US007860691B2

US 7,860,691 B2

(12) **United States Patent**
Beltran et al.

(10) **Patent No.:** US 7,860,691 B2
(45) **Date of Patent:** Dec. 28, 2010

(54) **DYNAMIC BLOCKS**

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(73) Assignee: **Autodesk, Inc.**, San Rafael, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 315 days.

(21) Appl. No.: **11/455,288**

(22) Filed: **Jun. 15, 2006**

(65) **Prior Publication Data**

US 2007/0120714 A1 May 31, 2007

Related U.S. Application Data

(60) Provisional application No. 60/740,524, filed on Nov. 28, 2005.

(51) **Int. Cl.**
G06F 17/50	(2006.01)
G06F 19/00	(2006.01)
G06F 17/00	(2006.01)
G06F 3/00	(2006.01)
G06F 3/048	(2006.01)
G06T 15/00	(2006.01)
G06T 17/00	(2006.01)
G06G 5/00	(2006.01)

(52) **U.S. Cl.** **703/1**; 700/97; 700/98; 700/105; 700/121; 700/131; 715/255; 715/700; 715/765; 715/804; 715/853; 345/419; 345/420; 345/619

(58) **Field of Classification Search** 703/1; 345/419, 420, 619; 715/255, 700, 765, 804; 715/853; 700/97, 98, 105, 121, 131
See application file for complete search history.

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Assistant Examiner—Shambhavi Patel
(74) *Attorney, Agent, or Firm*—Fish & Richardson P.C.

(57) **ABSTRACT**

Tools and techniques for creating and editing a master block definition for a dynamic block, and manipulating a block instantiation of a dynamic block are described. One or more data structures that can be used to implement a dynamic block feature are described.

5 Claims, 32 Drawing Sheets
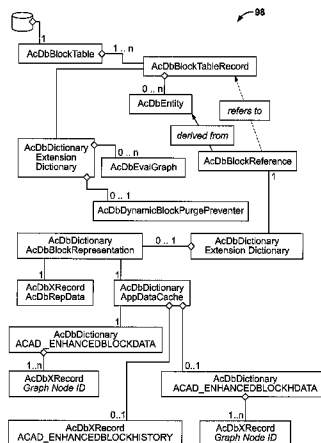
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Narrative description provided in the attached Information Disclosure Statement of a data structure that was used in AutoCAD software application available from Autodesk, Inc. of San Rafael, California; Fig. 1. schematically illustrating the data structure.

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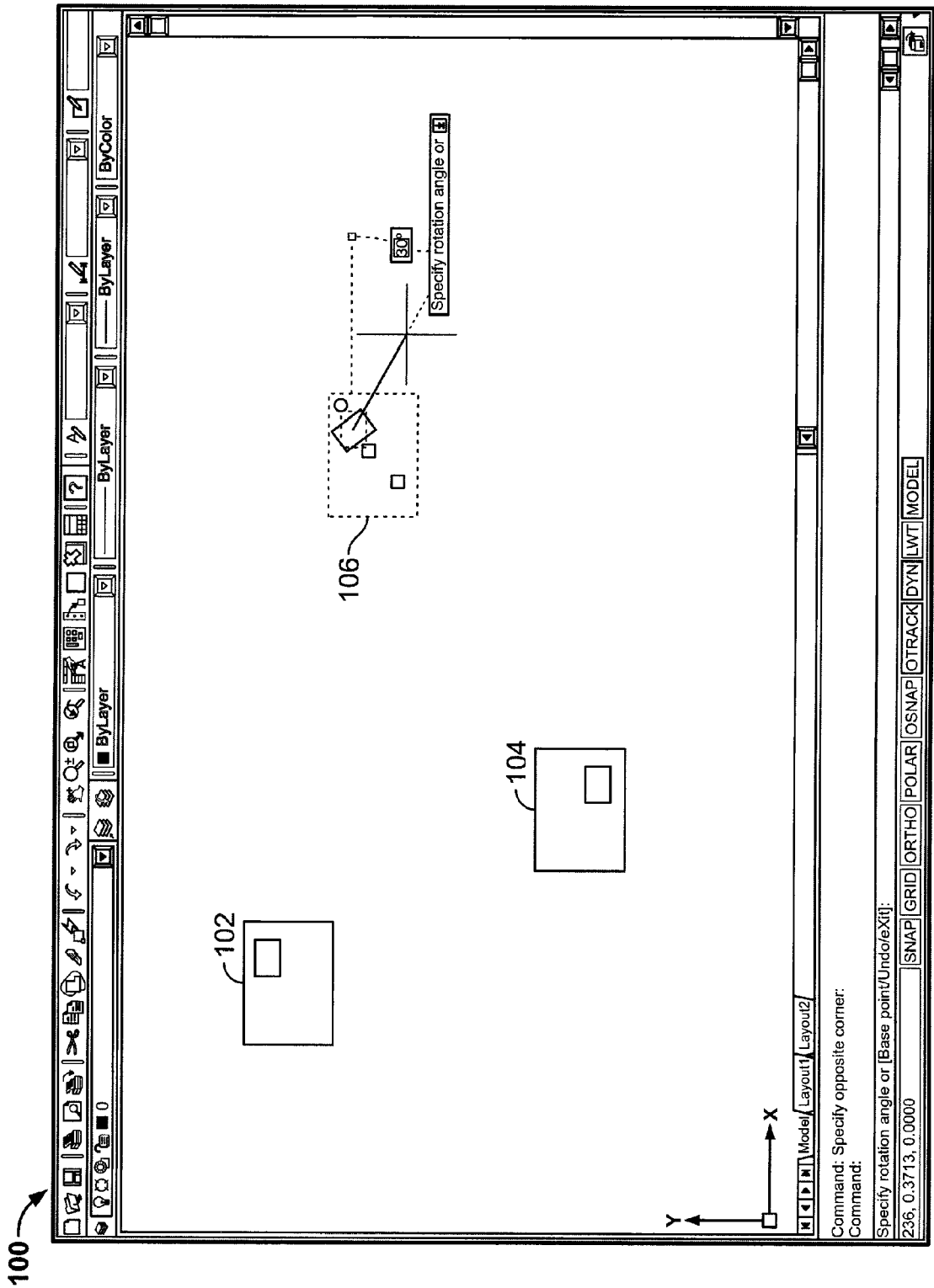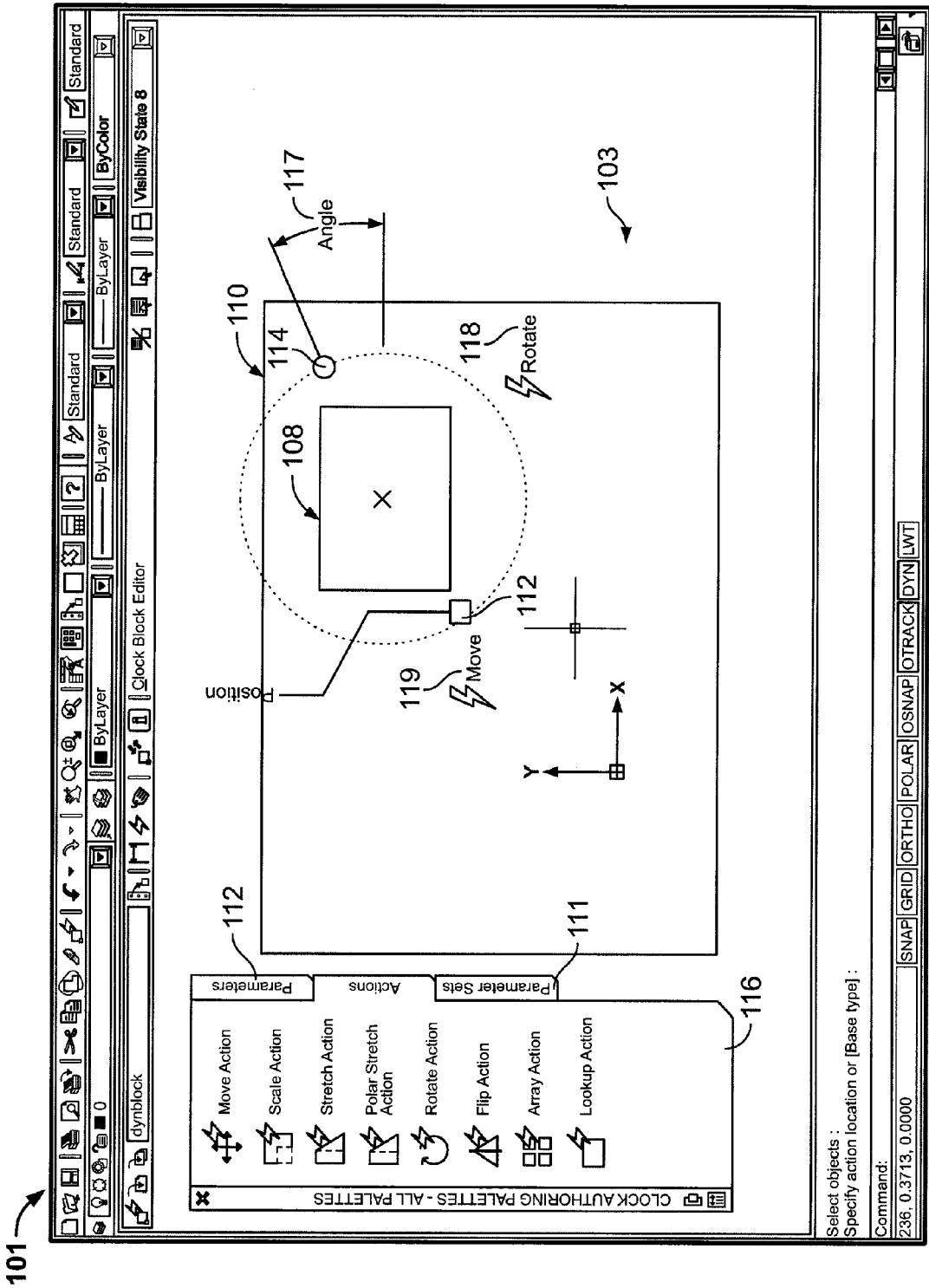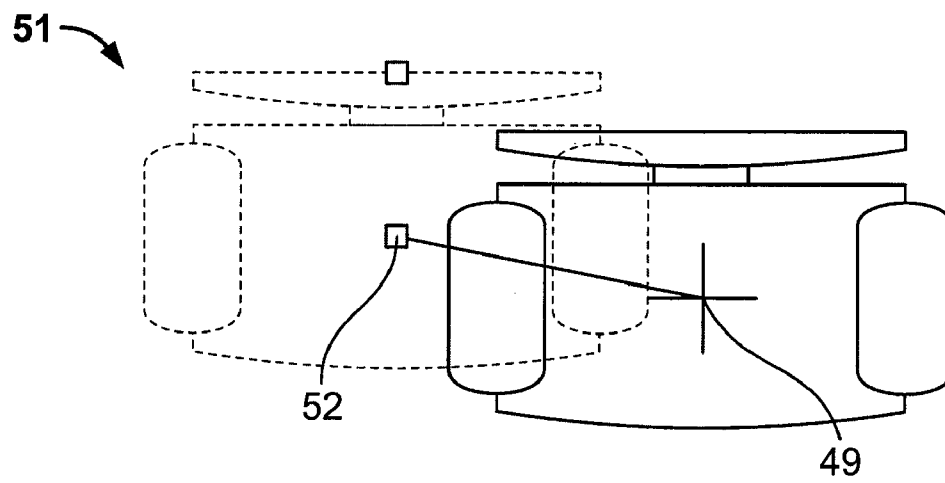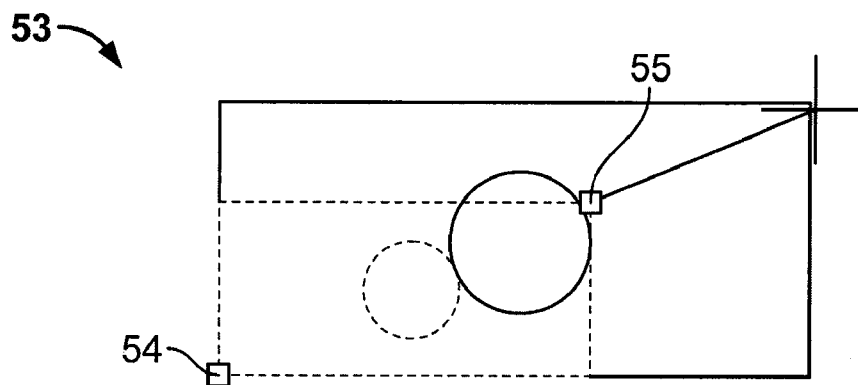
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FIG. 1

FIG. 2

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52

49

FIG. 3

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54

FIG. 4A

56

57   58

FIG. 4B

61   62

60

64   63

FIG. 5A

62   62   62

64   63   63   64   63
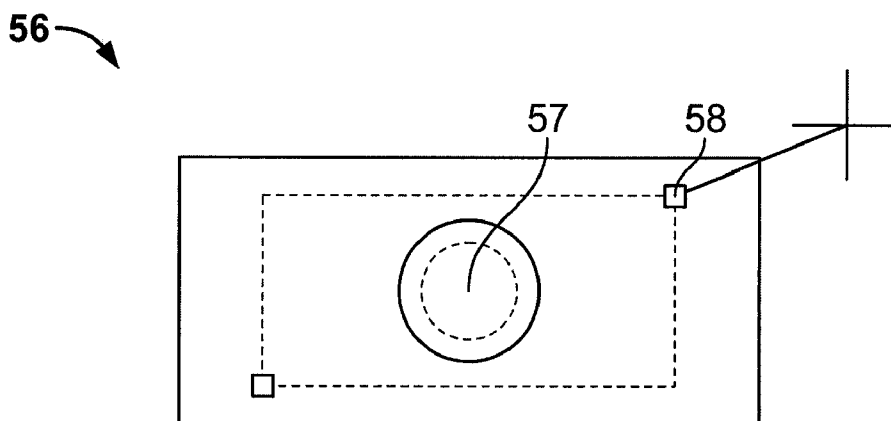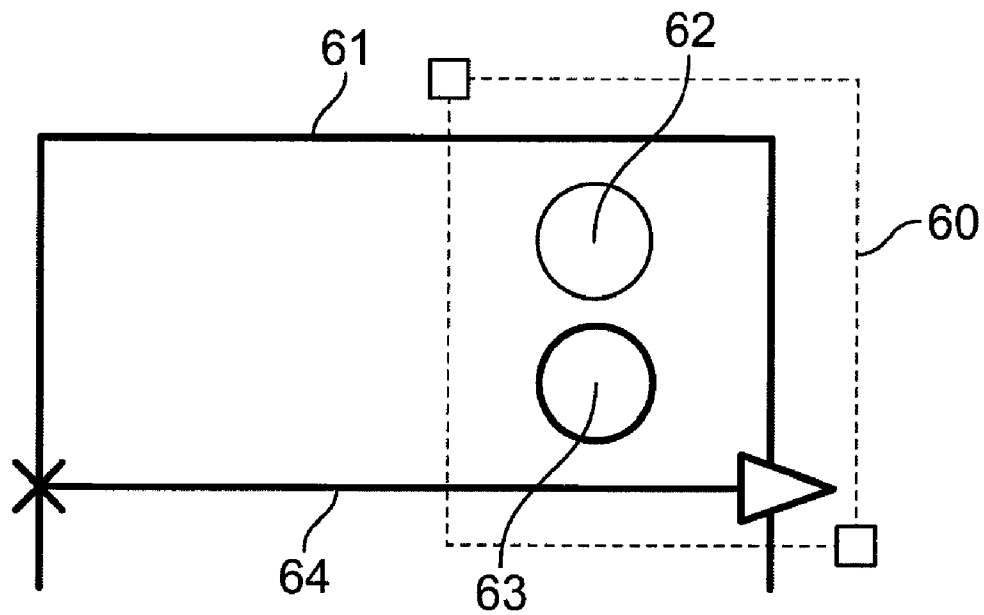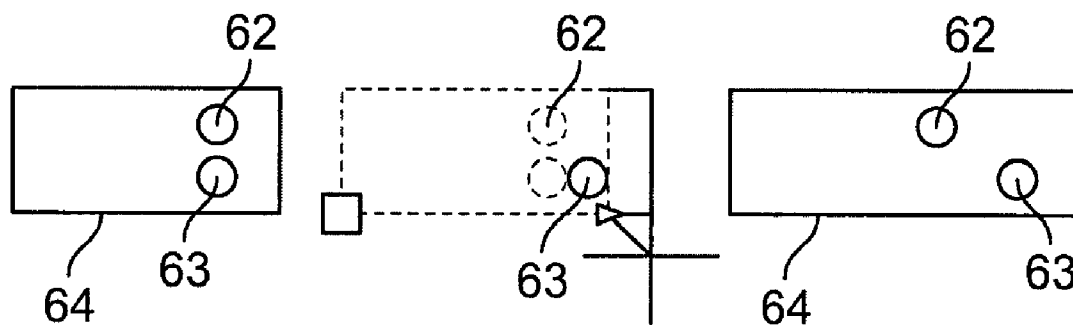
FIG. 5B
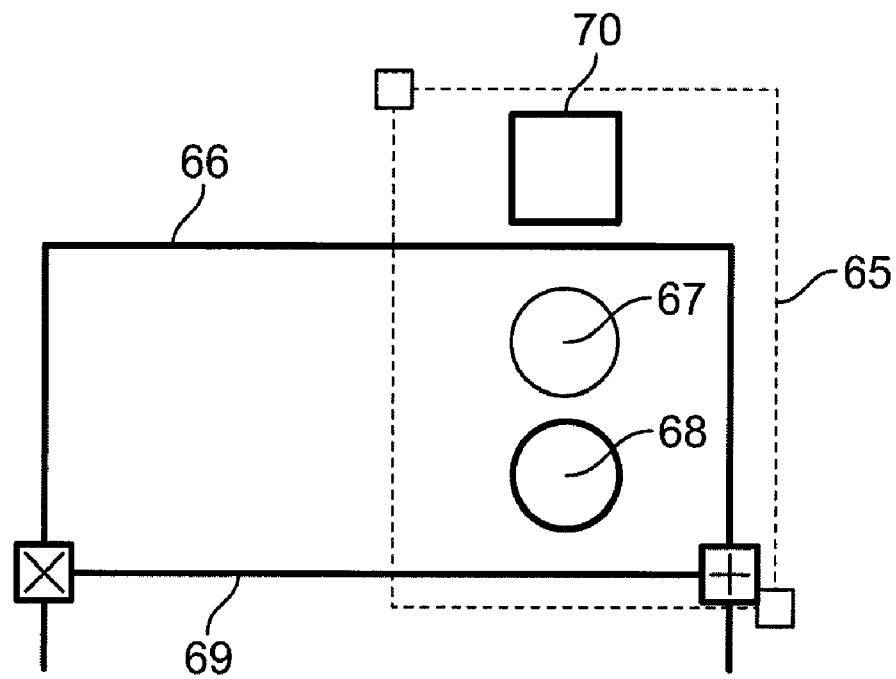
FIG. 6A

FIG. 6B

FIG. 7A

FIG. 7B

FIG. 7C

78

79

FIG. 8

80

FIG. 9A

83

82

FIG. 9B

83

FIG. 9C

83

FIG. 9D

FIG. 10

WLD1   WLD2

WLD3   WLD4
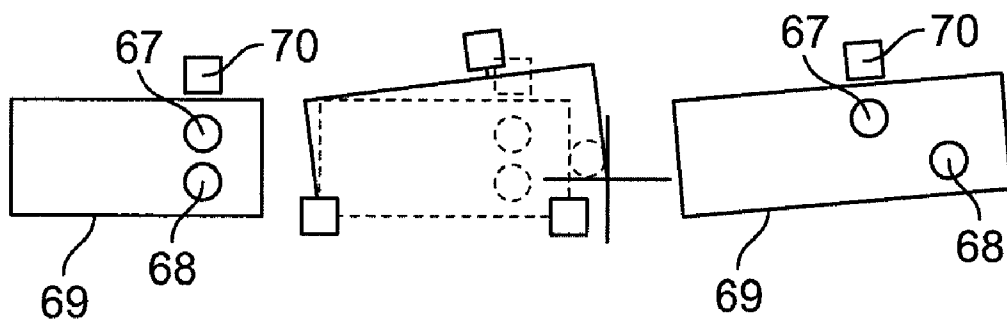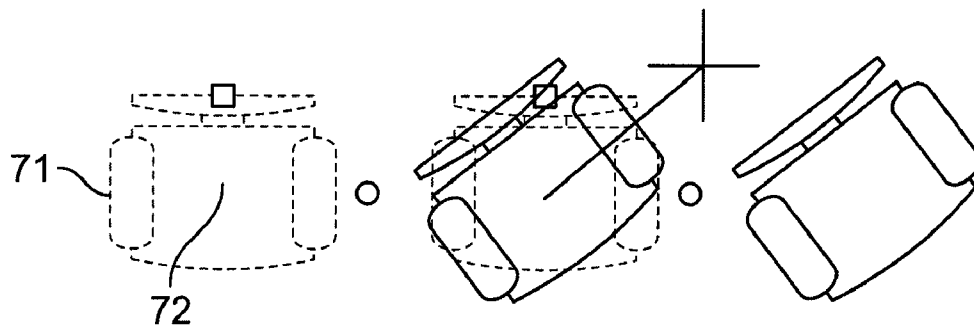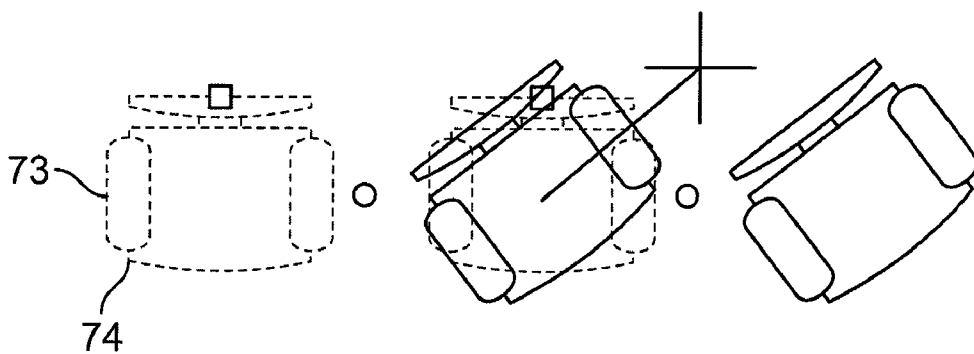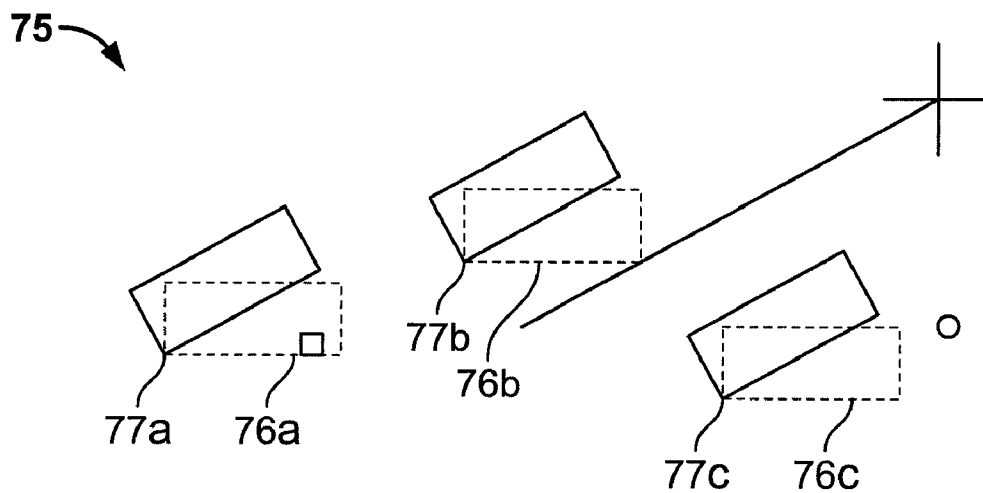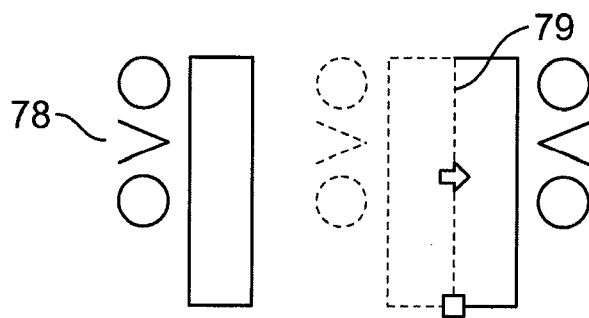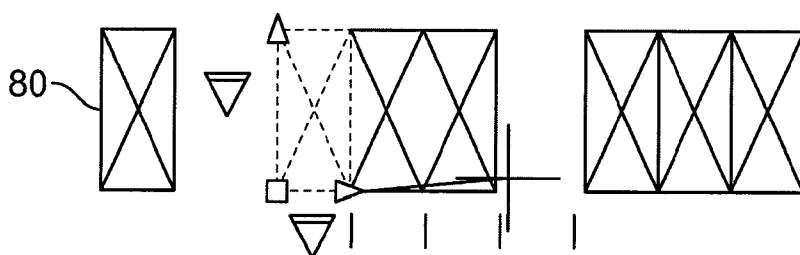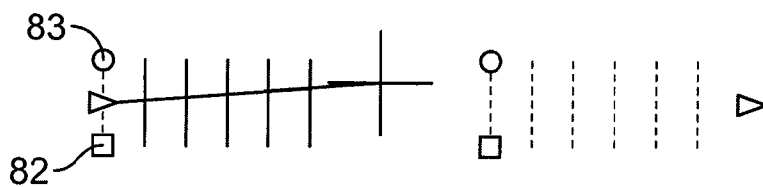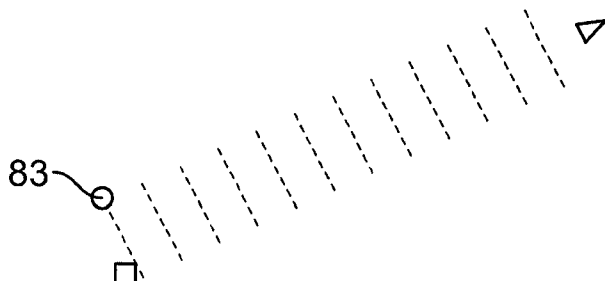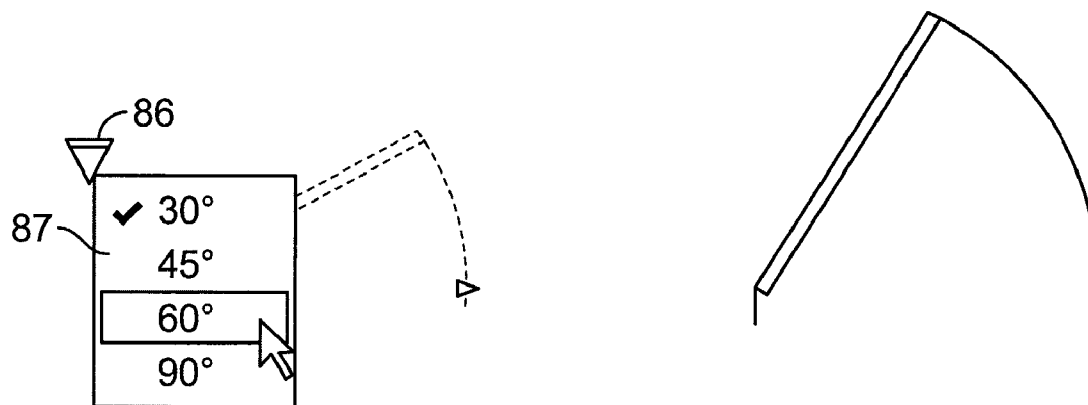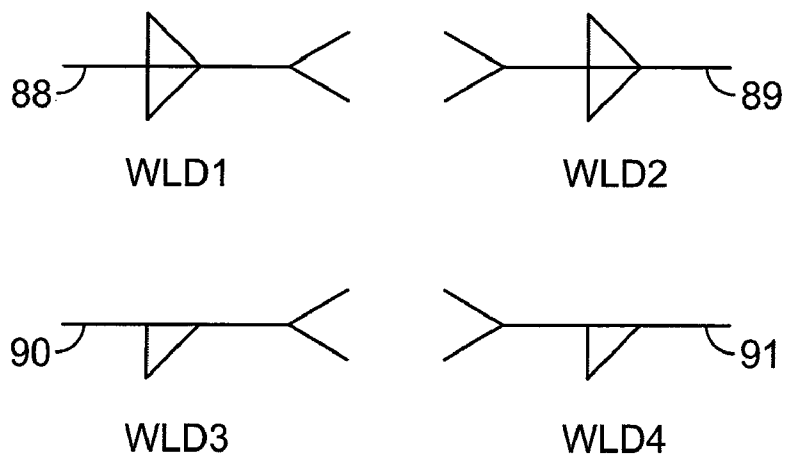
FIG. 11A

FIG. 11B

FIG. 11C

FIG. 11D

95

97   96   ⚡Move
                        Position

⚡Stretch

Distance

FIG. 12A

97

FIG. 12B

96   97

97   96
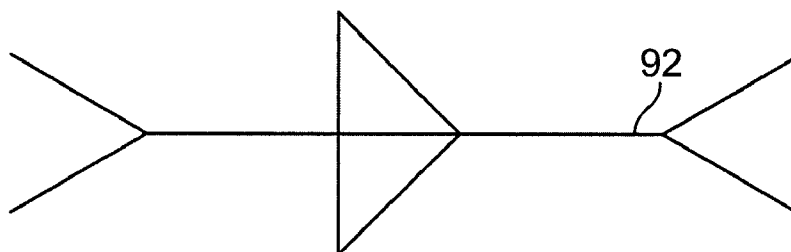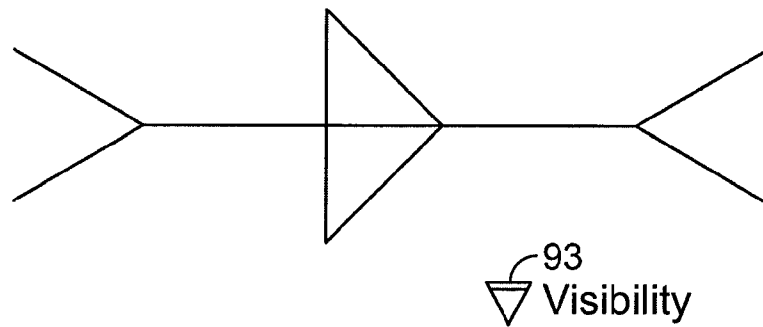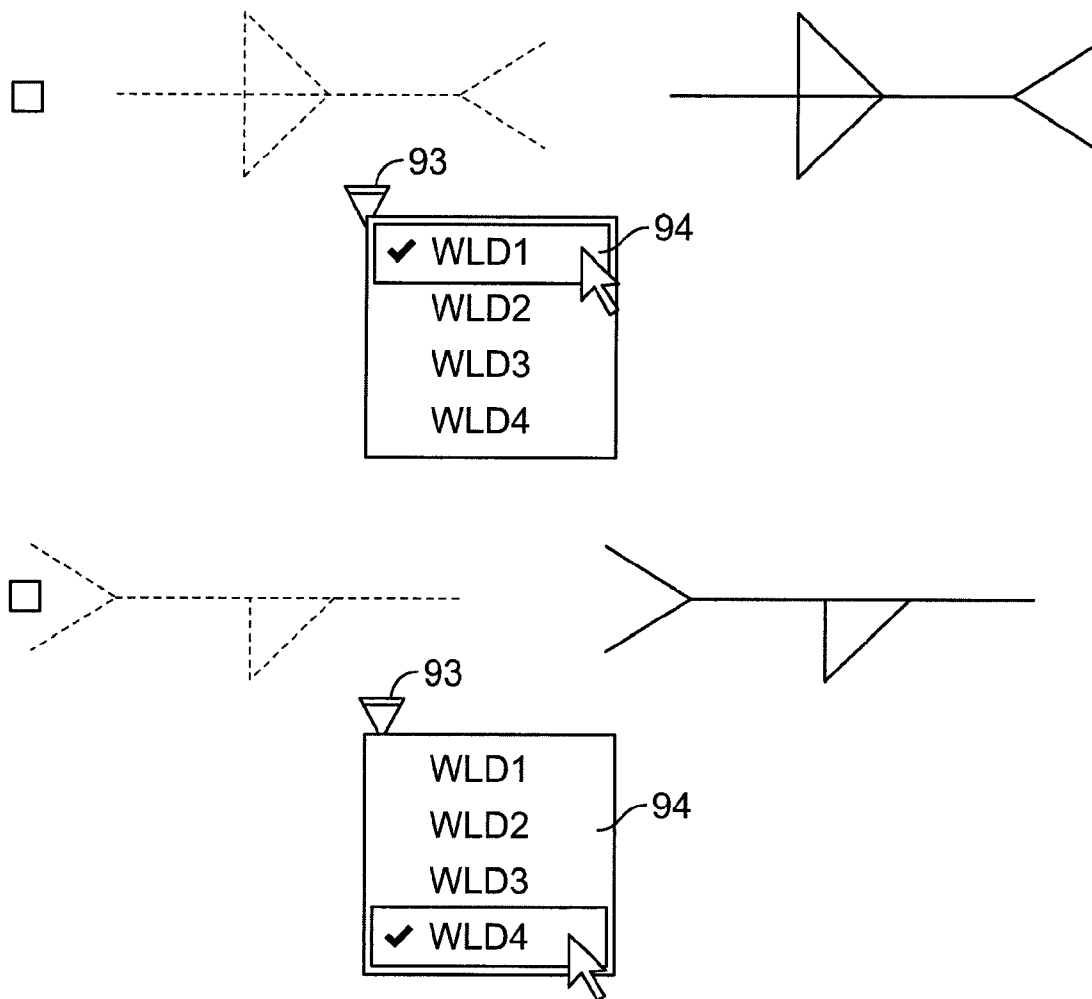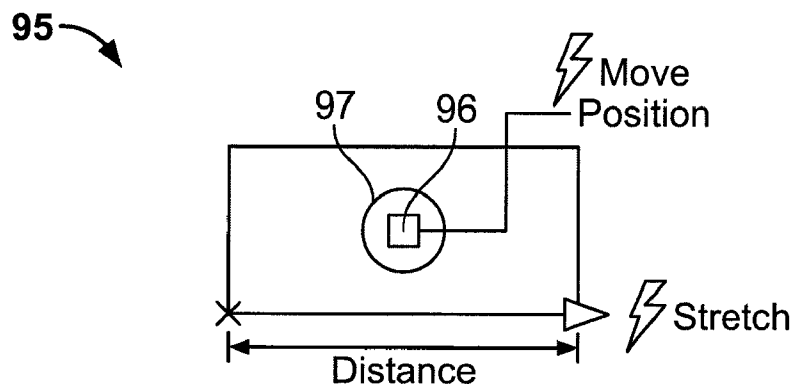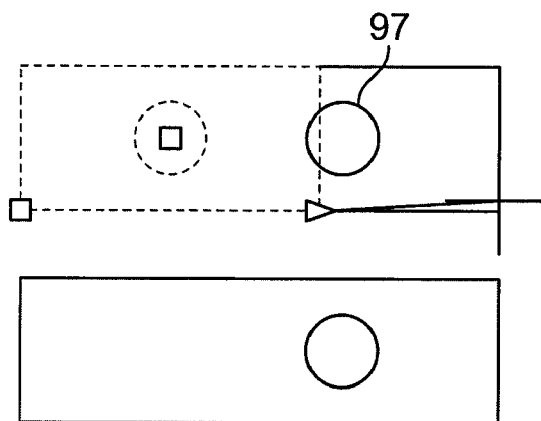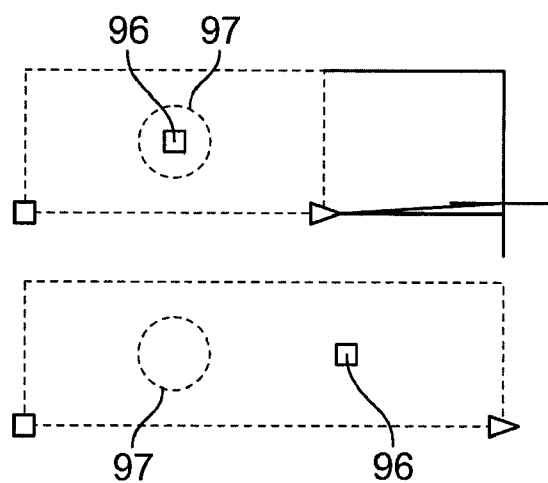
FIG. 12C
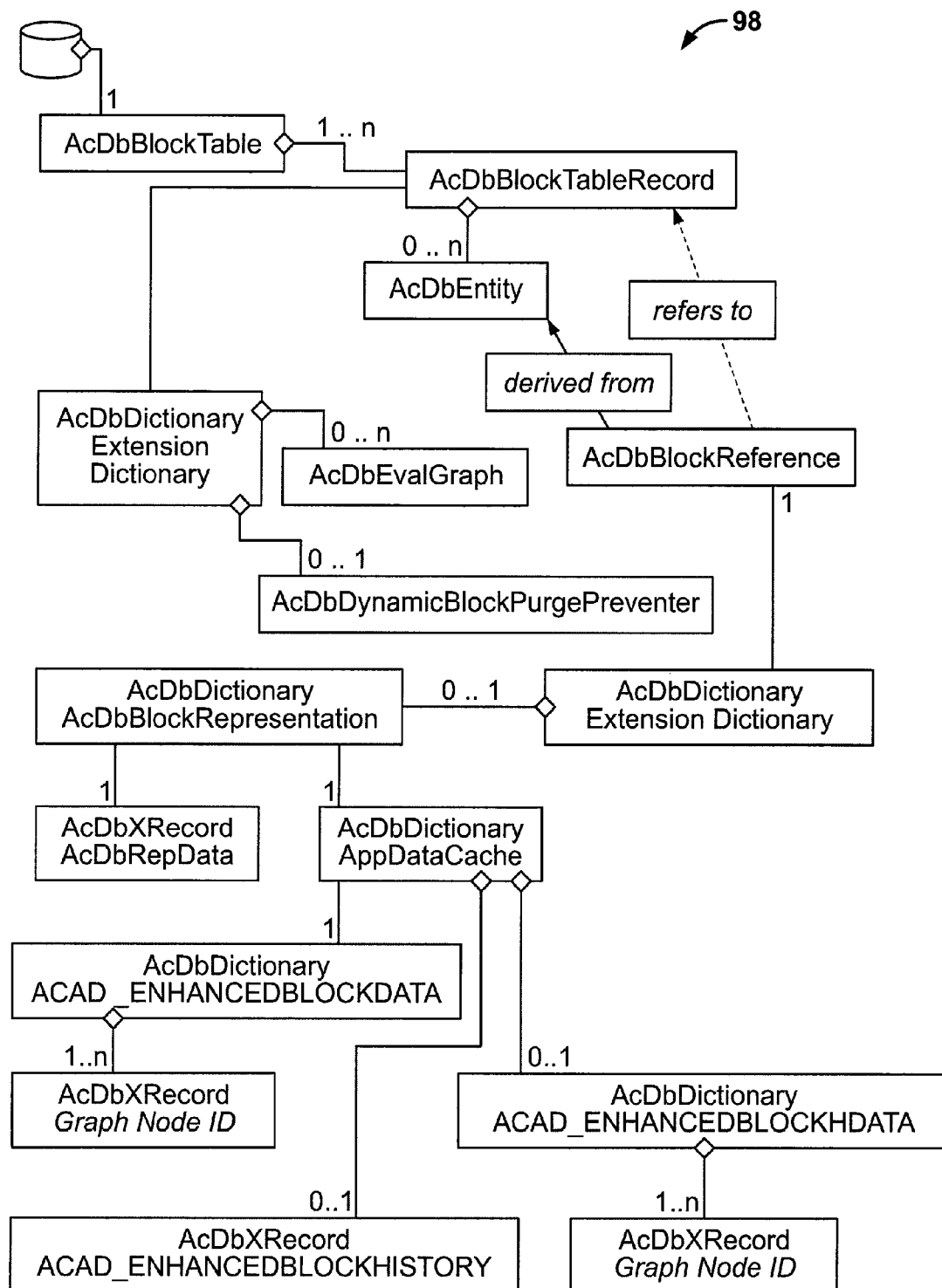
FIG. 13

class / object	specific name	type / derived from	defining table	per instance data table	comments
AcDbDynamicBlockPurgePreventer	block representation (anonymous)	AcDbBlockRepresentationData			a self reference that, by its presence, prevents purge of the anonymous block when read into earlier versions of AutoCAD
AcDbBlockRepresentation					held by extension dictionary
AcDbRepData	AcDbRepresentationData	AcDbDictionary	T1		
AppDataCache		AcDbXRecord	T2		held by the AcDbBlockRepresentation dictionary
<application name>DATA	ACAD_ENHANCEDBLOCKDATA	AcDbDictionary	T3		held by the AcDbBlockRepresentation dictionary, contains instance specific application data
Graph Node ID		AcDbXRecord	T5		held by the <application name>DATA dictionary, this AcDbXRecord is created for each node in the graph that needs to save per instance data
<application name>HISTORY	ACAD_ENHANCEDBLOCKHISTORY	AcDbXRecord	T6		held by the <application name>DATA dictionary, this AcDbXRecord is created when a dynamic block, requiring a history, is manipulated. For each manipulation of a node, a history entry is written. Each history entry consists of the following.
<application name>HDATA	ACAD_ENHANCEDBLOCKHDATA	AcDbDictionary	T7		held by the AcDbBlockRepresentation dictionary, created if a block that did not require a history, is redefined such that it now requires a history. This is a snapshot of the contents of the <application name>DATA dictionary at the time the block is redefined.
AcDbImpEvalExpr		AcDbObject	T8		base class for evaluation nodes in the graph
AcDbBlockElement		AcDbEvalExpr	T9		base class for dynamic block elements
AcDbBlockAction		AcDbBlockElement	T10	TT1	base class for all actions in dynamic blocks
AcDbBlockGrip		AcDbBlockElement	T11		base class for all grips in dynamic blocks
AcDbBlockParameter		AcDbBlockElement	T12		base class for all parameters in dynamic blocks
AcDbBlockActionWithBasePt		AcDbBlockAction	T13	TT2	
AcDbBlockArrayAction		AcDbBlockAction	T14		array action
AcDbBlockFlipAction		AcDbBlockAction	T15		flip action
AcDbBlockLookupAction		AcDbBlockAction	T16		lookup action
AcDbBlockMoveAction		AcDbBlockAction	T17	TT3	move action
AcDbBlockPolarStretchAction		AcDbBlockAction	T18	TT4	polar stretch action

FIG. 14

Class	T#	Base Class	TT#	Description
AcDbBlockRotateAction	T19	AcDbBlockActionWithBasePt	TT5	rotate action
AcDbBlockScaleAction	T20	AcDbBlockActionWithBasePt	TT6	scale action
AcDbBlockStretchAction	T21	AcDbBlockAction	TT7	stretch action
AcDbBlockAlignmentGrip	T22	AcDbBlockGrip	TT8	grip for alignment
AcDbBlockFlipGrip	T23	AcDbBlockGrip	TT9	grip for flip
AcDbImpBlockLinearGrip	T24	AcDbBlockGrip	TT10	linear grip
AcDbBlock1PtParameter	T25	AcDbBlockParameter	TT11	single point parameter
AcDbBlock2PtParameter	T26	AcDbBlockParameter	TT12	2 point parameter
AcDbBlockLookupParameter	T27	AcDbBlock1PtParameter	TT13	parameter for lookup action
AcDbBlockBasepointParameter	T28	AcDbBlock1PtParameter		
AcDbBlockPointParameter	T29	AcDbBlock1PtParameter		
AcDbBlockVisibilityParameter	T30	AcDbBlock1PtParameter		
AcDbBlockXYParameter	T31	AcDbBlock2PtParameter		
AcDbBlockAlignmentParameter	T32	AcDbBlock2PtParameter		
AcDbBlockFlipParameter	T33	AcDbBlock2PtParameter		
AcDbBlockLinearParameter	T34	AcDbBlock2PtParameter		
AcDbBlockPolarParameter	T35	AcDbBlock2PtParameter		
AcDbBlockRotationParameter	T36	AcDbBlock2PtParameter		
AcDbBlockElementEntity	T37	AcDbEntity	TT14	the base class for all element entities
AcDbBlockActionEntity	T38	AcDbBlockElementEntity		
AcDbBlockGripEntity	T39	AcDbBlockElementEntity		
AcDbBlockParameterEntity	T40	AcDbBlockElementEntity		
AcDbBlock1PtParameterEntity	T41	AcDbBlockParameterEntity		
AcDbBlock2PtParameterEntity	T42	AcDbBlockParameterEntity		
AcDbBlockLookupParameterEntity	T43	AcDbBlock1PtParameterEntity		
AcDbBlockPointParameterEntity	T44	AcDbBlock1PtParameterEntity		
AcDbBlockVisibilityParameterEntity	T45	AcDbBlock1PtParameterEntity		
AcDbBlockXYParameterEntity	T46	AcDbBlock1PtParameterEntity		
AcDbBlockFlipParameterEntity	T47	AcDbBlock2PtParameterEntity		
AcDbBlockLinearParameterEntity	T48	AcDbBlock2PtParameterEntity		
AcDbBlockPolarParameterEntity	T49	AcDbBlock2PtParameterEntity		
AcDbBlockRotationParameterEntity	T50	AcDbBlock2PtParameterEntity		

FIG. 14(cont.)

T1

AcDbBlockRepresentation

name	type	description
AcDbRepData	AcDbXRecord	
AppDataCache	AcDbDictionary	

T2

AcDbRepData

name	type	description
ACDB_BLOCKREPRESENTATION_DATA_VERSION	Int16	version
mBlockId	AcDbHardPointerId	a hard pointer to the dynamic block's representation data

T3

AppDataCache

name	type	description
ACAD_ENHANCEDBLOCKDATA	AcDbDictionary	
ACAD_ENHANCEDBLOCKHISTORY	AcDbXRecord	
ACAD_ENHANCEDBLOCKHDATA	AcDbDictionary	

T4

ACAD_ENHANCEDBLOCKDATA

name	type	description
Graph Node ID	AcDbXRecord	

T5

name	type	description
Graph Node ID		the value of the Graph Node ID serves as the key into the ACAD_ENHANCEDBLOCKDATA dictionary for storing specific per instance data for the block reference. If an element at a given Graph Node ID has per instance data to save, the details of that storage are elaborated in the description of that object. If an element does not have per instance data, a Graph Node ID/data pair is not created.

T6

ACAD_ENHANCEDBLOCKHISTORY

name	type	description
kHistoryRecordCurrentVersion	AcDb::kDxfXdInteger16	
nodeId	AcDb::kDxfXdInteger32	
property name	AcDb::DxfXTextString	
property value	struct resbuf	the new value for the specified node property, held in an AcDbEvalVariant object

FIG. 14(cont.)

T7

ACAD_ENHANCEDBLOCKHDATA

name	type	description
Graph Node ID	AcDbXRecord	

T8

AcDbEvalExpr

name	type	description
version marker	Adesk::UInt32	the value ~0, indicates to the filer that the version of this object follows
major version number	Adesk::UInt32	
maintenance release version	Adesk::UInt32	
value	AcDbXRecord	particular value associated with this node
node id	unsigned long	the graph node id for this node

T9

AcDbBlockElement

name	type	description
element name	AcDbXRecord	the localized name of the element
major version number	Adesk::UInt32	
maintenance release version	Adesk::UInt32	
alert state	Adesk::UInt32	

T10

AcDbBlockAction

name	type	description
m_ptDisplayLocation	AsGePoint3d	location where the graphics for the action are displayed in the dynamic block editor
number of selections	Adesk::UInt32	the number of things acted on by the action
soft IDs of selections	AcDbSoftPointerId	one soft pointer to each selection
number of dependent authoring elements	Adesk::UInt32	number of dependent nodes in the graph
node IDs of dependent authoring elements	AcDbEvalNodeId	node ID of dependent elements

T11

AcDbBlockGrip

name	type	description
node id X	AcDbEvalNodeId	id of the node containing the X display location for the grip
node id Y	AcDbEvalNodeId	id of the node containing the Y display location for the grip
display location	AcGePoint3d	geometric location of the grip
insertion cycling	bool	true/false indicating the state of insertion cycling
insertion cycling weight	Adesk::UInt32	

FIG. 14(cont.)

T12

AcDbBlockParameter

name	type	description
m_bShowProperties	bool	true/false indicating whether to show properties
m_bChainActions	bool	true/false indicating whether to chain actions

T13

AcDbBlockActionWithBasePt

name	type	description
m_ptBasePoint	AcGePoint3d	
m_nodeidBaseXDependency	AcDbEvalNodeId	
m_strBaseXDependency	AcString	
m_nodeidBaseYDependency	AcDbEvalNodeId	
m_strBaseYDependency	AcString	
m_bDependent	bool	
m_ptBasePointOffset	AcGeVector3d	

T14

AcDbBlockArrayAction

name	type	description
m_nodeidBaseDependency	AcDbEvalNodeId	
m_strBaseDependency	AcString	
m_nodeidEndDependency	AcDbEvalNodeId	
m_strEndDependency	AcString	
m_nodeidUpdatedBaseDependency	AcDbEvalNodeId	
m_strUpdatedBaseDependency	AcString	
m_nodeidUpdatedEndDependency	AcDbEvalNodeId	
m_strUpdatedEndDependency	AcString	
m_dRowOffset	double	
m_dColumnOffset	double	

T15

AcDbBlockFlipAction

name	type	description
m_nodeidFlipStateDependency	AcDbEvalNodeId	
m_strFlipStateDependency	AcString	
m_nodeidUpdatedFlipStateDependency	AcDbEvalNodeId	
m_strUpdatedFlipStateDependency	AcString	
m_nodeidBaseDependency	AcDbEvalNodeId	
m_strBaseDependency	AcString	
m_nodeidEndDependency	AcDbEvalNodeId	
m_strEndDependency	AcString	

FIG. 14(cont.)

T16

AcDbBlockLookupAction

name	type	description
mnRows	Adesk::UInt32	number of rows in the lookup table
mnCols	Adesk::UInt32	number of columns in the lookup table
mTable	AcString	a string for each cell, rows X columns
(for each column)		
mConnectableId	AcDbEvalNodeId	
meType	Adesk::UInt32	
meUnits	Adesk::UInt32	
mbIsOutputColumn	bool	
msUnmatchedValue	AcString	
mbIsInvertible	bool	
msConnectinoName	AcString	

T17

AcDbBlockMoveAction

name	type	description
m_nodeidDeltaXDependency	AcDbEvalNodeId	
m_strDeltaXDependency	AcString	
m_nodeidDeltaYDependency	AcDbEvalNodeId	
m_strDeltaYDependency	AcString	
m_dDistanceMultiplier	double	
m_dOffsetAngle	double	
m_eXYTType	Adesk::UInt8	

T18

AcDbBlockPolarStretchAction

name	type	description
m_nodeidDeltaXDependency	AcDbEvalNodeId	
m_strDeltaXDependency	AcString	
m_nodeidDeltaYDependency	AcDbEvalNodeId	
m_strDeltaYDependency	AcString	
m_nodeidBaseDependency	AcDbEvalNodeId	
m_strBaseDependency	AcString	
m_nodeidEndDependency	AcDbEvalNodeId	
m_strEndDependency	AcString	
m_nodeidUpdatedBaseDependency	AcDbEvalNodeId	
m_strUpdatedBaseDependency	AcString	
m_nodeidUpdatedEndDependency	AcDbEvalNodeId	

FIG. 14(cont.)

stretch point map
please note: these are nested arrays

name	type	description
m_strUpdatedEndDependency	AcString	
stretch frame count	Adesk::UInt32	number of elements in the stretch frame
m_arrayStretchFrame[] elements	AcGePoint2d	stretch frame count elements
rotate only selection count	Adesk::UInt32	number of elements in the rotate only selection set
m_selsetRotateObly[] elements	AcDbSoftPointerId	ids of the rotate only selection set
stretch point map count	Adesk::UInt32	number of id/map array sets to follow
stretchPtsMap[] elements	AcDbSoftPointerId	id
number of elements in the map array	Adesk::UInt32	number of map elements to follow
map element	Adesk::UInt32	
...		

element stretch points map
please note: these are nested arrays

name	type	description
stretch point map count	Adesk::UInt32	number of elements/maps in the stretch frame
element id	AcDbEvalNodeId	
number of elements in the map array	Adesk::UInt32	number of map elements to follow
map element	Adesk::UInt32	
...		
...		
m_dDistanceMultiplier	double	
m_dOffsetAngle	double	
m_nodeidarrayRotateOnlyDependents.length()	Adesk::UInt32	number of elements in this array
m_nodeidarrayRotateOnlyDependents[]	AcDbEvalNodeId	dependent authoring element node ids

T19

AcDbBlockRotateAction

name	type	description
m_nodeidDeltaRotDependency	AcDbEvalNodeId	
m_strDeltaRotDependency	AcString	

T20

AcDbBlockScaleAction

name	type	description
m_nodeidScaleXYDependency	AcDbEvalNodeId	
m_strScaleXYDependency	AcString	
m_nodeidScaleXDependency	AcDbEvalNodeId	
m_strScaleXDependency	AcString	
m_nodeidScaleYDependency	AcDbEvalNodeId	
m_strScaleYDependency	AcString	
m_eXYType	Adesk::UInt8	

FIG. 14(cont.)

T21

AcDbBlockStretchAction

name	type	description
m_nodeidDeltaXDependency	AcDbEvalNodeId	
m_strDeltaXDependency	AcString	
m_nodeidDeltaYDependency	AcDbEvalNodeId	
m_strDeltaYDependency	AcString	

T22

AcDbBlockAlignmentGrip

name	type	description
m_gripOrientation	AcGeVector3d	

T23

AcDbBlockFlipGrip

name	type	description
m_nodeidFlip	AcDbEvalNodeId	
m_gripOrientation	AcGeVector3d	

T24

AcDbImpBlockLinearGrip

name	type	description
m_gripOrientation	AcGeVector3d	

T25

AcDbBlock1PtParameter

name	type	description
m_ptDefinitionPoint	AcGePoint3d	
m_mapUpdatedXConnections.size()	Adesk::UInt8	number of elements in this property connection. A property connection is a map of pairs. The pairs consist of an AcDbEvalNodeId and an AcString.
first element of first pair	AcDbEvalNodeId	
second element of first pair	AcString	(repeated "size" times)
...		
m_mapUpdatedYConnections.size()	Adesk::UInt8	number of elements in this property connection. A property connection is a map of pairs. The pairs consist of an AcDbEvalNodeId and an AcString.
first element of first pair	AcDbEvalNodeId	
second element of first pair	AcString	(repeated "size" times)
...		
m_gripNodeId	AcDbEvalNodeId	id of this parameter's grip

FIG. 14(cont.)

T26
AcDbBlock2PtParameter

name	type	description
m_ptDefinitionBasePoint	AcGePoint3d	
m_ptDefinitionEndPoint	AcGePoint3d	
m_mapUpdatedBaseXConnections.size()	Adesk::UInt8	number of elements in this property connection. A property connection is a map of pairs. The pairs consist of an AcDbEvalNodeId and an AcString.
first element of first pair	AcDbEvalNodeId	
second element of first pair	AcString	
...		(repeated "size" times)
m_mapUpdatedBaseYConnections.size()	Adesk::UInt8	number of elements in this property connection. A property connection is a map of pairs. The pairs consist of an AcDbEvalNodeId and an AcString.
first element of first pair	AcDbEvalNodeId	
second element of first pair	AcString	
...		(repeated "size" times)
m_mapUpdatedEndXConnections.size()	Adesk::UInt8	number of elements in this property connection. A property connection is a map of pairs. The pairs consist of an AcDbEvalNodeId and an AcString.
first element of first pair	AcDbEvalNodeId	
second element of first pair	AcString	
...		(repeated "size" times)
m_mapUpdatedEndYConnections.size()	Adesk::UInt8	number of elements in this property connection. A property connection is a map of pairs. The pairs consist of an AcDbEvalNodeId and an AcString.
first element of first pair	AcDbEvalNodeId	
second element of first pair	AcString	
...		(repeated "size" times)
m_arrayGripNodeIds[0]	AcDbEvalNodeId	node ids of the 4 grips for this parameter
m_arrayGripNodeIds[1]	AcDbEvalNodeId	
m_arrayGripNodeIds[2]	AcDbEvalNodeId	
m_arrayGripNodeIds[3]	AcDbEvalNodeId	
m_nBaseLocation	Adesk::Int16	flags informing how to interpret the base location

FIG. 14(cont.)

T27

AcDbBlockLookupParameter

name	type	description
m_LookupActionId	AcDbEvalNodeId	
m_strLookupName	AcString	
m_strLookupDescription	AcString	

T28

AcDbBlockBasePointParameter

name	type	description
m_ptPoint	AcGePoint3d	
m_ptUpdatedPoint	AcGePoint3d	

T29

AcDbBlockPointParameter

name	type	description
m_strPositionName	AcString	
m_strPositionDescription	AcString	
m_ptLabelPoint	AcGePoint3d	

T30

AcDbBlockVisibilityParameter

name	type	description
m_bInitializedByManager	bool	
m_strVisibilityName	AcString	
m_strVisibilityDescription	AcString	
m_CurrentVisibilitySet	Adesk::Int32	
m_EntityList.length()	Adesk::Int32	number of entity ids to follow
m_EntityList[]	AcDbSoftPointerId	
m_VisibilitySets.length()	Adesk::Int32	number of visibility sets to follow

for each visibility set

... m_name	AcString	
... m_entityList.length()	Adesk::Int32	number of entity ids to follow
... m_entityList[]	AcDbSoftPointerId	
... m_elementList.length()	Adesk::Int32	number of element ids to follow
... m_elementList[]	AcDbSoftPointerId	

FIG. 14(cont.)

T31

AcDbBlockXYParameter

name	type	description
m_strVertName	AcString	
m_strHorzName	AcString	
m_strVertDescription	AcString	
m_strHorzDescription	AcString	
mdXDisposition	double	
mdYDisposition	double	
xValueSet.mnOptions	Adesk::UInt32	
xValueSet.mdMin	double	
xValueSet.mdMax	double	
xValueSet.mdIncrement	double	
xValueSet.mValues.length()	UInt16	number of values to follow
xValueSet.mValues[]	double	
yValueSet.mnOptions	Adesk::UInt32	
yValueSet.mdMin	double	
yValueSet.mdMax	double	
yValueSet.mdIncrement	double	
yValueSet.mValues.length()	UInt16	number of values to follow
yValueSet.mValues[]	double	

T32

AcDbBlockAlignmentParameter

name	type	description
alignPerpendicular	bool	

T33

AcDbBlockFlipParameter

name	type	description
m_strFlipLabel	AcString	
m_strFlipDescription	AcString	
m_strBaseStateLabel	AcString	
m_strFlippedStateLabel	AcString	
m_ptLabelPoint	AcGePoint3d	
m_nodeidFlipStateDependency	AcDbEvalNodeId	
m_strFlipStateDependency	AcString	

FIG. 14(cont.)

T34

AcDbBlockLinearParameter

name	type	description
m_strDistanceName	AcString	
m_strDistanceDescription	AcString	
m_dOffset	AcString	
m_ValueSet.mnOptions	Adesk::UInt32	
m_ValueSet.mdMin	double	
m_ValueSet.mdMax	double	
m_ValueSet.mdIncrement	double	
m_ValueSet.mValues.length()	UInt16	number of values to follow
m_ValueSet.mValues[]	double	

T35

AcDbBlockPolarParameter

name	type	description
m_strDistanceName	AcString	
m_strDistanceDescription	AcString	
m_strAngleName	AcString	
m_strAngleDescription	AcString	
distanceValueSet().mnOptions	Adesk::UInt32	
distanceValueSet().mdMin	double	
distanceValueSet().mdMax	double	
distanceValueSet().mdIncrement	double	
distanceValueSet().mValues.length()	UInt16	number of values to follow
distanceValueSet().mValues[]	double	
angleValueSet().mnOptions	Adesk::UInt32	
angleValueSet().mdMin	double	
angleValueSet().mdMax	double	
angleValueSet().mdIncrement	double	
angleValueSet().mValues.length()	UInt16	number of values to follow
angleValueSet().mValues[]	double	

T36

AcDbBlockRotationParameter

name	type	description
m_ptDefinitionBaseAnglePoint	AcGePoint3d	
m_strAngleName	AcString	
m_strAngleDescription	AcString	
m_dOffset	double	

FIG. 14(cont.)

valueSet().mnOptions	Adesk::UInt32	
valueSet().mdMin	double	
valueSet().mdMax	double	
valueSet().mdIncrement	double	
valueSet().mValues.length()	UInt16	number of values to follow
valueSet.mValues[]	double	

T37

name	type	description

AcDbBlockElementEntity

name	type	description
msName	AcString	
msAlertOn	bool	

T38

name	type	description

AcDbBlockActionEntity

name	type	description
m_ptDisplayLocation	AcGePoint3d	

T39

name	type	description

AcDbBlockGripEntity

name	type	description
displayLocation()	AcGePoint3d	
insertionCycling()	bool	
insertionCyclingWeight()	Adesk::UInt32	

T40

name	type	description

AcDbBlockParameterEntity

name	type	description
m_bShowProperties	bool	

T41

name	type	description

AcDbBlock1PtParameterEntity

name	type	description
m_ptDefinitionPoint	AcGePoint3d	

T42

name	type	description

AcDbBlock2PtParameterEntity

name	type	description
m_ptDefinitionBasePoint	AcGePoint3d	
m_ptDefinitionEndPoint	AcGePoint3d	

T43

name	type	description

AcDbBlockLookupParameterEntity

name	type
m_strLookupName	AcString
m_strLookupDescription	AcString

FIG. 14(cont.)

T44

AcDbBlockPointParameterEntity

name	type	description
m_strPositionName	AcString	
m_strPositionDescription	AcString	
m_ptLabelPoint	AcGePoint3d	

T45

AcDbBlockVisibilityParameterEntity

name	type	description
m_strVisibilityName	AcString	
m_strVisibilityDescription	AcString	

T46

AcDbBlockXYParameterEntity

name	type	description
m_strVertName	AcString	
m_strHorzName	AcString	
m_strVertDescription	AcString	
m_strHorzDescription	AcString	
mdXDisposition	double	
mdYDisposition	double	
xValueSet.mnOptions	Adesk::UInt32	
xValueSet.mdMin	double	
xValueSet.mdMax	double	
xValueSet.mdIncrement	double	
xValueSet.mxValues.length()	UInt16	number of values to follow
xValueSet.mxValues[]	double	
yValueSet.mnOptions	Adesk::UInt32	
yValueSet.mdMin	double	
yValueSet.mdMax	double	
yValueSet.mdIncrement	double	
yValueSet.myValues.length()	UInt16	number of values to follow
yValueSet.myValues[]	double	

FIG. 14(cont.)

T47

AcDbBlockFlipParameterEntity

name	type	description
m_strFlipLabel	AcString	
m_strFlipDescription	AcString	
m_strBaseStateLabel	AcString	
m_strFlippedStateLabel	AcString	
m_ptLabelPoint	AcGePoint3d	

T48

AcDbBlockLinearParameterEntity

name	type	description
m_strDistanceName	AcString	
m_strDistanceDescription	AcString	
m_dOffset	double	
ValueSet().mnOptions	Adesk::UInt32	
ValueSet().mdMin	double	
ValueSet().mdMax	double	
ValueSet().mdIncrement	double	
ValueSet().mValues.length()	UInt16	number of values to follow
ValueSet().mValues[]	double	

T49

AcDbBlockPolarParameterEntity

name	type	description
m_strDistanceName	AcString	
m_strDistanceDescription	AcString	
m_strAngleName	AcString	
m_strAngleDescription	AcString	
m_dOffset	double	
distanceValueSet().mnOptions	Adesk::UInt32	
distanceValueSet().mdMin	double	
distanceValueSet().mdMax	double	
distanceValueSet().mdIncrement	double	
distanceValueSet().mdistanceValues.length()	UInt16	number of values to follow
distanceValueSet().mdistanceValues[]	double	
angleValueSet().mnOptions	Adesk::UInt32	
angleValueSet().mdMin	double	
angleValueSet().mdMax	double	

FIG. 14(cont.)

name	type	description
angleValueSet().mdIncrement	double	
angleValueSet().mangleValues.length()	UInt16	number of values to follow
angleValueSet().mangleValues[]	double	

T50

AcDbBlockRotationParameterEntity

name	type	description
m_strAngleName	AcString	
m_strAngleDescription	AcString	
m_dOffset	double	
m_ptDefinitionBaseAnglePoint	AcGePoint3d	
valueSet().mnOptions	Adesk::UInt32	
valueSet().mdMin	double	
valueSet().mdMax	double	
valueSet().mdIncrement	double	
valueSet().mvalues.length()	UInt16	number of values to follow
valueSet().mvalues[]	double	

FIG. 14(cont.)

TT1

type key	value	description
AcDbBlockElement		
		The AcDbBlockElement "brands" each piece of per instance data generated by each derived class. This branding is accomplished by using a hash to encode the name of the derived class. This hash involves taking the integer value of each character in the name, multiplying it by an arbitrary constant real number, and adding the result to a running sum. Finally that running sum is truncated to an integer and stored as a key.
AcDb::kDxfXdInteger32	a	This is the "brand" key, as described above, generated by processing the name in left to right order.
AcDb::kDxfXdInteger32	b	This is the "brand" key, as described above, generated by processing the name in right to left order.
AcDb::kDxfInt16	AcDb::kDHL_CURRENT	major release version
AcDb::kDxfInt16	AcDb::kMReleaseCurrent	maintenance release version

TT2

type key	value	description
AcDbBlockActionWithBasePt		
AcDb::kDxfXCoord	mt_ptPoint	description

TT3

type key	value	description
AcDbBlockMoveAction		
AcDb::kDxfReal	angleOffset()	description

TT4

type key	value	description
AcDbBlockPolarStretchAction		
AcDb::kDxfReal	angleOffset()	description

TT5

type key	value	description
AcDbBlockStretchAction		
AcDb::kDxfReal	angleOffset()	description

TT6

type key	value	description
AcDbBlockAlignment Grip		
AcDb::kDxfInt16	mnInvertFlag	description

TT7

type key	value	description
AcDbBlockFlipGrip		
AcDb::kDxfInt16	mnInvertFlag	
AcDb::kDxfInt16	nFlipState	

FIG. 14(cont.)

FIG. 14(cont.)

TT8

AcDbBlock1PtParameter

type key	value	description

TT9

| AcDb::kDxfReal | angleOffset() | |
| type key | value | description |

AcDbBlock2PtParameter

AcDb::kDxfXCoord	m_ptBasePoint	
AcDb::kDxfXCoord	m_ptEndPoint	
AcDb::kDxfXCoord	m_vecNormal	

TT10

type key	value	description

AcDbBlockLookupParameter

| AcDb::kDxfText | m_strCurrentValue | |

TT11

type key	value	description

AcDbBlockVisibilityParameter

| AcDb::kDxfText | m_VisibilitySets[m_CurrentVisibilitySet]->m_name | |

TT12

type key	value	description

AcDbBlockFlipParameter

| AcDb::kDxfInt16 | m_nFlipState | |

TT13

type key	value	description

AcDbBlockPolarParameter

| AcDb::kDxfXCoord | m_ptBaseAnglePoint | |

TT14

type key	value	description

AcDbBlockRotationParameter

| AcDb::kDxfXCoord | m_ptBaseAnglePoint | |

FIG. 15

FIG. 16

200

202

Create Master Block Definition

204

Create Block Instantiation

206

Receive User Input Manipulating Block Instantiation

208

Clone Master Block Definition to Generate Anonymous Block Definition

210

Record Manipulated Geometry of Block Instantiation in Anonymous Block Definition

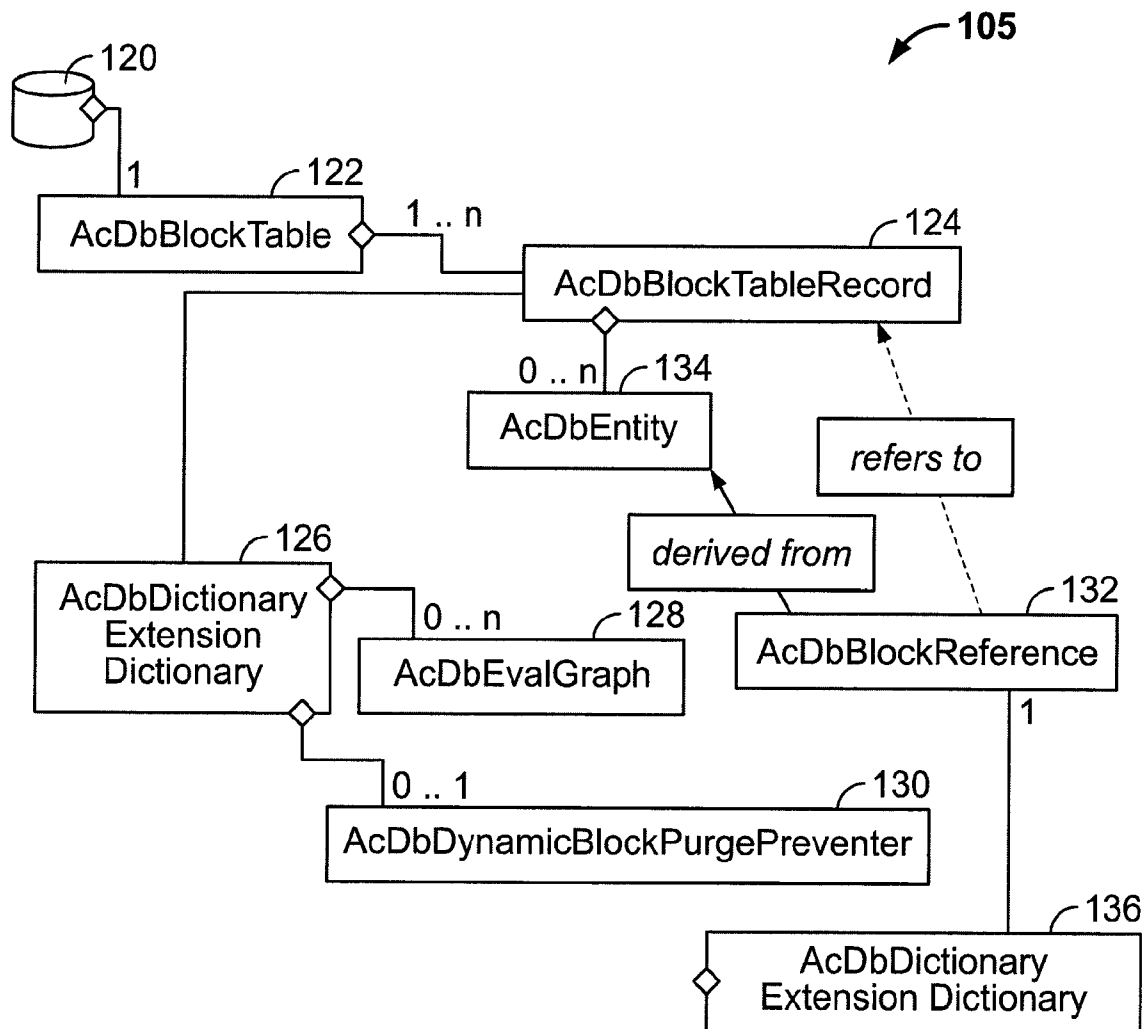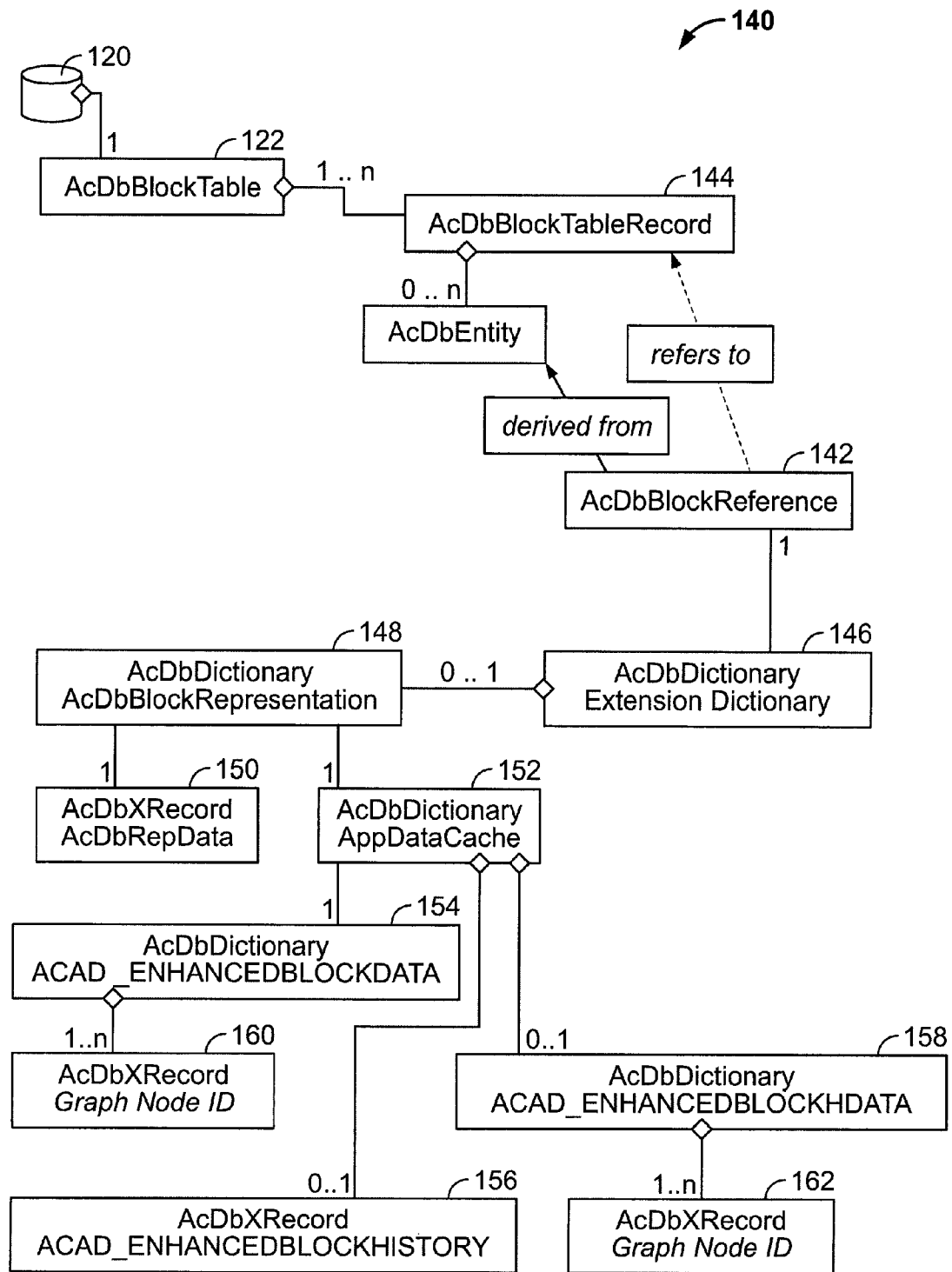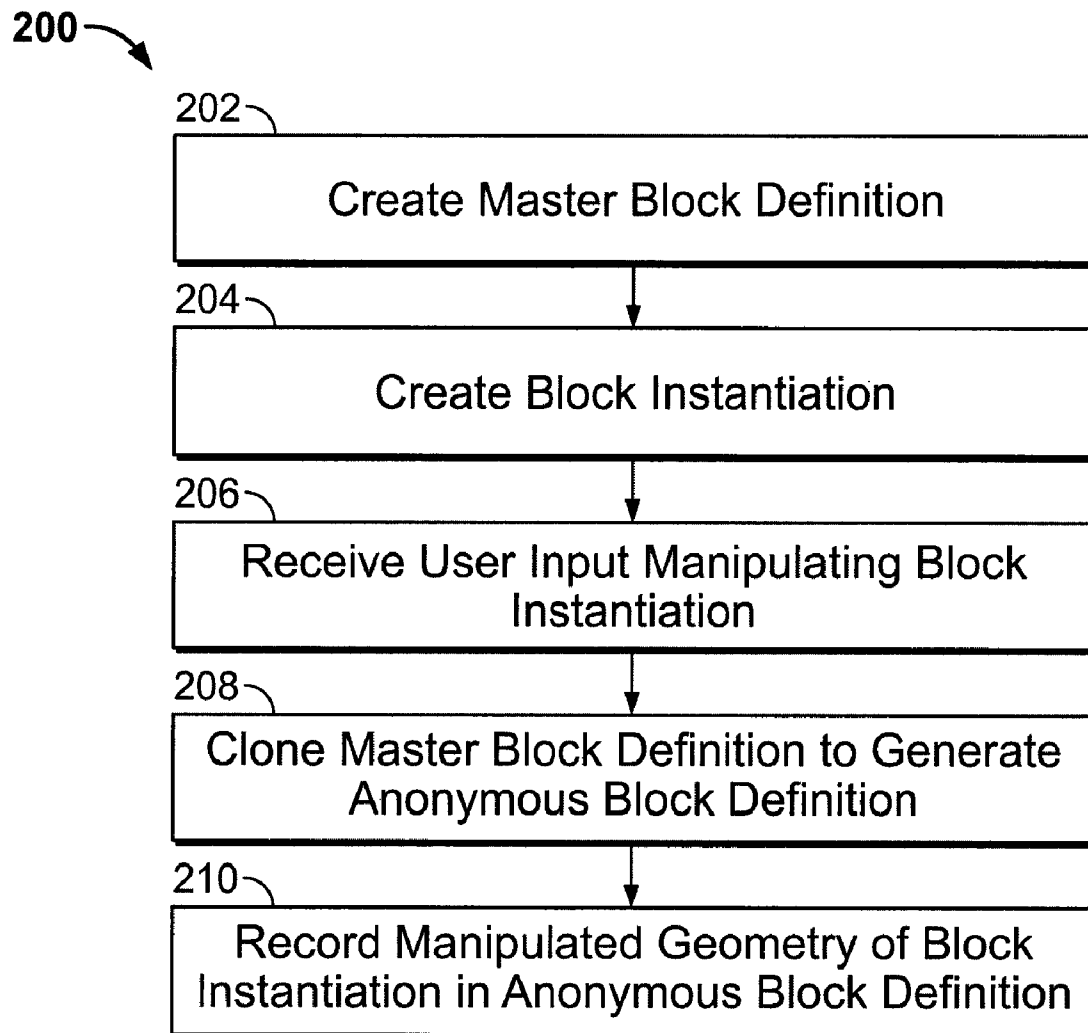**FIG. 17**

DYNAMIC BLOCKS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to pending U.S. Provisional Application Ser. No. 60/740,524 entitled "Dynamic Blocks", filed on Nov. 28, 2005, the entire contents of which is hereby incorporated by reference.

BACKGROUND

This disclosure relates to data structures and methods for processing and storing formatted data.

Computer-aided design (CAD) software applications have been available for many years to assist in preparing two dimensional and three dimensional drawings and models. AutoCAD® software available from Autodesk, Inc. of San Rafael, Calif. is an example of a widely used CAD software application. A software application may allow a user to create an object including one more entities, sometimes referred to as a block, where the block can be identically replicated throughout the drawing or model. This saves the user time in having to redraw an identical object more than one time.

SUMMARY

This disclosure generally describes data structures and methods for processing and storing data. In general, in one aspect, the invention features a data structure defining a master block definition associated with instantiations of a block to be included in a computer-aided design application. The data structure includes a block table record in a database and an extension dictionary associated with the block table record and including a dependency graph. The block table record includes a geometry of a block defined by the master block definition, the block including one or more graphical entities and at least one allowable manipulation. The dependency graph includes relationship information about the one or more graphical entities and the at least one allowable manipulation.

In general, in another aspect, the invention features a data structure defining a block instantiation of a block. The data structure includes a block reference including a geometry of a block instantiation and an extension dictionary associated with the block reference and including a block representation dictionary. The block representation dictionary includes a record including a pointer to a block table record including a master block definition of a block. The block representation dictionary further includes an application data cache dictionary including an enhanced block data dictionary, where the enhanced block data dictionary includes one or more graph node ID records. A graph node ID record includes node values for nodes in a dependency graph included in the master block definition.

Implementations of the invention may include one or more of the following. A data structure defining the master block definition of the block can include a block table record in a block table in a database and an extension dictionary associated with the block table record and including a dependency graph. The block table record includes a geometry of the block defined by the master block definition, the block including one or more graphical entities and at least one allowable manipulation. The dependency graph includes relationship information about the one or more graphical entities and the at least one allowable manipulation. The application data cache dictionary can further include an enhanced block his-

tory record including a chain of manipulations performed on the block instantiation. Additionally, the application data cache dictionary can further include an enhanced block data dictionary including one or more second graph node ID records, where the one or more second graph node ID records include node values for nodes in a dependency graph included in the master block definition capturing a state of the block instantiation just prior to a modification to the master block definition.

The invention may include one or more of the following advantages. A user can define a master block to allow for block instantiations. A block can be a "dynamic" block if manipulations of each instantiation are permissible. Changes to the master block definition are replicated to all block instantiations. A user can add parameters and actions to a block to make the block dynamic using a graphical tool, for example, the block editor described herein. The block editor is user friendly and does not require the user to have programming skills to create the dynamic block.

The invention may include one or more of the following advantages. A user can define a master block to allow for block instantiations. A block can be a "dynamic" block if manipulations of each instantiation are permissible. Changes to the master block definition are replicated to all block instantiations. A user can add parameters and actions to a block to make the block dynamic using a graphical tool, for example, the block editor described herein. The block editor is user friendly and does not require the user to have programming skills to create the dynamic block.

DRAWINGS

FIG. **1** is a screen shot illustrating a dynamic block feature in a CAD software application.

FIG. **2** is a screen shot illustrating a block editor feature in a CAD software application.

FIG. **3** is an exemplary dynamic block illustrating a point parameter and move action.

FIGS. **4**A-B show an exemplary dynamic block illustrating a scale action.

FIGS. **5**A-B show an exemplary dynamic block illustrating a stretch action.

FIGS. **6**A-B show an exemplary dynamic block illustrating a polar action.

FIGS. **7**A-C show exemplary dynamic blocks illustrating a rotate action.

FIG. **8** shows an exemplary dynamic block illustrating a flip action.

FIGS. **9**A-D show exemplary dynamic blocks illustrating an array action.

FIG. **10** shows an exemplary dynamic block illustrating a look-up grip.

FIGS. **11**A-D show exemplary dynamic blocks illustrating visibility states.

FIGS. **12**A-C show exemplary dynamic blocks illustrating chained actions.

FIG. **13** is a class diagram.

FIG. **14** is a table including descriptions of class elements.

FIGS. **15** and **16** are class diagrams.

FIG. **17** is a flow chart illustrating a process for generating a block instantiation.

DETAILED DESCRIPTION

Referring to FIG. **1**, a screen shot **100** showing a graphical user interface of a computer-aided design (CAD) application is shown. The CAD application can be, for example, AutoCad

3

available from Autodesk, Inc., in San Rafael, Calif., or another CAD application or other software application with CAD functionality. A CAD design is shown that includes three instantiations 102, 104, 106 of a dynamic block. A dynamic block feature in a CAD application allows an object (i.e., a dynamic block) to be instantiated, and allows modifications to an instantiation without modifying a master block definition defining the dynamic block, as shall be described in further detail below.

Referring to FIG. 2, a second screen shot 101 showing a graphical user interface of a CAD application is shown illustrating a user interface presented by a block editor. A user can create a master block definition defining a dynamic block using the block editor user interface. A block editor can be a software application or a tool included in a software application. The block editor can be implemented in software, hardware or firmware. As mentioned above, the block editor can have a user interface configured to receive input from a user and present information to a user. The user interface can include tools allowing a user to create and edit a master block definition for a dynamic block.

In this example, the user created a dynamic block 103 including an inner rectangular shaped entity ("inner entity") 108 nested within an outer rectangular shaped entity ("outer entity") 110. The user has further defined the dynamic block to include parameters and actions allowing manipulation of the entities within the block. In this example, the user included the following two parameters and actions: one related to movement and the second related to rotation. That is, an instantiation of the dynamic block can be manipulated by a user to rotate the inner entity 108 and/or to move the inner entity 108. In this implementation, to move the inner entity 108, the user can click and drag a grip 112. To rotate the inner entity 108, the user can click and move a grip 114. When defining the dynamic block 103, the user could have permitted other manipulations, for example, scale or stretch shown on the actions palette 116. Other permitted manipulations are possible, and the ones shown are exemplary.

A "static block" includes a definition in which the user has not included any permissible manipulations of the one or more entities within the block, i.e., defined a set position of the inner entity 108 relative to the outer entity 110. Any instantiations of the block would appear identical to one another, and changes to the block would only be possible by changing the master block definition, in which case, changes would replicate in all block instantiations. A dynamic block is different than a static block. A dynamic block is one in which the master block definition allows for one or more manipulations to the block, where each block instantiation can be manipulated differently, allowing for unique block instantiations.

In one implementation, dynamic behavior can be added to a new or existing block definition by adding parameters and actions to the block using the block editor. Parameters define custom properties for the dynamic block by specifying positions, distances and angles for geometry in the block. Actions define how the geometry of a dynamic block will move or change when an instantiation of the block is manipulated in a drawing. When a user adds actions to the dynamic block, typically the user must associate the actions with parameters.

In one implementation, a user can add parameters to a master block definition using the parameters palette 113 in the block editor user interface (see FIG. 2). A user can add actions to the master block definition using the actions palette 116 in the block editor user interface.

By way of example, referring again to FIG. 2, the block 103 includes an "angle" that represents a rotation parameter 117

4

and a rotate action 118, which the user interface displays as a lightening bolt and a "rotate" label. Additionally, a move action 119 is included, which the user interface displays as a lightening bolt and a "move" label. For a block to be dynamic, there must be at least one parameter, e.g., the rotation parameter 117. At least one action must be associated with the parameter, e.g., the rotate action 118 is associated with the rotation parameter 117. In this implementation, adding a parameter to the block 103 includes adding an associated grip. The grip can be used to manipulate the block 103. For example, the rotation parameter 117 includes grip 114. The grip 114 can be moved to change the value of the angle, thereby rotating the block 103. In one implementation, when a user selects a parameter, grip or action while in the block editor, any associated objects or dependencies are highlighted. For example, if the user selects the rotate action 118, the rotation parameter 117 and grip 114 are highlighted.

Parameters

The following table shows the relationships among parameters, grips and actions in one implementation. The parameter type column shows a list of 10 different parameters a user can specify for a dynamic block. The grip type column shows a list of corresponding grips that are added to the dynamic block in association with the parameter, for example, so that the value of the parameter can be manipulated. The actions column shows the one or more actions that can be associated with a given parameter. For example, the rotation parameter, discussed above in the context of FIG. 2, can be associated with the rotate action.

TABLE 1

Parameter Type	Grip	Type	Actions You Can Associate with a Parameter
Point		Standard	Move, Stretch
Linear		Linear	Move, Scale, Stretch, Array
Polar		Standard	Move, Scale, Stretch, Polar Stretch, Array,
XY		Standard	Move, Scale, Stretch. Array
Rotation		Rotation	Rotate
Flip		Flip	Flip
Alignment		Alignment	None (The action is implied and contained within the parameter.)
Visibility		Lookup	None (The action is implied and controlled by visibility states.)
Lookup		Lookup	Lookup
Base		Standard	None

A master block definition for a dynamic block must include at least one parameter. When a parameter is added, the grip associated with the key points of the parameter are automatically added. A key point is a point on a parameter that drives the associated action when edited. The user then adds an action to the master block definition and associates the action with the parameter. In a drawing, the user can use the grip to manipulate an instantiation of the block. In one implementation, a "properties" palette can be included in a user interface that includes values of parameters and a user can manipulate an instantiation of the block in a drawing by changing the value of the parameters in the properties palette. Changing the value of a parameter, e.g., by manipulating the grip or using the properties palette, drives the action that is associated with the parameter and can change the geometry of the block instantiation.

In one implementation, some parameters can have a fixed set of values, minimums and maximum values or increment

5

values. For example, a linear parameter used in a window block can have the following fixed set of values: 10, 20, 30 and 40. When an instantiation of the block is included in a drawing, a user can only change the window to one of the fixed set of values. The following table lists and describes the types of parameters that can be added to a master block definition of a dynamic block and the types of action that can be associated with each parameter. Other parameters are possible, and the listing below is merely illustrative.

TABLE 2

Parameter Type	Description	Supported Actions
Point	Defines an X and Y location in the drawing. In the Block Editor, looks similar to an ordinate dimension.	Move, Stretch
Linear	Shows the distance between two anchor points. Constrains grip movement along a preset angle. In the Block Editor, looks similar to an aligned dimension.	Move, Scale, Stretch, Array
Polar	Shows the distance between two anchor points and displays an angle value. You can use both grips and the Properties palette to change both the distance value and the angle. In the Block Editor, looks similar to an aligned dimension	Move, Scale, Stretch, Polar Stretch, Array,
XY	Shows the X and Y distances from the base point of the parameter. In the Block Editor, displays as a pair of dimensions (horizontal and vertical).	Move, Scale, Stretch, Array
Rotation	Defines an angle. In the Block Editor, displays as a circle.	Rotate
Flip	Flips objects. In the Block Editor, displays as a reflection line. Objects can be flipped about this reflection line. Displays a value that shows if the block reference has been flipped or not.	Flip
Alignment	Defines an X and Y location and an angle. An alignment parameter always applies to the entire block and needs no action associated with it. An alignment parameter allows the block reference to automatically rotate around a point to align with another object in the drawing. An alignment parameter affects the rotation property of the block reference. In the Block Editor, looks like an alignment line.	None (The action is implied and contained within parameter.)
Visibility	Controls the visibility of objects in the block. A visibility parameter always applies to the entire block and needs no action associated with it. In a drawing, you click the grip to display a list of visibility states available for the block reference. In the Block Editor, displays as text with an associated grip.	None (The action is implied and controlled by visibility states.)
Lookup	Defines a custom property that you can specify or set to evaluate a value from a list or table you define. It can be associated with a single lookup grip. In the block reference, you click the grip to display a list of available values. In the Block Editor, displays as text with an associated grip.	Lookup
Base	Defines a base point for the dynamic block reference relative to the geometry in the block. Cannot	None

6

TABLE 2-continued

Parameter Type	Description	Supported Actions
	be associated with any actions, but can belong to an action's selection set. In the Block Editor, displays as a circle with crosshairs.	

Actions

Actions define how the geometry of a dynamic block reference will move or change when the custom properties of a block instantiation are manipulated in a drawing. Generally, when an action is added to a master block definition of a dynamic block, the action is associated with a parameter. The table below includes a listing of exemplary action types and the associated parameters for one implementation.

TABLE 3

Action Type	Parameter
Move	Point, linear, polar, XY
Scale	Linear, polar, XY
Stretch	Point, linear, polar, XY
Polar Stretch	Polar
Rotate	Rotation
Flip	Flip
Array	Linear, polar, XY
Lookup	Lookup

Move Action

The move action causes an object to move a specified distance and/or angle. As indicated in Table 3, the move action can be associated with the point, linear, polar or XY parameters. In a block instantiation, if a user changes a value of a parameter associated with a move action, e.g., through a grip or the properties palette, the changed value may affect the key point on the parameter associated with the move action. If the key point is affected, the geometry in the move action's selection set will move. For example, referring to FIG. **3**, a dynamic block **51** representing a chair is shown. The block **51** includes a point parameter **49** and a move action associated with the point parameter. The move action's selection set includes all the geometry in the block **51** (i.e., the chair). When a user uses the grip **52** associated with the point parameter **49**, or changes the position X or position Y properties in the properties palette, to manipulate an instantiation of block **51**, the value of the point parameter changes. The change in value causes the block **51** to move. In the example shown, the instantiation of the block **51** is moved by dragging the point parameter grip **52**. The new position of the grip **52** is reported in the properties palette.

When a move action is associated with an XY parameter, the move action can have an override property called "distance type". This property specifies whether the distance applied to the move is the parameter's X value, Y value or X and Y coordinate value from the parameter's base point. For example, if a user specifies X distance as the distance type for a move action in a master block definition of a dynamic block, this means that a block instantiation can only be moved on the X axis and a user cannot move the block instantiation on the Y axis.

Scale Action

The scale action causes a dynamic block's selection set to scale when the associated parameter is edited, e.g., by moving grips or using the properties palette. In one implementation, a scale action is associated with an entire parameter, not a key

point on the parameter. As indicated in Table 3, a scale action can be associated with a linear, polar or XY parameter. After associating the scale action with a parameter, the user associates the action with a selection set of geometry. The scale action includes a property called "base type". With this property, a user can specify whether the base point for the scale factor is dependent or independent. If the base type is dependent, then the objects in the selection set scale relative to the base point of the parameter with which the scale action is associated. For example, referring to FIG. 4A, an instantiation of a block 53 is shown and a scale action is associated with an XY parameter. The scale action base type is dependent. The base point 54 of the XY parameter is located at the lower left corner of the rectangle. When the custom grip 55 is used to scale the block 53, the block 53 is scaled relative to the lower left corner of the rectangle, i.e., relative to the base point 54.

Referring to FIG. 4B, a scale action is associated with an XY parameter and the scale action base type is independent. If the base type is independent, the user specifies a base point independent of the parameter with which the scale action is associated. The objects in the selection set will scale relative to the independent base point specified. In the example shown, the block 56 includes an independent base point 57 located at the center of the circle. When the custom grip 58 is used to scale the block 56, the block 56 is scaled relative to the center of the circle, i.e., relative to the independent base point 57.

When a scale action is associated with an XY parameter, the scale action can include an override property called "scale type". This property specifies whether the scale factor applied is the parameter's X distance, Y distance or X and Y coordinate value distance from the parameter's base point. For example, if a user specifies X distance as the scale type for a scale action in a master block definition, then in a drawing when the user edits an instantiation of the block, e.g., by dragging a grip on the XY parameter, if the grip is only dragged along the Y axis, the associated geometry will not scale.

Stretch Action

A stretch action causes objects to move and stretch a specified distance in a specified location. As indicate in Table 3, a stretch action can be associated with a point, linear, polar or XY parameter. After associating a stretch action with a parameter, the user specifies a stretch frame for the stretch action. The user then selects the objects for the stretch action's selection set. The stretch frame determines how the objects within or crossed by the frame are edited in a block instantiation. For example, in one implementation a stretch frame is defined such that: objects entirely within the frame are moved; objects that cross the frame are stretched; objects within or crossed by the frame, but not included in the selection set are not stretched or moved; and objects outside the frame and included in the selection set are moved. Other variations of the stretch frame definition are possible.

Referring to FIG. 5A, a stretch frame 60 is indicated by a dashed line and the selection set 61 has a haloed effect. The top circle 62, while enclosed by the stretch frame 60, is not included in the selection set, so the top circle 62 will not move. The bottom circle 63 is entirely enclosed in the stretch frame 60 and included in the selection set 61, so the bottom circle 63 will move. The rectangle 64 is crossed by the stretch frame 60 and included in the selection set 61 and so the rectangle 64 will stretch. If in an instantiation of the block, the value of a parameter associated with the stretch action is changed, e.g., through a grip or the properties palette, the key

point on the parameter may be affected. If the key point is affected, the geometry in the stretch action's selection set will move, as shown in FIG. 5B.

When a stretch action is associated with an XY parameter, the stretch action can have an override property called "distance type". This property specifies whether the distance applied to the move is the parameter's X value, Y value or X and Y coordinate values from the parameter's base point. For example, if a user specifies X distance as the distance type for a stretch action in a master block definition of a dynamic block, then in a drawing when a user tries to edit an instantiation of the block by dragging the key point only along the Y axis, the associated geometry will not move.

Polar Stretch Action

A polar stretch action rotates, moves and stretches objects a specified angle and distance when a key point on the associated polar parameter is changed, e.g., through a grip or the properties palette. A polar stretch can only be associated with a polar parameter. The base point for the stretch part of the action is the parameter point opposite the key point. Referring to FIG. 6A, after associating a polar stretch action with a polar parameter, the user specifies a stretch frame 65 for the polar stretch action. The user then selects objects to stretch and objects to rotate, for example, in one implementation the stretch frame is defined such that: objects entirely within the frame 65 are moved; objects that cross the frame 65 are stretched; objects in the action's selection set specified to rotate only are not stretched; objects within the frame are moved linearly after they are rotated; objects crossed by the frame are stretched linearly after they are rotated; objects within or crossed by the frame, but not included in the selection set, are not stretched or rotated; and objects outside the frame and included in the selection set are moved. Other variations of the stretch frame are possible.

In the example shown, the frame 65 is indicated by the dashed line and selection set 66 has a haloed effect. The top circle 67, while enclosed by the stretch frame, is not included in the selection set 66, so the top circle 67 will not move. The bottom circle 68 is entirely enclosed in the stretch frame and included in the stretch selection set, so the bottom circle 68 will move. The rectangle 69 is crossed by the stretch frame 65 and included in the selection set 66, so the rectangle 69 will stretch. The square 70 is entirely enclosed in the frame 65 and included in the rotate selection set, but not the stretch selection set, so the square will rotate only. In a block instantiation, if a user changes the value of a parameter associated with a polar stretch action, e.g., through a grip or the properties palette, the change may affect the key point on the parameter associated with the polar stretch action. If the key point is affected, the geometry in the polar stretch action's selection set will move or rotate depending on how the block was defined. An example of affect of changing a value of a parameter is shown in FIG. 6B.

Rotate Action

The rotate action causes associated objects to rotate when the associated parameter is edited, e.g., through a grip or the properties palette. A rotate action can only be associated with a rotation parameter, and is associated with the entire parameter not a key point on the parameter. After associating a rotate action with a rotation parameter, the user associates the action with a selection set of geometry. The rotate action can include a property called "base type". With this property, a user can specify whether the base point for the rotation is the base point of the parameter or an independent base point that the user specifies in the master block definition. If the base type is set to dependent, the block rotates around the associated rotation parameter's base point. For example, as shown in

FIG. 7A, the chair block **71** includes a rotation parameter and an associated rotate action. The rotate action's base type is dependent. The base point **72** of the parameter is at the center of the chair. Thus, the chair **71** rotates about the center point **72**.

If a user sets the base type to independent, the user can specify a base point for the rotate action other than the base point of the associated rotation parameter. This independent base point can be shown in the block editor as an X marker. The location of the independent base point can be changed by dragging the base point or by editing the base X and base Y values in the overrides section of the properties palette. Referring to FIG. 7B, the chair block **73** includes a rotation parameter and an associated rotate action. The rotate action's base type is independent. The independent base point **74** is located at the lower left corner of the chair block **73**. Thus, the chair rotates about the lower left corner, i.e., the base point **74**.

Referring to FIG. 7C, a block instantiation **75** is shown including three rectangles **76**a-c. Each of the three rectangles **76**a-c rotates about an independent base point **77**a-c located at the lower left corner of each rectangle. One way to achieve this is to assign one rotation parameter. A user then adds three rotate actions. Each rotate action is associated with the rotate parameter. Each rotate action is then associated with a different object, i.e., **76**a, b or c, and assigned a different independent base point, i.e., **77**a, b or c. The same result can also be achieved by using dependent base points, each with a different base offset, for each rotation action.

Flip Action

A flip action allows a block instantiation to be flipped about a specified axis referred to as a reflection line when the associated parameter is edited, e.g., through a grip or the properties palette. A flip action can only be associated with a flip parameter, and is associated with the entire parameter, not a key point on the parameter. After associating a flip action with a flip parameter, the user associates the action with a selection set of geometry. Only the selected objects will flip about the reflection line. Referring to FIG. 8, a block **78** is shown. The block **78** can be flipped about the rejection line **79**, as shown on the right hand side of the drawing.

Array Action

An array action causes associated objects to copy and array in a rectangular pattern when the associated parameter is edited, e.g., through a grip or the properties palette. An illustrative example of an array action is shown in reference to block **80** in FIG. 9A. An array action can be associated with a linear, polar or XY parameter. After associating an array action with a parameter, the user associates the action with a selection set of geometry. When an array action is associated with a liner or polar parameter, the user specifies a column offset for the arrayed objects. The column offset determines the distance between the array objects. When a user edits the parameter in a block instantiation, the distance of the parameter (from base point to second point) is divided by the column offset to determine the number of columns (the number of objects). For example, a user may associate an array action with a linear parameter. The user specifies that the array action has a column offset of 2. When the linear parameter in a block instantiation is changed to a distance of 10, the number of columns for the block instantiation is 5. If an array action is associated with an XY parameter, the user can also specify the row offset.

If a user includes a parameter in an array action's selection set, it has no effect on the behavior of the block instantiation. The parameter is not copied with the other objects in the selection set. Additional grips are not displayed in the block instantiation. In the example shown in FIG. 9B, a parking lot

block **82** can be arrayed to include any number of parking spaces. The vertical line defining a parking space can also be rotated. Notice that even after the block **82** has been array, the block **82** still includes only one rotation grip **83**. However, if a user edits the grip **83** for the parameter included in the array action's selection set, the parameter's associated action is triggered for all instances of the objects. The same behavior occurs when the parameter is not included in the array actions selection set.

A dynamic block can include an array action and a rotate action that have the same selection set. The order in which the block instantiation is arrayed and rotated affects the display of the block. For example, referring to FIG. 9C, when a user rotates the block first and then arrays it, all instances of the arrayed objects are individually rotated around their own base point. By contrast, referring to FIG. 9D, when a user arrays the block first and then rotates it, all instances of the arrayed objects are rotated about a single base point.

Look-up Action

A look-up action can be added to a master block definition for a dynamic block and associated with a look-up parameter. This will create a look-up table. The look-up table can be used to assign custom properties and values to a dynamic block.

Override Properties

Some actions can include offset override properties. These properties allow a user to specify a factor by which a parameter value is increased or decreased when the parameter is edited in a block instantiation. Action overrides are properties of actions. However, they have no effect on the block instantiation until the block instantiation is manipulated in a drawing. In one implementation, there are two types of overrides: distance multiplier and angle offset. A user can use the distance multiplier property to change a parameter value by a specified factor. For example, if the distance multiplier property is set to 2 for a stretch action, the associated geometry in the block instantiation increases and doubles the distance of the grip movement. The angle offset property can be used to increase or decrease the angle of a changed parameter value by a specified amount. For example, if the angle offset property of a move action is set to 90, the block instantiation will move 90 degrees beyond the angle value of the grip movement.

In one implementation, a user can specify the action override properties by following the prompts on the command line when a user adds an action to a master block definition. A user can also specify these properties in the properties palette when selecting an action in the block editor. The following table shows the available override properties for each type of action in one implementation.

TABLE 4

Action Type	Available Override Properties
Move	Distance Multiplier, Angle Offset
Scale	None
Stretch	Distance Multiplier, Angle Offset
Polar Stretch	Distance Multiplier, Angle Offset
Rotate	None
Flip	None
Array	None
Lookup	None

Parameter Sets

Referring again to FIG. **2**, the "Parameter Sets" tab **111** on the block authoring palette can be used to add commonly paired parameters and actions to a master block definition for a dynamic block. A parameter set can be added to a dynamic

block the same way a parameter can be added. The action included in the parameter set is automatically added to the master block definition and associated with the added parameter. The user must then associate a selection set (geometry) with each action. The following table lists the parameter sets provided on the Parameter Sets tab **111** in one implementation.

TABLE 5

Parameter Set	Description
Point Move	Adds a point parameter with one grip and an associated move action to the dynamic block definition.
Linear Move	Adds a linear parameter with one grip and an associated move action to the dynamic block definition.
Linear Stretch	Adds a linear parameter with one grip and an associated stretch action to the dynamic block definition.
Linear Array	Adds a linear parameter with one grip and an associated array action to the dynamic block definition.
Linear Move Pair	Adds a linear parameter with two grips and a move action associated with each grip to the dynamic block definition.
Linear Stretch Pair	Adds a linear parameter with two grips and a stretch action associated with each grip to the dynamic block definition.
Polar Move	Adds a polar parameter with one grip and an associated move action to the dynamic block definition.
Polar Stretch	Adds a polar parameter with one grip and an associated stretch action to the dynamic block definition.
Polar Array	Adds a polar parameter with one grip and an associated array action to the dynamic block definition.
Polar Move Pair	Adds a polar parameter with two grips and a move action associated with each grip to the dynamic block definition.
Polar Stretch Pair	Adds a polar parameter with two grips and a stretch action associated with each grip to the dynamic block definition.
XY Move	Adds an XY parameter with one grip and an associated move action to the dynamic block definition.
XY Move Pair	Adds an XY parameter with two grips and move action associated with each grip to the dynamic block definition.
XY Move Box Set	Adds an XY parameter with four grips and a move action associated with each grip to the dynamic block definition.
XY Stretch Box Set	Adds an XY parameter with four grips and a stretch action associated with each grip to the dynamic block definition.
XY Array Box Set	Adds an XY parameter with four grips and an array action associated with each grip to the dynamic block definition.
Rotation	Adds a rotation parameter with one grip and an associated rotate action to the dynamic block definition.
Flip	Adds a flip parameter with one grip and an associated flip action to the dynamic block definition.
Visibility	Adds a visibility parameter with one grip. No action is required with a visibility parameter.
Lookup	Adds a lookup parameter with one grip and a lookup action to the dynamic block definition.

When a parameter is added to a master block definition, custom grips associated with key points of the parameter are automatically added to the dynamic block, as discussed above in reference to the various exemplary parameters. In a drawing, a user can use the custom grips to manipulate the geometry of a block instantiation. Certain of the parameters have a property called "Number of Grips". When a user selects a

parameter in the block editor, the Number of Grips property is displayed in the properties palette. The property allows a user to specify, e.g., from a preset list, the number of grips the user wants displayed for the parameter. A user can specify that a parameter has 0 grips, in which case the user can still edit a block instantiation through the properties palette.

Visibility States

Referring to FIG. **10**, if a dynamic block includes visibility states or a look-up table, the user can define the dynamic block so that the only grip that is displayed is a look-up grip **86**. When the look-up grip is clicked on a block instantiation, a drop-down list **87** is displayed. The drop-down list **87** includes a list of available visibility states for the block. When an item from the list **87** is selected, the display of the block instantiation can change accordingly. For example, the list **87** shown includes the angles 30, 45, 60 and 90 degrees, meaning there are four visibility states and in each state the stated angle is the angle of the door relative to a horizontal line. The drawing to the left shows the door at an angle of 30 degrees, whereas the drawing to the right shows the door at an angle of 60 degrees. Each drawing represents a different visibility state of the block.

In one implementation, grips are automatically added at key points on the parameter. However, in one implementation, a user can reposition a grip anywhere in the block space relative to the grip's associated key point on the parameter. When a grip is repositioned, it is still tied to the key point with which it is associated. No matter where the grip is shown in the block instantiation, it will still manipulate the key point with which it is associated. If a user moves or changes the key point of the parameter, the grip's position relative to the key point is maintained.

Visibility states can be used to make geometry visible or invisible in a dynamic block. One block can have any number of visibility states. Using visibility states is a powerful way to create a dynamic block that has many different graphical representations. For example, referring to FIG. **11A**, four different weld symbols **88**, **89**, **90** and **91** are shown. Using visibility states, the four weld symbols **88-91** can be combined into a single dynamic block. Referring to FIG. **11B**, an example of the geometry of a combined weld symbol **92** is shown. After combining the geometry in the block editor, the user can add a visibility parameter. A visibility parameter is not associated with an action. The user can create and name a different visibility state for each of the weld symbols **88-91**, for example, WLD1, WLD2, WLD3 and WLD4. The user can make particular geometry visible or invisible for each of the four states.

Referring to FIG. **11C**, the WLD1 visibility state is displayed in the block editor. The geometry that displays in a dimmed state is invisible for the WLD1 visibility state. Note how the WLD1 visible geometry corresponds to the weld symbol **88** shown in FIG. **11A**. The visibility parameter includes a look-up grip **93**. This grip is displayed in a block instantiation that includes visibility states. Referring to FIG. **11D**, when a user clicks the grip **93** in a block instantiation, a drop-down list **94** of all of the visibility states in the block instantiation is displayed. The user can select one of the states from the list **94** and the geometry that is visible for the state is displayed in the drawing.

Value Sets

A user can define a value set for a linear, polar, XY or rotation parameter. A value set is a range or list of values specified for a parameter. These values can be displayed for a block instantiation as a drop-down list next to the parameter label under custom in the properties palette. When a user defines a value set for a parameter, the parameter is limited to

these values when the block instantiation is manipulated in a drawing. For example, if a user defines a linear parameter in a dynamic block that represents a window to have a value set of 20, 40 and 60, then the window can only be stretched to 20, 40 or 60 units. In one implementation, when a user creates a value list for a parameter, the value of the parameter as it exists in the master block definition is automatically added to the value set. This is the default value for the block instantiation when inserted into a drawing. In one implementation, if a user changes a parameter's value to a value other than one in the list, the parameter will adjust to the closest valid value.

Chain Actions

In one implementation, polar, linear, XY and rotation parameters have a property called "Chain Actions". This property affects the parameter behavior if the parameter is part of an action's selection set. For example, a user may include a point parameter in the selection set of a stretch action that is associated with a linear parameter. When the linear parameter is edited in a block instantiation, its associated stretch action triggers a change in its selection set. Because the point parameter is included in the selection set, the point parameter is edited by the change in the linear parameter. Referring to FIG. 12A, an example of a dynamic block 95 in a block editor is shown. The point parameter 96 is included in the stretch action's selection set. If the Chain Actions property for the point parameter is set to "Yes", then a change in the linear parameter will trigger the move action associated with the point parameter, just as if the user edited the point parameter in the block instantiation, e.g., through a grip or custom property. That is, in the example shown in FIG. 12B, the circle 97 will move. Referring to FIG. 12C, if the Chain Actions property is set to "No", then the point parameter's associated move action is not triggered by the changes to the linear parameter, thus the circle 97 does not move.

The master block definition of a dynamic block can be modified in the block editor. A user can delete, add and modify the parameters, actions, geometry, visibility states, look-up tables, grips and properties. The master block definition can then be saved in the block editor. In one implementation, the current values of the geometry and parameters in the dynamic block are set as default values for instantiations of the block.

Described above are tools and techniques for creating and editing a master block definition for a dynamic block, and uniquely modifying—to the extent allowable by the master block definition—instantiations of the dynamic block in a drawing. The following is a description of one example of a data structure or data structures that can be used for creating and storing said master block definitions and block instantiations.

Referring to FIG. 13, a class diagram 98 is shown illustrating classes and objects that can be used to implement a dynamic block feature. Elements in the class diagram 98 and additional class and object information is described in the table shown in FIG. 14. The table includes the name of a particular element, the type of the element and a description of the element.

Referring to FIG. 15, a portion of the class diagram 90 of FIG. 13 is shown. The class diagram 140 in FIG. 15 only includes the classes and objects used when instantiating a dynamic block without performing any manipulations. An AcDb database 120 includes an AcDb Block Table 122. The AcDb Block Table 122 can include multiple block table records (i.e., 1 to n). An AcDb Block Table Record 124 is shown that includes the master block definition of the dynamic block 103. An AcDb Extension Dictionary 126 is attached to the AcDb Block Table Record 124. Generally, an

AcDb Dictionary is an object that includes a collection of names (strings) and object pairs (AcDb objects) and when attached to another object in an AcDb database is referred to as an AcDb Extension Dictionary.

An object, such as the dynamic block 103, can include a number of manipulatable entities, e.g., the inner entity 108 and the outer entity 110. Entities of an object can depend on other entities of the object. Dependency relationships between entities of an object can be described by a dependency graph. A dependency graph includes linked nodes, each node having a value. Recording the values of the nodes can record per instance data for a block instantiation. When the user creates the dynamic block 103, thereby defining the master block definition, the AcDb Evaluation Graph 128, which in one implementation is a dependency graph, is generated. The master block definition includes the geometry of the dynamic block 103, the allowed manipulations and the initial values of the nodes in AcDb Evaluation Graph 128.

The AcDb Dynamic Block Purge Preventer 130 optionally can be included in the AcDb Extension Dictionary 126. The AcDb Dynamic Block Purge Preventer 130 can include a piece of a data to ensure the AcDb Block Table Record 124 attached to the AcDb Extension Dictionary 126 is not purged even if there is no AcDb Entity directly pointing to the AcDb Block Table Record 124.

AcDb Block Table Records include AcDb Entities 134; an AcDb Block Reference 132 is a kind of AcDb Entity 134. There can be none, one or more AcDb Block References referring to the same AcDb Block Table Record, i.e., the master block definition. For each block instantiation of the dynamic block 103 that has not been manipulated relative to the dynamic block 103 (i.e., maintains the original appearance of the dynamic block 103), there is an AcDb Block Reference 132 that refers to the AcDb Block Table Record 124 including the master block definition. An AcDb Extension Dictionary 136 is attached to the AcDb Block Reference 132 and can include information related to the AcDb Block Reference 132.

Referring again to FIG. 1, block instantiation 102 is an instance of the dynamic block 103 that has not been manipulated. Referring now to FIG. 15, in one example, the AcDb Block Reference 132 can represent the block instantiation 102. The block instantiation 102 refers to the master block definition. The master block definition, i.e., AcDb Block Table Record 124, includes the geometry of the dynamic block 103. The block instantiation 102 can be drawn using the master block definition.

Referring back to FIG. 1, block instantiation 106 is in the process of being manipulated. Once the changes to the block's appearance are accepted by the user, the block instantiation 106 will appear different than an un-manipulated block instantiation, e.g., block instantiation 102. Block instantiation 104 is an example of a block instantiation that has been manipulated. In this example, the inner entity 108 has been moved from the upper right corner of the outer entity 110 to the lower right corner.

Referring now to FIG. 16, a class diagram 140 is shown. In this class diagram 140, the AcDb Block Reference 142 represents the manipulated block instantiation 104. A manipulated block instantiation, e.g., block instantiation 104, does not refer to the AcDb Block Table Record 124 representing the master block definition. Rather, once changes to the block instantiation 104 are accepted, an "anonymous block definition" is generated. AcDb Block Table Record 144 includes the anonymous block definition. The AcDb Block Reference 142 representing the block instantiation 104 refers to the AcDb Block Table Record 144 including the anonymous block defi-

nition. The anonymous block definition includes the geometry of the block instantiation **104**. In one implementation, the anonymous block definition is generated by making a copy of the contents of the master block definition and recording the manipulations to the block instantiation's geometry, thereby recording the geometry of the manipulated block instantiation **104**. The block instantiation **104** can be drawn using the anonymous block definition.

The class diagram **140** for a manipulated block instantiation **104** further can include a number of additional elements. An AcDb Block Representation **148** is included in the AcDb Extension Dictionary **146** attached to the AcDb Block Reference **142**. The AcDb Block Representation **148** includes an AcDb Xrecord **150**. Generally, an Xrecord is an object that includes a linked list of typed values (e.g., strings, longs, integers, etc.). The AcDb Xrecord **150** includes a pointer to the master block definition, i.e., a pointer to the AcDb Block Table Record **124** shown in FIG. **14**. Thus, although the AcDb Block Reference **142** refers to the anonymous block definition, i.e., AcDb Block Table Record **144**, the AcDb Block Reference **154** still includes a pointer to the master block definition. The pointer to the master block definition is needed to retrieve the AcDb Evaluation Graph **128**, i.e., when the master block definition has been modified the anonymous block definition is changed or replaced, as discussed further below.

The AcDb Block Representation **148** can further include an Application Data Cache **152**. The Application Data Cache **152** can include three objects including an Enhanced Block Data AcDb Dictionary **154**, an Enhanced Block History AcDb Xrecord **156** and an Enhanced Block Hdata AcDb Dictionary **158**.

The Enhanced Block Data AcDb Dictionary **154** can include one or more Graph Node ID AcDb Xrecords **160** and can be configured to record per instance data. As discussed above, the master block definition includes an AcDb Evaluation Graph **128** (e.g., a dependency graph) setting forth the relationship of the entities forming the dynamic block **103** to one another and the defining the permissible manipulations. In other implementations, a data structure other then a dependency graph can be used. When a dependency graph is used, the per instance values of the nodes of the dependency graph for the block instantiation **104** are recorded as Graph Node ID AcDb Xrecords **160** in the Enhanced Block Data AcDb Dictionary **154**.

The Enhanced Block History AcDb Xrecord **156** includes a history of manipulations of the block instantiation **104**. In one implementation, a history is recorded if the interdependencies of the nodes is such that when multiple property changes are applied to block instantiations, the anonymous block definitions that result are different, depending on the order in which the property changes were applied. As mentioned above, an Xrecord is a chain of values. In the case of the Enhanced Block History AcDb Xrecord **156**, a sequence of operations is stored as values in a chain. For each operation, a value is added to the chain, which continues to grow. For example, referring again to FIG. **2**, a block instantiation can be edited by moving grip **112** to move the inner entity **108** relative to the outer entity **110**. An identifier of the grip **112** that was moved and the coordinates of the position of the grip **112** can be recorded as values in the Enhanced Block History AcDb Xrecord **156** to record the move operation. One or more compression algorithms can be used to reduce the number of items in an Xrecord chain, which is discussed in further detail below.

The Enhanced Block Hdata AcDb Dictionary **158** includes one or more Graph Node ID AcDb Xrecords. The Enhanced

Block Hdata AcDb Dictionary **158** is used to record a "pseudo history" of the block instantiation **104**. A pseudo history can be required when a dynamic block **103** initially did not include interdependencies making the sequence of operations significant, and therefore a history of manipulations was not recorded. However, if the dynamic block **103** and therefore the master block definition is subsequently modified to introduce such interdependencies, then going forward a history of manipulations is recorded in the Enhanced Block History AcDb Xrecord **156** described above. The pseudo history captures the state of a block instantiation just before the modification to the master block definition. The per instance data of the block instantiation **104** is recorded as Graph Node ID AcDb Xrecords **162** in the Enhanced Block Hdata AcDb Dictionary **158**; the per instance data forms the pseudo history.

A modification to the master block definition, e.g., a modification introducing interdependencies as discussed above, affects all instances of the dynamic block **103**. For example, a change to the geometry, such as modifying the inner entity **108** from a rectangular shape to a circular shape, is replicated to all instances of the dynamic block **103**, including the block instantiations **102**, **104** and **106**.

When the master block definition is modified, the existing anonymous block definitions are replaced or modified. For example, referring again to FIG. **1**, block instantiation **102** has not been manipulated and therefore refers to the AcDb Block Table Record **124** including the master block definition. Block instantiations **104** and **106** have been manipulated and therefore each refer to an AcDb Block Table Record including an anonymous block definition. As already discussed above, block instantiation **104** refers to AcDb Block Table Record **144** including the anonymous block definition of the block instantiation **104**. Block instantiation **106** refers to a different AcDb Block Table Record that includes the anonymous block definition of that block instantiation.

In one implementation, when the master block definition is modified, the AcDb Block Table Record **144** is replaced by a new AcDb Block Table Record that includes a new anonymous block definition corresponding to the block instantiation **104**. The AcDb Block Reference **132** refers to the new AcDb Block Table Record. In another implementation, the AcDb Block Table Record **144** can be modified rather then replaced by a new AcDb Block Table Record. In either implementation, the anonymous block definition for the block instantiation **104** is replaced (or changes) due to the changes to the master block definition.

The "new" anonymous block definition is generated using the modified master block definition and the per instance data (i.e., the node values, history or pseudo history values) for the block instantiation. That is, the per instance node values for the block instantiation **104**, which were recorded in the Graph Node ID AcDb Xrecords **160**, are used to populate the AcDb Evaluation Graph **128** of the modified master block definition. The AcDb Evaluation Graph **128** is evaluated with the per instance values of the block instantiation **104** and evaluating the graph generates the anonymous block definition with the new geometry. When a history is not present, the per instance values are individually applied to the graph and the entire graph is evaluated (i.e., a value is applied, the graph is evaluated; this is repeated for each per instance value until all have been applied and evaluated).

If a history of manipulations of the block instantiation **104** was being recorded in the Enhanced Block History AcDb Xrecord **156** (i.e., if the master block definition before the modification included interdependencies where sequence of operations was significant), then the history of manipulations

is also used when evaluating the AcDb Evaluation Graph **128**. When a history is present, the per instance values stored in the ACAD_EnhancedBlockData dictionary **154** are not used. Instead, the individual history changes are applied by individually setting the properties and evaluating the graph in the order in which they appear in the history (oldest first). If a pseduo-history is also present, the pseudo-history values are applied prior to replaying the history in exactly the same way that per instance data values are applied.

Referring now to FIG. **17**, a flow chart is shown illustrating a process **200** for generating a block instantiation, e.g., block instantiation **104**, that has been manipulated relative to the original dynamic block **103** appearance. A master block definition is created (step **202**). For example, in the block editor mode shown in FIG. **2**, a user can draw inner and outer entities, position them relative to one another, and identify permissible manipulations, e.g., move and rotate. A block instantiation is created (step **204**). For example, the user can select to generate an instance of the dynamic block **103** in a CAD design. Initially, the block instantiation appears identical to the dynamic block **103**, for example, block instantiation **102**. User input is received to manipulate the block instantiation (step **206**). For example, block instantiation **106** is in the process of being manipulated as shown in FIG. **1**; user input has been received manipulating the angle of the inner entity **108**. Once the user manipulates the block instantiation **104** relative to the dynamic block **103**, a clone of the master block geometry, i.e., AcDb Block Table Record **124** (FIG. **14**), is generated and forms the anonymous block definition, i.e., AcDb Block Table Record **144** (FIG. **15**) (step **208**). Additionally, the manipulations of the block instantiation **104** are recorded and included in the anonymous block definition (step **210**). For example, the manipulations are recorded by creating an AcDbBlockRepresentation dictionary **142** and associated data (AppDataCache **152**, ACAD_Enhanced-BlockData dictionary **154**, graph node data **160** and optionally ACAD_EnhancedBlockHistory **156**).

In one implementation, a compression algorithm can be used to reduce the number of entries of an Xrecord chain (e.g., the Enhanced Block History AcDb Xrecord) and/or to reduce the number of anonymous block definition AcDb Block Table Records. One example of a compression technique is described below, although other compression techniques can be used.

For illustrative purposes, consider that dynamic block **103** has interdependent properties "P" and "Q" with current values of "P0" and "Q0". A user attempts to change the value of "P" to "P1", resulting in an actual value for "P" of "P2". To capture this change for a block instantiation, e.g., block instantiation **104**, the property being changed is captured, i.e., "P" and the final value after the requested operation has been performed, i.e., "P2", is captured. The final property value is captured instead of the requested property value, i.e., "P1", to avoid interpretation of requested operations that are a by-product of applying the requested operation.

The following example illustrates the above described concept. A Linear Distance parameter in the dynamic block **103** may include a "Distance" property, which is constrained to values of 30, 36 and 40. If the user requests, e.g., either through grip editing or via a property palette, that the "Distance" become 34, the graph evaluation (i.e., the evaluation of AcDb Evaluation Graph **128** (FIG. **15**)) results in a properly constrained value, in this example, 36. If the "requested" value (i.e., 34) had been recorded instead of the final value, then changes to the allowed set of constraints in the master block definition might result in unexpected changes when the history of manipulations of the block instantiation **104** is later

replayed. For example, if the user subsequently changes the master block definition to allow constrained values of 30, 33, 36 and 40 and the requested history change of 34 was applied, the "Distance" property for the block instantiation would become 33, even though its prior value, i.e., 36, was still valid. When replaying a block instantiation's history, the user operations are replayed in the order in which they are recorded.

Drawing space can be saved by compressing the history of manipulations saved for each block instantiation. As mentioned previously, the history for block instantiations of a dynamic block that does not have interdependent properties or operations can be omitted. In one implementation, a history is recorded if one of the following conditions is satisfied:

Any action that maintains an action selection set causes a history to be maintained if any object in the action selection set is another authoring element. The exception to this is a visibility parameter, which has visibility states (akin to a selection set) but never requires a history to be maintained.

If an action, e.g., A1, has in its action selection set an entity that is also in the action selection set of another action, e.g., A2, then a history will be maintained if A1 is an array, flip, rotate, stretch or polar stretch action.

If a history is maintained, then the history itself can be selectably compressed. In one implementation, compression depends on the parameter whose property has changed as a result of an operation. For example, by the AcDbBlockElement can include a HistoryCompression parameter, which has the following values:

kNoCompression A complete history for the element is maintained. No compression is performed, each change to the element is persisted for the lifetime of the history.

kCompressAdjacent If the same property is changed by consecutive operations, only the most recent operation is maintained. For example, if a block has properties P and Q, both of which support kCompressAdjacent, and are manipulated to the following values in the following order: P1, P2, P3, Q1, Q2, P4, Q3; then the consecutive changes to P and Q are compressed in the history so that only the last entry in a chain is retained, i.e., P3, Q2, P4, Q3.

kCompressAll Only the most recent property change is retained, and all preceding operations for a given property are discarded. Using the example above for kCompressAdjacent, if P supports kCompressAll, then the resulting compressed history becomes: Q2, P4, Q3.

In one implementation, grip editing operations are compressed in a fashion similar to kCompressAdjacent, described above. In one implementation, grip operations are captured as a vector offset, instead of an absolute grip position, and the adjacent grip edit history entries are combined by adding their vectors.

In another implementation, drawing space can also be more efficiently used by re-using anonymous block definitions when two block instantiations are determined to be "equivalent" to one another. Two block instantiations without histories are considered equivalent if they are instances of the same dynamic block, e.g., dynamic block **103**, and if all of their per-instance dynamic block properties (i.e., per instance data node values) are equal. In one implementation, two block instantiations with histories are considered equivalent if they are instances of the same dynamic block and their history of property changes are equal entry-for-entry. The comparison of the per-instance properties (i.e., per instance data node

values) in this case is unnecessary, since applying the same changes to two graphs starting out in the same state results in the same final graph state.

In one implementation, when an anonymous block definition is generated to represent a block instantiation, the anonymous block definition is compared to other anonymous block definitions generated from the same dynamic block **103**. If two anonymous block definitions have the same number of entities and total extents, then a detailed comparison of the block instantiation's parameters is performed. If all comparisons succeed, the anonymous block definitions are considered to be "equivalent" and all of the dependent references are updated to point to one of the anonymous block definitions and the other is deleted.

In one implementation, an AcDbBlockRefContext class is the object through which user operations on instances of a dynamic block are performed. For example, grip editing and property palette can funnel though this class. The class is responsible for obtaining the AcDb Evaluation Graph **128** from the master block definition (i.e., AcDb Block Table Record **124**), initializing the AcDb Evaluation Graph **128** with per-instance data cached on the block instantiation **104** (i.e., in the Enhanced Block Data AcDb Dictionary **154**), applying changes to the AcDb Evaluation Graph **128** for a requested operation and updating the per-instance data on the block instantiation **104** with the updated data. Side effects of this process can include the creation of anonymous block definitions by cloning the master block definition, or even another anonymous block definition, via the AcDbBlockRepresentation **148** complex, manipulation of objects in the anonymous block definition **144**, and traversing the AcDb Database **120** to maximize the re-use of anonymous block definitions.

As was discussed above, a user can modify a master block definition, and modifications are then replicated to existing block instantiations. The AcDb Evaluation Graph **128** is traversed as the graph is initialized, but before changes are applied, to determine if any authoring elements require a history to be maintained. If a history is required, after applying changes to the master block definition, a history entry for the property can be appended to the end of the existing history chain. When propagating changes made to the master block definition of the dynamic block **103**, e.g., to the block instantiation **104**, the ACAD_EnhancedBlockData **154** dictionary is replaced after all of the properties for the instance have been reapplied, either by re-applying the per instance values (as recorded in the Enhanced Block Data AcDb Dictionary **154**) or by re-applying the history (as recorded in the Enhanced Block History AcDbXrecord **156**). The block instantiation's history is maintained as a resbuf chain in the Enhanced Block History AcDbXrecord **156**. If the new master block definition does not require a history, then any existing history (i.e., Enhanced Block History AcDbXrecord **156**) and pseudo-history (i.e., ACAD_EnhancedBlockHdata **158**) is discarded. If a history is required and one already existed, then the existing history is saved with the caveat that individual history entries for properties that no longer exist in the master block definition are removed from the history chain. In one implementation, the resbuf chain includes a single version header resbuf, followed by triplet resbufs including a single history entry maintaining the AcDb Evaluation Graph Node ID, Property Nane that changed and final Property Value.

The above description of classes and objects that can be used to implement a dynamic block feature are illustrative of one implementation, however, other techniques can be used to implement such a feature. Other structures and formats for data are possible. In one implementation, the data is config-

ured to be included in a .DWG or .DXF (Document eXchange Format). These file formats are compatible with CAD software such as AutoCAD available from Autodesk, Inc. of San Rafael, Calif.

The invention and the functional operations described herein can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. The invention can be implemented as a computer program product, i.e., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable storage device or in a propagated signal, for execution by, or to control the operation of, data processing apparatus, e.g., a programmable processor, a computer, or multiple computers. A computer program can be written in any form of programming language, including compiled or interpreted languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

Method steps can be performed by one or more programmable processors executing a computer program to perform functions of the invention by operating on input data and generating output. Method steps can also be performed by, and apparatus of the invention can be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application-specific integrated circuit).

Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. The essential elements of a computer are a processor for executing instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto-optical disks, or optical disks. Information carriers suitable for embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in special purpose logic circuitry.

To provide for interaction with a user, the invention can be implemented on a computer having a display device, e.g., a CRT (cathode ray tube) or LCD (liquid crystal display) monitor, for displaying information to the user and a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input.

As described above, a block editor can be provided, the block editor being implemented in software, firmware and/or hardware. In one implementation, the block editor is a tool executing in a CAD software application and provides a user interface for receiving input from a user. The input can be transformed into one or more of the data structures described herein that can be used to implement a dynamic block feature.

The block editor can provide one or more tools in the user interface for receiving user interaction, for example, manipulatable grips or menu palettes for receiving user selections.

The invention can be implemented in a computing system that includes a back-end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front-end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation of the. invention, or any combination of such back-end, middleware, or front-end components. The components of the system can be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network ("LAN") and a wide area network ("WAN"), e.g., the Internet.

The computing system can include clients and servers. A client and server are generally remote from each other and typically interact through a communication network. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other.

The invention has been described in terms of particular embodiments. Other embodiments are within the scope of the following claims. For example, the steps of the invention can be performed in a different order and still achieve desirable results.

What is claimed is:

1. A tangible memory for access by an application program being executed on a computer and a data structure stored in said tangible memory, the data structure defining a master block definition associated with instantiations of a block to be included in a computer-aided design and included in a electronic file used by the application program to display the computer-aided design including the instantiation of the block, where a computer-aided design is a two or three dimensional drawing prepared using a computer-aided design software application, the data structure comprising:

a block table record in a database; and

an extension dictionary associated with the block table record and including a dependency graph;

where:

the block table record includes a master block definition defining a geometry of a block where one or more block instantiations of the block are to be included in the computer-aided design and defining an action of the block, where an action is an allowable manipulation of at least one graphical entity included in the block and each block instantiation can be manipulated differently, the block including one or more graphical entities and the at least one allowable manipulation, and

the dependency graph includes relationship information about the one or more graphical entities and the at least one allowable manipulation and when the dependency graph is evaluated with per instance values of a particular block instantiation an anonymous block definition is generated comprising a new geometry for the particular block instantiation in accordance with the allowable manipulation of the block as defined in the master block definition.

2. A tangible memory for access by an application program being executed on a computer and a data structure stored in said tangible memory, the data structure defining a master block definition associated with instantiations of a block to be included in a computer-aided design and included in a electronic file used by the application program to display the computer aided design including the instantiation of the block, where a computer-aided design is a two or three dimensional drawing prepared using a computer-aided design software application, the data structure comprising:

a block reference including a geometry of a block instantiation; and

an extension dictionary associated with the block reference and including a block representation dictionary, the block representation dictionary including:

a record including a pointer to a block table record, where the block table record includes a master block definition of a block and where a master block definition defines a geometry of a block to be included in the computer-aided design and defines an action of the block, where an action is an allowable manipulation of at least one graphical entity included in the block and different block instantiations can be manipulated differently; and

an application data cache dictionary including an enhanced block data dictionary, where the enhanced block data dictionary includes one or more graph node ID records, where a graph node ID record includes node values for nodes in a dependency graph included in the master block definition and when the dependency graph is evaluated using the node values an anonymous block definition is generated comprising the geometry for the block instantiation in accordance with the allowable manipulation of the block as defined in the master block definition.

3. The memory of claim 2, where a data structure defining the master block definition of the block includes:

a block table record in a block table in a database;

a extension dictionary associated with the block table record and including a dependency graph;

where the block table record includes a geometry of the block defined by the master block definition, the block including one or more graphical entities and at least one allowable manipulation, and the dependency graph includes relationship information about the one or more graphical entities and the at least one allowable manipulation.

4. The memory of claim 2, where the application data cache dictionary further includes:

an enhanced block history record including a chain of manipulations performed on the block instantiation.

5. The memory of claim 3, where the application data cache dictionary further includes:

an enhanced block data dictionary including one or more second graph node ID records, where the one or more second graph node ID records include node values for nodes in a dependency graph included in the master block definition capturing a state of the block instantiation just prior to a modification to the master block definition.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO.   : 7,860,691 B2
APPLICATION NO. : 11/455288
DATED   : December 28, 2010
INVENTOR(S)   : Beltran et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:
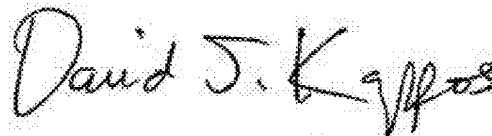
On the Title Page:

The first or sole Notice should read --

Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 299 days.

In Claim 1, column 21, line 33, after "and included in", delete "a" and insert -- an --, therefor.

In Claim 2, column 22, line 5, after "and included in", delete "a" and insert -- an --, therefor.

Signed and Sealed this
Twenty-sixth Day of April, 2011

David J. Kappos
Director of the United States Patent and Trademark Office