The default action is to not repeat the bitmap along either axis (as in a decal).

See also: `bumpflat`

1.132 Primitive Object Types

Primitives are the basic building blocks of the objects found lying about ray traced scenes. No matter what you see, all Magic Camera scenes are filled with triangles, parallelograms, planes, spheres, and rings.

Triangles and parallelograms make up the bulk of the objects seen, although they are the least common found in scripts. Most often, they are specified indirectly by using constructed elements such as boxes, spins, and extrudes.

The primitive elements are:

- Triangles
- Parallelograms
- Planes
- Spheres
- Rings

1.133 `pattern`

Subelement: pattern
Shorthand: patt
Data type: Identifier
Legal values: The name of any previously declared pattern
Default value: None

This subelement is mandatory for all primitives and all constructed elements.

Description:

Attaches a named pattern to a primitive.

1.134 texture

Subelement: texture
Shorthand: text
Data type: Identifier
Legal values: The name of any previously declared texture
Default value: None

This subelement is optional for all primitives and all constructed elements.

Description:

Attaches a named texture to an object.

1.135 origin

Subelement: origin
Shorthand: None
Data type: Point
Legal values: Any legal value for Point
Default value: None

This subelement is optional for all primitives and all constructed elements.

Description:

Causes the given point to be considered the origin for pattern and texture computation. If you are building an object and require no discontinuities ←
in
patterns and textures across the boundaries of individual elements, then use the " ←
origin"
statement to give them the same reference point for pattern computation.

Normally, the origin is derived from some part of the element's description, normally the "location" statement. The "origin" statement overrides this, giving better user control.

1.136 offtree

Subelement: offtree
 Shorthand: None
 Data type: None
 Legal values: None
 Default value: None

This subelement is optional for all primitives and all constructed elements.

Description:

Occasionally, a single primitive will be so large as to interfere with octree construction. In this case, use the "offtree" flag to cause the object to be considered a global object and not be added to the octree. ←

The only example I can give of the usefulness of this is a script I was working on in which a spacecraft was in the foreground with a planet (a large sphere) in the background. The sphere was large enough to dwarf the spacecraft, and caused the octree to become heavily unbalanced. I added this flag to prevent this, and trace time was reduced considerably.

Keep in mind that this flag causes the object to generate an intersect test for ALL rays traced (which doesn't normally happen), so use it sparingly.

1.137 Triangles

The triangle primitive creates a single triangle. Like the parallelogram primitive, it is rarely used directly in scripts. Its most common use is by programs which translate other object formats into Magic Camera scripts. ←

There are two formats for the triangle primitive. One uses named vertices, the other does not.

Without named vertices:

```
triangle {
  location Point
  v1 Vector
  v2 Vector
  pattern Identifier
  [texture] Identifier]
  [origin Point]
  [offtree]
}
```

Using named vertices:

```
triangle {
  p1 Identifier
  p2 Identifier
```

```
p3 Identifier
pattern Identifier
[texture Identifier]
[origin Point]
[offtree]
}
```

In either case, the shorthand "tri" can be used in place of the full word "triangle"

1.138 triangle.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: Any legal value for Point
Default value: None

This subelement is mandatory.

Description:

Defines the location of the first corner of the triangle. This point is also considered the origin for pattern and texture computation.

See Also: triangle
origin

1.139 triangle.v1, triangle.v2

Subelement: v1, v2
Shorthand: None
Data type: Vector
Legal values: Any legal value for Vector
Default value: None

These subelements are mandatory.

Description:

Defines the vectors from the location of the triangle to the second and third corners of the triangle. Note that these are vectors, and not absolute points.

Example:

If the triangle to be created has the corners $\langle 3, 4, 2 \rangle$, $\langle 4, 2, 1 \rangle$, and $\langle 4, 3, 3 \rangle$, the location would be $\langle 3, 4, 2 \rangle$, v1 would be $\langle 1, -2, -1 \rangle$, and v3 would be $\langle 1, -1, 1 \rangle$.

See Also: triangle

1.140 triangle.p1, triangle.p2, triangle.p3

Subelement: p1, p2, p3
Shorthand: None
Data type: Identifier
Legal values: Any previously declared vertex.
Default value: None

These subelements are mandatory.

Description:

Defines the vertices to be used as the three corners of the triangle. The vertex named by p1 is considered to be the origin for pattern and texture computations.

See Also: triangle
origin

1.141 Parallelograms

The parallelogram primitive is very similar to the triangle primitive, except that a four-sided parallelogram is created. Also, the parallelogram declaration does not allow vertex based definitions.

When defining a parallelogram, only three points are explicitly specified. The fourth is computed from these three. This is because, for parallelograms, when three points are given, there is only one possible point which will complete the parallelogram.

The definition:

```
parallelogram {  
    location Point  
    v1 Vector  
    v2 Vector  
    pattern Identifier  
    [texture] Identifier]  
    [origin Point]  
    [offtree]  
}
```

Sharp observers will note that this is exactly the same as for triangles.

The shorthand "paragram" can be used in place of the full word "parallelogram". The term "quad" will also be accepted for historical reasons.

1.142 parallelogram.location

Subelement: location
Shorthand: loc

Data type: Point
Legal values: Any legal value for Point
Default value: None

This subelement is mandatory.

Description:

Defines the location of the first corner of the parallelogram. This point is also considered the origin for pattern and texture computation.

See Also: parallelogram
origin

1.143 parallelogram.v1, parallelogram.v2

Subelement: v1, v2
Shorthand: None
Data type: Vector
Legal values: Any legal value for Vector
Default value: None

These subelements are mandatory.

Description:

Defines the vectors from the location of the parallelogram to the second and third corners of the parallelogram. The fourth corner of the parallelogram is computed by adding location, v1, and v2 together.

Note that these are vectors, not absolute points.

Example:

If the parallelogram to be created has the corners $\langle 3, 4, 2 \rangle$, $\langle 4, 2, 1 \rangle$, $\langle 4, 3, 3 \rangle$, and $\langle 5, 1, 2 \rangle$, the location would be $\langle 3, 4, 2 \rangle$, v1 would be $\langle 1, -2, -1 \rangle$, and v3 would be $\langle 1, -1, 1 \rangle$.

See Also: parallelogram

1.144 Planes

A plane is an infinite flat surface. The most common use of a plane is to define the "ground" or "floor" of a scene. The definition of a plane looks similar to that of a triangle or a parallelogram. Note that a plane does not have the "offtree" subelement, since a plane is infinite and therefore cannot be bounded by an octree.

```
plane {  
    location Point  
    v1 Vector  
    v2 Vector
```

```
    pattern Identifier
    [texture] Identifier]
    [origin Point]
}
```

1.145 plane.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: Any legal value for Point
Default value: None

This subelement is mandatory.

Description:

Defines one point through which the plane will pass. This point is also considered the origin for pattern and texture computation.

See Also: plane
origin

1.146 plane.v1, plane.v2

Subelement: v1, v2
Shorthand: None
Data type: Vector
Legal values: Any legal value for Vector
Default value: None

These subelements are mandatory.

Description:

Defines the vectors with which the plane will be parallel. Another way to think of it is that the plane will pass through the points specified by location, location plus v1, and location plus v2.

Example:

If the plane to be created is to pass through the points $\langle 0, 5, 0 \rangle$, $\langle 3, 4, 1 \rangle$, and $\langle 2, 2, 3 \rangle$, the location would be $\langle 0, 5, 0 \rangle$, v1 would be $\langle 3, -1, 1 \rangle$, and v2 would be $\langle 2, -3, 3 \rangle$.

To define a ground plane:

```
plane {
    loc    <0, 0, 0>
    v1    <1, 0, 0>
    v2    <0, 0, 1>
    patt  ground.patt
}
```

```
}
```

See Also: `plane`

1.147 Spheres

Using the "sphere" element creates a "perfect" sphere (as opposed to a "geometric" sphere made up of several triangles).

The definition of a sphere is:

```
sphere {  
  location Point  
  radius Real  
  pattern Identifier  
  [texture] Identifier]  
  [origin Point]  
  [offtree]  
}
```

Note: A sphere cannot be rotated. If a sphere is rotated, the pattern or texture attached to the sphere will not appear to rotate with the sphere (it will not move at all), so the sphere will appear as if it has not rotated. To produce spheres which behave properly under all transformations, use `psphere`.

1.148 sphere.location

Subelement: `location`
Shorthand: `loc`
Data type: `Point`
Legal values: Any legal value for `Point`
Default value: `None`

This subelement is mandatory.

Description:

Defines the center of the sphere. This point is also considered the origin for pattern and texture computation.

See Also: `sphere`
`origin`

1.149 sphere.radius

Subelement: `radius`
Shorthand: `None`
Data type: `Real`
Legal values: Greater than zero

Default value: None

This subelement is mandatory.

Description:

Defines the radius of the sphere.

See Also: sphere

1.150 Rings

To create a ring or disk shape, use the "ring" element.

The definition of a ring is:

```
ring {
  location Point
  v1 Vector
  v2 Vector
  in Real
  out Real
  pattern Identifier
  [texture Identifier]
  [origin Point]
  [offtree]
}
```

Note: Rotating a ring has unpredictable results. If a pattern or texture is attached to the ring, the pattern or texture may appear to rotate in an unusual manner. Otherwise, the ring itself will rotate normally. Fully transformable rings can be created using the spin construct.

1.151 ring.location

Subelement: location

Shorthand: loc

Data type: Point

Legal values: Any legal value for Point

Default value: None

This subelement is mandatory.

Description:

Defines the center of the ring. This point is also considered the origin for pattern and texture computation.

See Also: ring
origin

1.152 ring.v1, ring.v2

Subelement: v1, v2
Shorthand: None
Data type: Vector
Legal values: Any legal value for Vector
Default value: None

These subelements are mandatory.

Description:

Defines the vectors with which the plane on which the ring lies will be parallel. Another way to think of it is that the ring will lie on a plane which will pass through the points specified by location, location plus v1, and location plus v2.

Example:

If the ring to be created is to pass through the points $\langle 0, 3, 0 \rangle$ and be parallel to the plane $y=0$, the location would be $\langle 0, 3, 0 \rangle$, v1 would be $\langle 1, 0, 0 \rangle$, and v2 would be $\langle 0, 0, 1 \rangle$.

See Also: ring

1.153 ring.in, ring.out

Subelement: in, out
Shorthand: None
Data type: Real
Legal values: "in" must be greater than or equal to zero.
"out" must be greater than "in".
Default value: None

These subelements are mandatory.

Description:

Defines the inner and outer radii of the ring. If the inner radius is equal to zero, a disk will be formed instead of a ring.

See Also: ring

1.154 Primitive Constructions

As you can imagine, building complex shapes from triangles can be a trying task. In order to help out, the Magic Camera parsing routines can build some shapes for you. These shapes include rotational solids ("lathed" objects), extruded objects, etc. These are the primary means of building objects using Magic Camera.

The types of constructed objects supported are:

- Height Fields
- Rotational Solids
- Boxes
- Extrusions
- Filled Polygons
- Skinned Polygon Frames
- Polygon Spheres

1.155 Smoothing Constructions

Subelement: smooth
Shorthand: None
Data type: None
Legal values: None
Default value: None

This subelement is optional.

Description:

This flag causes the smoothing algorithms to be applied to the construction. It is equivalent to placing the construction inside of a "smoothon/smoothoff" pair.

See Also: Smoothing

1.156 Height Fields

A height field is used to build terrain-like objects. Essentially, a plane is built from a grid of triangles. The vertices of the triangles are the perturbed vertically from the plane according to data read in from a separate file (see `hfield.file` for the format of this file). The format for a height field is:

```
hfield {  
  location Point  
  v1 Vector  
  v2 Vector  
  [up Vector]  
  [height Real]  
  [floor Real]  
  file Filename  
  pattern Identifier  
  [texture Identifier]  
  [origin Point]  
  [smooth]
```

```
}
```

1.157 hfield.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: any legal value
Default value: None

This subelement is mandatory.

Description:

Defines the location of the plane which is used to build the height field. It is similar to plane.location

See Also: hfield

1.158 hfield.v1, hfield.v2

Subelement: v1, v2
Shorthand: None
Data type: Vector
Legal values: any legal value
Default value: None

These subelement are mandatory.

Description:

Defines the two vectors along which lies the plane used to build the height field. It is similar to plane.v1 and plane.v2

See Also: hfield

1.159 hfield.up

Subelement: up
Shorthand: None
Data type: Vector
Legal values: any legal value
Default value: Computed from hfield.v1 and hfield.v2

This subelement is optional.

Description:

Defines the direction which is considered "up" from the plane of the height field. If it is not specified, it is computed to be perpendicular to the plane (the cross product of `hfield.v1` and `hfield.v2`).

See Also: `hfield`

1.160 `hfield.height`

Subelement: `height`
Shorthand: None
Data type: Real
Legal values: any legal value
Default value: 1.0

This subelement is optional.

Description:

Defines the height of the height field. This values read from `hfield.file` are multiplied by this number, providing easy scaling of the field \leftrightarrow without having to rewrite the (potentially large) file. The height of any point in the field is computed by:

$$\text{height} = \text{data} * \text{hfield.height} - \text{hfield.floor}$$

Where "data" is the value read from `hfield.file` for that point. If the value of height is less than zero, it is set to zero.

See Also: `hfield`

1.161 `hfield.floor`

Subelement: `floor`
Shorthand: None
Data type: Real
Legal values: any legal value
Default value: 0.0

This subelement is optional.

Description:

Defines the minimum value used in the height field. This value is subtracted from all data points in the height field. The height of any point in the field is computed by:

$$\text{height} = \text{data} * \text{hfield.height} - \text{hfield.floor}$$

Where "data" is the value read from hfield.file for that point. If the value of height is less than zero, it is set to zero.

See Also: hfield

1.162 hfield.file

Subelement: file
Shorthand: None
Data type: Filename
Legal values: the name of any existing file
Default value: None

This subelement is mandatory.

Description:

Tells the parser which file to read the height data from. All numbers in the file are ASCII, so you can create the file with a text editor. The data in the file must have the following format:

1. An integer value (dim) giving the dimension of the data. If this value is 8, then the data forms an 8x8 array.
2. Dim squared floating point values. If dim=8, then there must be 64 floating point values in the file. These values form an array, with the X dimension increasing across the rows, and the Y dimension increasing down the columns.

There are no provisions for comments in the file. An example file follows:

```
4
1.0 .7 .7 1.4
.8 .2 .2 .6
.2 .3 .4 .2
.5 .4 .6 .6
```

See Also: hfield

1.163 Rotational Solids (Spins)

A rotational solid is an object created by spinning a shape about an axis. These are the types of objects often created on a woodworker's lathe. Any object that is circularly symmetrical can be created using the "spin" command. The format is:

```
spin {
    location Point
    [segments Integer]
```

```
    slice Identifier
    [start Real]
    [end Real]
    [rise Real]
    [fillfirst]
    [filllast]
    pattern Identifier
    [texture Identifier]
    [origin Point]
    [smooth]
}
```

NOTE: Currently, all spins are made around the Y axis.

1.164 spin.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: all legal values
Default value: None

This subelement is mandatory.

Description:

Gives the location at which the spin is placed. This point will be the point at which any point $\langle 0, 0 \rangle$ in the given slice is located.

See Also: spin

1.165 spin.segments

Subelement: segments
Shorthand: segs
Data type: Integer
Legal values: greater than or equal to 3
Default value: 8

This subelement is optional.

Description:

Tells how many different "segments" the spin will be broken into. Since the spin is made from individual triangles, it has flat sides. This subelement determines how many flat sides there are to the spin. Increasing this number produces rounder looking spins, but causes more triangles to be generated, increasing memory consumption and rendering time.

See Also: spin

1.166 spin.slice

Subelement: slice
Shorthand: None
Data type: Identifier
Legal values: the name of any previously defined slice
Default value: None

This subelement is mandatory.

Description:

Gives the name of the slice which defines the shape to be rotated. In this slice, the first coordinate of each 2-D point indicates the radius, the second of each pair indicates the height above (or below, for negative numbers) `spin.location`.

See Also: `spin`

1.167 spin.start, spin.end

Subelement: start, end
Shorthand: None
Data type: Real
Legal values: all legal values, end must be larger than start
Default value: start=0.0, end=360.0

These subelements are optional.

Description:

These two subelements allow spins which are not exactly 360 degrees around. Each takes a value in degrees of where the spin is to start or to end. Zero degrees corresponds to the positive X axis.

Note that the values can be greater than 360 degrees, this is particularly useful in creating spiral shapes which spiral around for more than one revolution.

See Also: `spin`
`spin.rise`
`spin.fillfirst`, `spin.filllast`

1.168 spin.rise

Subelement: rise
Shorthand: None
Data type: Real
Legal values: all legal values
Default value: 0.0

This subelement is optional.

Description:

If a value for rise is specified, spiraling shapes can be made. As the slice is rotated about the axis, it is shifted upwards (or downwards, for negative values) so that the end of the spin is "rise" units higher than the first.

See Also: spin

1.169 spin.fillfirst, spin.filllast

Subelement: fillfirst, filllast

Shorthand: first, last

Data type: None

Legal values: None

Default value: None

These subelements are optional.

Description:

When using spin.start, spin.end or spin.rise, the start and end of the spin will be unfilled, or open ended. Specifying "fillfirst" or "filllast" closes the starting slice or ending slice, respectively.

See Also: spin

1.170 Boxes

Sometimes you just want to create a simple box. This is how you do it:

```
box {
  location Point
  v1 Vector
  v2 Vector
  v3 Vector
  pattern Identifier
  [texture Identifier]
  [origin Point]
  [smooth]
}
```

1.171 box.location

Subelement: location
 Shorthand: loc
 Data type: Point
 Legal values: All legal values
 Default value: None

This subelement is mandatory.

Description:

Determines the location of one corner of the box. The other locations are determined by box.v1, box.v2, and box.v3.

See Also: box

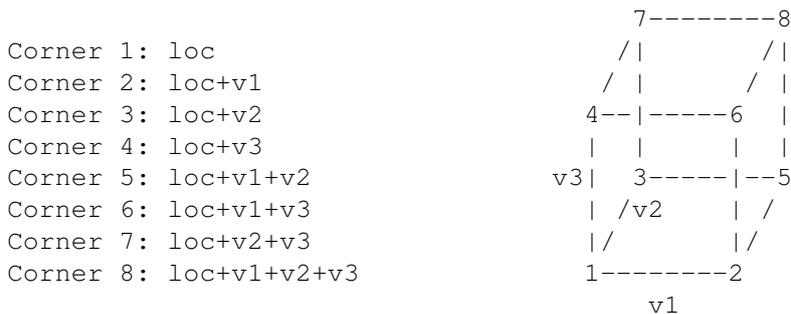
1.172 box.v1, box.v2, box.v3

Subelement: v1, v2, v3
 Shorthand: None
 Data type: Vector
 Legal values: All legal values
 Default value: None

These subelements are mandatory.

Description:

Determines the location of the corners of the box in relation to box.location. The exact locations of the eight corners of the box are determined by:



Note that v1, v2, and v3 do not have to be orthogonal. That is, the box can be slanted.

See Also: box

1.173 Filled Slices

Filling a previously defined slice is an easy way to create a complex polygon from triangles. The format for a fill is:

```
fill {
  location Point
  slice Identifier
  [hole Identifier]
  xaxis Vector
  yaxis Vector
  pattern Identifier
  [texture Identifier]
  [origin Point]
}
```

1.174 fill.location

Subelement: location
Shorthand: loc
Data type: Point
Legal values: All legal values
Default value: None

This subelement is mandatory.

Description:

Determines the location of the fill. The point <0, 0> in fill.slice would be placed here.

See Also: fill

1.175 fill.slice

Subelement: slice
Shorthand: None
Data type: Identifier
Legal values: Any previously defined slice
Default value: None

This subelement is mandatory.

Description:

Determines which slice is to be used in the fill. This slice defines the outline of the polygon. The slice must have been defined using the "closed" subelement. The slice may not cross itself, that is, no edge of the slice may cross any other edge of the slice.

See Also: fill

1.176 fill.hole

Subelement: hole
Shorthand: None
Data type: Identifier
Legal values: Any previously defined slice
Default value: None

This subelement is optional.

Description:

This slice is used to cut a hole from inside the filled polygon. The slice must have been defined using the "closed" subelement. The hole must be completely contained within the slice being filled and may not cross itself, that is, no edge of the hole may cross any other edge of the hole. Currently, only one hole may be used per fill.

See Also: fill

1.177 fill.xaxis, fill.yaxis

Subelement: xaxis, yaxis
Shorthand: None
Data type: Vector
Legal values: All legal values
Default value: None

These subelements are mandatory.

Description:

Determines the orientation of the polygon in 3D space. The xaxis corresponds with the first coordinate in the slice's 2D pair, the yaxis corresponds with the second.

See Also: fill

1.178 Skinned Polygon Frames

This command will allow you to build very complex shapes in much the same manner as is used to build wooden model airplanes. Previously defined slices are used as "forms" or "ribs", and a skin is stretched over these slices. The format is:

```
skin {  
  slice Identifier Point Vector Vector  
  fillfirst  
  filllast  
  pattern Identifier
```

```
[texture Identifier]
[origin Point]
[smooth]
}
```

1.179 skin.slice

Subelement: slice
Shorthand: None
Data type: Identifier Point Vector Vector
Legal values: Any previously define slice, any legal values for the point and the vectors
Default value: None

This subelements is mandatory. It may be repeated as many times as is necessary.

Description:

This complex subelement takes four arguments. The first is the name of a slice which is to be used as the form for this section of the skin. The second is a point which gives the location of the form in 3D space. The two vectors are the X and Y axes for on which the slice is oriented. The skin will be built over the slices in the order that they appear. At least two slices must appear. All slices must be either closed or not closed.

See Also: skin

1.180 skin.fillfirst, skin.filllast

Subelement: fillfirst, filllast
Shorthand: first, last
Data type: None
Legal values: None
Default value: None

These subelements are optional.

Description:

Causes either the first and/or the last of the slices to be filled.

See Also: skin

1.181 Extrusions

This is a simple version of the skin command. It allows only one slice to be used. Essentially, that slice is stretched, or extruded, from two dimensions into three. This could be used, for example, to create a 3D font. The format is:

```
extrude {
  location Point
  xaxis Vector
  yaxis Vector
  slice Identifier
  direct Vector
  length Real
  fillfirst
  filllast
  pattern Identifier
  [texture Identifier]
  [origin Point]
  [smooth]
}
```

1.182 extrude.location

Subelement: location
Shorthand: loc
Data type: Vector
Legal values: All legal values
Default value: None

This subelement is mandatory.

Description:

The location of the extrude.

See Also: extrude

1.183 extrude.xaxis, extrude.yaxis

Subelement: xaxis, yaxis
Shorthand: None
Data type: Vector
Legal values: All legal values
Default value: None

These subelements are mandatory.

Description:

Determines the orientation of the extrude in 3D space.

See Also: extrude

1.184 extrude.slice

Subelement: slice
Shorthand: None
Data type: Identifier
Legal values: The name of a previously defined slice
Default value: None

This subelement is mandatory.

Description:

Names the slice to be used in the extrude.

See Also: extrude

1.185 extrude.direct

Subelement: direct
Shorthand: dir
Data type: Vector
Legal values: All legal values
Default value: None

This subelement is mandatory.

Description:

Determines the direction (away from extrude.loc) in which the extrusion will be done. If extrude.length is not specified, the length of this vector determines the length of the extrude.

See Also: extrude

1.186 extrude.length

Subelement: length
Shorthand: len
Data type: Real
Legal values: Greater than zero
Default value: Computed from extrude.direct

This subelement is optional.

Description:

Determines the length of the extrusion. If this subelement is defined, the length of the `extrude.direct` is irrelevant.

See Also: `extrude`

1.187 `extrude.fillfirst, extrude.filllast`

Subelement: `fillfirst, filllast`
Shorthand: `first, last`
Data type: `None`
Legal values: `None`
Default value: `None`

These subelements are optional.

Description:

These subelements cause either the front and/or rear faces of the `extrude` to be filled.

See Also: `extrude`

1.188 Spheres

Using the `"psphere"` element creates a "geometric" sphere made up of several triangles.

The definition of a `psphere` is:

```
psphere {
  location Point
  radius Real
  pattern Identifier
  hsegments Integer
  vsegments Integer
  [texture] Identifier]
  [origin Point]
  [offtree]
  [smooth]
}
```

1.189 `psphere.location`

Subelement: `location`
Shorthand: `loc`
Data type: `Point`

Legal values: Any legal value for Point
Default value: None

This subelement is mandatory.

Description:

Defines the center of the sphere. This point is also considered the origin for pattern and texture computation.

See Also: psphere
origin

1.190 psphere.radius

Subelement: radius
Shorthand: None
Data type: Real
Legal values: Greater than zero
Default value: None

This subelement is mandatory.

Description:

Defines the radius of the sphere.

See Also: psphere

1.191 psphere.hsegments, psphere.vsegments

Subelement: hsegments, vsegments
Shorthand: hsegs, vsegs
Data type: Integer
Legal values: 3 or higher
Default value: 16, 8

This subelement is optional.

Description:

Defines how many division will make up the sphere. The value of hsegments defines the number of divisions around the equator. The value of vsegments defines the number of divisions between the poles. Higher values make better spheres but increase trace time.

See Also: psphere

1.192 Named Objects and Instancing

In order to allow animation, Magic Camera is capable of naming and instancing objects. This works by giving an object, or a group of objects, a name, and then invoking that object by instancing it. This allows an object to be described once and used many times, and it allows an object to be moved, rotated, and scaled.

To name an object, enclose it inside an object/endobject pair:

```
object object_name

/* primitives and constructions here */

endobject
```

Where "object_name" is an Identifier which will be used as the name of the object. All primitives and constructions inside the object/endobject pair will belong to the named object. Other elements, such as patterns and textures, may appear inside the object/endobject pair, but they will not specifically belong to that object.

When primitives and constructions appear inside an object/endobject pair, they will not be immediately added to the scene. To make them a part of the scene, they must be instanced:

```
instance object_name
```

A more complex form of instancing allows the patterns and textures to be changed:

```
instance {
  object    object_name
  subpatt   old_pattern_name new_pattern_name    /* optional, may
                                                    be repeated */
  subtext   old_texture_name new_texture_name    /* optional, may
                                                    be repeated */
}
```

Any primitive using a pattern named "old_pattern_name" will be given the pattern named "new_pattern_name". Likewise for textures. If the original object has no textures, use the texture name "NULLTEXT" for "old_texture_name".

Once an object has been named, it may be transformed before being instanced:

```
/* move the object by the point value given */
translate object_name Point

/* scale the object */
scale object_name Point

/* rotating around the X, Y, or Z axes */
xrotate object_name Real    /* value in degrees */
yrotate object_name Real    /* value in degrees */
```

```

zrotate object_name Real    /* value in degrees */

    /* to return an object to its original state */
reset object_name

```

Transformations of an object take affect only if it appears before instancing. Use "reset" to get an object back to its original state if you intend to instance the object again. That way, you'll be sure of where the object is when it is instanced or transformed again.

When an object is transformed, its pattern and texture are not transformed with it. This causes the object to appear to move "through" the pattern/texture. To prevent this, use:

```
lockobject object_name
```

before transforming. Locking an object prevents most pattern/texture problems in transformation. However, spheres and rings may still suffer problems under rotation due to the way they are formed. If you must rotate a sphere or a ring, try building it by using the spin element instead.

To free up the memory used by the object after it has been instanced, use:

```
killobject object_name
```

Do not instance an object after it has been freed. This command only destroys the back-up copy of the object. Instances of the object will not be affected.

Child Objects

This next section explains the most powerful part of instancing objects.

Imagine you've built an object which is an airplane, and you want to animate the plane. As the plane moves, the propeller spins; that is, the propeller is part of the plane, but it rotates independently of the plane. This is accomplished by using the "child" command inside of an object/endobject pair:

```

object airplane
child propeller
    /* the rest of the plane here */
endobject

```

The propeller has now become a child of the airplane. Where ever the plane goes, the propeller goes with it. But the propeller can also be transformed independently, so it can be rotated:

```
zrotate propeller 5
```

In general, any child of an object does all the same transformations as its parent does, and, in addition, does all of its own also. This is different from:

```
object airplane
```

```
instance propeller
  /* the rest of the plane */
endobject
zrotate propeller 5
```

In this example, the propeller is not a child of the airplane, it is a part of the airplane. The "zrotate" has no effect on the propeller (until it's instanced again, and then the propeller is rotate only for instances following "zrotate").

Keep in mind that, after an object has been made into a child, any transformations on that object will affect the child. So if you're using child objects, and strange transformations occur, check for transformations later in the file that could affect the child.

1.193 'Undocumented' Features

This section contains features which I consider experimental and extremely risky to use. They may not work, they may cause the renderer to crash or lock up, they may cause syntax errors, or they may do nothing at all.

You should consider this a preview of coming attractions, but don't expect them right away. Some of these are causing me a headache, which is why they're not finished.

Constructed Solid Geometry (CSG)

This needs much work. It is on the priority list somewhere right after finishing this documentation.

In short, CSG allows objects to be built by adding one object to or subtracting it from another. For example, using a cylinder to drill a hole in a sphere. CSG allows very complex shapes to be built.

The basic framework for CSG is written. However, shadows and reflections do no work properly with CSG. I also need to work out how to transform and instance objects built with CSG.

Everything you need to know in order to use CSG (in its limited current implementation) is in the parser and scanner description files included in the package. If you can read these files, try CSG (on VERY simple objects) and see how it works.

1.194 Technical Description

This section of the documentation was intended to give you a better understanding of some of Magic Camera's peculiarities. It will probably end up being a mish-mash of topics that are written as they come up. In either case, it will hopefully explain why some things happen and other things don't. Most likely, it will bore you.

Topics Discussed

```

-----
The Magic Camera Color Model
Anti-Aliasing
Ray-intersect Optimization Using an Octree

```

1.195 The Magic Camera Color Model

A rendering program's color model is the method it uses to shade the objects it renders. Typically, this model combines diffuse color, reflection, transparency, and specular reflection, and is written up in one long equation which uses lots of confusing symbols. Here is Magic Camera's long equation with lots of confusing symbols (it'll take a few paragraphs to get it all in):

$$\text{color} = \text{diffuse} + \text{reflect} + \text{transmit} + \text{specular} \quad (\text{eq. 1})$$

First of all, all symbols designate an RGB triplet. The equation is actually repeated three times, once each for red, green, and blue.

Second, all values are always between 0.0 and 1.0. This causes some problems, but is necessary. There is a minimum and a maximum intensity of any color that your computer can generate at each pixel. I say this causes problems because, if each of the elements of the color model can be 1.0, how can they be added together and still be guaranteed to be less than 1.0? They can't. If Magic camera ever finds a color value which is greater than 1.0, it is reset to 1.0. Solution: think a little bit when lighting scenes and specifying colors. Typically, the sum of `color.diffuse`, `color.reflect`, and `color.transmit` should not be too much more than 1.0. You should also consider the lamps in the scene. The intensities of all lamps added together and multiplied by the sum of all elements of the color concerned should not be much more than 1.0. I try to use 1.5 or so. To put this into an equation:

$$(\text{sum of lamp.color for all lamps}) \\ * (\text{color.diff} + \text{color.refl} + \text{color.trans}) < 1.5 \text{ or so}$$

There's no exact maximum limit to the above equation because the lamps will not always shine on all objects with their maximum intensities.

Here's how each of the values which go into equation 1 are formed.

```

Diffuse
-----

```

When a ray hits an object, and it is determined that that object is visible, more rays are cast to each of the lamps in order to find shadows. (In the case of soft shadows, many shadow rays are cast and the results are averaged.) This value is multiplied by the shading coefficient, which is the dot product of the surface normal of the object and the vector from the intersect point to the lamp. This is done for all lamps, and these are added together, along with `color.ambient` to get the total light falling from the surface. This looks like:

$$\text{lamp_light} = \text{sum of } (\text{lamp.color} * (\text{surf_normal dot lamp_ray}))$$

```

total_light = sum of (lamp_light [for each non-obstructed lamp]) +
color.ambient
diffuse = total_light * color.diffuse

```

Reflect -----

If a color is reflective, that is `color.reflect` is not $\langle 0, 0, 0 \rangle$, then a ray is cast in the appropriate direction to see what is visible. This ray returns `reflect_color`, which is multiplied by `color.reflect`.

```
reflect = reflect_color * color.reflect
```

Transmit -----

Transmit is similar to reflect, but more complex. First you must understand that a ray is either inside a transmissive object or not. Rays from the camera are always considered to be not inside of glass. This condition is marked by an "inglass" flag. Every time a ray hits a transmissive surface, "inglass" is toggled. This allows the length that the ray travels inside of glass to be tracked (I'll call this `glass_len`).

If the surface is transmissive, that is `color.transmit` is not $\langle 0, 0, 0 \rangle$, then a ray is cast to get `transmit_color`. If the original (parent) ray is not in glass, then `glass_len` is multiplied by `color.filter`. This is subtracted from `color.transmit`. The result is then multiplied by `color.transmit`. If the parent ray is in glass, then it is leaving glass at this intersection, and `color.filter` is ignored. So:

For rays entering glass:

```
transmit = (color.transmit - (glass_len * color.filter)) *
transmit_color
```

For rays leaving glass:

```
transmit = color.transmit * transmit_color
```

Specular -----

This component is responsible for those shiny spots on objects. It approximates the reflection of a light source on an object.

First of all, the same ray as cast in "Shadow" above is used to determine if the light is obstructed or not. If so, nothing is done. If it is not, then a dot product is taken between the incident ray and the vector to the lamp. This result is raised to the power of `color.speccoef`, then multiplied by `color.specrefl`, and then by `lamp.color`. The result is:

```
specular = lamp.color * color.specrefl * (in_ray DOT
lamp_ray)**color.speccoef
```

Conclusion (or should I say, Confusion)

Well, there it is, the Magic Camera color model. This is how all the elements of the color pattern are brought together. I hope you understood it.

1.196 Anti-Aliasing

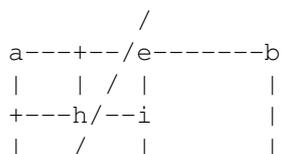
Aliasing is a problem in computer image generation which is most commonly characterized by "jaggies", or stair step distortions along straight lines. Anti-aliasing is the process of removing and/or preventing these distortions.

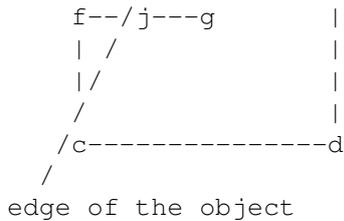
Ray tracers form an image using a process called sampling (a ray, is in fact, a sample). The rays used have an infinitely small area (actually zero area), but the pixels in the final image have an extended area. That is, rays with an area of zero must be used to fill a pixel which has an area which is greater than zero. These zero-area samples must be extrapolated to form the pixels.

Matters are complicated by the fact that the edges of objects in the scene almost never line up with the edges of the pixels. Therefore, it is possible for a pixel to contain objects of more than one color. But the pixel itself can only be one color, so the best that can be done is to form a weighted average of all objects in the pixel (an object which occupies 30% of the pixels contributes 30% to the final color of the pixel. Throw in the fact that, using patterns, an object may also be more than one color.

Given the above two paragraphs, the problem becomes one of finding exactly how much of the pixel is occupied by a given object so that the weighted average may be computed. Magic Camera does this using an anti-aliasing method called adaptive supersampling. Supersampling simply means that more than one sample is taken for each pixel. Adaptive means that these samples are taken only when necessary.

Magic Camera starts by taking one sample at each corner of the pixel, giving four samples per pixel. Using the corners of the pixel is highly efficient, since these samples may be shared with adjacent pixels. The samples are averaged, and then a check is then performed to see if one the corners of the pixel differs significantly from the average. If the difference exceeds a given amount (see maxaadiff), then that quadrant of the pixel is subdivided, each corner of the quadrant is sampled, the samples are averaged, and the corner samples are again compared with the average, and if necessary, the quadrant is again subdivided. This divide/sample/average/check cycle continues until either the maximum difference is not exceeded, or the pixel has been subdivided maxaadepth times. The following diagram applies:





Samples are taken at points a, b, c, and d. They are averaged, and point a differs by more than maxaadiff. So that quadrant is divided, sampled (points a, e, f, and g) and averaged. This time point g differs, so its quadrant is divided, sampled (h, i, j & g). Since maxaadept would be exceeded by continuing, no further sampling is done. The average of samples g, h, i & j are used in place of point g, then a, e, f and g are averaged and used in place of point a. Points a, b, c, and d are averaged and used as the pixel color. The final color is:

$$(((a+e+f+(g+h+i+j)/4)/4)+b+c+d)/4$$

1.197 The Octree

First of all, let's compute amount of time it takes to ray trace a scene. We'll say that there are 1000 objects in the scene, and the final image will be 640 by 480 pixels. To simplify the example, we'll say that there are no shadows, reflections, or transparencies, and no anti-aliasing is done. One ray will be traced per pixel (307,200 total rays). Since, in a simple ray tracer, each ray intersects each object, there will be a total of 307,200,000 intersection tests. On a fairly quick machine (25Mhz 68030), we may get 2000 intersection tests per second. This means that the scene will take about 153,600 seconds, or about 42 hours and 20 minutes to render. Not acceptable, especially considering the simplicity of the scene (no shadows, etc.).

So how can the rendering time be decreased? Simple, decrease the number of objects in the scene (not acceptable), the resolution of the scene (not acceptable), or buy a faster computer (get your checkbook out).

Or make the ray tracer smarter. In the above example, each object is tested for intersection with each ray. However, most rays will only come close to a few objects. The ideal is to only perform intersection tests on objects which the ray will actually hit (1 test per ray). This may never be achieved, but we can sure try. The trouble is finding which objects can be intersected by the rays. This is done by a process called "object bounding." In object bounding, "bounding box" is formed around all objects in the scene. If, and only if, the ray enters the bounding box the objects inside are tested for intersection.

Magic Camera implements object bounding using data structure called an "octree". The basic process is, first a box is placed around the entire scene. If the number of objects in the box exceed a preset value (see maxobcube), then that box is evenly divided into eight smaller boxes. The number of objects inside each box is then counted, and any box which has more than maxobcube objects inside is further subdivided. This continues until either no box contains more than maxobcube objects inside, or there are maxoctdepth levels of subdivision. It is necessary to limit the number of divisions to prevent the

octree from becoming too large. It is possible for the octree to expand so much that it will actually slow the rendering down (through overhead processing). This diagram shows the process in two dimensions:

```

A---J---E-----B
|o o|  |      o|   maxobcube = 1
M---N---K      |   maxoctdepth = 2
| o |  |      |
H---L---I-----F
| o    |      |
|      |      |
|      |      o |
D-----G-----C

```

First, box ABCD is created around the whole scene. There are six objects in the box ABCD (more than maxobcube), so the box is divided into four quadrants (in three dimensions, there would be eight octants formed). Quadrant AEIH still contains more than maxobcube objects, so it is divided again. Now box AJNM has two objects, still more than maxobcube, but since there have been maxoctdepth divisions, it will not be divided.

An octree is not the ideal way to build bounding boxes, but it is a solution to the problem which works well for most cases. It has the advantage that it is adaptive, meaning that the scene is more finely divided only in areas that require finer subdivisions.

1.198 Run-time Options

ToolType Options
Options Window
Command Line Options

1.199 ToolType Options

For a description of what tooltypes are and how to change them, see your Amiga Workbench user's manual.

Tooltype options are always overridden by values read from input scripts. In otherwords, they provide a means for setting new defaults.

The following tooltypes may be used:

NOSMOOTH Cause no polygon smoothing to be done.

FRAME Sets a value for the FRAME script variable. If only one value follows, a single frame will be rendered. Default is 0.

FIRSTFRAME Indicates the first frame to be rendered. If not given, will be the same as for FRAME.

If different from LASTFRAME, multiple frames will be rendered. The frame number will be appended to the output file's name.

LASTFRAME	Indicates the last frame to be rendered. If not given, will be the same as for FIRSTFRAME. If different from FIRSTFRAME, multiple frames will be rendered. The frame number will be appended to the output file's name.
OUTFILE	Indicates the name of the output file. If this option is not given, the output file name is "mc.out"
MAXRDEPTH	Sets the maximum resolve depth for ray-tracing. Resolve depth is essentially the number of times a ray may be reflected or refracted before dying. Default is 6.
NOSHADOWS	Causes no shadows to be calculated.
NOREFLECT	Causes no reflections to be calculated.
NOTRANS	Causes no transparencies to be calculated.
ILLUMINATE	Causes all objects to appear fully illuminated.
HOLD	Causes Magic Camera to pause before exiting. MC will wait for the closewindow box to be clicked before exiting. Use this in conjunction with NOTRACE to examine the preview window.
NOTRACE	MC will not render the scene. Use this to see the preview only.
XRES	Sets the X resolution of the image. Overrides camera.res.
YRES	Sets the Y resolution of the image. Overrides camera.res.
MAXOCTDEPTH	Sets the maximum octree depth. Overrides maxoctdepth. Default is 5.
MAXOBCUBE	Sets the maximum number of objects per octree cube. Overrides maxoxcube. Default is 2.
MAXAADEPTH	Sets the maximum depth for adaptive anti-aliasing. Overrides maxaadepth. Default is 1.
HFOV	Sets the horizontal field-of-view. Overrides camera.hfov. Default is 45 degrees.

VFOV	Sets the vertical field-of-view. Overrides camera.vfov. Default is computed from hfov, aspect, and image resolution.
ASPECT	Sets the pixel aspect ratio. Overrides camera.aspect. Default is 0.56 (320x400 interlaced mode).
SQUARE	Sets the pixel aspect ratio to 1.0, and the image resolution to 640x480. These are common settings for square-pixel images.
LACE	Sets the pixel aspect and resolution to create a 320x400 interlaced Amiga image.
NOLACE	Sets the pixel aspect and resolution to create a 320x200 non-interlaced Amiga image.
HIRES	Sets the pixels aspect and resolution to create a 640x200 non-interlaced Amiga image.
HIRESLACE	Sets the pixel aspect and resolution to create a 640x400 interlaced Amiga image.
OUTPUT	Sets the format of the output file. Accepted values are RAW, "QRT" (output format same as from the popular qrt ray-tracer), or "IFF24", for 24bit IFF.IIWM output (default).

1.200 Command Line Options

Usage:

```
mc [-nosmooth] [-frame frameno | -frame firstframe lastframe]
  [-quiet] [-terse] [-verbose] [-o outputfile]
  [-rd resolve_depth] [-ns] [-nr] [-nt] [-il] [-hold]
  [-r xres yres] [-notrace] [-mod maxoctdepth]
  [-moc maxobcube] [-aa maxaadepth] [-hfov horizfov]
  [-vfov vertfov] [-fov horizfov vertfov]
  [-aspect aspect_ratio] [-square] [-lace] [-nolace]
  [-out outputformat]
```

Running Magic Camera from the command line without any options will cause the options window to be used.

In the case where an option is entered twice on the command line, the latter occurrence of the option will take precedence, as is the case with conflicting options (i.e. -quiet -verbose).

Command line options always override any values found in input scripts.

Option Description

-
- nosmooth Cause no polygon smoothing to be done
- frame Sets a value for the FRAME script variable. If only one value follows, a single frame will be rendered. If two values are given, they indicate the first and last frame to be rendered, and multiple frames will be rendered. The frame number will be appended to the output file's name. FIRSTFRAME and LASTFRAME are also set by this option. Default is 0.
- quiet MC will only print error messages.
- terse MC will print only necessary messages. This is default.
- verbose MC will become quite chatty, telling you more than you probably want to know.
- o Indicates the name of the output file. If this option is not given, the output file name is "mc.out"
- rd Sets the maximum resolve depth for ray-tracing. Resolve depth is essentially the number of times a ray may be reflected or refracted before dying. Default is 7.
- ns Causes no shadows to be calculated.
- nr Causes no reflections to be calculated.
- nt Causes no transparencies to be calculated.
- il Causes all objects to appear fully illuminated.
- hold Causes Magic Camera to pause before exiting. MC will wait for a carriage return at the command line before exiting. Use this in conjunction with -notrace to examine the preview window.
- notrace MC will abort before rendering the scene.
- r Sets the X and Y resolution of the image. Overrides camera.res. Default is 320x400.
- mod Sets the maximum octree depth. Overrides maxoctdepth. Default is 5.
- moc Sets the maximum number of objects per octree cube. Overrides maxoxcube. Default is 2.
- aa Sets the maximum depth for adaptive anit-
-

- aliasing. Overrides maxaadepth.
Default is 1.
- hfov Sets the horizontal field-of-view. Overrides camera.hfov.
Default is 45 degrees.
- vfov Sets the vertical field-of-view. Overrides camera.vfov.
Default is computed from hfov, aspect, and image resolution.
- fov Sets the horizontal and vertical field-of-view. Overrides both camera.hfov. and camera.vfov.
- aspect Sets the pixel aspect ratio. Overrides camera.aspect.
Default is 0.56 (Amiga 320x400 interlace).
- square Sets the pixel aspect ratio to 1.0, and the image resolution to 640x480. These are common settings for square-pixel images.
- lace Sets the pixel aspect and resolution to create a 320x400 interlaced Amiga image. This is default.
- nolace Sets the pixel aspect and resolution to create a 320x200 non-interlaced Amiga image.
- hires Sets the pixels aspect and resolution to create a 640x200 non-interlaced Amiga image.
- hireslace Sets the pixel aspect and resolution to create a 640x400 interlaced Amiga image.
- out Sets the format of the output file. Accepted values are RAW, "QRT" (output format same as from the popular qrt ray-tracer), or "IFF24", for 24bit IFF.ILBM output (default).

1.201 Options Window

The options window looks like this...

```

+-----+
|
| Filename _____ BROWSE      SMOOTHING      |
| Outfile  _____ BROWSE      SHADOWS         |
| Output IFF24...   Frames ___ to ___ REFLECT       |
| XRes  ___ YRes  ___ Aspect ___ SCREENMODE  TRANSMIT |
| Octree Depth ___ Resolve Depth ___          ILLUMINATE |
| Objects/Cube ___ Max AA Depth ___          OVERRIDE SCRIPT |
|
+-----+

```

```
|   GO!                               QUIT   |
+-----+
```

Underscores (____) indicate a text entry gadget, ALL CAPS indicates a button gadget.

The gadgets mean:

Filename	The filename of the script to read. Hit browse to get an ASL file requester (if your version of AmigaDOS supports ASL file requesters).
Outfile	The filename of the output file. Hit browse to get an ASL file requester (if your version of AmigaDOS supports ASL file requesters).
Output	Selects between 24 bit IFF files, QRT output files, or MC's own raw 24 output format.
Frames	Indicates starting and ending framenumbers. For use with animated scripts.
XRes, YRes, Aspect	Indicates the properties of the rendered image. See Camera
Screen Mode	Allows the use of the ASL screen mode requester to select the XRes, YRes, and Aspect values. Available only if you have the proper version of the ASL libraries.
Octree Depth, Objects/Cube	Fine tunes the Octree.
Resolve Depth	Sets the resolve depth, which is the maximum number of reflect/transmit generations a primary ray may generate.
Max AA Depth	See Anti-Aliasing
Soothing, Shadows, Reflect, Transmit, Illuminate	Perform the same functions as the global flags.
Override Script	When selected, causes options window values to override any values found in the input script file.
Go!	Start tracing!
Quit	Exit without doing anything.

1.202 RGB

RGB stands for red, green, and blue. This is the color model used by Magic Camera (and most other programs which use color). In RGB various amounts of red, green, and blue light are mixed to form different shades of color.

1.203 IFF Files

IFF stand for Interchange File Format, and is the file format used by almost all Amiga programs to store bitmapped image data. IFF bitmaps come in several flavors, including 24 bit, HAM, and color table (32 color, 16 color, etc.) images. Magic Camera currently understands the following type of IFF images:

- 24 bit
- HAM8 (AGA Mode)
- HAM
- Halfbright
- 256 color
- 128 color
- 64 color
- 32 color
- 16 color
- 8 color
- 4 color
- 2 color

Magic camera doesn't understand the special effects, such as masking planes, etc., used in some IFF files.

1.204 misc_raw24

Magic Camera can read raw 24 bit bitmaps stored in a special file format. If you have to write your own program to convert bitmaps for use by Magic Camera, it will be easier to convert the bitmaps into this format than to 24 bit IFF.

The Raw24 format used by Magic Camera is:

1. The first 4 bytes are an unsigned long specifying the X dimension of the image (pixels per row). Bytes are stored in MSB first (Motorola) order.
2. The second 4 bytes are an unsigned long specifying the Y dimension of the image (number of rows). Bytes are stored in MSB first (Motorola) order.
3. The remaining data consists of triplets of unsigned bytes which contain the RGB data. These triplets are written by rows, so that all pixels of the first row are written (in increasing X order) before the second row is written. Rows are written in increasing Y order. The first pixel written (0, 0) is the upper left hand corner of the image. The following pseudo-code applies:

```
for y = 0 to num_rows
```

```
    for x = 0 to pix_per_row
      write red
      write green
      write blue
    next x
next y
```