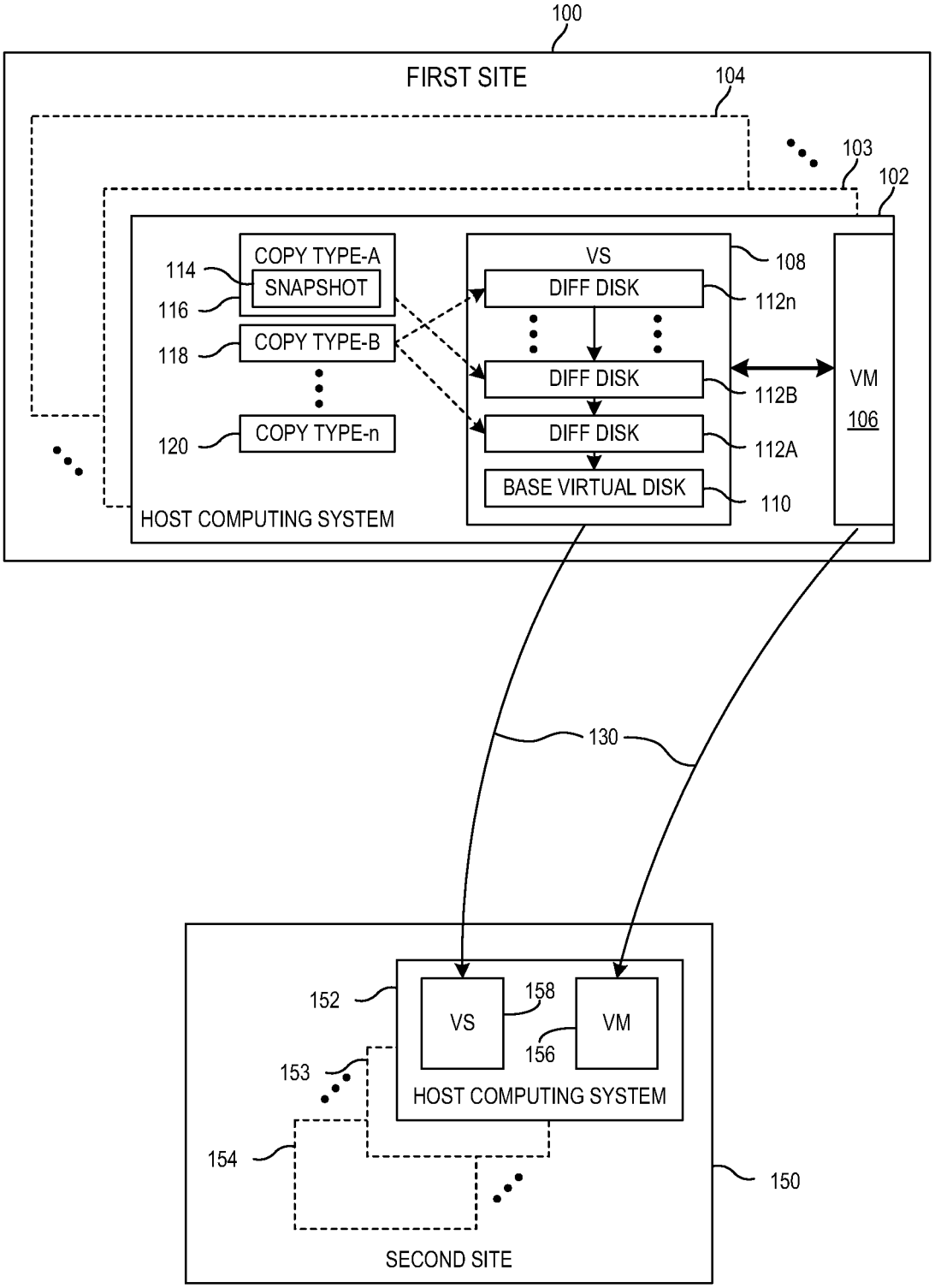
100
FIRST SITE
104
103
102
COPY TYPE-A
SNAPSHOT
114
116
COPY TYPE-B
118
120
COPY TYPE-n
HOST COMPUTING SYSTEM
VS
108
DIFF DISK
112n
DIFF DISK
112B
DIFF DISK
112A
BASE VIRTUAL DISK
110
VM
106
130
152
VS
158
VM
156
153
HOST COMPUTING SYSTEM
154
150
SECOND SITE

FIG. 1

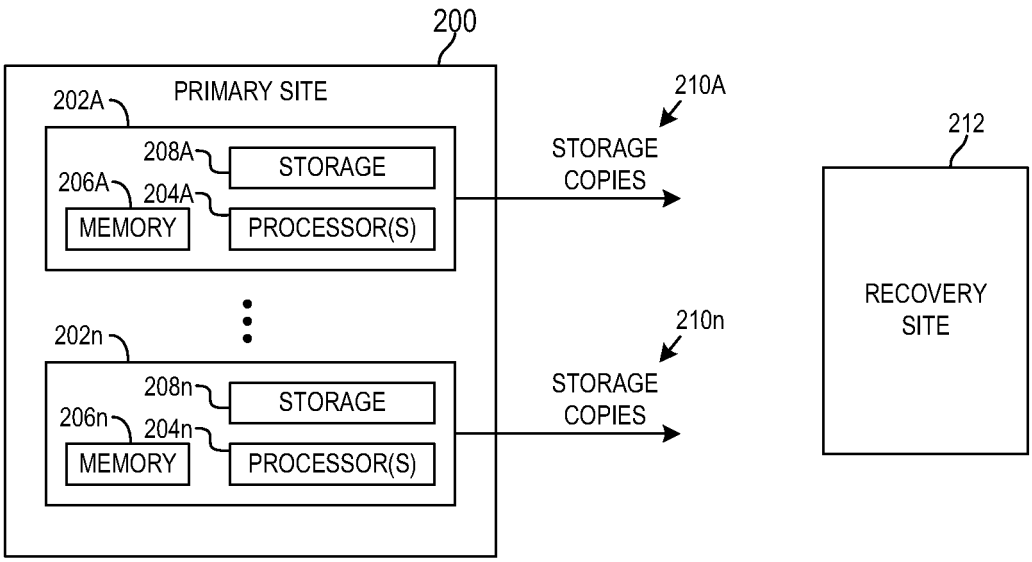
200
PRIMARY SITE
202A
208A
STORAGE
206A
204A
MEMORY
PROCESSOR(S)
202n
208n
STORAGE
206n
204n
MEMORY
PROCESSOR(S)
210A
STORAGE COPIES
210n
STORAGE COPIES
212
RECOVERY SITE

FIG. 2A

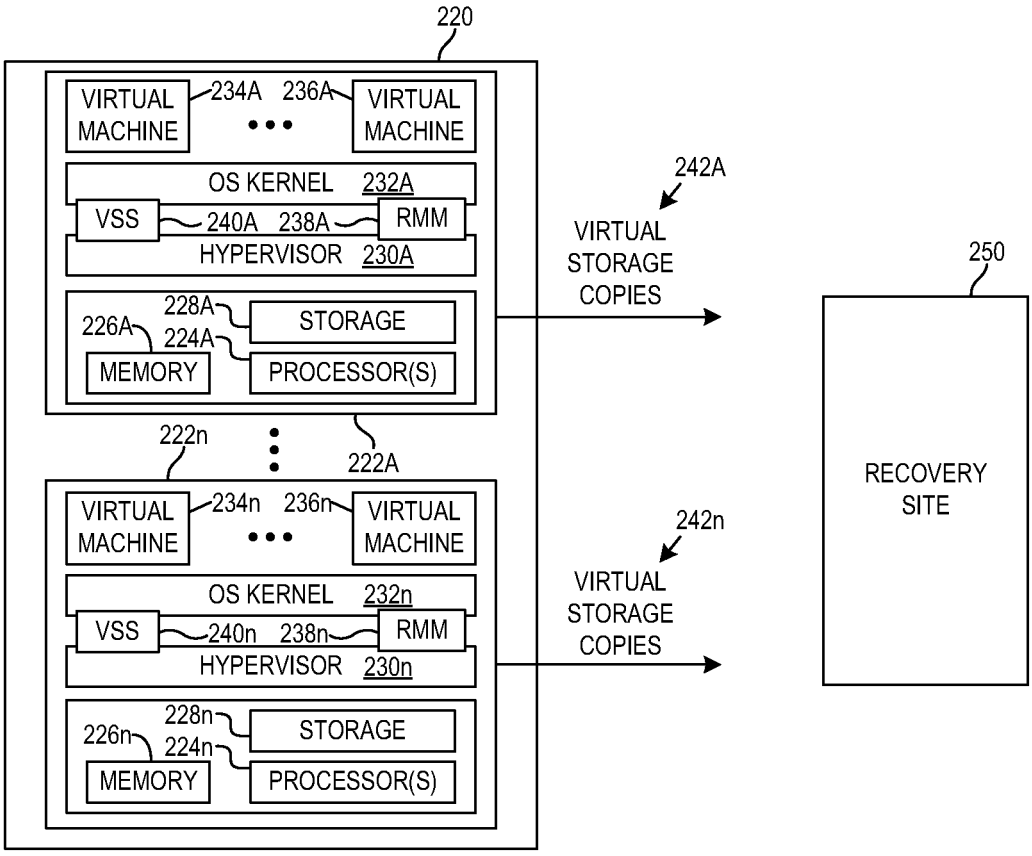
220
VIRTUAL MACHINE
234A
236A
VIRTUAL MACHINE
OS KERNEL 232A
VSS
240A
238A
RMM
HYPERVISOR 230A
228A
226A
224A
STORAGE
MEMORY
PROCESSOR(S)
222n
222A
VIRTUAL MACHINE
234n
236n
VIRTUAL MACHINE
OS KERNEL 232n
VSS
240n
238n
RMM
HYPERVISOR 230n
228n
226n
224n
STORAGE
MEMORY
PROCESSOR(S)
242A
VIRTUAL STORAGE COPIES
242n
VIRTUAL STORAGE COPIES
250
RECOVERY SITE

FIG. 2B

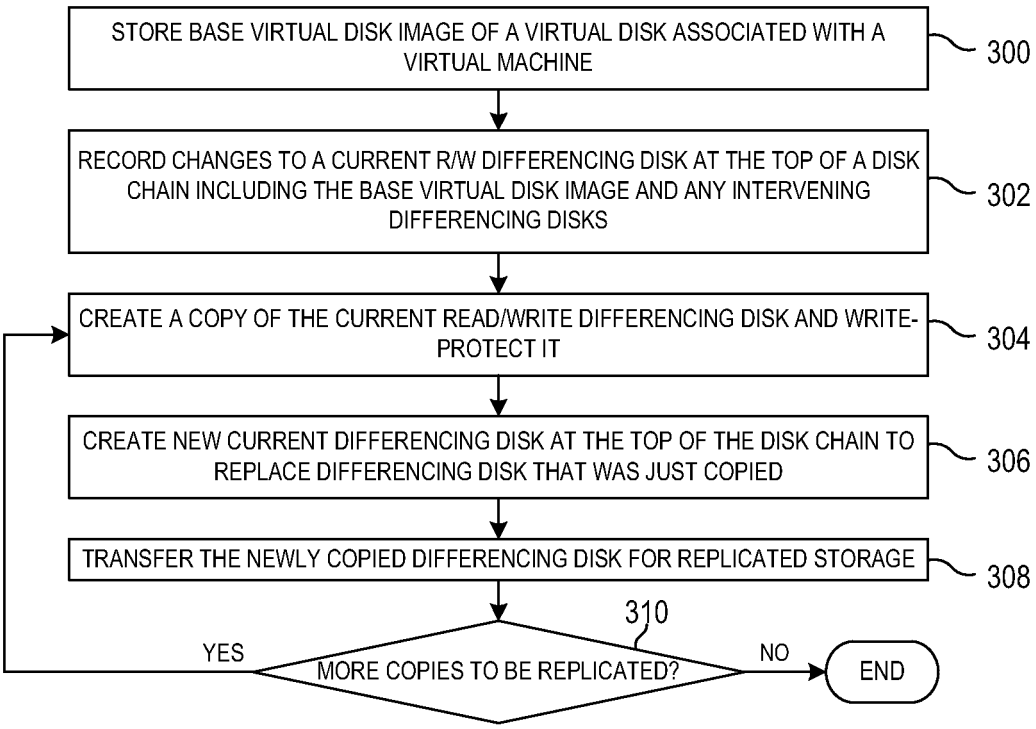

FIG. 3

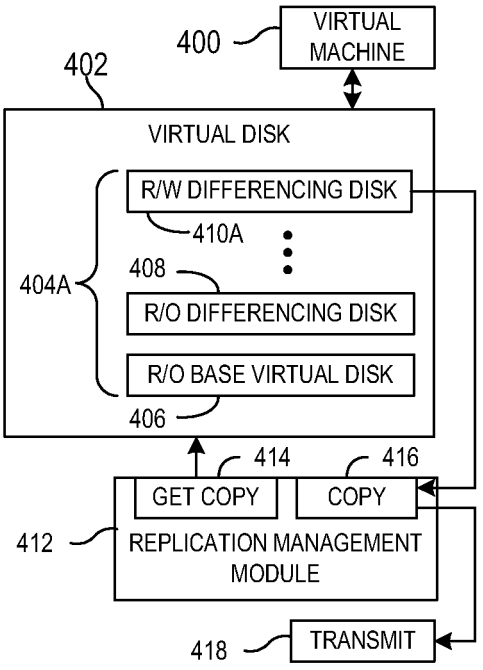

FIG. 4A

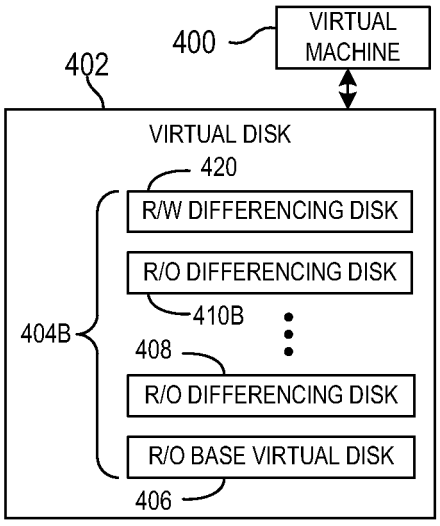

FIG. 4B

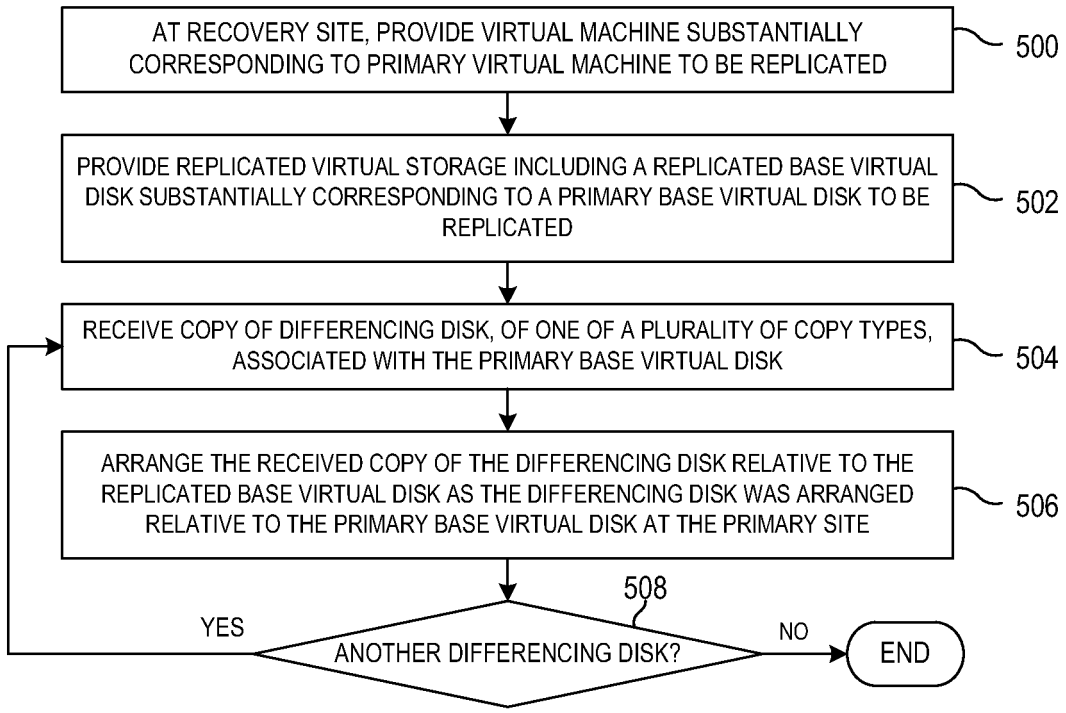
AT RECOVERY SITE, PROVIDE VIRTUAL MACHINE SUBSTANTIALLY CORRESPONDING TO PRIMARY VIRTUAL MACHINE TO BE REPLICATED
500
PROVIDE REPLICATED VIRTUAL STORAGE INCLUDING A REPLICATED BASE VIRTUAL DISK SUBSTANTIALLY CORRESPONDING TO A PRIMARY BASE VIRTUAL DISK TO BE REPLICATED
502
RECEIVE COPY OF DIFFERENCING DISK, OF ONE OF A PLURALITY OF COPY TYPES, ASSOCIATED WITH THE PRIMARY BASE VIRTUAL DISK
504
ARRANGE THE RECEIVED COPY OF THE DIFFERENCING DISK RELATIVE TO THE REPLICATED BASE VIRTUAL DISK AS THE DIFFERENCING DISK WAS ARRANGED RELATIVE TO THE PRIMARY BASE VIRTUAL DISK AT THE PRIMARY SITE
506
508
YES
ANOTHER DIFFERENCING DISK?
NO
END

FIG. 5

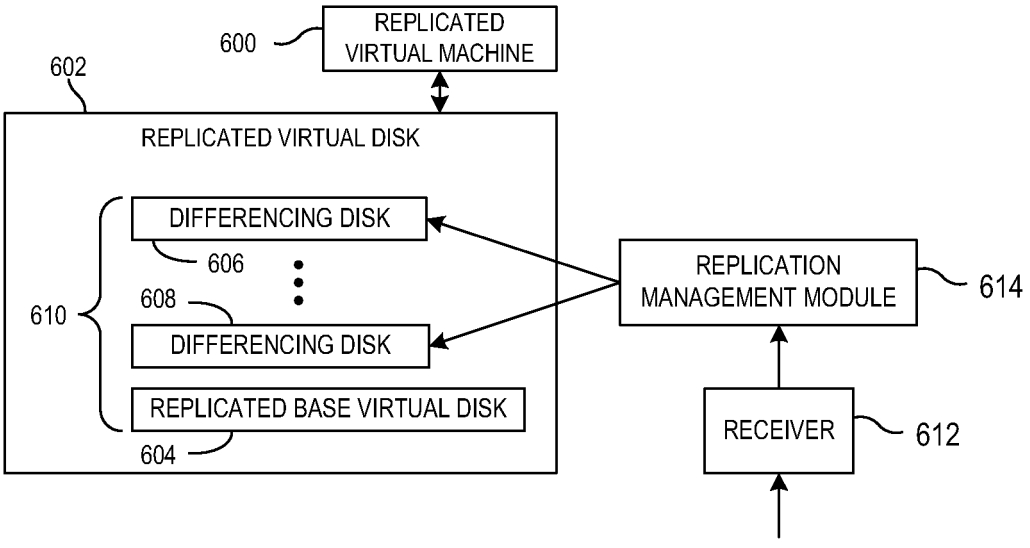
600
REPLICATED VIRTUAL MACHINE
602
REPLICATED VIRTUAL DISK
DIFFERENCING DISK
606
608
610
DIFFERENCING DISK
REPLICATED BASE VIRTUAL DISK
604
REPLICATION MANAGEMENT MODULE
614
RECEIVER
612

FIG. 6

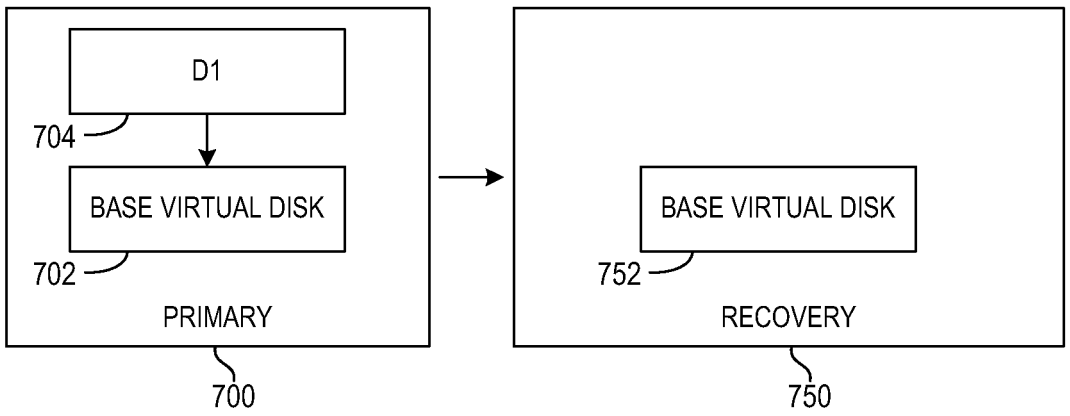

FIG. 7A

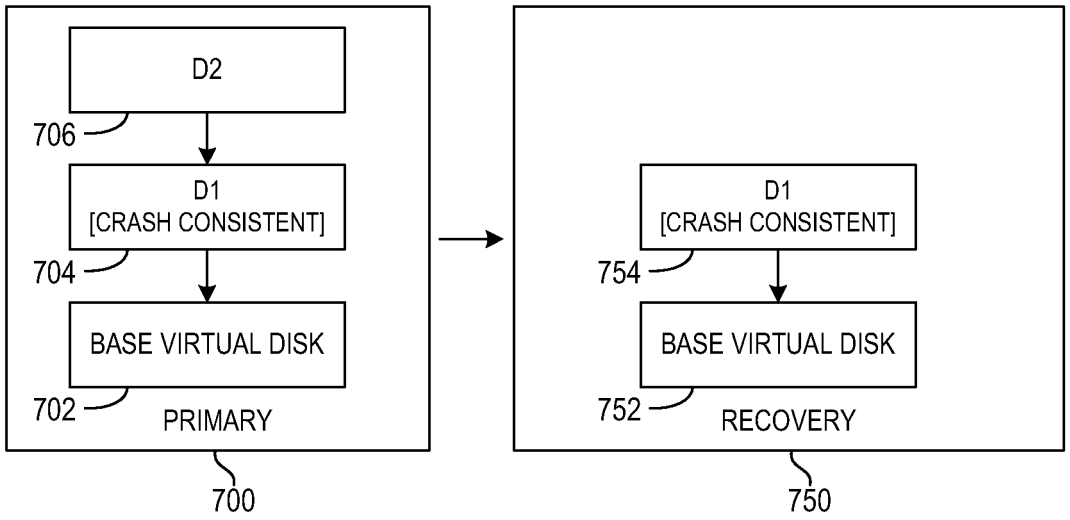

FIG. 7B

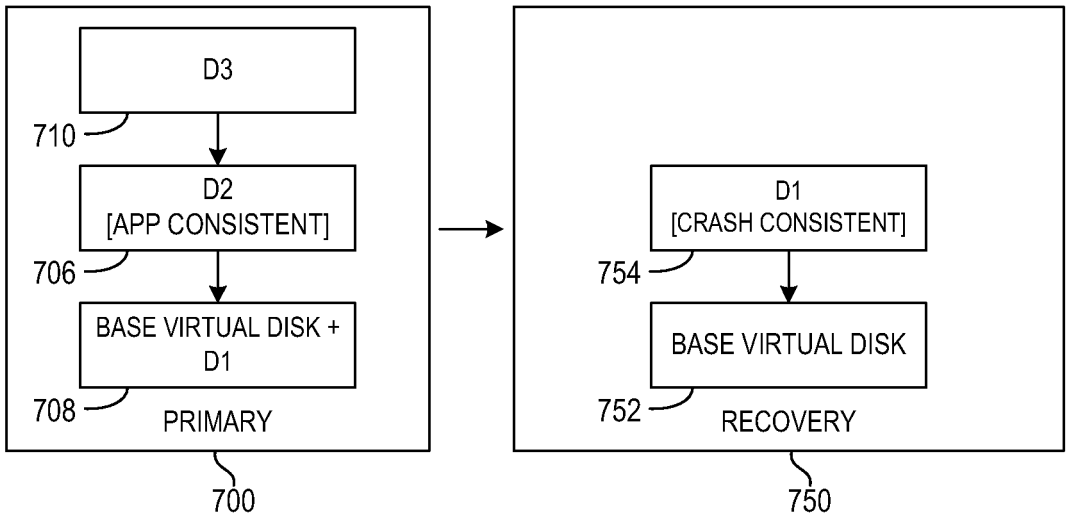

FIG. 7C

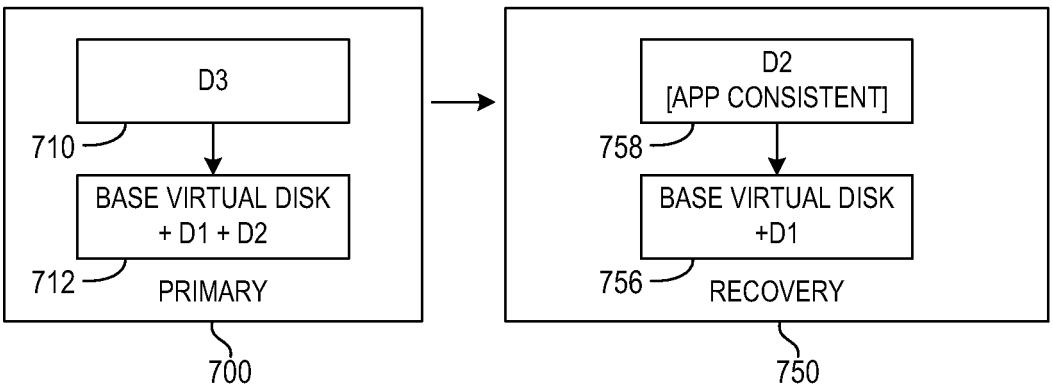

FIG. 7D

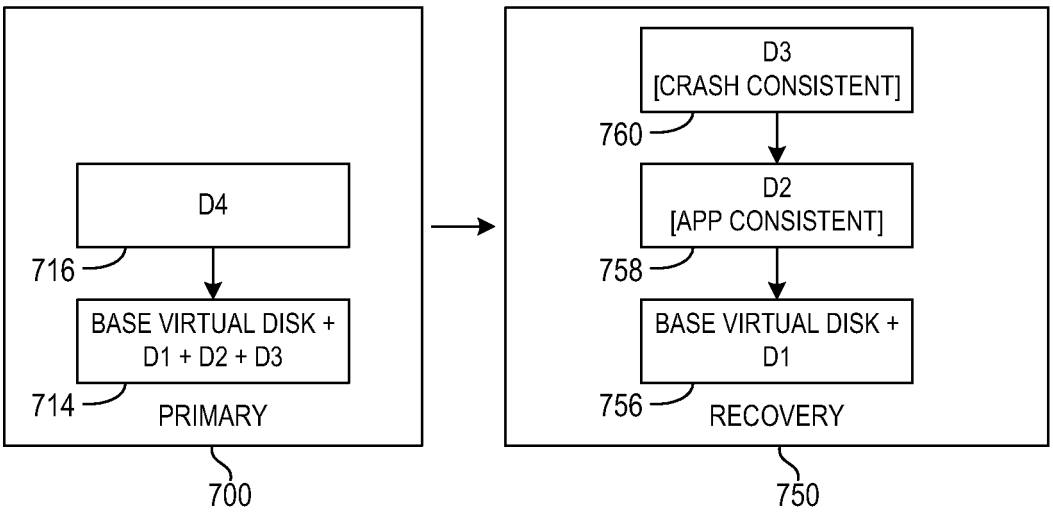

FIG. 7E

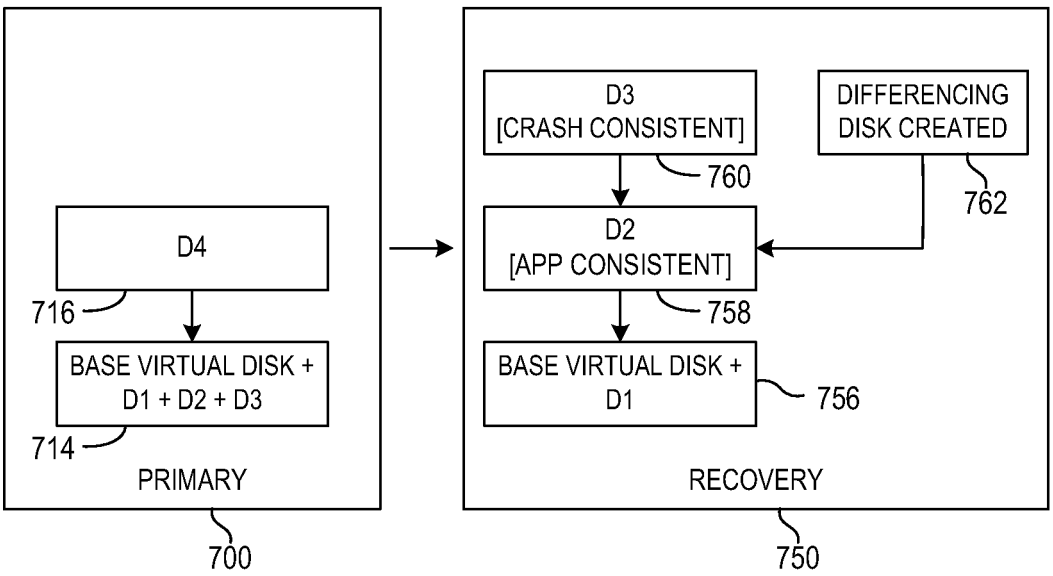

FIG. 7F

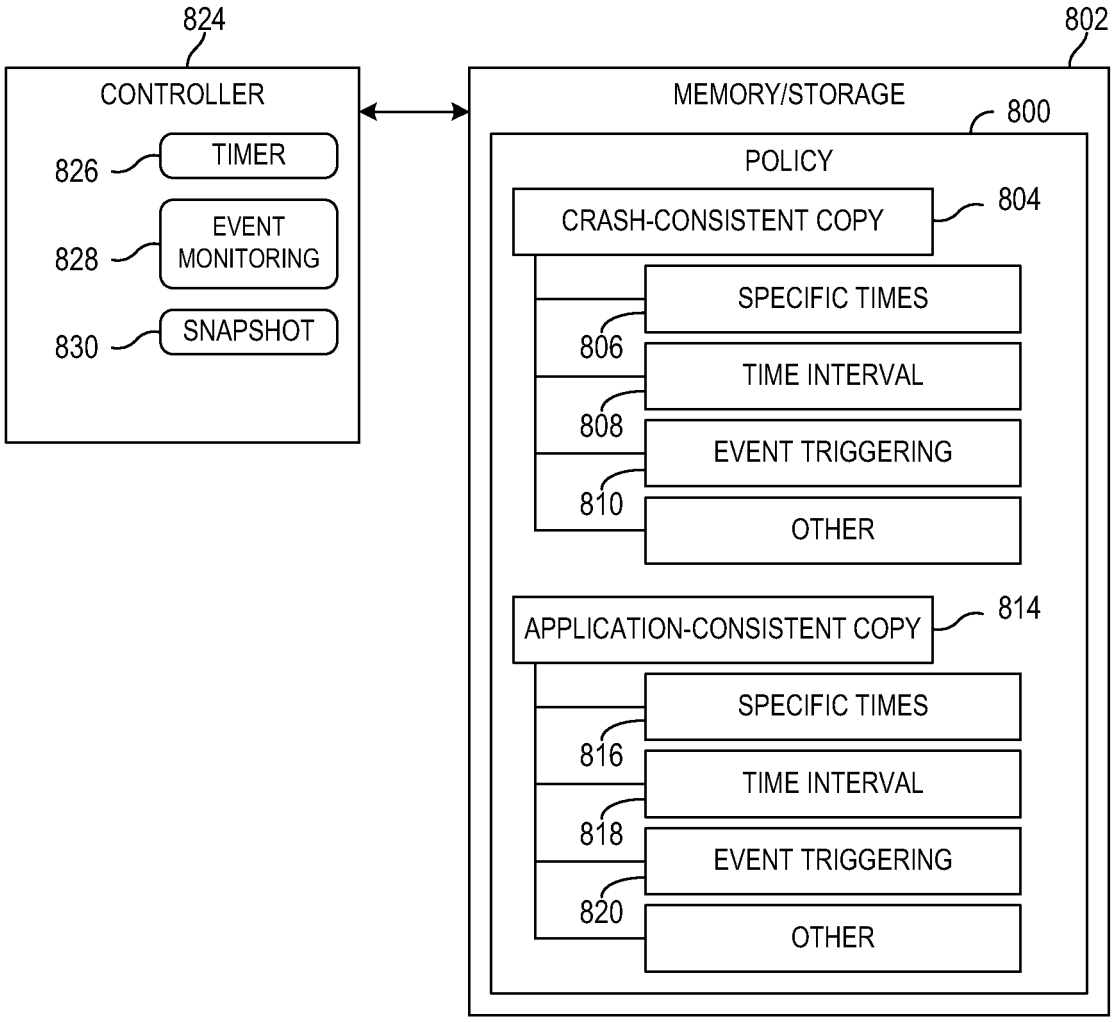
824
CONTROLLER
826
TIMER
828
EVENT MONITORING
830
SNAPSHOT
802
MEMORY/STORAGE
800
POLICY
CRASH-CONSISTENT COPY
804
SPECIFIC TIMES
806
TIME INTERVAL
808
EVENT TRIGGERING
810
OTHER
APPLICATION-CONSISTENT COPY
814
SPECIFIC TIMES
816
TIME INTERVAL
818
EVENT TRIGGERING
820
OTHER

FIG. 8

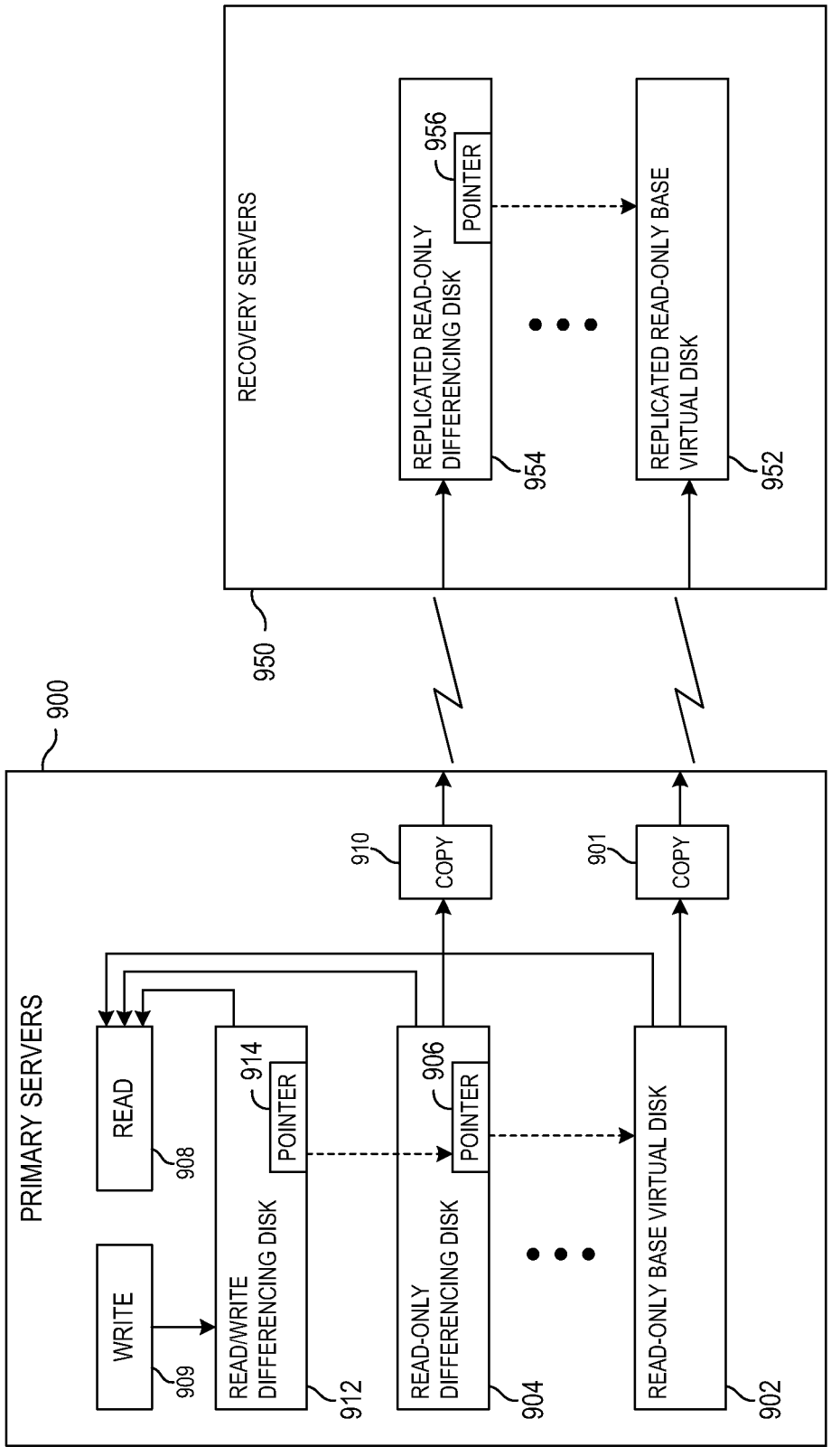
RECOVERY SERVERS
REPLICATED READ-ONLY DIFFERENCING DISK
956
POINTER
954
REPLICATED READ-ONLY BASE VIRTUAL DISK
952
950
900
PRIMARY SERVERS
910
COPY
901
COPY
READ
908
WRITE
909
READ/WRITE DIFFERENCING DISK
914
POINTER
912
READ-ONLY DIFFERENCING DISK
906
POINTER
904
READ-ONLY BASE VIRTUAL DISK
902

FIG. 9

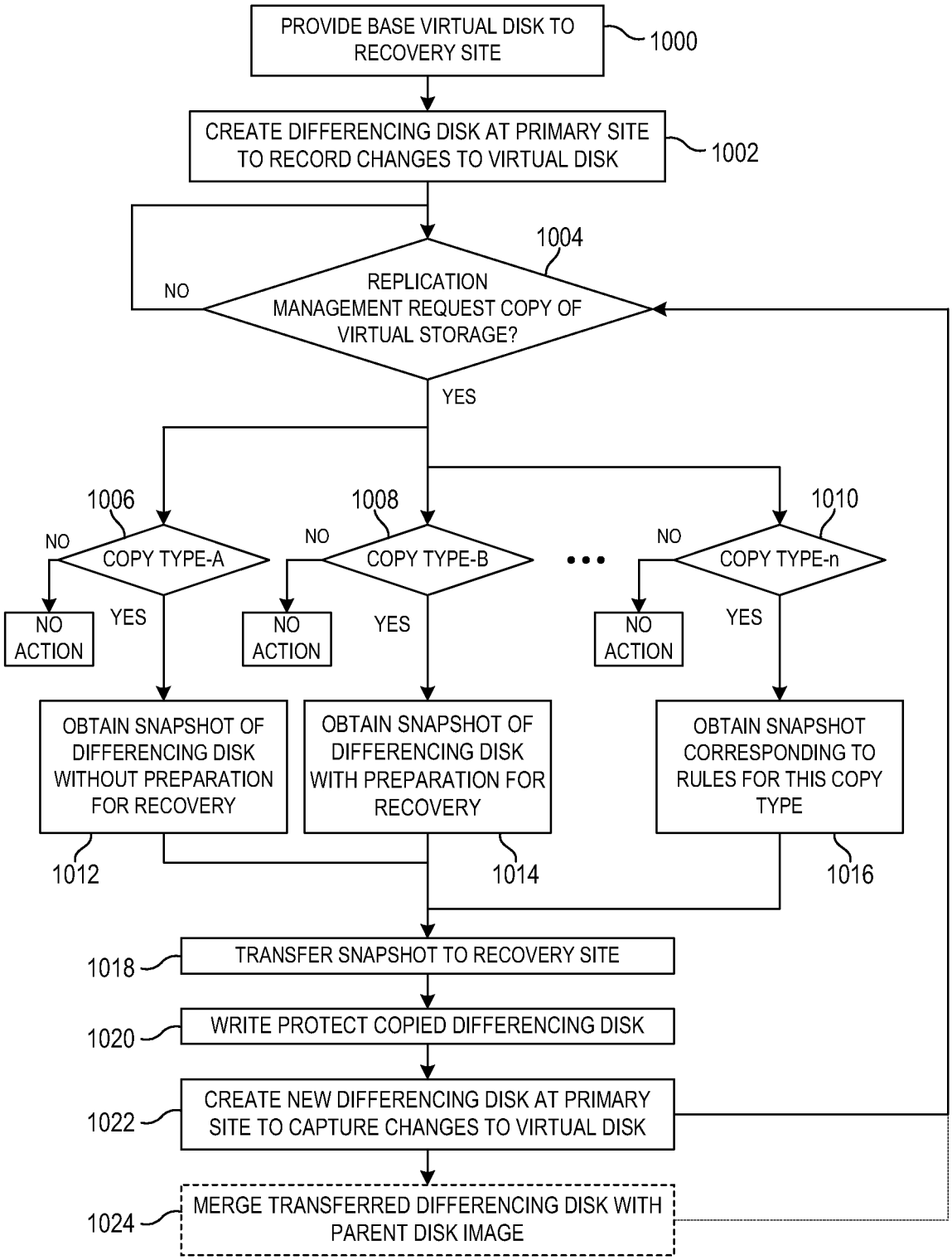
PROVIDE BASE VIRTUAL DISK TO RECOVERY SITE
1000
CREATE DIFFERENCING DISK AT PRIMARY SITE TO RECORD CHANGES TO VIRTUAL DISK
1002
1004
NO
REPLICATION MANAGEMENT REQUEST COPY OF VIRTUAL STORAGE?
YES
1006
1008
1010
NO
COPY TYPE-A
NO
COPY TYPE-B
NO
COPY TYPE-n
NO ACTION
YES
NO ACTION
YES
NO ACTION
YES
OBTAIN SNAPSHOT OF DIFFERENCING DISK WITHOUT PREPARATION FOR RECOVERY
OBTAIN SNAPSHOT OF DIFFERENCING DISK WITH PREPARATION FOR RECOVERY
OBTAIN SNAPSHOT CORRESPONDING TO RULES FOR THIS COPY TYPE
1012
1014
1016
1018
TRANSFER SNAPSHOT TO RECOVERY SITE
1020
WRITE PROTECT COPIED DIFFERENCING DISK
1022
CREATE NEW DIFFERENCING DISK AT PRIMARY SITE TO CAPTURE CHANGES TO VIRTUAL DISK
1024
MERGE TRANSFERRED DIFFERENCING DISK WITH PARENT DISK IMAGE

FIG. 10

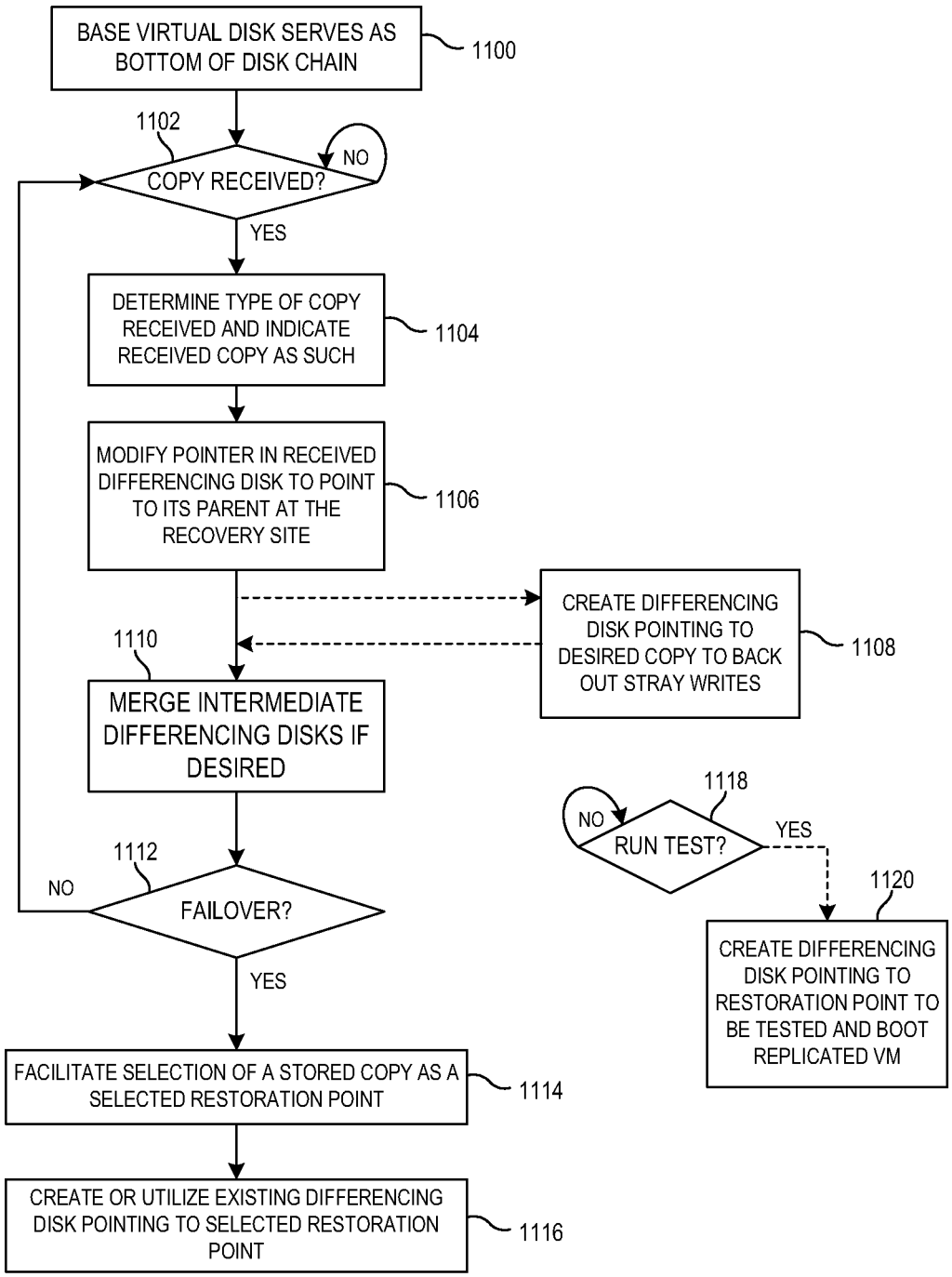
BASE VIRTUAL DISK SERVES AS BOTTOM OF DISK CHAIN
1100
1102
COPY RECEIVED?
NO
YES
DETERMINE TYPE OF COPY RECEIVED AND INDICATE RECEIVED COPY AS SUCH
1104
MODIFY POINTER IN RECEIVED DIFFERENCING DISK TO POINT TO ITS PARENT AT THE RECOVERY SITE
1106
CREATE DIFFERENCING DISK POINTING TO DESIRED COPY TO BACK OUT STRAY WRITES
1108
1110
MERGE INTERMEDIATE DIFFERENCING DISKS IF DESIRED
1118
NO
RUN TEST?
YES
1120
CREATE DIFFERENCING DISK POINTING TO RESTORATION POINT TO BE TESTED AND BOOT REPLICATED VM
1112
NO
FAILOVER?
YES
FACILITATE SELECTION OF A STORED COPY AS A SELECTED RESTORATION POINT
1114
CREATE OR UTILIZE EXISTING DIFFERENCING DISK POINTING TO SELECTED RESTORATION POINT
1116

FIG. 11

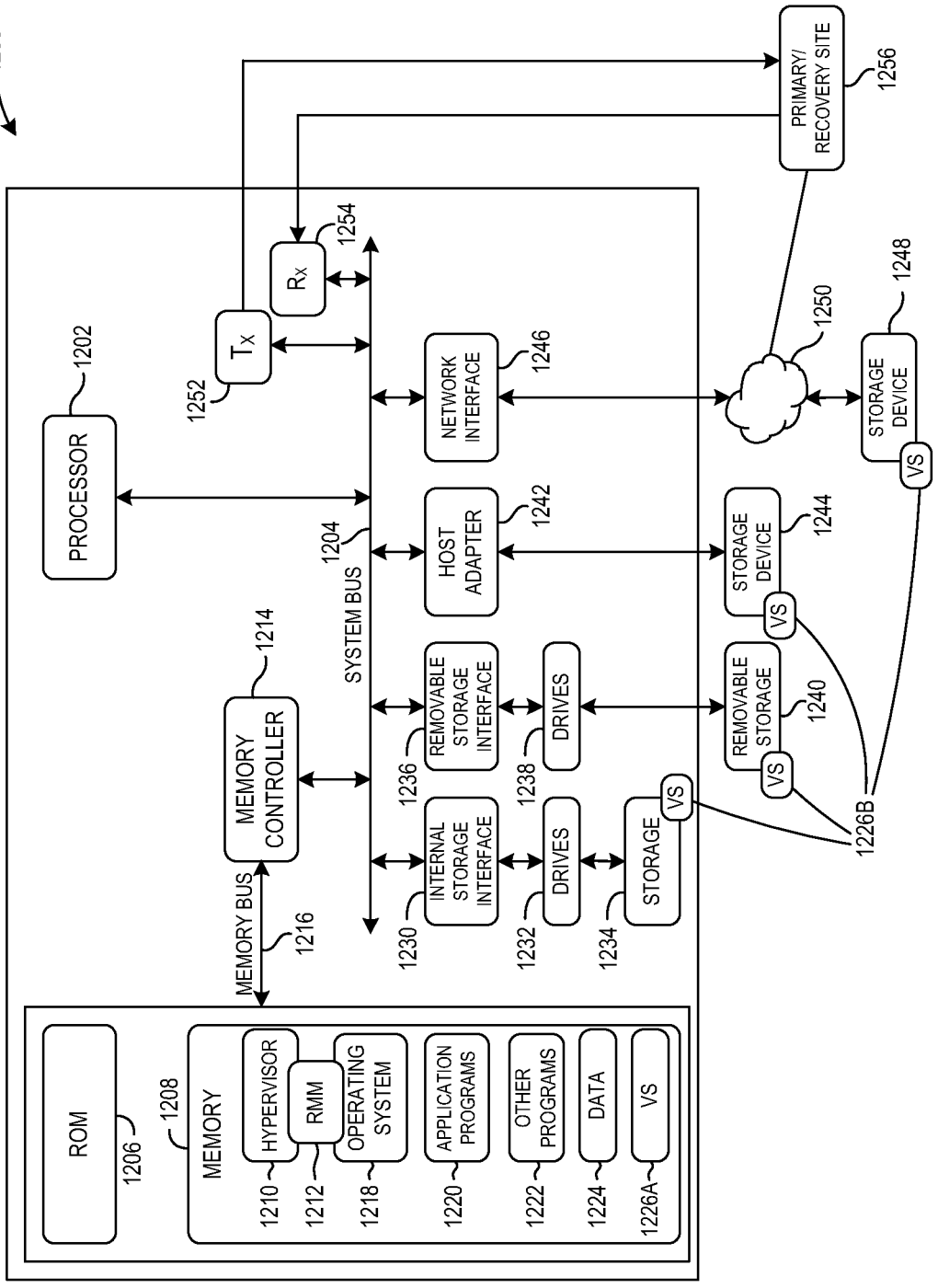
1200
PRIMARY/ RECOVERY SITE
1256
PROCESSOR
1202
Tx
1252
Rx
1254
NETWORK INTERFACE
1246
1250
STORAGE DEVICE
1248
VS
SYSTEM BUS
1204
HOST ADAPTER
1242
STORAGE DEVICE
1244
VS
MEMORY CONTROLLER
1214
REMOVABLE STORAGE INTERFACE
1236
DRIVES
1238
REMOVABLE STORAGE
1240
VS
MEMORY BUS
1216
INTERNAL STORAGE INTERFACE
1230
DRIVES
1232
STORAGE
1234
VS
1226B
ROM
1206
MEMORY
1208
HYPERVISOR
1210
RMM
1212
OPERATING SYSTEM
1218
APPLICATION PROGRAMS
1220
OTHER PROGRAMS
1222
DATA
1224
VS
1226A

FIG. 12