OPTIMIZATION

OPTIM (REFERENCE MANUAL SECTION) COMMAND PROMPTS

VARIABLES

CREATING VARIABLES

VARIABLE or **VARI** - The "VARIABLE" or "VARI" command causes the program to leave the CMD level and enter the VARIABLE input level. The variables memory area is wiped clean and is ready for new variables input. Between "VARIABLE" or "VARI" and "EOS" or "END", any VARIABLE input level command may be entered.

EOS or **END** - The "EOS" or "END" or "END" command, issued from the VARIABLE level, causes the program to return to the CMD level. The variables set is left in memory and is ready for optimization.

MODIFYING VARIABLES

UPDATE VARIABLE or **U VB** - "UPDATE VARIABLE" command, or its abbreviated form "U VB", causes the program to leave the CMD level and enter the UPDATE VARIABLE level. The variables memory area is opened and is ready for modification. Between "UPDATE VARIABLE" or "U VB" and "EOS" or "END", any UPDATE VARIABLE level command may be entered.

DEL (variable name) , i , - The "DEL" command, issued from the UPDATE VARIABLE level, causes the program to delete the variable with name = "variable name" at surface "i" and alternate configuration "j". If "j" is not explicitly entered, it is assumed to be 1, the main configuration.

EOS or **END** - The "EOS" or "END" command, issued from the UPDATE VARIABLE level, causes the program to return to the CMD level. The variables set is left in memory and is ready for optimization.

(Variable Name) , i , wt , dincr , limit value 1 , limit value 2 or **(Variable Name) ALL , wt , dincr , limit value 1 , limit value 2** - "i" is the surface number in the lens database to which the variable is associated. "wt" is the relative weight or importance of the variable in the optimization process. The weight may range from 0.0 (not important) to 1.0 (most important). The default for "wt" is always 1.0. The "dincr" is the change to the variable value used in the derivative calculation. "dincr" values, if not explicitly input by the user, are set to "default" values. The default "dincr" values vary for each variable. They are listed in the next table. The "limit value 1" and "limit value 2" are boundary condition values. The order of input, i.e. high or low, is not important. Their defaults are -1.0D+20 and +1.0D+20, respectively for most variables. The default limits for angle variables are +/- 360.0 degrees. For NSS variables, "i" is the NSS surface number.

VARIABLE NAME	DESCRIPTION	DEFAULT "dincr" VALUE
RD	Radius of curvature. This is automatically converted to CV.	
CV	Surface curvature	1.0D-5
TH	Axial distance to next surface	1.0D-5
CC	Surface conic constant	1.0D-7
AD	4th order aspheric coefficient	1.0D-11 / 1.0D-7 *
AE	6th order aspheric coefficient	1.0D-15 / 1.0D-7 *
AF	8th order aspheric coefficient	1.0D-19 / 1.0D-7 *
AG	10th order aspheric coefficient	1.0D-23 / 1.0D-7 *
AH	12th order aspheric coefficient	1.0D-27 / 1.0D-7 *
AI	14th order aspheric coefficient	1.0D-31 / 1.0D-7 *
AJ	16th order aspheric coefficient	1.0D-35 / 1.0D-7 *
AK	18th order aspheric coefficient	1.0D-37 / 1.0D-7 *
AL	20th order aspheric coefficient	1.0D-41 / 1.0D-7 *
RDTOR	Toric radius of curvature. This is automatically converted to CVTOR.	
CVTOR	Toric curvature	1.0D-5
CCTOR	Toric conic constant	1.0D-7
ADTOR	4th order anamorphic aspheric term	1.0D-11 / 1.0D-7 *
AETOR	6th order anamorphic aspheric term	1.0D-15 / 1.0D-7 *
AFTOR	8th order anamorphic aspheric term	1.0D-19 / 1.0D-7 *
AGTOR	10th order anamorphic aspheric term	1.0D-23 / 1.0D-7 *
ALPHA	Alpha surface tilt angle	1.0D-7 (degree)
BETA	Beta surface tilt angle	1.0D-7 (degree)
GAMMA	Gamma surface tilt angle	1.0D-7 (degree)
XD	Surface X-decentration	1.0D-7
YD	Surface Y-decentration	1.0D-7
ZD	Surface Z-decentration	1.0D-7
GALPHA	Global alpha surface tilt angle	1.0D-7 (degree)
GBETA	Global beta surface tilt angle	1.0D-7 (degree)
GGAMMA	Global gamma surface tilt angle	1.0D-7 (degree)
GXD	Surface global X-decentration	1.0D-7
GYD	Surface global Y-decentration	1.0D-7
GZD	Surface global Z-decentration	1.0D-7
N1 through N10	Refractive index at wavelength 1 to 10 for a "MYGLASS" material	1.0D-6

INDEX	Nd value of a "MODEL" glass	1.0D-6
VNUM	Vd value of a "MODEL" glass	1.0D-6
DPART	Partial Dispersion shift of a "MODEL" glass	1.0D-6
C1 through C96	96 special surface coefficients	1.0D-11
AC	2nd order surface aspheric term	1.0D-7 / 1.0D-7 *
CLPX	X - clear aperture height	1.0D-5
CLPY	Y - clear aperture height	1.0D-5
GRS	diffraction grating spacing	1.0D-5
ACTxxxx	Normalized actuator position for actuator number xxxx on a deformable surface. Range lies between 1.0 and –1.0. NOTE: ACTxxxx variables are only available at CFG 1. The xxxx values specify specific actuators which are to be variables. The counting scheme is illustrated in the LENS section of this manual in the DEFORMABLE surface description.	1.0D-11
MACVAR	Storage variable register. In the case of this variable, the first numeric word is the general purpose storage register number rather than a surface number.	1.0D-11
NSSXPOS	X-position of the NSS database surface	1.0D-7
NSSYPOS	Y-position of the NSS database surface	1.0D-7
NSSZPOZ	Z-position of the NSS database surface	1.0D-7
NSSALPHA	Alpha rotation of the NSS database surface	1.0D-7 (degree)
NSSBETA	Beta rotation of the NSS database surface	1.0D-7 (degree)
NSSGAMMA	Gamma rotation of the NSS database surface	1.0D-7 (degree)
V1	Numeric word #1 of the SPROFILE definition	1.0D-7
V2	Numeric word #2 of the SPROFILE definition	1.0D-7
V3	Numeric word #3 of the SPROFILE definition	1.0D-7
V4	Numeric word #4 of the SPROFILE definition	1.0D-7
V5	Numeric word #5 of the SPROFILE definition	1.0D-7
P001 to P200	Value of NSS surface parameter 1 to 200	1.0D-7

CONTROL OF VARIABLE LIMITS

Variable limits are held as hard limits beyond which the variable will not go. Variable limits are generally set in the syntax of the variable input or variable change syntax. There are a few instances wherein limits for all variables of one specific type may wish to be set. The default limits for the variables "TH", "CV" and "CVTOR" may.be controlled using the following CMD level commands:

MXT , mxt - The "MXT" command resets the maximum allowable value for all TH variables to the value "mxt". By default, the value is 1.0D+20.

MNT , mnt - The "MNT" command resets the minimum allowable value for all TH variables to the value "mnt". By default, the value is -1.0D+20. For refractive systems in which no thicknesses should become zero, "mnt" should be set to some small non-zero value like 0.001.

MPR , mpr - The "MPR" command resets the maximum allowable value for all CV and CVTOR variables so that the resulting radius never takes on a value between "mnt" and "mxt". By default "mxt" = 1.0D-20.

MNR , mnr - The "MNR" command resets the minimum allowable value for all CV and CVTOR variables so that the resulting radius never takes on a value between "mnt" and "mxt". By default "mnt" = -1.0D-20.

CONFIGURATIONS FOR VARIABLES

CFG, i - The "CFG" command is a "sticky" command. It causes any variable added to the variables set to be active only for alternate configuration "i". Alternate configuration "i" will remain the understood configuration for variables input until changed by another "CFG" command or until an "EOS" or "END" command is issued. If the "CFG" is not entered, the main configuration, 1, is assumed.

DEFAULT DINCR VALUES

DINCR (variable name) , i - During variable input or update, a specific "dincr" value may be input for a each variable. If this is not done, then the default values listed in the previous table will be used as the "dincr" values. The "DINCR" command is a CMD level command which has been added to allow the user to change the default "dincr" values which will be used if specific "dincr" values are not input during variable input or update. For example; to change the default "dincr" value for all thickness variables to 0.01, the command "DINCR TH , 0.01" would be entered. If the user wishes to always have a different set of default "dincr" values each time the program is run, then the user can put a set of customized "DINCR" commands in the DEFAULTS.DAT file. If a variable has two default "dincr" values associated with it, the second default "dincr" value is changed by using the "DINCR" command with the variable name to which a "2" has been appended. To change the first default "dincr" value associated with ADTOR to .001, the command "DINCR ADTOR .001 would be used. To change the second default "dincr" value associated with ADTOR to .00003, the command "DINCR ADTOR2 .00003 would be issued.

INTERROGATION OF VARIABLES - The next four commands are valid at the VARIABLE, the UPDATE VARIABLE and also at the CMD levels.

VB , i - The "VB" command displays the variable name, the associated lens database surface number, the associated alternate configuration number, the current variable value and the last change made to the variable. If "i" is explicitly input, only the variable data for variable number "i" will be

displayed. If "i" is omitted, data for all current variables will be displayed.
VBA , i - The "VBA" command displays auxiliary variable data. Auxiliary variable data consists of the variable name, the associated lens database surface number, the associated alternate configuration number, the low limit value, the high limit value, the weighting factor and the current "dincr" multiplied by the current "DINMUL" value. If "i" is explicitly input, only the auxiliary variable data for variable number "i" will be displayed. If "i" is omitted, auxiliary data for all current variables will be displayed.
VB CFG , i - The "VB" command, issued with the qualifier word "CFG" and an explicit alternate configuration number "i", displays the variable names, the associated lens database surface number, the associated alternate configuration number, the current variable value and the last change made to the variable for all variables which are active in the specified alternate configuration. "i" must be explicitly input.
VBA CFG , i - The "VBA" command, issued with the qualifier word "CFG" and an explicit alternate configuration number "i", displays the variable names, the associated lens database surface number, the associated alternate configuration number, the low limit value, the high limit value, the weighting factor and the current "dincr" multiplied by the current "DINMUL" value for all variables which are active in the specified alternate configuration. "i" must be explicitly input.

DEFAULT OPERAND BUILDER

MONO and **POLY** - Sets the default merit function builder to monochromatic or polychromatic mode.

NUMBER OF FIELD POSITIONS

DFP , n - The CMD command "DFP" is used to set the number of field of view positions to be used to construct the default merit function. The default value of "n", if "DFP" is not issued, is "3". All field positions are specified in terms of fractional object heights as is done when using the "FOB" command during regular ray tracing. A maximum of 25 field of view positions are allowed.
FP , i , fx , fy , fwt , λ# - The CMD command "FP" is used to specify the fractional object or FOB values for field of view position "i". The "fwt" entry allows assigning different weights to operands belonging to different fields of view. If not explicitly entered, all field weights, "fwt", are set to 1.0. "λ#" is the wavelength at which the rays for that field point will be traced. Its default value will be the control wavelength. Before these field of view positions are set up, the FIELDS and RAYS discussed earlier are reset to their default values via automatic executions of the "FIELDS RESET" and "RAYS RESET" commands. It is almost never necessary to trace the chief rays generated by the "FP" commands at any wavelength other than the control wavelength. If no "FP" commands are issued, then the default values for the first three field of view positions will be:

i	fy	fx	fwt	λ#
1	0.0	0.0	1.0	control wavelength
2	0.7	0.0	1.0	control wavelength
3	1.0	0.0	1.0	control wavelength

RAY GRID SHAPE

DFGRID (RECT or **HEX** - The CMD command "DFGRID" is used to specify whether the ray grid distribution over the aperture is to be a rectangular grid, similar to the type of ray grid used in CODE-V or a hexapolar grid similar to the one used in ZEMAX. The default shape is "RECT".

RAY GRID SIZE

DFHEX , nring, nsec - This command is used to specify the number of pie sections in every ring, "nsec" (default = 8) and the number of radial rings, "nring" (default is 1) which are to be used when the ray grid shape is set to "HEX". The radii of the rings will be set automatically so as to best sample the aperture. Maximum value for "nsec" is 32. Maximum value for "nring" is 20.
DFDEL , dfdel - The CMD command "DFDEL" is used to set the fractional ray spacing in the reference surface for the grid of rays used by the operands. Valid input values range from 0.1054 to 1.414213. The ray pattern is rectangular and is always an even pattern (no ray at the reference surface center). For rectangular apertures, a square pattern of rays is used which covers the rectangle. For non-rectangular apertures, a circularly clipped rectangular pattern of rays is used which covers the non-rectangular aperture. The following table lists the number of rays in a "circularly clipped" pupil for various values of "dfdel". The default value is 0.385. This is the same ray pattern used in CODE-V.

"dfdel"	# rays (non-rect. aperture)
1.41423 – 0.632456	4
0.632455 – 0.471405	12
0.471404 – 0.392233	16
0.392232 – 0.342998	24
0.342997 – 0.282843	32
0.282842 – 0.262613	44
0.262612 – 0.232496	52
0.232495 – 0.220864	60
0.220863 – 0.210819	68
0.210818 - 0.202031	76
0.202030 – 0.194258	80
0.194257 – 0.181072	88
0.181072 – 0.175412	96
0.175411 – 0.165522	112
0.165521 – 0.157135	120
0.157134 – 0.153393	124
0.153392 – 0.149907	140

0.149906 – 0.143592	148
0.143591 – 0.140720	156
0.140719 – 0.135458	164
0.135457 – 0.133039	172
0.133038 – 0.130745	180
0.130744 – 0.128565	188
0.128564 – 0.126492	192
0.126491 – 0.120825	208
0.120824 – 0.117445	216
0.117444 – 0.115857	232
0.115856 – 0.114333	240
0.114332 – 0.112867	248
0.112866 – 0.108786	256
0.108786 – 0.107521	268
0.107520 – 0.105400	276

STARTING RECOMMENDATIONS
For rotationally symmetric systems with spherical surfaces start with dfdel = 0.385. For systems with conics use dfdel = 0.28. For systems with aspherics and anamorphics start at dfdef = 0.22 and go down as needed.

OPERAND TYPES - There are two operand types. The first type is based only on transverse ray aberrations (positional for MODE FOCAL and UFOCAL and angular for MODE AFOCAL and UAFOCAL). The second type adds to these transverse aberrations, the derivatives of these aberrations with respect to position in the aperture and also adds Optical Path Differencs (OPD).
DFTYPE , merit type designator , wt1 , wt2 , wt3 - The CMD command "DFTYPE" is used to set the type of operands used in the default merit function according to the following table:

merit type designator	Operands used
1	DR *
2	DR, DRDR and OPD*

* The default type is type 1. If the lens mode is AFOCAL OR UAFOCAL, then DR is replaced by DRA and DRDR by DRADR. The "wt1" is used to assign a relative weight to the DR operands. "wt2" is used to assign a weight to the DRDR operands. "wt3" is used to assign a weight to the OPD operands. By default, "wt1", "wt2" and "wt3" are set to 1.0. The "VIG" command now works with all these operands.

CREATING/UPDATING OPERANDS
MAKEAUTO , cfg# - The "MAKEAUTO" command causes the program to create (if no operands exist) or update (if operands already exist) the merit function using a number of automatically generated UPDATE MERIT commands. All operands are created or modified using the current field and ray position definitions, APOD setting, and wavelength number λ#. Operands will be created for all wavelengths which have non-zero spectral weights. If "cfg#" is not specified, operands will be designated as alternate configuration #1 operands. Field and Ray position definitions are rebuilt each time the "MAKEAUTO" command is issued, based upon the field position definitions, the ray grid spacing definitions and the wavelength definitions stored with the field positions and specified in the "MAKEAUTO" command. Non-chief rays are always traced at the wavelength specified by the "MAKEAUTO" command. All "default" operands are understood to be evaluated at the final surface of the current lens database. It is not usually efficient to create full lists of operands for every wavelength unless it is known that the shape of the aberrations is a strong function of wavelength. It is better to create one set of operands at the control wavelength and then correct chromatic effects using operands like PACM, PACZ , PLCM, PLCZ, SACM, SACZ, SLCM and/or SLCZ.

CONFUSED – TRY THIS - Take all the defaults by simply entering the command "MAKEAUTO". This will yield a respectably good merit function for rotationally symmetric systems using spherical surfaces.

CMD LEVEL OPTIMIZATION COMMANDS
ITER , n or **IT , n** - The "ITER" or "IT" command initiates "n" [blank = 1] cycles of a Levenberg-Marquart Damped Least Squares (DLS) optimization cycle. First, the current "dincr" value for each variable multiplied by the current "DINMUL" is used to calculate partial derivatives of each operand in the merit function. These first partial derivatives form the so-called "derivative matrix". Using the current PFAC or damping factor, the linearized least squares problem is then solved using Singular Value Decomposition (SVD). The result is a "solution vector". This is a vector whose components are the changes to the current variables which should cause the figure of merit to decrease. This "solution vector" is applied to the LENS, CONFIGS and/or SPSRF databases as appropriate, the operands are then re-evaluated and the new figure of merit and the change in figure of merit are displayed. The new figure of merit is also automatically placed in the accumulator or X-register.
SV - The "SV" command initiates an abbreviated Levenberg-Marquart Damped Least Squares (DLS) optimization cycle using the current damping factor. If a derivative matrix already exists, it is used instead of calculating a new matrix. If no derivative matrix exists, then this command operates exactly as if it had been an "ITER" command.
RSV - The "RSV" command acts by issuing a "RESTORE" command followed by a "SV" command and is useful when doing a PFAC search by hand. If no derivative matrix exists, then this command operates exactly as if it had been an "ITER" command.
PFIND , max cycl. , change factor - The "PFIND" command causes a series of "PM PFAC (new damping factor)"and "RESOLVE" commands to be issued until an "optimum" damping factor has been found. The default "max cycl." is 10. The default "change factor" for constant multiplicative damping is 0.6. The default "change factor" for constant additive damping is 0.01. A "RESOLVE" is then performed and the current figure of merit is compared to the previous figure of merit. A decision is made as to whether a new "pfac" value will continue to reduce the figure of merit. When

more than two unsuccessful attempts to reduce the figure of merit occur or when ten ("max cycl.") cycles have been performed, the process is stopped and the best damping factor and corresponding figure of merit are displayed.
If "PFIND" parameters are reset, they remain as set until reset again or until program termination.
ITER FULL , n or **IT F , n** - "ITER FULL" or "IT F" causes "n" (blank = 1) cycles of ITER FULL to be executed. Each cycle consists of an "ITER" command followed by a "PFIND" command followed by a second "ITER" command to be issued. "RESTORE" will not undo this command.
ITER DIR , n or **IT D , n** - "ITER DIR" or "IT D" causes "n" (blank = 1) cycles of a "direct" rather than a "damped least squares" solution to be attempted. This only works when there is known to be an exact solution and can cause unexpected results if only an approximate solution exists.
ITER POWL , n or **IT P , n** - "ITER POWL" causes "n" (blank=1) cycles of Powell's optimization method to be performed. Each cycle of "ITER POWL" or "IT P" causes one full cycle of "Powell's Method" to be performed. If a damped least squares matrix exists, that matrix is made used. Powell's method is powerful and unrelated to the "damped least squares" method. It is provided as another tool which may have some merit in freeing some "stuck" systems. The damping factor has no effect during "ITER POWL.
ITER ADJUST , (n , m) or **IT A , (n , m)** or **IT ADJ (n , m)** "ITER ADJUST" adjusts the lengths of each column in the change matrix used in damped least squares optimization by adjusting the variable "dincr" values so that the sums of the absolute values of each column of the change matrix (column totals) are each equal to the average of the sum of all the column totals. If "n" is present (any value), no new matrix is created if one already exists, else a new matrix is created. If "m" is present (any value), then the program operating condition "LINTOL" is used per the description for "LINTOL" to automatically re-set the DINMUL value, else the DINMUL value is left unchanged by "ITER ADJUST".
RESTORE , i - The "RESTORE" command causes the lens to be restored to its state before the last "ITER" or "ITER,1" command. The default value for "i" is 0 indicating a complete restore. "i" may range from 0 to 1. A non-zero "i" indicates the restore will be made as a fractional distance from the previous state to the current state. A value of "i" = 1 means that no restore will be applied. Restoration is made through fractional movement along the last solution vector.
RESTORE MIN- The "RESTORE MIN" initiates a search along the current solution vertor for a minimum solution. The derivative matrix is not used.
ROBB, β , δ , rmax - In the December 15, 1979 issue of APPLIED OPTICS, Vol. 18, No. 24, Paul N. Robb published a paper entitled "Accelerating convergence in automatic lens design". The article states that if a solution vector exists, that a greater improvement in the system figure of merit may sometimes be had by applying a scale factor to the solution vector and then applying that scaled solution vector to the lens. The paper only discussed this acceleration technique as it applied to a solution vector which came from a "damped least squares" solution method. This may be where the acceleration technique has its greatest potential benefit. In this program, the "ROBB" acceleration technique may be applied to any solution vector obtained from any of the solution methods listed above. The "ROBB" command causes a sequence of solution vector scaling by the scalar constant (β times δ). If the resultant figure of merit is less than it was using the un-scaled solution vector, then the scale factor is again multiplied by δ and the process is repeated. If the figure of merit fails to be reduced, the process stops and the last scaled solution vector which produced an improvement in the figure of merit is applied to the lens. By default β = 1.0 and δ = 1.1. Any values for β and δ may be issued with the "ROBB" command.
ITER MDUMP or **IT MDP** - The "ITER MDUMP" command causes the current change or difference matrix to be displayed in a compact form. Four variables at a time are listed across the display and 20 operands at a time are listed down the display. If no matrix exists, a message to that effect is issued.
ITER MDUMPA or **IT MDPA** - The "ITER MDUMPA" command causes the current change or difference matrix to be displayed in a non-compact way with more attendant captioning. If no matrix exists, a message to that effect is issued. In order to avoid conflicts with the user-defined optimization described in the OPTUSER manual section (the optimization which specifically uses the macro named "MACROOPT"), the "IT", "ITER", "RESOLVE", "RSV", "RESTORE", "PFIND" and "ROBB" commands should NOT be used from within a macro while the macro "MACROOPT" is being used to define operands. This restriction does NOT apply when using macro functions to perform operand definitions.

VERBOSE ITER
OVERBOSE ("ON" or "YES" or "OFF" or "NO") - Whenever the user enters an "ITER" or a "RESOLV" command, the program outputs the resultant figure of merit at the conclusion of that optimization cycle. Sometimes the use wishes to automatically see the current values of all variables and operands after each iteration, even when multiple cycles of "ITER" are requested using the optional numeric word input for "ITER". Setting the "OVERBOSE" flag to "ON" or "YES" with the "OVERBOSE" command, causes this additional data to be output at the end of each cycle. The program default setting is "OVERBOSE OFF/NO". The setting is remembered as part of each specific lens database.

BOUNDARY CONDITIONS - The upper and lower limit values, which can be input in the variables definitions, are used only to trigger warning messages to be displayed if these boundary conditions are violated. It is up to the user to freeze and unfreeze variables if they move to unreasonable values.

NEW-TRY THIS - Programs which take control or optimization are nice right up to the point that they stop working. Then they are as useless as ZEMAX on a MAC. This program does not take that control. It leaves it with you, the designer. I personally start with "ITER". Then I try to see if "PFIND" can find a better damping factor. Then another ITER. If the figure of merit increases, use "PFAC" to increase the damping factor. Also try "ROBB" and "ITER POWELL". No method works the same for any two designs. You will need to try different approaches, possible even changing the "dinmul" value with the "DINMUL" command. RESTORE will help go back a step if things blow up. Save good lenses before trying things during optimization as it is terrible to know you had and lost a good design after you optimized into a terrible design.
OPERAND ACTION - The default operands described above, were all in the COR mode. The following commands designate how each operand is to be treated during the optimization process.
COR - Any operand added to the merit function after the issuance of a "COR" command will be considered an active part of the merit function. The optimization process will attempt to "correct" the operand's value so that it becomes as similar to the specified target as is possible.
BYP - Any operand added to the merit function after the issuance of a "BYP" command will be considered an inactive part of the merit function. The optimization process will not attempt to "correct" the operand's value. The operand's value will be kept up to date and displayed when the "OPRD" command is issued.
HLD - Any operand added to the merit function after the issuance of an "HLD" command will be considered an active part of the merit function. The first time the operand value is calculated, that value will be assigned as the target value and the "HLD" will be converted to a "COR".
BLO or **GTE** - Any operand added to the merit function after the issuance of a "BLO" command will be considered an active part of the merit

function when its value drops algebraically below that of the target value. This is equivalent to specifying that the value of the operand must remain Greater Than or Equal to the target value using the "GTE" command. The optimization process will attempt to maintain the operand's value so that it remains greater than or equal to the specified target. When the operand value (say for the i^{th} operand) drops below the target value, its contribution to the merit function will be set to:

$$fmt_i = \left(wt_i \times \left[opval_i - tarval_i\right]\right)^2$$

The current value for the i^{th} operand is $opval_i$ and its target value is $tarval_i$.

BHI or **LTE** - Any operand added to the merit function after the issuance of a "BHI" command will be considered an active part of the merit function when its value exceeds the value of the target in an algebraic sense. This is equivalent to specifying that the value of the operand must remain Less Than or Equal to the target value using the "LTE" command. The optimization process will attempt to maintain the operand's value so that it remains less than or equal to the specified target. The current value for the i^{th} operand is $opval_i$ and its target value is $tarval_i$. When the operand value (say for the i^{th} operand) exceeds the target value, its contribution to the merit function will be set to:

$$fmt_i = \left(wt_i \times \left[opval_i - tarval_i\right]\right)^2$$

INTERROGATING THE MERIT FUNCTION - The next eight commands are valid at the MERIT, the UPDATE MERIT and the CMD levels:

(OP or MR) , i - The "OP" or "MR" commands display the operand number, operand name, target value, weight and the values of the optional numeric words #3, #4 and #5 if they apply to the operand. If "i" is explicitly input, only the operand data for operand number "i" will be displayed. If "i" is omitted, data for all current operands will be displayed.

(OPA or MRA) , i - The "OPA" or "MRA" commands display auxiliary operand data. Auxiliary operand data consists of the operand number, operand name, target value, weight, associated macro function name if the operand is not a predefined operand, the value of numeric word #3 if applicable to the operand, the correction mode and the operand configuration number. If "i" is explicitly input, only the auxiliary operand data for operand number "i" will be displayed. If "i" is omitted, data for all current operands will be displayed.

(OP or MR) CFG , i - The "OP" or "MR" commands, issued with the qualifier word "CFG" and an explicit alternate configuration number "i", display the operand number, operand name, target value, weight and the values of the optional numeric words #3, #4 and #5 if they apply to the operand for all operands which are active in the specified alternate configuration. "i" must be explicitly input.

(OPA or MRA) CFG , i - The "OPA" or "MRA" commands, issued with the qualifier word "CFG" and an explicit alternate configuration number "i", display the operand number, operand name, target value, weight, associated macro function name if the operand is not a predefined operand, the value of numeric word #3 if applicable to the operand, the correction mode and the operand configuration number for all operands which are active in the specified configuration. displayed. "i" must be explicitly input.

OPRD , i - The "OPRD" command displays current operand data in the merit function. The display consists of the operand name, current value, target value, weight, the contribution to the merit function and correction mode. If "i" is omitted, data for all current operands will be displayed. If "i" is explicitly input, only data for operand number "i" will be displayed. The program keeps track as to whether or not the operand values are up-to-date. If they are not, they will be brought up-to-date" prior to the listing. If they are up-to-date, the current values will be displayed.

OPRD CFG , i - The "OPRD" command, issued with the qualifier word "CFG" and an explicit alternate configuration number "i", displays current operand data in the merit function which is active in the specified alternate configuration. The display consists of the operand name, current value, target value, weight, the contribution to the merit function and correction mode. "i" must be explicitly input. The program keeps track as to whether or not the operand values are up-to-date. If they are not, they will be brought up-to-date" prior to the listing. If they are up-to-date, the current values will be displayed.

FMT , i - The "FMT" command displays the "figure of merit" for the current merit function value. The "figure of merit" is the sum of the squares of the differences between the current operand values and their target values multiplied by the operand weights. This definition implies that the square of the weights play the important role in the calculation of the "figure of merit". If "i" is omitted, the full figure of merit will be displayed. If "i" is explicitly input, only the figure of merit contribution due to operand number "i" will be displayed. The program keeps internal track as to whether or not the figure of merit is "up to date". If it is not, it will be re-evaluated prior to the listing. If it is up to date, the current value will be displayed. The "figure of merit" is just the sum of the individual operand contributions to the "figure of merit". "n" is the total number of operands.

$$fmt = \sum_{i=1}^{n} \left(wt_i \times \left[opval_i - tarval_i\right]\right)^2$$

FMT CFG , i - The "FMT" command, issued with the qualifier word "CFG" and an explicit alternate configuration number "i", displays the "figure of merit" for operands active in alternate configuration number "i". "i" must be explicitly input. The program keeps internal track as to whether or not the figure of merit is "up to date". If it is not, it will be re-evaluated prior to the listing. If it is up to date, the current value will be displayed.

OPTIMIZATION CONTROL PARAMETERS

PMP (qualifier word) - The "PMP command displays the current value of the parameter identified by "qualifier word". This command is also described in the CMD section.

PM (qualifier word) , i - The "PM" command is used to set a control parameter, identified by "qualifier word", to the numeric value specified by "i". This command is also described in the CMD section. The table below lists the various control parameters:

QUALIFIER	DESCRIPTION
DINMUL	This is the multiplicative factor used with variable increment or "dincr" scaling. **Default value = 1.0. Minimul value = 1.0D-15.**

PFAC	This is the damping factor used for damped least squares optimization. **Default value = 1.0**
MAXOPT	This sets the maximum number of variables and operands. Maximum allowed value is 100,000. **Default (also minimum) value = 4000**
ONTOL	This sets the tolerance to determine if an operand is dependent upon a variable change. It is in units of the operand. If the operand's change is less than ONTOL, the derivative will be set identically to zero before the solution vector is calculated. Default **value = 1.0D-10**
SINGTOL	This sets the tolerance to determine if an element in the singular value decomposition is to be zeroed out to remove a singularity before the solution vector is computed. **Default value = 1.0D-12.**
LINTOL	This sets the fractional tolerance to determine if a change value in the damped least squares change matrix is sufficiently small compared to its associated operand value to be considered "linear" in change matrix space. If it is not and the second numeric word of the ITER ADJUST command is present, the DINMUL will automatically be changed so that the linearity condition is regained. **Default value = 0.1. Valid values are > 0.0 and < or = to 1.0.**

If any of the above operating condition qualifier words is issued as a command word rather than a qualifier word, and if they are issued without numeric input, they are then treated as if they had been preceded by the "PMP" command. If they are entered with appropriate numeric input, they are then treated as if they had been preceded by the "PM" command.

SAVING AND RELOADING OPTIMIZATION DATA

AUTO SAVE and **AUTO SAVE2** - The "AUTO SAVE" and "AUTO SAVE2" commands cause all current variables and merit function definitions to be stored on disk either in the "AUTO.DAT" file or the "AUTO2.DAT" file. This allows for two different sets of optimization definitions to be stored to disk.

AUTO RELOAD and **AUTO RELOAD2** - The "AUTO RELOAD" and "AUTO RELOAD2" commands cause all current variables and merit function definitions stored on disk in the "AUTO.DAT" or the "AUTO2.DAT" files to be reloaded into memory ready to be used for optimization.

DUMPING OPTIMIZATION DATA TO A MACRO

MACDMP (macro name) , (kode) - The "MACDMP" command causes all current variables and merit function definitions to be stored in the macro named by the qualifier word. If the numeric value of "kode" is omitted, both variables and merit definitions will be saved. If a 1 is entered for "kode", then only the variables definitions will be saved. If a 2 is entered for "kode", then only the merit definitions will be saved. The variable and merit definitions will be saved in a form which will allow them to be re-established by simply typing the macro's name at the CMD level. This is an excellent way to save the final optimization definitions when a design has been completed. Macros may only be up to 1024 lines long.

THE DO IT YOURSELF MERIT FUNCTION

CREATING THE MERIT FUNCTION

MERIT - The "MERIT command causes the program to leave the CMD level and enter the MERIT input level. The merit function is wiped clean and is ready for new merit function input. Between "MERIT" and "EOS" or "END", any MERIT input level command may be entered. It is in the MERIT and the UPDATE MERIT levels where operands are defined and input.

EOS or **END** - The "EOS" or "END" command, issued from the MERIT level, causes the program to return to the CMD level. The merit function is left in memory and is ready for optimization.

MODIFYING MERIT FUNCTIONS

UPDATE MERIT or **U M** - The "UPDATE MERIT" command, or its abbreviated form "U M", causes the program to leave the CMD level and enter the UPDATE MERIT level. The merit memory area is opened and is ready for modification. Between "UPDATE MERIT" or "U M" and "EOS" or "END", any UPDATE MERIT level command may be entered. It is in the MERIT and the UPDATE MERIT levels where operands are defined and input.

DEL , i - The "DEL" command, issued from the UPDATE MERIT level, causes the program to delete the "i"th operand from the current merit function.

EOS or **END** - The "EOS" or "END" command, issued from the UPDATE MERIT level, causes the program to return to the CMD level. The merit function is left in memory and is ready for optimization.

OPERANDS AND OPERAND ENTRY

FIELD POSITION DEFINITIONS

F(n) , Y , X , Z , n - If any of these field position definitions are changed, they will remain as changed from program session to program session. The "F(n)" command has the similar syntax as the "FOB" command but takes no qualifier word. The "F(n)" command, entered as F1 or F2 or F50, etc., is used to custom define the 200 field positions used in "ray-based", pre-defined operand specification. "Y", "X" are the fractional y and x-coordinates of the object point measured in the plane of the current object surface. Z is the z-position, in lens units, of the object point measured from and in the local coordinate system of the current object surface plane. "n" is the reference ray wavelength. If "n" is explicitly input, it can be 1 through 10, the reference ray is then traced at wavelength number "n". If "n" is not explicitly entered, it will be assumed to be the "control wavelength (cw)". The first 41 field position definitions have initial default values which are given in the next table. If these are modified by the user, they remain modified from program session to program session.

DEFAULT FIELD POSITION DEFINITIONS					
F #	Y-FOB	X-FOB	Z-POS	n	(note)
1	0.0	0.0	0.0	cw	on-axis
2	1.0	0 0	0.0	cw	YZ-plane

3	-1.0	0 0	0.0	cw	YZ-plane
4	0.0	1 0	0.0	cw	XZ-plane
5	0.0	-1.0	0.0	cw	XZ-plane
6	0.866	0.0	0.0	cw	YZ-plane
7	-0.866	0.0	0.0	cw	YZ-plane
8	0.0	0 866	0.0	cw	XZ-plane
9	0.0	-0.866	0.0	cw	XZ-plane
10	0.707	0.0	0.0	cw	YZ-plane
11	-0.707	0.0	0.0	cw	YZ-plane
12	0.0	0 707	0.0	cw	XZ-plane
13	0.0	-0.707	0.0	cw	XZ-plane
14	0.5	0.0	0.0	cw	YZ-plane
15	-0.5	0.0	0.0	cw	YZ-plane
16	0.0	0 5	0.0	cw	XZ-plane
17	0.0	-0.5	0.0	cw	XZ-plane
18	1.0	1.0	0.0	cw	quad #1
19	1.0	-1.0	0.0	cw	quad #2
20	-1.0	1.0	0.0	cw	quad #4
21	-1.0	-1.0	0.0	cw	quad #3
22	0.866	0.866	0.0	cw	quad #1
23	0.866	-0.866	0.0	cw	quad #2
24	-0.866	0.866	0.0	cw	quad #4
25	-0.866	-0.866	0.0	cw	quad #3
26	0.707	0.707	0.0	cw	quad #1
27	0.707	-0.707	0.0	cw	quad #2
28	-0.707	0.707	0.0	cw	quad #4
29	-0.707	-0.707	0.0	cw	quad #3
30	0.5	0.5	0.0	cw	quad #1
31	0.5	-0.5	0.0	cw	quad #2
32	-0.5	0.5	0.0	cw	quad #4
33	-0.5	-0.5	0.0	cw	quad #3
34	0.612	0.612	0.0	cw	quad #1
35	0.612	-0.612	0.0	cw	quad #2
36	-0.612	0.612	0.0	cw	quad #4
37	-0.612	-0.612	0.0	cw	quad #3
38	0.354	0.354	0.0	cw	quad #1
39	0.354	-0.354	0.0	cw	quad #2
40	-0.354	0.354	0.0	cw	quad #4
41	-0.354	-0.354	0.0	cw	quad #3

The notation "quad" means that a field point is in a 45-degree orientation in one of the four quadrants of the XY-plane in the coordinate system of the current object surface. Field positions #42 to #200 are not automatically defined the first time the program runs. From program session to program session, the field settings are remembered in the disk file FIELDS.DAT in the main program directory.

FIELDS i , j - The "FIELDS" command is a CMD level command used to querry the current definition of fields number "i" through "j". To querry the definition of only one field, enter the field number as both "i" and "j".

FIELDS RESET - The "FIELDS RESET" command is a CMD level command used reset the field definitions to their original default values. It erases all user modifications to the field definitions.

RAY POSITION DEFINITIONS

R(n) , Y , X , n - If any of the position definitions are changed, they will remain as changed from program session to program session. The "R(n)" command has the same syntax as the "RAY" command but takes no qualifier word. The "R(n)" command, entered as R1 or R2 or R50, etc., is used to custom define the 5000 ray positions used in "ray-based", pre-defined operand specification. "Y", "X" are the fractional y and x-coordinates in the plane of the current reference surface. "n" is the ray wavelength. If "n" is explicitly input, it can be 1 through 10; the ray is then traced at wavelength number "n". If "n" is not explicitly entered, it will be assumed to be the "control wavelength". The first 123 ray position definitions have initial default values which are given in the next table. If these are modified by the user, they remain modified from program session to program session.

DEFAULT RAY POSITION DEFINITIONS				
R #	Y	X	n	(note)
1	0.0	0.0	cw	on-axis
2	1.0	0 0	cw	YZ-plane
3	-1.0	0 0	cw	YZ-plane
4	0.0	1.0	cw	XZ-plane
5	0.0	-1.0	cw	XZ-plane
6	0.866	0.0	cw	YZ-plane

7	-0.866	0.0	cw	YZ-plane
8	0.0	0 866	cw	XZ-plane
9	0.0	-0.866	cw	XZ-plane
10	0.707	0.0	cw	YZ-plane
11	-0.707	0.0	cw	YZ-plane
12	0.0	0 707	cw	XZ-plane
13	0.0	-0.707	cw	XZ-plane
14	0.5	0.0	cw	YZ-plane
15	-0.5	0.0	cw	YZ-plane
16	0.0	0 5	cw	XZ-plane
17	0.0	-0.5	cw	XZ-plane
18	1.0	1.0	cw	quad #1
19	1.0	-1.0	cw	quad #2
20	-1.0	1.0	cw	quad #4
21	-1.0	-1.0	cw	quad #3
22	0.866	0.866	cw	quad #1
23	0.866	-0.866	cw	quad #2
24	-0.866	0.866	cw	quad #4
25	-0.866	-0.866	cw	quad #3
26	0.707	0.707	cw	quad #1
27	0.707	-0.707	cw	quad #2
28	-0.707	0.707	cw	quad #4
29	-0.707	-0.707	cw	quad #3
30	0.5	0.5	cw	quad #1
31	0.5	-0.5	cw	quad #2
32	-0.5	0.5	cw	quad #4
33	-0.5	-0.5	cw	quad #3
34	0.612	0.612	cw	quad #1
35	0.612	-0.612	cw	quad #2
36	-0.612	0.612	cw	quad #4
37	-0.612	-0.612	cw	quad #3
38	0.354	0.354	cw	quad #1
39	0.354	-0.354	cw	quad #2
40	-0.354	0.354	cw	quad #4
41	-0.354	-0.354	cw	quad #3

The notation "quad" means that a ray is in a 45-degree orientation in one of the four quadrants of the XY-plane in the coordinate system of the current reference surface.

RAYS i , j - The "RAYS" command is a CMD level command used to querry the current definition of rays number "i" through "j". To querry the definition of only one ray, enter the ray number as "i" and "j".

RAYS RESET - The "RAYS RESET" command is a CMD level command used reset the ray definitions to their original default values. It erases all user modifications to the ray definitions.

VIG (ON or YES or OFF or NO) - The "VIG" command is a CMD level command used to indicate if vignetting is to be automatically considered during the computation of some selected operands (see operand list). "ON" or "YES" turns the option on. "OFF" or "NO" turns the option off. When "OFF", marginal or fractional marginal rays are traced to fractional coordinates in the reference surface relative to the reference aperture height. When "ON", marginal or fractional rays are traced to a fractional coordinate in the reference surface relative to the height of the "highest" non-failing ray in the reference surface. Only operands which explicitly say they use the vignetting option are affected by this setting. "VIG" is set to "ON" by default when the program starts.

DIFERENTIAL RAY TRACING

OPDIF (ON or YES or OFF or NO) - Turns differential ray tracing ON or OFF in optimization.

SPOT DIAGRAMS USED IN OPTIMIZATION

SPOT RAY GRID DEFINITIONS

OPSPOT (RECT, RING, RAND) - The CMD level "OPSPOT" command, issued with one of the three qualifier words ("RECT", "RING" or "RAND"), is used to set the type of grid or ray distribution to be used in spot diagram ray tracing during optimization. "RING" is the default type. "RING" causes circular or elliptical rings of rays to be traced. A temporary circular clear aperture will be assigned to the reference surface if no clear aperture is assigned to that surface. The default spot diagram will contain 33 rays. One ray at the center and eight rays each in four rings. The eight rays will be uniformly distributed in each ring. The default fractional reference surface diameters of the four default rings will be 0.5, 0.7, 0.866 and 1.0. The maximum number of rays which may be traced for and spot diagram or complex aperture function, per wavelength, is 100 excluding the central or chief ray. "RECT" causes a rectangular ray grid to be defined over the reference surface. "RECT" also causes circular clear aperture to be assigned to the reference surface if one has not yet been assigned. If the reference surface clear aperture is not square or circular, rays will have different spacings in the X and Y-direction orientations in the reference surface. If the qualifier "RAND" is used, a pseudo-random ray distribution over the reference surface will be traced. If no clear aperture is assigned to the reference surface, a circular clear aperture will be assigned. If a rectangular or racetrack clear aperture is used, the rays will be randomly distributed over a rectangular aperture. If a circular or elliptical clear

aperture is used, the rays will be randomly distributed over the circular or elliptical aperture. Issued without a qualifier or with the interrogator "?", the current grid style will be displayed.

OPRINGS , n - The CMD level "OPRINGS" command is used to specify the number of rings to be used whenever the "OPSPOT RING" command is in effect. The maximum number of rings is set at 50. In general, these rings will be first defined as circular. Rays will be distributed uniformly around each circular ring and then, if needed, the circular ring will be scaled to the appropriate ellipse. Elliptical rings are used when an elliptical clear aperture has been assigned to the reference surface or when the SAY and SAX values are not equal. The program default for "n" is 4. These four default rings will have fractional aperture heights (relative fractional radius) of 0.4, 0.7, 0.866 and 1.0. Each default ring will have eight equally spaced rays on that ring. Angular offsets will be zero in this default configuration. Issued with no numeric input or with the special interrogator "?", "RINGS" displays the current number of rings that will be used.

OPRING , i , r , m , θ - The CMD level "OPRING" command is used to specify the relative fractional radius "r" of ring "i", the number of rays "m" to be used in ring "i" and the angular offset "θ" of the first ray in ring "i". The program default value for "r", if "OPRING" is explicitly issued, is the reciprocal of the total number of rings times the number of the current ring. The maximum value for "r" is always 1.0. The maximum value for "m" is 100 per ring. The program default is 8 rays per ring. "θ" is the first ray angular offset value measured clockwise from the local Y-axis of the reference surface coordinate system toward the local X-axis of the reference surface coordinate system. The default value for " θ" is 0.0. With this default value in effect, the first ray in the ring will always lie on the local Y-axis of the reference surface coordinate system. Issued with no numeric input or with the special interrogator "?", "OPRING" displays the current data for each ring. Issued with numeric word #1 input only, "OPRING" displays the current data for ring "I".

OPRECT , n - The CMD level "OPRECT" command is used to specify the dimensions of the "n" X "n" rectangular grid of rays to be traced when "OPSPOT RECT" is in effect. The default value for "n" is 10. The maximum is 300.. Issued with no numeric input or with the special interrogator "?", "OPRECT" displays the current number value of "n".

OPRANNUM , n - The CMD level "OPRANNUM" command is used to specify the total number of rays to be traced per wavelength when "OPSPOT RAND" is in effect. The default value for "n" is 50. There is no maximum. Issued with no numeric input or with the special interrogator "?", "OPRANNUM" displays the current numeric value of "n".

OPSPDRST - The CMD level "OPSPDRST" command is used to reset all spot diagram parameters used during spot diagram ray tracing, to their program default values. Whenever the characteristics of a spot pattern is modified by the user, all characteristics must be reset by the user. If, for example, the user sets the number of rings to 20, then the characteristics of every ring will need to be reset by the user using the "RING" command.

CAPFNS IN OPTIMIZATION - Complex aperture functions (CAPFNs) as used in optimization are similar to the complex aperture functions described in the CMD and OPTIMIZATION sections of this manual. The following two CMD level commands apply to CAPFNs when then are used in optimization:

GAUSS or **NOGAUSS** - The CMD level "GAUSS" and "NOGAUSS" commands apply only to predefined spot disgram and CAPFN operands.They specify as to whether or not Gaussian apodization will be ON or OFF during the spot diagram, optimization ray tracing. For setting the grid size for complex aperture function and MTF calculations:

OPNRD , opnrd - The CMD level "OPNRD" command sets the number of rays across the exit pupil in CAPFN calculations when used in optimization. "opnrd" can be set to any even integer value greater than or equal to 16. The default value is 16. Once set, the "opnrd" value remains set until changed by the user or until the program terminates. The "APOD" settings, set with the "APOD" command and used in spot diagram optimization, also apply to aperture ray weighting in CAPFN calculations. The maximum number of rays which may be traced for any spot diagram or complex aperture function, per wavelength, is 100 excluding the central or chief ray.

CONFIGURATIONS FOR PREDEFINED OPERANDS

CFG, i - The MERIT and UPDATE MERIT level "CFG" command applys only to predefined operands and is always ignored for user-defined operands. It is a "sticky" command. It causes any predefined operand added to the operand list to be evaluated only for alternate configuration "i". Alternate configuration "i" will remain the understood configuration for predefined operand input until changed by another "CFG" command or until an "EOS" or "END" command is issued. If the "CFG" is not entered, the main configuration, 1, is assumed. This command has no effect upon user-defined operands.

OPERAND DESCRIPTORS

OP_DESC (operand designator) (operand descrition 1 to 69 characters) - Sets the operand description.

PREDEFINED OPERANDS

All predefined operands are entered at the MERIT and UPDATE MERIT levels with the following command:

(predefined operand name) , t , wt , i , j , k - "t" is the operand "target" value set by the user. Its default is 0.0. "wt" is the relative weight assigned to the target. Its default value is 1.0. The names of all predefined operands and the meanings of the "i", "j" and "k" values, numeric words (nw) #3, #4 and #5, are listed in the following table:

PREDEFINED LENS DATABASE OPERANDS				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
RD	surf #	(not used)	(not used)	Radius of curvature at surface "i"
CV	surf #	(not used)	(not used)	Curvature at surface "i"
TH	surf #	(not used)	(not used)	Thickness at surface "i"
CC	surf #	(not used)	(not used)	Conic constant at surface "i"
AC	surf #	(not used)	(not used)	2nd order aspheric at surface "i"
AD	surf #	(not used)	(not used)	4th order aspheric at surface "i"
AE	surf #	(not used)	(not used)	6th order aspheric at surface "i"
AF	surf #	(not used)	(not used)	8th order aspheric at surface "i"

AG	surf #	(not used)	(not used)	10th order aspheric at surface "i"
AH	surf #	(not used)	(not used)	12th order aspheric at surface "i"
AI	surf #	(not used)	(not used)	14th order aspheric at surface "i"
AJ	surf #	(not used)	(not used)	16th order aspheric at surface "i"
AK	surf #	(not used)	(not used)	18th order aspheric at surface "i"
AL	surf #	(not used)	(not used)	20th order aspheric at surface "i"
RDTOR	surf #	(not used)	(not used)	Toric radius of curvature at surface "i"
CVTOR	surf #	(not used)	(not used)	Toric curvature at surface "i"
CCTOR	surf #	(not used)	(not used)	Toric conic constant at surface "i"
ADTOR	surf #	(not used)	(not used)	Toric 4th order aspheric at surface "i"
AETOR	surf #	(not used)	(not used)	Toric 6th order aspheric at surface "i"
AFTOR	surf #	(not used)	(not used)	Toric 8th order aspheric at surface "i"
AGTOR	surf #	(not used)	(not used)	Toric 10th order aspheric at surface "i"
ALPHA	surf #	(not used)	(not used)	ALPHA surface tilt angle (degrees) at surface "i"
BETA	surf #	(not used)	(not used)	BETA surface tilt angle (degrees) at surface "i"
GAMMA	surf #	(not used)	(not used)	GAMMA surface tilt angle (degrees) at surface "i"
VNUM	surf #	(not used)	(not used)	V-number specifier for the "MODEL" glass at surface "i"
DPART	surf#	(not used)	(not used)	Partial Dispersion shift for the "MODEL" glass at surface "i".
ABBE	surf#	(not used)	(not used)	V-number for the glass at surface "i" It is equal to: $VNUM = \frac{(N_{cw} - 1)}{(N_{pcw1} - N_{pcw2})}$ Where: pcw1 and pcw2 are the primary wavelength pair defined in the lens database.
PARTL	surf #	(not used)	(not used)	Partial Dispersion for the glass at surface "i". It is equal to: $PARTL = \frac{(N_{cw} - N_{pcw2})}{(N_{pcw1} - N_{pcw2})}$ Where: pcw1 and pcw2 are the primary wavelength pair defined in the lens database.
INDEX	surf #	(not used)	(not used)	Refractive index Nd or the "MODEL" glass at surface "i".
N1 to N10	surf #	(not used)	(not used)	Refractive index value at wavelengths #1 to #10 at surface "i".
XD	surf #	(not used)	(not used)	X-decenter at surface "i"
YD	surf #	(not used)	(not used)	Y-decenter at surface "i"
ZD	surf #	(not used)	(not used)	Z-decenter at surface "i"
XVERT	surf #	Global ref surf #	(not used)	Global X-coordinate of the vertex of surface "i", referenced to a global origin at surface "j".
YVERT	surf #	Global ref surf #	(not used)	Global Y-coordinate of the vertex of surface "i", referenced to a global origin at surface "j".
ZVERT	surf #	Global ref surf #	(not used)	Global Z-coordinate of the vertex of surface "i", referenced to a global origin at surface "j".
LXVERT	surf #	Global ref surf #	(not used)	Global X-direction cosine of the local X-axis of surface "i", referenced to a global origin at surface "j".
MXVERT	surf #	Global ref surf #	(not used)	Global Y-direction cosine of the local X-axis of surface "i", referenced to a global origin at surface "j".
NXVERT	surf #	Global ref surf #	(not used)	Global Z-direction cosine of the local X-axis of surface "i", referenced to a global origin at surface "j".

LYVERT	surf #	Global ref surf #	(not used)	Global X-direction cosine of the local Y-axis of surface "i", referenced to a global origin at surface "j".
MYVERT	surf #	Global ref surf #	(not used)	Global Y-direction cosine of the local Y-axis of surface "i", referenced to a global origin at surface "j".
NYVERT	surf #	Global ref surf #	(not used)	Global Z-direction cosine of the local Y-axis of surface "i", referenced to a global origin at surface "j".
LZVERT	surf #	Global ref surf #	(not used)	Global X-direction cosine of the local Z-axis of surface "i", referenced to a global origin at surface "j".
MZVERT	surf #	Global ref surf #	(not used)	Global Y-direction cosine of the local Z-axis of surface "i", referenced to a global origin at surface "j".
NZVERT	surf #	Global ref surf #	(not used)	Global Z-direction cosine of the local Z-axis of surface "i", referenced to a global origin at surface "j".
LENGTH or OAL	surf # (def=0)	surf # (def=last)	(not used)	Algebraic sum of axial thicknesses from surface "i" to surface "j"
MLENGTH or OPTLEN	surf # (def=0)	surf # (def=last)	(not used)	Physical length from surface "i" to surface "j" along a path connecting surface vertices and ignoring tilts and decentrations. This is the sum of the axial thicknesses multiplied by the refractive index in each space.
ET or ETY	surf #	(not used)	(not used)	Edge thickness from surface "i" to surface "i"+1. Surface tilts and decentrations are ignored. If clear apertures are assigned, they are assumed circular with the YZ-plane value being used. The larger of the values on surface "i" and "i"+1 is used. If no clear apertures are assigned, then the larger of the sums of PY+PCY on surfaces "i" and "i"+1 are used in the calculation. Clear aperture decentrations and tilts are ignored.
ETX	surf #	(not used)	(not used)	Edge thickness from surface "i" to surface "i"+1. Surface tilts and decentrations are ignored. If clear apertures are assigned, they are assumed circular with the XZ-plane value being used. The larger of the values on surface "i" and "i"+1 is used. If no clear apertures are assigned, then the larger of the sums of PX+PCX on surfaces "i" and "i"+1 are used in the calculation. Clear aperture decentrations and tilts are ignored.
C1 through C96	surf #	(not used)	(not used)	Any one of the 96 coefficients of a special surface attached to surface "i"
SHAPEFAC	surf #	(not used)	(not used)	This returns the shape factor for the lens element which begins at surface "i" and terminates at surface "i+1". The shape factor is defined by : $$\text{SHAPEFAC} = \frac{r_{i+1} + r_i}{r_{i+1} - r_i}$$ where: r is the radius of curvature
PIVX	surf #	(not used)	(not used)	X-alternate pivot point at surface "i"
PIVY	surf #	(not used)	(not used)	Y-alternate pivot point at surface "i"
PIVZ	surf #	(not used)	(not used)	Z-alternate pivot point at surface "I"
CLPX	surf #	(not used)	(not used)	X-dimension of the clear aperture height at surface "I". Zero is returned if no clear aperture is assigned.
CLPY	surf #	(not used)	(not used)	Y-dimension of the clear aperture height at surface "I". Zero is returned if no clear aperture is assigned.
GRS	surf#	(not used)	(not used)	diffraction grating spacing

WEIGHT	surf # (def=0)	surf # (def=last)	(not used)	MASS in Kgs of elements from surface "i" to surface "j". This calculation assumes spherical surfaces and ignores all decenters and tilts. It uses the specific gravity assigned to surfaces with the lens database command "SPGR".
COST	surf # (def=0)	surf # (def=last)	(not used)	Cost in cost units based upon a WEIGHT calculation multiplied by the individual surface price/Kg values stored in the lens database.
ACT	surf #	actuator #	(not used)	The actuator value between –1.0 and 1.0 for actuator "j" on surface "i" if surface "i" is defined as a deformable surface.
ACTMAX	surf #	(not used)	(not used)	Returns the maximun actuator value on surface "i" if surface "i" is defined as a deformable surface.
ACTMIN	surf #	(not used)	(not used)	Returns the minumum actuator value on surface "i" if surface "i" is defined as a deformable surface.
ACTMEAN	surf #	(not used)	(not used)	Returns the average of all active actuator values on surface "i" if surface "i" is defined as a deformable surface.
ACTSDEV	surf #	(not used)	(not used)	Returns the standard deviation from the mean of all active actuator values on surface "i" if surface "i" is defined as a deformable surface.
ACTPTOV	surf #	(not used)	(not used)	Returns the peak to valley value for all active actuator values on surface "i" if surface "i" is defined as a deformable surface.

PREDEFINED REAL SINGLE RAY BASED OPERANDS				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
X	surf # (def=img)	Field Pos. #	Ray Pos.#	X-local coordinate at surface "i" at field position number "j" and ray position number "k" of last ray traced
Y	surf # (def=img)	Field Pos. #	Ray Pos.#	Y-local coordinate at surface "i" at field position number "j" and ray position number "k" of last ray traced
Z	surf # (def=img)	Field Pos. #	Ray Pos.#	Z-local coordinate at surface "i" at field position number "j" and ray position number "k" of last ray traced
DCL or K	surf # (def=img)	Field Pos. #	Ray Pos.#	L-direction cosine at surface "i" at field position number "j" and ray position number "k" of last ray traced
DCM or L	surf # (def=img)	Field Pos. #	Ray Pos.#	Z-direction cosine at surface "i" at field position number "j" and ray position number "k" of last ray traced
DCN or M	surf # (def=img)	Field Pos. #	Ray Pos.#	Z-direction cosine at surface "i" at field position number "j" and ray position number "k" of last ray traced
DX	surf # (def=img)	Field Pos. #	Ray Pos.#	DX at surface "i" of last ray traced X-Ray Coordinate minus X-Chief ray Coordinate. The "VIG" setting affects this operand.
DY	surf # (def=img)	Field Pos. #	Ray Pos.#	DY at surface "i" of last ray traced Y-Ray Coordinate minus Y-Chief ray Coordinate. The "VIG" setting affects this operand.
DXA	surf # (def=img)	Field Pos. #	Ray Pos.#	DXA at surface "i" of last ray traced XANG-Ray slope minus XANG-Chief ray slope (radians). The "VIG" setting affects this operand.
DYA	surf # (def=img)	Field Pos. #	Ray Pos.#	DYA at surface "i" of last ray traced YANG-Ray slope minus YANG-Chief ray slope (radians). The "VIG" setting affects this operand.

DR	surf # (def=img)	Field Pos. #	Ray Pos.#	DR at surface "i" of last ray traced Radial-Ray Coordinate minus Radial-Chief ray Coordinate. The "VIG" setting affects this operand.
DRA	surf # (def=img)	Field Pos. #	Ray Pos.#	DRA at surface "i" of last ray traced Radial-Ray slope minus Radial-Chief ray slope (radians). The "VIG" setting affects this operand.
XANG	surf # (def=img)	Field Pos. #	Ray Pos.#	XZ-plane slope angle at surface "i" of the last ray traced (radians)
YANG	surf # (def=img)	Field Pos. #	Ray Pos.#	YZ-plane slope angle at surface "i" of the last ray traced (radians)
OPL	surf #	Field Pos. #	Ray Pos.#	Optical path length along the specified ray from surface "i-1" to surface "i" (in lens units)
OPD	Field Pos #	Ray Pos. #	(not used)	Optical path difference between the specified ray and the reference ray (in lens units). The "VIG" setting affects this operand.
OPDW	Field Pos #	Ray Pos. #	(not used)	Optical path difference between the specified ray and the reference ray (in waves at the wavelength used to trace the reference ray). The "VIG" setting affects this operand.
LOLD	surf # (def=img)	Field Pos. #	Ray Pos.#	X-direction cosine at surface "i" of the specified ray (before refraction, reflection or diffraction)
MOLD	surf # (def=img)	Field Pos. #	Ray Pos.#	Y-direction cosine at surface "i" of the specified ray (before refraction, reflection or diffraction)
NOLD	surf # (def=img)	Field Pos. #	Ray Pos.#	Z-direction cosine at surface "i" of the specified ray (before refraction, reflection or diffraction)
LEN	surf #	Field Pos. #	Ray Pos.#	Physical length along the specified ray from surface "i-1" to surface "i"
AII	surf # (def=img)	Field Pos. #	Ray Pos.#	Cosine of the angle of incidence of specified ray at surface "i"
AIP	surf # (def=img)	Field Pos. #	Ray Pos.#	Cosine of the angle of refraction, reflection or diffraction of specified ray at surface "i"
LN	surf #	Field Pos. #	Ray Pos.#	Local surface coordinate system X-direction cosine of the surface normal at surface "i" where the specified ray intersects surface "i"
MN	surf #	Field Pos. #	Ray Pos.#	Local surface coordinate system Y-direction cosine of the surface normal at surface "i" where the specified ray intersects surface "i"
NN	surf #	Field Pos. #	Ray Pos.#	Local surface coordinate system Z-direction cosine of the surface normal at surface "i" where the specified ray intersects surface "i"
PXPX	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the X-coordinate of the specified chief ray traced with respect to a change in that chief ray's X-coordinate at the current object surface.
PXPY	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the X-coordinate of the specified chief ray traced with respect to a change in that chief ray's Y-coordinate at the current object surface.
PYPX	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the Y-coordinate of the specified chief ray traced with respect to a change in that chief ray's X-coordinate at the current object surface.
PYPY	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the Y-coordinate of the specified chief ray traced with respect to a change in that chief ray's Y-coordinate at the current object surface.
PXAPX	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the XZ-plane radian measure slope angle of the specified chief ray traced with respect to a change in that chief ray's X-coordinate at the current object surface.

PXAPY	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the XZ-plane radian measure slope angle of the specified chief ray traced with respect to a change in that chief ray's Y-coordinate at the current object surface.
PYAPX	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the YZ-plane radian measure slope angle of the specified chief ray traced with respect to a change in that chief ray's X-coordinate at the current object surface.
PYAPY	surf # (def=img)	Field Pos. #	(not used)	Derivative, at surface "i", of the YZ-plane radian measure slope angle of the specified chief ray traced with respect to a change in that chief ray's Y-coordinate at the current object surface.
DXDX	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the X-coordinate of the specified ray traced with respect to a change in that ray's X-coordinate at the current reference surface. The "VIG" setting affects this operand.
DXDY	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the X-coordinate of the specified ray traced with respect to a change in that ray's Y-coordinate at the current reference surface. The "VIG" setting affects this operand.
DYDX	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the Y-coordinate of the specified ray traced with respect to a change in that ray's X-coordinate at the current reference surface. The "VIG" setting affects this operand.
DYDY	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the Y-coordinate of the specified ray traced with respect to a change in that ray's Y-coordinate at the current reference surface. The "VIG" setting affects this operand.
DXADX	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the XZ-plane radian measure slope angle of the specified ray traced with respect to a change in that chief ray's X-coordinate at the current reference surface. The "VIG" setting affects this operand.
DXADY	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the XZ-plane radian measure slope angle of the specified ray traced with respect to a change in that chief ray's Y-coordinate at the current reference surface. The "VIG" setting affects this operand.
DYADX	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the YZ-plane radian measure slope angle of the specified ray traced with respect to a change in that chief ray's X-coordinate at the current reference surface. The "VIG" setting affects this operand.
DYADY	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the YZ-plane slope angle of the specified ray traced with respect to a change in that ray's Y-coordinate at the current reference surface. The "VIG" setting affects this operand.
DRDR	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the radial-coordinate of the specified ray traced with respect to a change in that ray's radial-coordinate at the current reference surface. The "VIG" setting affects this operand.

DRADR	surf # (def=img)	Field Pos. #	Ray Pos.#	Derivative, at surface "i", of the radial-coordinate (angular) of the specified ray traced with respect to a change in that ray's radial-coordinate at the current reference surface. The "VIG" setting affects this operand.
XREF	surf # (def=img)	Field Pos. #	(not used)	X-coordinate of the specified reference ray at surface "i"
YREF	surf # (def=img)	Field Pos. #	(not used)	Y-coordinate of the specified reference ray at surface "i"
ZREF	surf # (def=img)	Field Pos. #	(not used)	Z-coordinate of the specified reference ray at surface "i"
LREF	surf # (def=img)	Field Pos. #	(not used)	X-direction cosine of the specified reference ray at surface "i" after refraction, reflection or diffraction
MREF	surf # (def=img)	Field Pos. #	(not used)	Y-direction cosine of the specified reference ray at surface "i" after refraction, reflection or diffraction
NREF	surf # (def=img)	Field Pos. #	(not used)	Z-direction cosine of the specified reference ray at surface "i" after refraction, reflection or diffraction
LREFOL	surf # (def=img)	Field Pos. #	(not used)	X-direction cosine of the specified reference ray at surface "i" before refraction, reflection or diffraction
MREFOL	surf # (def=img)	Field Pos. #	(not used)	Y-direction cosine of the specified reference ray at surface "i" before refraction, reflection or diffraction
NREFOL	surf # (def=img)	Field Pos. #	(not used)	Z-direction cosine of the specified reference ray at surface "i" before refraction, reflection or diffraction
LENREF	surf #	Field Pos. #	(not used)	Physical length along the specified reference ray from surface "i-1" to surface "i"
OPLREF	surf #	Field Pos. #	(not used)	Optical path length along the specified reference ray from surface "i-1" to surface "i"
IREF	surf # (def=img)	Field Pos. #	(not used)	Cosine of the angle of incidence of the specified reference ray at surface "i"
IPREF	surf # (def=img)	Field Pos. #	(not used)	Cosine of the angle of refraction, reflection or diffraction of the specified reference ray at surface "i"
XAREF	surf # (def=img)	Field Pos. #	Ray Pos.#	XZ-plane slope angle of the specified reference ray at surface "i", measured in radians
YAREF	surf # (def=img)	Field Pos. #	(not used)	YZ-plane slope angle of the specified reference ray at surface "i", measured in radians
LNREF	surf #	Field Pos. #	(not used)	X-direction cosine of the surface normal at surface "i" where the specified reference ray intersects surface "i"
MNREF	surf #	Field Pos. #	(not used)	Y-direction cosine of the surface normal at surface "i" where the specified reference ray intersects surface "i"
NNREF	surf #	Field Pos. #	(not used)	Z-direction cosine of the surface normal at surface "i" where the specified reference ray intersects surface "i"
GLX	surf #	Field Pos. #	Ray Pos.#	Global X-coordinate of the specified ray at surface "i"
GLY	surf #	Field Pos. #	Ray Pos.#	Global Y-coordinate of the specified ray at surface "i"
GLZ	surf #	Field Pos. #	Ray Pos.#	Global Z-coordinate of the specified ray at surface "i"
GLL	surf #	Field Pos. #	Ray Pos.#	Global X-direction cosine of the specified ray traced at surface "i" after refraction, reflection or diffraction
GLM	surf #	Field Pos. #	Ray Pos.#	Global Y-direction cosine of the specified ray traced at surface "i" after refraction, reflection or diffraction

GLN	surf #	Field Pos. #	Ray Pos.#	Global Z-direction cosine of the specified ray traced at surface "i" after refraction, reflection or diffraction
GLLOLD	surf #	Field Pos. #	Ray Pos.#	Global X-direction cosine of the specified ray traced at surface "i" before refraction, reflection or diffraction
GLMOLD	surf #	Field Pos. #	Ray Pos.#	Global Y-direction cosine of the specified ray traced at surface "i" before refraction, reflection or diffraction
GLMOLD	surf #	Field Pos. #	Ray Pos.#	Global Z-direction cosine of the specified ray traced at surface "i" before refraction, reflection or diffraction
SYMX (symmetrical aberration determined from two rays in the XZ-plane of the current reference surface)	fractional ray height	Field Pos. #	Wavelength.#	For two rays traced in the XZ-plane of the current reference surface at fractional ray heights + and - "i", at field position "j" and at wavelength number "k", SYMX is the difference between the DX values of the two rays divided by 2.0 (modes FOCAL and UFOCAL) and is the difference between the DXA values of the two rays divided by 2.0 (modes AFOCAL ans UAFOCAL). The "VIG" setting affects this operand.
SYMY (symmetrical aberration determined from two rays in the YZ-plane of the current reference surface)	fractional ray height	Field Pos. #	Wavelength.#	The same as SYMX but using DY or DYA values of rays traced in the YZ-plane of the current reference surface at field position "j" and at wavelength number "k". The "VIG" setting affects this operand.
ASYMX (asymmetrical aberration determined from two rays in the XZ-plane of the current reference surface)	fractional ray height	Field Pos. #	Wavelength.#	For two rays traced in the XZ-plane of the current reference surface at fractional ray heights + and - "i", at field position "j" and at wavelength number "k", ASYMX is the sum of the DX values of the two rays divided by 2.0 (modes FOCAL and UFOCAL) and is the sum of the DXA values of the two rays divided by 2.0 (modes AFOCAL ans UAFOCAL). The "VIG" setting affects this operand.
ASYMY (symmetrical aberration determined from two rays in the YZ-plane of the current reference surface)	fractional ray height	Field Pos. #	Wavelength.#	The same as ASYMX but using DY or DYA values of rays traced in the YZ-plane of the current reference surface at field position "j" and at wavelength number "k". The "VIG" setting affects this operand.
PACM	(not used)	(not used)	(not used)	Primary Axail Color Marginal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four on-axis marginal rays, traced at the current primary wavelength pair.
PACZ	(not used)	(not used)	(not used)	Primary Axail Color Zonal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four on-axis 0.7 zonal rays, traced at the current primary wavelength pair.
SACM	(not used)	(not used)	(not used)	Secondary Axail Color Marginal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four on-axis marginal rays, traced at the current secondary wavelength pair.

SACZ	(not used)	(not used)	(not used)	Secondary Axail Color Zonal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four on-axis 0.7 zonal rays, traced at the current secondary wavelength pair.
PLCM	(not used)	(not used)	(not used)	Primary Lateral Color Marginal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four full FOV , zero relative height rays, traced at the current primary wavelength pair.
PLCZ	(not used)	(not used)	(not used)	Primary Lateral Color Zonal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four 0.7 zonal FOV, zero relative height rays, traced at the current primary wavelength pair.
SLCM	(not used)	(not used)	(not used)	Secondary Lateral Color Marginal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four full FOV , zero relative height rays, traced at the current secondary wavelength pair.
SLCZ	(not used)	(not used)	(not used)	Secondary Lateral Color Zonal. Sums of the absolute values of real ray DX and DY (mode FOCAL or UFOCAL) or DXA and DYA (mode AFOCAL or UAFOCAL) value differences, at the current image surface, for four 0.7 zonal FOV, zero relative height rays, traced at the current secondary wavelength pair.
DMINUSD	(not used)	(not used)	(not used)	Conrady Σ(D-d)Δn achromatization operand, where D are the optical path lengths along the +0.7, YZ-plane marginal ray traced from an on-axis image point at the control wavelength, d are axial separations and Δn are the refractive index variations for the primary chromatic pair of wavelegths. The summation is over all surfaces.

PREDEFINED SPOT DIAGRAM AND COMPLEX APERTURE FUNCTION (CAPFN) BASED OPERANDS				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
CENTX	Field Pos. #	Wavelength #	(not used)	X- centroid location in the current image surface of the spot diagram centroid. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
CENTY	Field Pos. #	Wavelength #	(not used)	Y- centroid location in the current image surface of the spot diagram centroid. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RMS	Field Pos. #	Wavelength #	(not used)	RMS spot diameter for the spot diagram, at the specified field position, centered about the spot centroid location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.

RMSX	Field Pos. #	Wavelength #	(not used)	X-dimension of the RMS spot size for the spot diagram, at the specified field position,. centered about the spot centroid location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RMSY	Field Pos. #	Wavelength #	(not used)	Y-dimension of the RMS spot size for the spot diagram centered about the spot centroid location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RSS	Field Pos. #	Wavelength #	(not used)	RSS spot diameter for the spot diagram, at the specified field position, centered about the chief ray location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RSSX	Field Pos. #	Wavelength #	(not used)	X-dimension of the RSS spot size for the spot diagram ,at the specified field position, centered about the chief ray location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RSSY	Field Pos. #	Wavelength #	(not used)	Y-dimension of the RSS spot size for the spot ,at the specified field position, diagram centered about the cheif ray location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RMSYX	Field Pos. #	Wavelength #	(not used)	Ratio of the Y-dimension of the RMS spot size to the X-dimension spot size for the spot ,at the specified field position, diagram centered about the cheif ray location. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
RMSOPD	Field Pos. #	Wavelength #	(not used)	RMSOPD, in waves at the control wavelength, of the CAPFN at the specified field position. If numeric word "j" is not explicitly entered, all wavelengths and spectral weights are used.
ZERN37	Field Pos. #	Zern Coef #	Wavelength #	If a CAPFN for the specified field position does not exist, it is created using the default CAPFN ray grid. The wavefront, at wavelength "k",is fitted to a 37-term Fringe-Zernike Polynomial. The coefficient number "j" becomes the operand.
GREYS	Field Pos. #	OPD weight	Wavelength #	See the section above which describes Grey's optimization method. This operand uses the spot diagram ray pattern currently in effect. Ray are traced from the specified Field Pos # and Wavelength #. The "VIG" setting affects this operand.
MGOTF or GOTFM	Field Pos. #	spatial frequency	Orientation 0=vert bars 90=horiz bars	Value of the modulus of the geometrical polychromatic optical transfer function at field position "i" and spatial frequency "j".
PGOTF or GOTFP	Field Pos. #	spatial frequency	Orientation 0=vert bars 90=horiz bars	Value of the phase of the geometrical polychromatic optical transfer function at field position "i" and spatial frequency "j".
MDOTF or DOTFM	Field Pos. #	spatial frequency	Orientation 0=vert bars 90=horiz bars	Value of the modulus of the diffraction polychromatic optical transfer function at field position "i" and spatial frequency "j".
PDOTF or DOTFP	Field Pos. #	spatial frequency	Orientation 0=vert bars 90=horiz bars	Value of the phase of the diffraction polychromatic optical transfer function at field position "i" and spatial frequency "j".
RED	Field Pos #	% energy	(not used)	Diameter of the circle, in the appropriate units depending upon lens mode, which encircles "j" percent of the energy in a spot for field position "i". This is based upon the geometrical spot diagram and ignores diffraction. It is centered at the chief ray of field position "i".

REDCEN	Field Pos #	% energy	(not used)	Diameter of the circle, in the appropriate units depending upon lens mode, which encircles "j" percent of the energy in a spot for field position "i". This is based upon the geometrical spot diagram and ignores diffraction. It is centered at the location of the spot centroid.

PREDEFINED PARAXIAL RAY BASED OPERANDS				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
PWRY	surf # (def=0)	surf # (def=last)	(not used)	YZ-plane paraxial, optical power of optical system from surface "i" to surface "j". Defaults for "i" and "j" are 0 and the final surface number.
PWRX	surf # (def=0)	surf # (def=last)	(not used)	Same as above except in the XZ-plane.
FLCLTH or FLCLTHY	surf # (def=0)	surf # (def=last)	(not used)	YZ-plane, paraxial, effective focal length at the control wavelength of optical system from surface "i" to surface "j". Defaults for "i" and "j" are 0 and the final surface number.
FLCLTHX	surf # (def=0)	surf # (def=last)	(not used)	Same as FLCLTH except in the XZ-plane.
PY	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, marginal paraxial ray height at surface "i" and at wavelength "j"
PX	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PCY	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, chief paraxial ray height at surface "i" and at wavelength "j"
PCX	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PUY	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, marginal paraxial ray tangent at surface "i" and at wavelength "j" after refraction or reflection
PUX	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PUCY	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, chief paraxial ray tangent at surface "i" and at wavelength "j" after refraction or reflection
PUCX	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PIY	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, marginal paraxial ray incident angle tangent at surface "i" and at wavelength "j"
PIX	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PICY	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, chief paraxial ray incident angle tangent at surface "i" and at wavelength "j" before refraction or reflection
PICX	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PIYP	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, marginal paraxial ray angle of refraction or reflection (tangent) at surface "i" and at wavelength "j"
OPERAND NAME	"i" (nw#3)	"j" (nw#4)	"k" (nw#5)	DESCRIPTION
PIXP	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.
PICYP	surf # (def=last)	wavelength # (def=cw)	(not used)	YZ-plane, chief paraxial ray angle of refraction or reflection (tangent) at surface "i" and at wavelength "j"
PICXP	surf # (def=last)	wavelength # (def=cw)	(not used)	Same as above except in the XZ-plane.

IMDISX	surf #	(not used)	(not used)	XZ-plane. This is the position at which the paraxial marginal ray, in the space following surface "i", has zero height. It is represented in the coordinate system of surface "i".
IMDISY	surf #	(not used)	(not used)	Same as above except in the XZ-plane.

PREDEFINED PARAXIAL CHROMATIC OPERANDS				
NOTE: Entering the number of the last surface (the default) for "i" in the next eight aberrations results in the system aberration total for that aberration being used as the operand value.				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
PACY	surf # (def=last)	(not used)	(not used)	YZ-plane, primary axial chromatic aberration at surface "i". If "i" is the final surface, system totals are calculated. This is the same data as displayed in the "FCHY" and "FCHX" commands.
PACX	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
PLCY	surf # (def=last)	(not used)	(not used)	YZ-plane, primary lateral chromatic aberration at surface "i". If "i" is the final surface, system totals are calculated. This is the same data as displayed in the "FCHY" and "FCHX" commands.
PLCX	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
SACY	surf # (def=last)	(not used)	(not used)	YZ-plane, secondary axial chromatic aberration at surface "i". If "i" is the final surface, system totals are calculated. This is the same data as displayed in the "FCHY" and "FCHX" commands.
SACX	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
SLCY	surf # (def=last)	(not used)	(not used)	YZ-plane secondary lateral chromatic aberration at surface "i". If "i" is the final surface, system totals are calculated. This is the same data as displayed in the "FCHY" and "FCHX" commands.
SLCX	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.

PREDEFINED SPECIAL REAL RAY/PARAXIAL RAY BASED OPERANDS				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
MAGX	Field Pos. #	(not used)	(not used)	XZ-plane magnification. Uses the ratio of the X-slope of differential chief ray at the current object surface to the X-slope of differential chief ray at the current image surface.
MAGY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
MAGXOR	Field Pos. #	(not used)	(not used)	XZ-plane reference magnification. Uses the ratio of X-slope of differential chief ray at object surface to the X-slope of differential chief ray at reference surface.
MAGYOR	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
FFLX	Field Pos. #	(not used)	(not used)	XZ-plane front focal length. Based upon differential ray data.
FFLY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
BFLX	Field Pos. #	(not used)	(not used)	XZ-plane back focal length. Based upon differential ray data.
BFLY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
FFNX	Field Pos. #	(not used)	(not used)	XZ-plane front F-number. Uses the reciprocal of -2 times the scaled up slope of differential marginal ray at the current object surface.

FFNY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
BFNX	Field Pos. #	(not used)	(not used)	XZ-plane back F-number. Uses the reciprocal of -2 times the scaled up slope of differential marginal ray at the current image surface.
BFNY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
EFLX	Field Pos. #	(not used)	(not used)	XZ-plane effective focal length. Based upon differential ray data.
EFLY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
ENDIAX	Field Pos. #	(not used)	(not used)	XZ-plane entrance pupil diameter. Based upon differential ray data.
ENDIAY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
EXDIAX	Field Pos. #	(not used)	(not used)	XZ-plane exit pupil diameter. Based upon differential ray data.
EXDIAY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
ENPOSX	Field Pos. #	(not used)	(not used)	X-coordinate of the center of the entrance pupil. Differential ray data is used in the calculation and the value is represented in the coordinate system of the NEWOBJ+1 surface.
ENPOSY	Field Pos. #	(not used)	(not used)	Same as above except the Y-coordinate.
ENPOSZ	Field Pos. #	(not used)	(not used)	Same as above except the Z-coordinate.
EXPOSX	Field Pos. #	(not used)	(not used)	X-coordinate of the center of the exit pupil. Differential ray data is used in the calculation and the value is represented in the coordinate system of the NEWIMG surface.
EXPOSY	Field Pos. #	(not used)	(not used)	Same as above except the Y-coordinate.
EXPOSZ	Field Pos. #	(not used)	(not used)	Same as above except the Z-coordinate.
FNUMX	Field Pos. #	(not used)	(not used)	Image space F-number. Uses extreme upper and lower real marginal rays in the XZ-plane of the reference surface for the current FOB. Takes vignetting into account automatically. If no chief ray exist, a paxaial value is used instead.
FNUMY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
OBFNUMX	Field Pos. #	(not used)	(not used)	Object space F-number. Uses extreme upper and lower real marginal rays in the XZ-plane of the reference surface for the current FOB. Takes vignetting into account automatically. If no chief ray exist, a paxaial value is used instead.
OBFNUMY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
ENPDIAX	Field Pos. #	(not used)	(not used)	Entrance pupil diameter. Uses extreme upper and lower real marginal rays in the XZ-plane of the reference surface for the current FOB. Takes vignetting into account automatically. If no chief ray exist, a paxaial value is used instead.
ENPDIAY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
EXPDIAX	Field Pos. #	(not used)	(not used)	Exit pupil diameter. Uses extreme upper and lower real marginal rays in the XZ-plane of the reference surface for the current FOB. Takes vignetting into account automatically. If no chief ray exist, a paxaial value is used instead.

EXPDIAY	Field Pos. #	(not used)	(not used)	Same as above except in the YZ-plane.
PUPDIAX	surf #	(not used)	(not used)	XZ-plane. This is 2.0 times the height of the paraxial marginal ray at the position relative to surface "i" at which the paraxial chief ray has zero height.
PUPDIAY	surf #	(not used)	(not used)	Same as above except in the YZ-plane.
PUPDISX	surf #	(not used)	(not used)	XZ-plane. This is the position at which the paraxial chief ray, in the space folloing surface "i", has zero height. It is represented in the coordinate system of surface "i".
PUPDISY	surf #	(not used)	(not used)	Same as above except in the YZ-plane.
CHFIMX	surf #	(not used)	(not used)	XZ-plane. This is the height of the paraxial chief ray at the position relative to surface "i" at which the paraxial marginal ray has zero height.
CHFIMY	surf #	(not used)	(not used)	Same as above except in the YZ-plane.
GPX	surf #	Field Pos. #	(not used)	XZ-plane generalized paraxial marginal ray height based upon differential rays about the chief ray.
GPY	surf #	Field Pos. #	(not used)	Same as above except in the YZ-plane.
GPUX	surf #	Field Pos. #	(not used)	XZ-plane generalized paraxial marginal ray slope based upon differential rays about the chief ray.
GPUY	surf #	Field Pos. #	(not used)	Same as above except in the YZ-plane.
GPCX	surf #	Field Pos. #	(not used)	XZ-plane generalized paraxial chief ray height based upon differential rays about the chief ray.
GPCY	surf #	Field Pos. #	(not used)	Same as above except in the YZ-plane.
GPUCX	surf #	Field Pos. #	(not used)	XZ-plane generalized paraxial chief ray slope based upon differential rays about the chief ray.
GPUCY	surf #	Field Pos. #	(not used)	Same as above except in the YZ-plane.
DIST	Field Pos. #	(not used)	(not used)	Uses real chief and real chief differential ray traces to calculate percent distortion at the specified field point. Calculation is performed at the wavelength specified by the field point definition and for the current lens configuration. Value is valid for tilted and decentered systems. All surface types including special surfaces are recognized. See the "DIST" command in the CMD section.
FISHDIST	Field Pos. #	(not used)	(not used)	Similar to DIST but uses ray slope angles rather than slope angle tangents. See the "FISHDIST" command in the CMD section.
XFOC	Field Pos. #	(not used)	(not used)	XFOC returns the distance from the current image surface to the focus position of close XZ-plane marginal differential rays traced about the specified field point. Calculation is performed at the wavelength specified by the field point definition and for the current lens configuration. This distance is measured along the local Z-axis of the current image surface in the coordinate system of the current image surface **This is the X-field curvature. In modes FOCAL and UFOCAL, the units are lens units. In modes AFOCAL and UAFOCAL, the units are diopters. If, in the AFOCAL or UAFOCAL mode, the field curvature is too large to represent, it will be set to 1.0D20.**

YFOC	Field Pos. #	(not used)	(not used)	**Same as above except in the YZ-plane. This is the Y-field curvature. In modes FOCAL and UFOCAL, the units are lens units. In modes AFOCAL and UAFOCAL, the units are diopters. If, in the AFOCAL or UAFOCAL mode, the field curvature is too large to represent, it will be set to 1.0D20.**
AST	Field Pos. #	(not used)	(not used)	AST returns the the astigmatism along the specified field point. It is just the YFOC value minus the XFOC value. Calculation is performed at the wavelength specified by the field point definition and for the current lens configuration. **In modes FOCAL and UFOCAL, the units are lens units. In modes AFOCAL and UAFOCAL, the units are diopters. If, in the AFOCAL or UAFOCAL mode, the astigmatism is too large to represent, it will be set to 1.0D20.**

PREDEFINED 3RD, 5TH AND 7TH ORDER ABERRATION OPERANDS				
NOTE: Entering the number of the last surface (the default) for "i" in the 3rd, 5th and 7th order aberrations results in the system aberration total for that aberration being used as the operand value.	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
OPERAND NAME	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order SPHERICAL ABERRATION at surface "i" and at the control wavelength
SA3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA3	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order COMA at surface "i" and at the control wavelength
CMA3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA3	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order ASTIGMATISM at surface "i" and at the control wavelength
AST3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XAST3	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order DISTORTION at surface "i" and at the control wavelength
DIS3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS3	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order PETZVAL CURVATURE at surface "i" and at the control wavelength
PTZ3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZ3	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SPHERICAL ABERRATION at surface "i" and at the control wavelength
SA5	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA5	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order COMA at surface "i" and at the control wavelength
CMA5	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA5	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order ASTIGMATISM at surface "i" and at the control wavelength

AST5	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XAST5	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order DISTORTION at surface "i" and at the control wavelength
DIS5	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS5	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order PETZVAL CURVATURE at surface "i" and at the control wavelength
PTZ5	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZ5	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order TANGENTIAL OBLIQUE SPHERICAL ABERRATION at surface "i" and at the control wavelength
TOBSA	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTOBSA	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SAGITTAL OBLIQUE SPHERICAL ABERRATION at surface "i" and at the control wavelength
SOBSA	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSOBSA	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order ELLIPTICAL COMA at surface "i" and at the control wavelength
ELCMA	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XELCMA	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order TANGENTIAL ASTIGMATISM at surface "i" and at the control wavelength
TAS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTAS	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SAGITTAL ASTIGMATISM at surface "i" and at the control wavelength
SAS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSAS	surf # (def=last)	(not used)	(not used)	YZ-plane, 7th order SPHERICAL ABERRATION at surface "i" and at the control wavelength
SA7	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA7	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order SPHERICAL ABERRATION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SA3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA3P	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order COMA, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
CMA3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA3P	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order ASTIGMATISM, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
AST3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.

XAST3P	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order DISTORTION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
DIS3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS3P	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order PETZVAL CURVATURE, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
PTZ3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZ3P	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SPHERICAL ABERRATION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SA5P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA5P	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order COMA, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
CMA5P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA5P	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order ASTIGMATISM, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
AST5P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XAST5P	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order DISTORTION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
DIS5P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS5P	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order PETZVAL CURVATURE, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
PTZ5P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZ5P	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order TANGENTIAL OBLIQUE SPHERICAL ABERRATION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
TOBSAP	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTOBSAP	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SAGITTAL OBLIQUE SPHERICAL ABERRATION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SOBSAP	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.

XSOBSAP	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order ELLIPTICAL COMA, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
ELCMAP	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XELCMAP	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order TANGENTIAL ASTIGMATISM, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
TASP	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTASP	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SAGITTAL ASTIGMATISM, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SASP	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSASP	surf # (def=last)	(not used)	(not used)	YZ-plane, 7th order SPHERICAL ABERRATION, PRIMARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SA7P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA7P	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order SPHERICAL ABERRATION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SA3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA3S	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order COMA, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
CMA3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA3S	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order ASTIGMATISM, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
AST3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XAST3S	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order DISTORTION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
DIS3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS3S	surf # (def=last)	(not used)	(not used)	YZ-plane, 3rd order PETZVAL CURVATURE, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
PTZ3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.

XPTZ3S	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SPHERICAL ABERRATION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SA5S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA5S	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order COMA, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
CMA5S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA5S	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order ASTIGMATISM, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
AST5S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XAST5S	surf #	(not used)	(not used)	YZ-plane, 5th order DISTORTION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
DIS5S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS5S	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order PETZVAL CURVATURE, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
PTZ5S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZ5S	surf #	(not used)	(not used)	YZ-plane, 5th order TANGENTIAL OBLIQUE SPHERICAL ABERRATION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
TOBSAS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTOBSAS	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order SAGITTAL OBLIQUE SPHERICAL ABERRATION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SOBSAS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSOBSAS	surf #	(not used)	(not used)	YZ-plane, 5th order ELLIPTICAL COMA, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
ELCMAS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XELCMAS	surf # (def=last)	(not used)	(not used)	YZ-plane, 5th order TANGENTIAL ASTIGMATISM, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
TASS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.

XTASS	surf #	(not used)	(not used)	YZ-plane, 5th order SAGITTAL ASTIGMATISM, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SASS	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSASS	surf # (def=last)	(not used)	(not used)	YZ-plane, 7th order SPHERICAL ABERRATION, SECONDARY CHROMATIC DIFFERENCES at surface "i" and at the control wavelength
SA7S	surf #	(not used)	(not used)	Same as above except in the XZ-plane.
XSA7S	surf #	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order SPHERICAL ABERRATION at surface "i" and at the control wavelength
SA5I	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA5I	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order COMA at surface "i" and at the control wavelength
CMA5I	surf #	(not used)	(not used)	Same as above except in the XZ-plane.
XCMA5I	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order ASTIGMATISM at surface "i" and at the control wavelength
AST5I	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XAST5I	surf #	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order DISTORTION at surface "i" and at the control wavelength
DIS5I	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XDIS5I	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order PETZVAL CURVATURE at surface "i" and at the control wavelength
PTZ5I	surf #	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZ5I	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order TANGENTIAL OBLIQUE SPHERICAL ABERRATION at surface "i" and at the control wavelength
TOBSAI	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTOBSAI	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order SAGITTAL OBLIQUE SPHERICAL ABERRATION at surface "i" and at the control wavelength
SOBSAI	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSOBSAI	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order ELLIPTICAL COMA at surface "i" and at the control wavelength
ELCMAI	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XELCMAI	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order TANGENTIAL ASTIGMATISM at surface "i" and at the control wavelength

TASI	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XTASI	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 5th order SAGITTAL ASTIGMATISM at surface "i" and at the control wavelength
SASI	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSASI	surf # (def=last)	(not used)	(not used)	Intrinsic surface contribution; YZ-plane, 7th order SPHERICAL ABERRATION at surface "i" and at the control wavelength
SA7I	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XSA7I	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order SPHERICAL ABERRATION at surface "i" and at the control wavelength
PSA3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPSA3	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order COMA at surface "i" and at the control wavelength
PCMA3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
PXCMA3	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order ASTIGMATISM at surface "i" and at the control wavelength
PAST3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPAST3	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order DISTORTION at surface "i" and at the control wavelength
PDIS3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPDIS3	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order PETZVAL CURVATURE at surface "i" and at the control wavelength
PPTZ3	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPPTZ3	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order SPHERICAL ABERRATION, PRIMARY CHROMATIC DIFFERENCES at surface "i"
PSA3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPSA3P	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order COMA, PRIMARY CHROMATIC DIFFERENCES at surface "i"
PCMA3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPCMA3P	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order ASTIGMATISM, PRIMARY CHROMATIC DIFFERENCES at surface "i"
PAST3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.

XPAST3P	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order DISTORTION, PRIMARY CHROMATIC DIFFERENCES at surface "i"
PDIS3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPDIS3P	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order PETZVAL CURVATURE, PRIMARY CHROMATIC DIFFERENCES at surface "i"
PPTZ3P	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPPTZ3P	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order SPHERICAL ABERRATION, SECONDARY CHROMATIC DIFFERENCES at surface "i"
PSA3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
PXSA3S	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order COMA, SECONDARY CHROMATIC DIFFERENCES at surface "i"
PCMA3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPCMA3S	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order ASTIGMATISM, SECONDARY CHROMATIC DIFFERENCES at surface "i"
PAST3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPAST3S	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order DISTORTION, SECONDARY CHROMATIC DIFFERENCES at surface "i"
PDIS3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPDIS3S	surf # (def=last)	(not used)	(not used)	Exit pupil; YZ-plane, 3rd order PETZVAL CURVATURE, SECONDARY CHROMATIC DIFFERENCES at surface "i"
PPTZ3S	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPPTZ3S	surf # (def=last)	(not used)	(not used)	This is the YZ-plane, third order Petzval curvature. Its value is independent of lens mode.
PTZCV	surf # (def=last)	(not used)	(not used)	Same as above except in the XZ-plane.
XPTZCV				

PREDEFINED GAUSSIAN BEAM OPERANDS	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
OPERAND NAME	surf #	Field Pos. #	(not used)	The XZ-plane $1/e^2$ semi-diameter of the gaussian beam at surface "i" and at field position "j". Wavelength defined in the field position definition.
GBRADX	surf #	Field Pos. #	(not used)	This is the same as GBRADX except that it works in the YZ-plane.

GBRADY	surf #	Field Pos. #	(not used)	The distance from surface "i" to the next XZ-plane beam waist in the image space of surface "i". Wavelength defined in the field position definition.
GBDISX	surf #	Field Pos. #	(not used)	This is the same as GBDISX except that it works in the YZ-plane.
GBDISY	surf #	Field Pos. #	(not used)	The XZ-plane wavefront radius of curvature at surface "i" in the image space of surface "i". Wavelength defined in the field position definition.
GBRCVX	surf #	Field Pos. #	(not used)	This is the same as GBRCVX except that it works in the YZ-plane.
GBRCVY	surf #	Field Pos. #	(not used)	The XZ-plane $1/e^2$ semi-diameter of the beam waist in the image space of surface "I". Wavelength defined in the field position definition.
GBWAISTX	surf #	Field Pos. #	(not used)	This is the same as GBWAISTX except that it works in the YZ-plane.

GBWAISTY				
PREDEFINED REAL RAY SPECTROMETER OPERANDS (See description following the GET list in the CMD section)	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
OPERAND NAME	wavelength #	pixel size (optional)	(not used)	Cross-track Spectral Co-registration Error at wavelength number "i".
CTSX or CTSY	pixel size (optional)	(not used)	(not used)	Spatial Co-registration Error for all defined wavelengths.
SCEX or SCEY				

PREDEFINED REAL RAY COMPOSITE OPERANDS (Not available in GET or Tolerancing)				
OPERAND NAME	**"i" (nw#3)**	**"j" (nw#4)**	**"k" (nw#5)**	**DESCRIPTION**
CLEARX	fob#1.ray#1 example: 001.012	fob#2.ray#2 example: 034.005	surf#1.surf#2 example: 005.007	"i" and "j" are decimal entries with three digits to the left of the decimal point and four digits to the right. "k" is a decimal entry with three digits to the left of the decimal point and three digits to the right. For "i" and "j", the input represents the FOB and RAY numbers representing two rays as defined in the current Fields and Rays definitions. For "k", the input represents two surface numbers. The value returned as the "clearance-X" operand is: The signed, globally referenced perpendicular-distance from the "first" ray as defined by "i" leaving the "first" surface defined in "k" to a point defined by the intersection of the "second" ray as defined in "j" with the "second" surface defined in "k". The calculation is performed on an XZ-plane projection. The returned operand value is positive if the point lies above or to the right of the line. All calculations are referenced to the global coordinate system of surface (surf#2). If the intersection point of the second ray with the second surface is to the right or above (greater Z or X), the returned value is positive.

CLEARY	fob#1.ray#1 example: 001.0012	fob#2.ray#2 example: 034.0005	surf#1.surf#2 example: 005.007	"i" and "j" are decimal entries with three digits to the left of the decimal point and four digits to the right. "k" is a decimal entry with three digits to the left of the decimal point and three digits to the right. For "i" and "j", the input represents the FOB and RAY numbers representing two rays as defined in the current Fields and Rays definitions. For "k", the input represents two surface numbers. The value returned as the "clearance-Y" operand is: The signed, globally referenced perpendicular-distance from the "first" ray as defined by "i" leaving the "first" surface defined in "k" to a point defined by the intersection of the "second" ray as defined in "j" with the "second" surface defined in "k". The calculation is performed on an YZ-plane projection. The returned operand value is positive if the point lies above or to the right of the line. All calculations are referenced to the global coordinate system of surface (surf#2). If the intersection point of the second ray with the second surface is to the right or above (greater Z or Y), the returned value is positive.

OPERAND CALCULATION SPEED - All ray based predefined operands use a field position or a field position and a ray position designator in order to specify the field or field and ray upon which a specific operand is to be based. If operands are grouped together in the MERIT FUNCTION by field and ray position designation, then the program will always know if the existing ray or spot diagram used for the previous operand may be used for the current operand. If the user does this grouping when constructing a MERIT FUNCTION, the user will minimize the amount of time consumed in ray tracing during optimization.

USER-DEFINED OPERAND ENTRY - In the cases where the predefined operands discussed above are not appropriate for a particular design problem, user-defined operands are available. User-defined operands are specified as members of the merit function through the following command:

(macro function name) (operand name) , t , wt , n , w1 , w2 - "macro function name" is the command word of this command. "macro function name" can be "FUNC01" through "FUNC10". (See the discussion of macro functions and macros in the MACRO section). For user-defined operand entry, the macro function name is always explicitly required. "operand name" is the qualifier word. This is the user-supplied name or label for the operand. It can be any valid eight-character name as long as it is not the same as one of the predefined operand names described above. "t" is the "target value" of the operand. The default value for "t" is 0.0. "wt" is the relative weight for the operand in the merit function. "wt" must be non-negative. The default value for "wt" is 1.0. "n" is the number of a general purpose storage register (valid range 1 to MAXOPT) where the value of the operand is to be found after it is evaluated in the macro function designated by the command word. (See the discussion of the general purpose storage registers in the CMD section). "n" must always be explicitly input. In order to explicitly input "n" = 11 while inputting default "t" and "wt" values for operand named "OP1", using macro function number 1, the entry would be:

FUNC01 OP1,,,11

"w1" and "w2" are optional numeric words #1 and #2 which may be used to transfer additional numeric input into the macro function designated by the command word. (See the discussion of the "NSUB" command in the MACRO section.). The user adds an operand definition to the merit function using the above command. The user then writes a macro function with the name designated by the command word. In that macro function, the value or values of operands are defined and placed in the appropriate general purpose storage registers. The designated macro functions are executed and operand values are evaluated and stored in the designated general purpose storage registers, automatically, during the optimization process. Anything that can be calculated in a macro function can be used as an operand. Since macro functions are always memory resident and are precomplied, they execute very fast. This architecture is extremely flexible and powerful.

VARIABLES EXAMPLES - It is assumed that the designer has decided which design parameters of an optical prescription are to be varied during optimization. For the sake of this sample variables definition, the designer will vary the radius of curvature of surfaces 1, 3, 5, 7 and 12, the thickness of surface 2 and 6 and the conic constant of surface 3.

From the CMD level, the designer would type:

VARIABLE
RD 1
RD 3
RD 5
RD 7
RD 12
TH 2
TH 6
CC 3
EOS or END

Alternatively, the designer could write a macro (lets name it MYVAR) which, when run, sets up the variables subfile. From the CMD level the designer would type:

```
MACRO MYVAR
VARIABLE
RD 1
RD 3
RD 5
RD 7
RD 12
TH 2
TH 6
CC 3
EOS or END
EOM
```

Then, by typing the name of the macro, "MYVAR", the variables subfile would be created. Remember: A macro may also be created using the macro edit or MEDIT process described in the MACRO section of this manual or it may be created using a DOS level editor. Using a macro to store and initiate optimization files is the best way to ensure that the subfiles are not inadvertantly lost. After creation, the variable definition can be querried using the "VB" and VBA" CMD level commands described in this manual section. The variable definition will continue to exist until the next "VARIABLE" command is issued or until the program terminates. The automatic save and reload commands described above in this section may also be used to store and recall optimization definitions. They are easy to use. Just type "AUTO SAVE" or "AUTO SAVE2" to save and "AUTO RELOAD" or "AUTO RELOAD2" to reload.

MERIT FUNCTION EXAMPLES - These are not "default" merit funtions. "DEFAULT" merit functions are inherently bad things which make for poor designers and less than average designs. This program has no "default" merit function. We feel strongly on this point. Every user-defined operand definition has two parts. Part 1 is a macro funtion named "FUN01" through "FUN10" which loads various designer selected lens database related parameter values into selected general purpose storage registers. Part II is the MERIT definition which gives user-defined names to the aforementioned lens database related parameter values, gives instruction as to the specific general purpose storage registers where the values may be found, specifies operand desired target values and specifies operand weighting factors. It sounds like a lot, and it is. Specific setups can be as simple or as complex as the design problem warrants. The first sample is an optimization subfile made up of one paraxial raytrace based parameter which will represent "FOCUS". The macro function "FUN01" will be used. The designer would type:

```
MDEL FUN01
MACRO FUN01
GET PY,,,,,1
EOM
```

The macro function will automatically load general purpose storage register #1 with the YZ-plane paraxial marginal ray height at the image surface also called PY. The designer will not need to "run" the macro function. It will be run automatically during an optimization cycle. The designer then types from the CMD level:

```
MERIT
FOCUS 0 1 1
EOS or END
```

The "PY" value at the image surface has been named "FOCUS". It has a target value specified to be "0" with relative weight "1". It will be found by the automatic optimization routines in general storage register #1. If macro function "FUN02" or any other macro function other than "FUN01" had been used, the above three commands would need to be:

```
MERIT
FUNC02 FOCUS 0 1 1
EOS or END
```

For predefined operands, no macro function is needed. To target the "Y" coordinate of ray number 2 at field position 1 and at surface 5 to a value of 0 with a weight of 1, the MERIT entry would be:

```
MERIT
Y 0 1 5 1 2
EOS or END
```

To target the "Y" coordinate (a predefined operand) of ray number 2 at field position 1 at the "default" image surface to a value of 0 with a weight of 1, the MERIT entry would be:

```
MERIT
Y 0 1 ,, 1 2
EOS or END
```

Further examples may be found in the TUTORIAL MANUAL.

USER OPTIM INFORMATION - User-defined optimization is similar to the lens database type of optimization. The only difference is that user-defined optimization supports one extra variable type and one extra operand type. User-defined optimization should be thought of as a super-set of the lens database optimization technique.

USER-VARIABLE COMMAND - Variable input syntax is exactly the same as described in the OPTIM section except that there is an additional variable named "MACVAR"."n" is the number of one of the 100000 (valid range 1 to 100000) general purpose storage registers available in the program. The default "dincr" value is 1.0D-10. Default limit values are -1.0D+20 AND +1.0D+20. The syntax of the command is:

MACVAR , n , wt , dincr , limit value 1 , limit value 2

OPERANDS AND OPERAND ENTRY - Operand entry is the same as described before except that there is one additional operand available named "MACOPT". The default operand target value "t" is 0.0. "wt" is the relative weight for the operand in the merit function. "wt" must be non-

negative. The default value for "wt" is 1.0. "n" is the number of a general purpose storage register (valid range 1 to 1000) where the value of the operand is to be found after it is evaluated by an automatic execution of a macro named "MACROOPT". If this specific macro does not exist, zero will be returned for the operand values and optimization won't work correctly. Macro "MACROOPT" may be as simple or as complex as desired and may call any number of other macros. "n" must always be explicitly input. The syntax of the command is: **MACOPT , t , wt , n**
In order to explicitly input "n" = 11 while inputting default "t" and "wt" values, the entry would be:

MACOPT,,,11

LENS DATABASE INTERACTION - Normally, the program re-initializes variable and operand definitions whenever certain condition arise. This re-initialization occures whenever a lens is retrieved from the lens library and whenever certain internal lens database manipulations occur. Issuing the command "OPTMINIT" with qualifier "NO" or "OFF" causes this reinitialization process to be skipped until the program terminates or until "OPTMINIT" is issued with the "YES" or "ON" qualifier. If lenses are input from stored files as in "INPUT ED" types of input, the internal setting associated with the "OPTMINIT" command will have NO EFFECT. The syntax of the command is: **OPTMINIT (YES** or **ON** or **NO** or **OFF)**