Fault Tree Analysis for Reliability Prediction of Gas Turbine Type Power Plants

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ELECTRIC POWER RESEARCH INSTITUTE

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Appendixes

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LEGAL NOTICE

Appendix A

GLOSSARY

Fault Tree - A logic diagram, drawn from an effect to cause (usually backward in time), which ties together the sequences that can lead to an undesired event from basic component failures.

Top Event - The (usually) undesired event that sits on top of the fault tree.

Cut Set - A set of components whose simultaneous failure will lead to the top event. The term, as used here, refers to the irreducible minimum number of components within each cut set.

Reliability - The probability that the system operates as desired for the amount of time specified.

Appendix B

FAULT TREE MODEL AND METHODOLOGY DESCRIPTION

Fault tree analysis is a procedure used to examine systems to determine component failure modes and other events (e.g., operator errors) which can, individually or in combination, cause a system failure resulting in downtime.

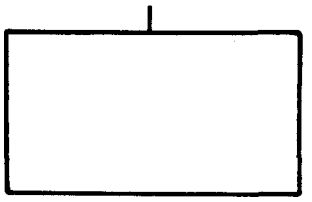
A system fault tree is a logic diagram which depicts the component failure modes and other fault events capable of producing, through AND and OR combinatorial logic, system failure. It is a binary model of the fault modes of a system and, as such, can be readily converted to a probabilistic model of the system. Individual component fault probabilities can be assigned to the model and combined to obtain system failure probabilities.

The symbolism used in the fault tree analysis in this study are shown and defined in Table B-1. Figure B-1 depicts the gas turbine at the Naval Station plant studied. All the subsequent figures show the tree top and its 35 branches that were constructed in this study.

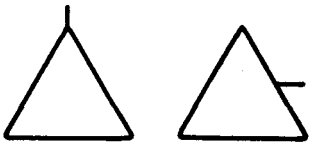
Table B-1

FAULT TREE SYMBOLOGY

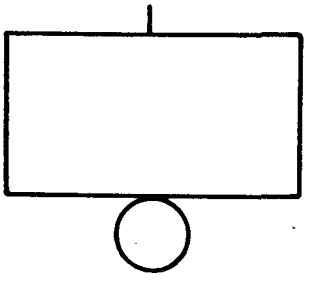
EVENT REPRESENTATIONS



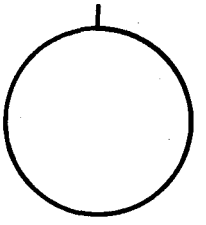
The rectangle identifies an event that results from the combination of fault events through the input logic gate.



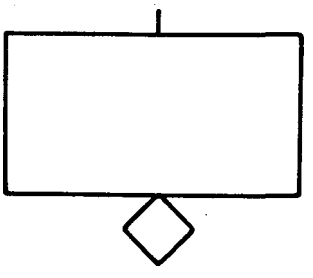
The triangles are used as transfer symbols. A line from the apex of the triangle indicates a transfer in and a line from the side denotes a transfer out.



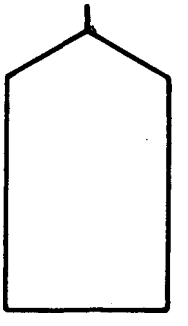
or



The circle describes a basic fault event that requires no further development. Frequency and mode of failure of items so identified are derived from empirical data.



The diamond describes a fault event that is considered basic in a given fault tree. The possible causes of the event are not developed because the event is of insufficient consequence or the necessary information is unavailable.

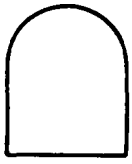


The house is used as a switch to include or eliminate parts of the fault tree as those parts may or may not apply to certain situations.

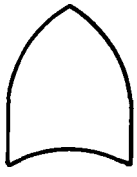
Table B-1

FAULT TREE SYMBOLOGY (Continued)

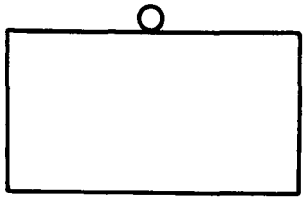
LOGIC OPERATIONS



AND gate describes the logical operation whereby the coexistance of all input events is required to produce the output event.



OR gate defines the situation whereby the output event will exist if one or more of the input events exists.



A small circle above the circle, diamond or rectangle indicates the negative of what is contained in that symbol.

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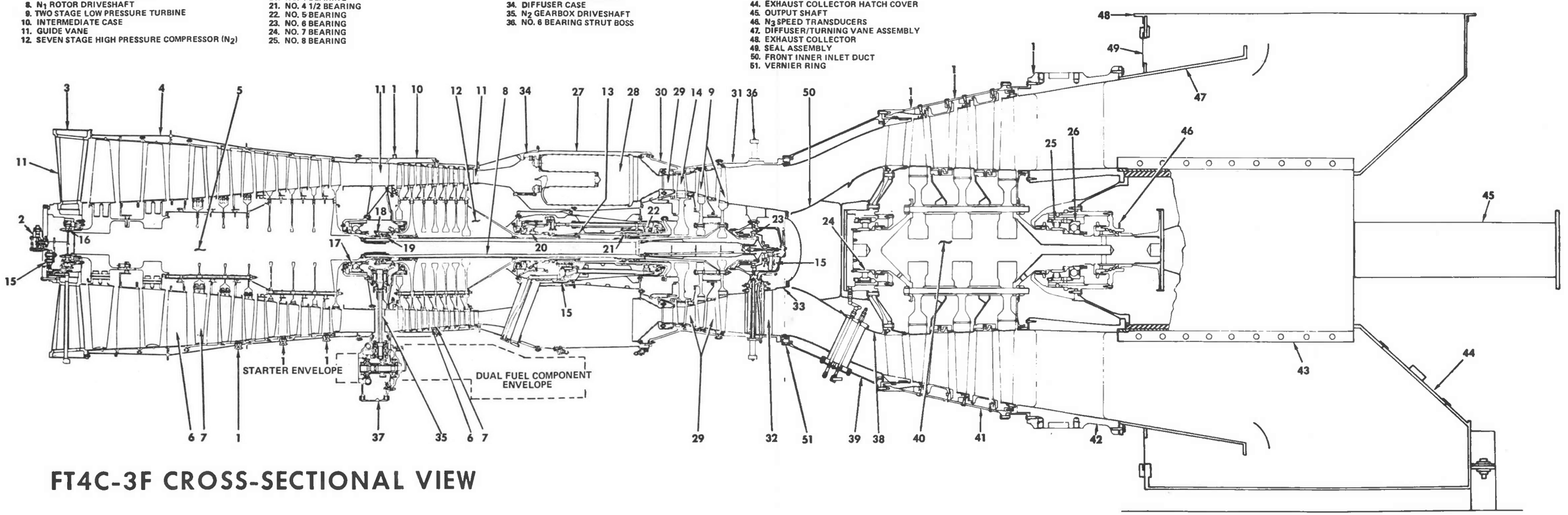
1. BORESCOPE PORT
2. N_1 SPEED TRANSDUCER
3. COMPRESSOR INLET CASE
4. FRONT COMPRESSOR CASE
5. NINE STAGE LOW PRESSURE COMPRESSOR (N_1)
6. COMPRESSOR STATOR VANE
7. COMPRESSOR ROTOR BLADE
8. N_1 ROTOR DRIVESHAFT
9. TWO STAGE LOW PRESSURE TURBINE
10. INTERMEDIATE CASE
11. GUIDE VANE
12. SEVEN STAGE HIGH PRESSURE COMPRESSOR (N_2)
13. N_2 ROTOR DRIVESHAFT
14. SINGLE STAGE HIGH PRESSURE TURBINE
15. SCAVENGE PUMP
16. NO. 1 BEARING
17. NO. 2 BEARING
18. NO. 2 1/2 BEARING
19. NO. 3 BEARING
20. NO. 4 BEARING
21. NO. 4 1/2 BEARING
22. NO. 5 BEARING
23. NO. 6 BEARING
24. NO. 7 BEARING
25. NO. 8 BEARING
26. NO. 9 BEARING
27. COMBUSTION CHAMBER CASE
28. COMBUSTION CHAMBERS
29. TURBINE VANE
30. TURBINE NOZZLE CASE
31. TURBINE EXHAUST CASE
32. TURBINE EXHAUST STRUT
33. TURBINE EXHAUST DUCT
34. DIFFUSER CASE
35. N_2 GEARBOX DRIVESHAFT
36. NO. 6 BEARING STRUT BOSS
37. N_2 GEARBOX, N_2 SPEED TRANSDUCERS
38. REAR INNER INLET DUCT
39. INLET CASE AND OUTER DUCT
40. THREE STAGE FREE TURBINE ROTOR
41. TURBINE CASE
42. EXHAUST CASE
43. OUTPUT SHAFT HEATSHIELDS
44. EXHAUST COLLECTOR HATCH COVER
45. OUTPUT SHAFT
46. N_3 SPEED TRANSDUCERS
47. DIFFUSER/TURNING VANE ASSEMBLY
48. EXHAUST COLLECTOR
49. SEAL ASSEMBLY
50. FRONT INNER INLET DUCT
51. VERNIER RING



FT4C-3F CROSS-SECTIONAL VIEW

L-58234

Figure B-1

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Figure B-2

-TOP-
STEAM NOT AVAILABLE
AT PLANT DISCHARGE

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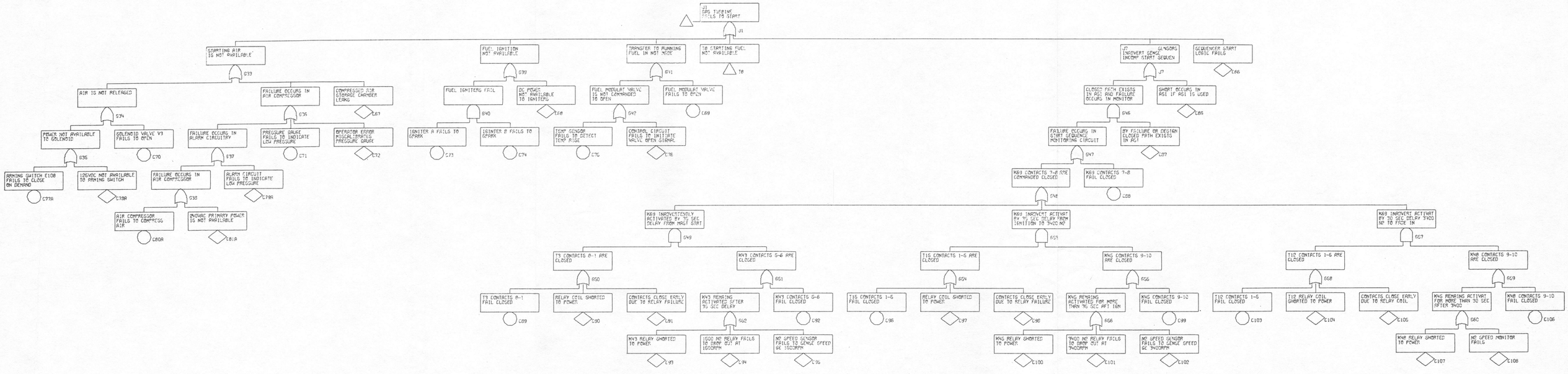

Figure B-3

J1 GAS TURBINE
FAILS TO START

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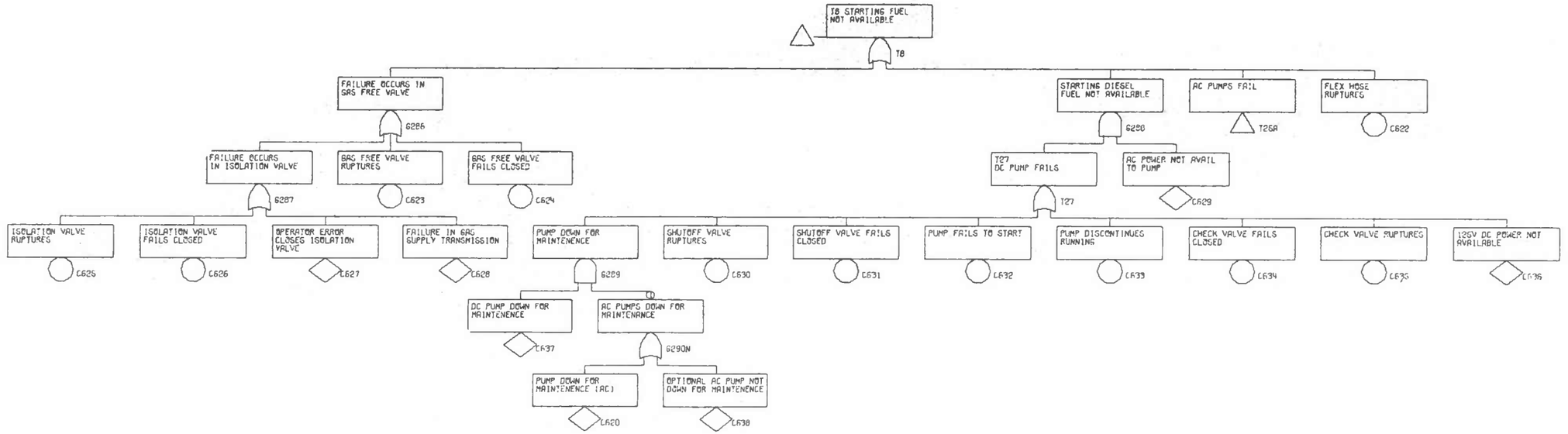

FIGURE B-4

T8 STARTING FUEL
NOT AVAILABLE

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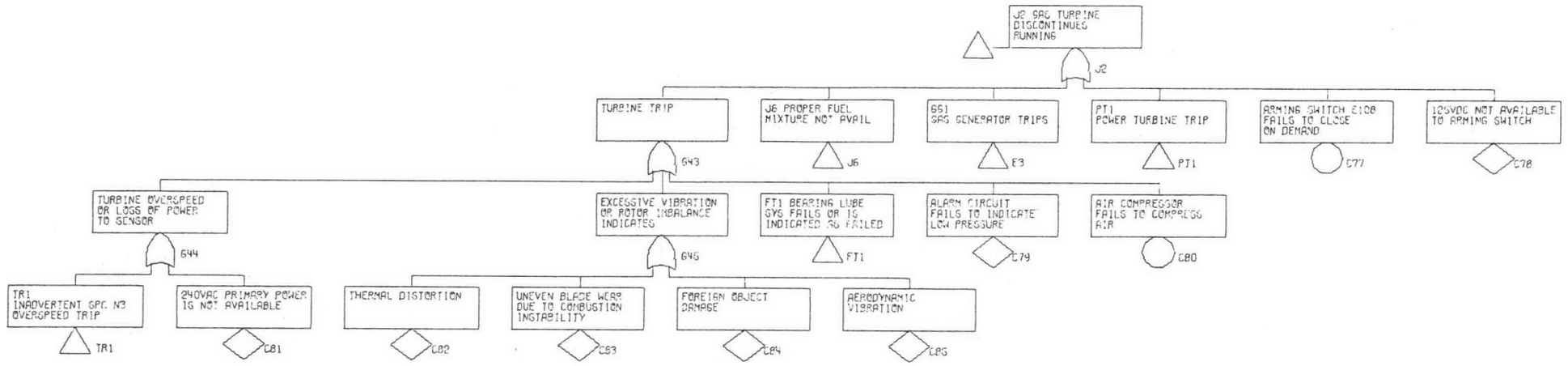

FIGURE B-5

J2 GAS TURBINE
DISCONTINUES RUNNING

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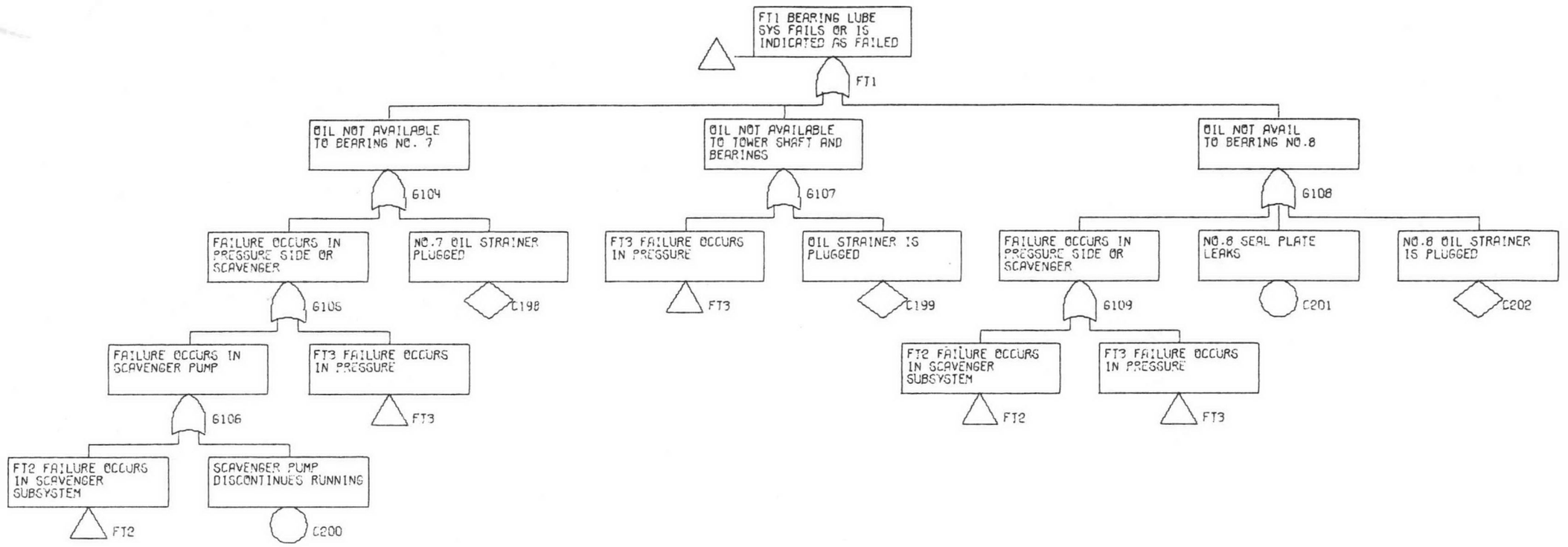

FIGURE B-7

FT1 BEARING LUBE
SYSTEM FAILS OR IS
INDICATED AS FAILED

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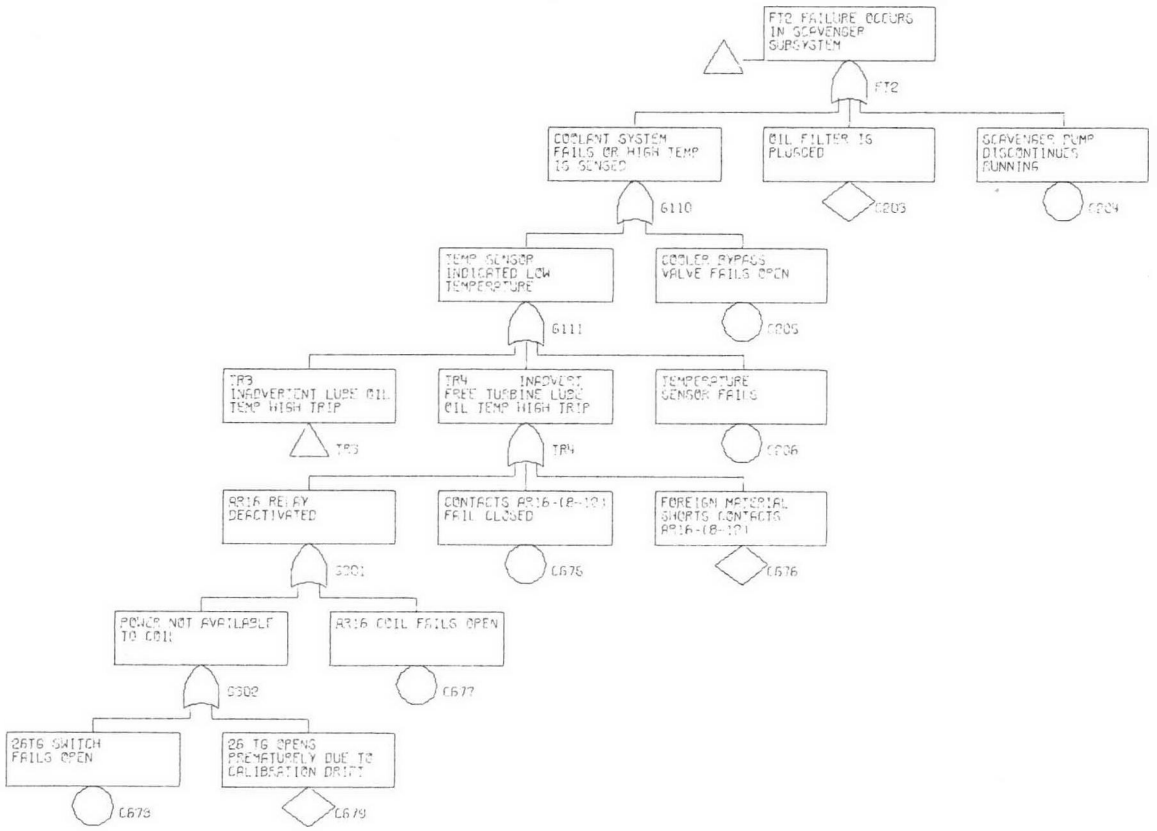

FIGURE B-8

FT2 FAILURE OCCURS
IN SCAVENGER
SUBSYSTEM

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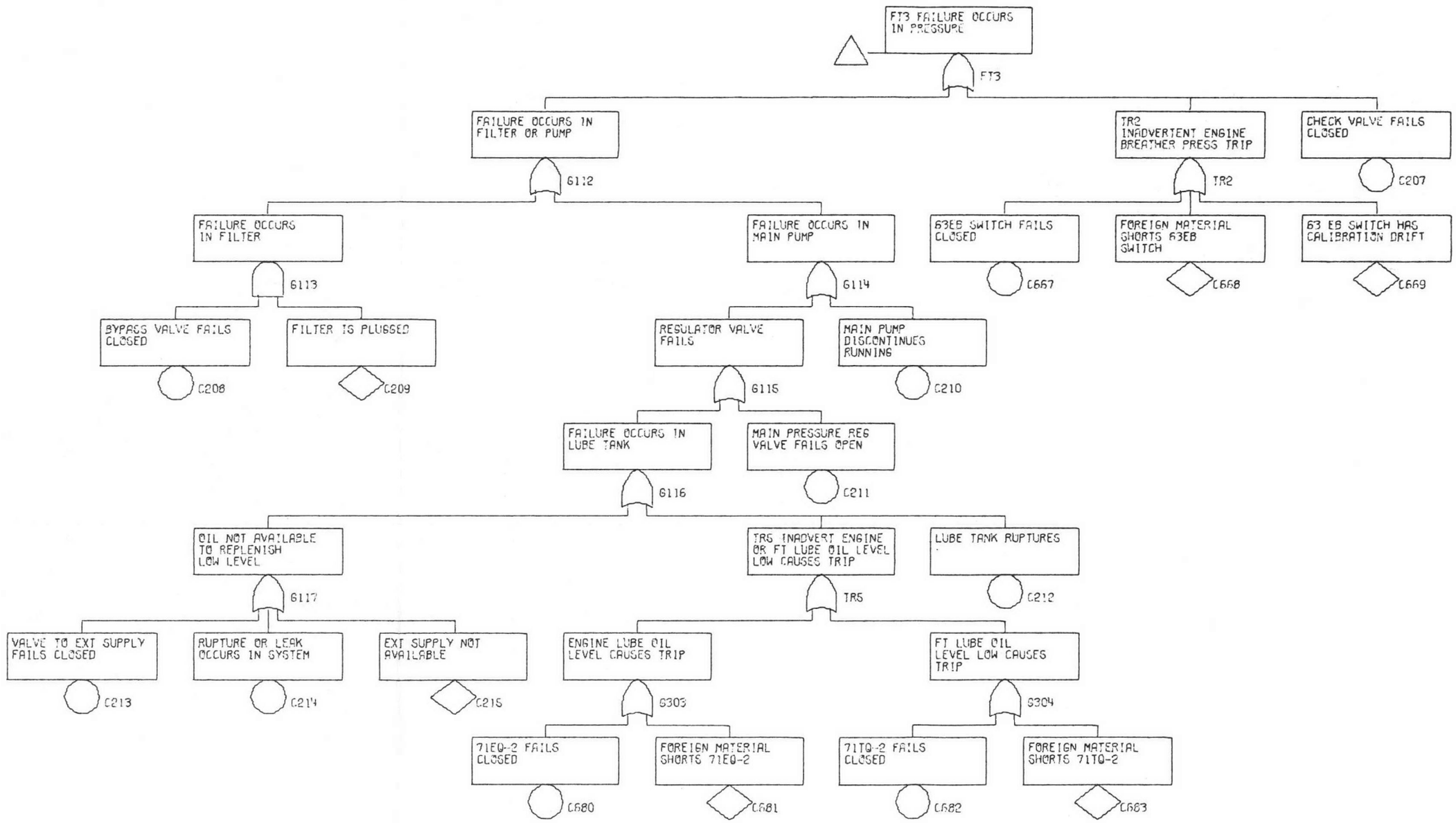

FIGURE B-9

FAILURE OCCURS IN PRESSURE

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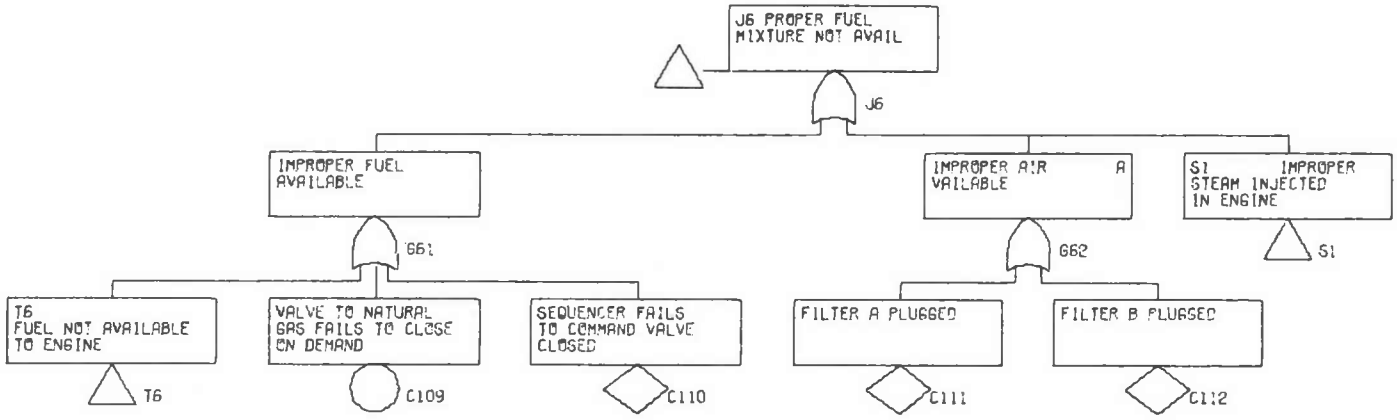

FIGURE B-10

J6 PROPER FUEL
MIXTURE NOT AVAILABLE

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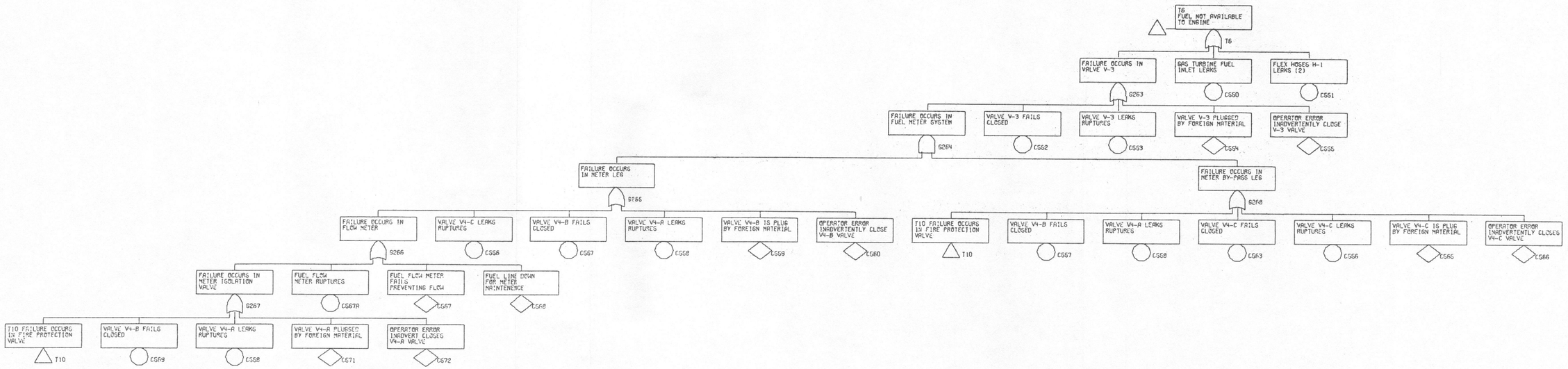

FIGURE B-11

T6 FUEL NOT AVAILABLE
TO ENGINE

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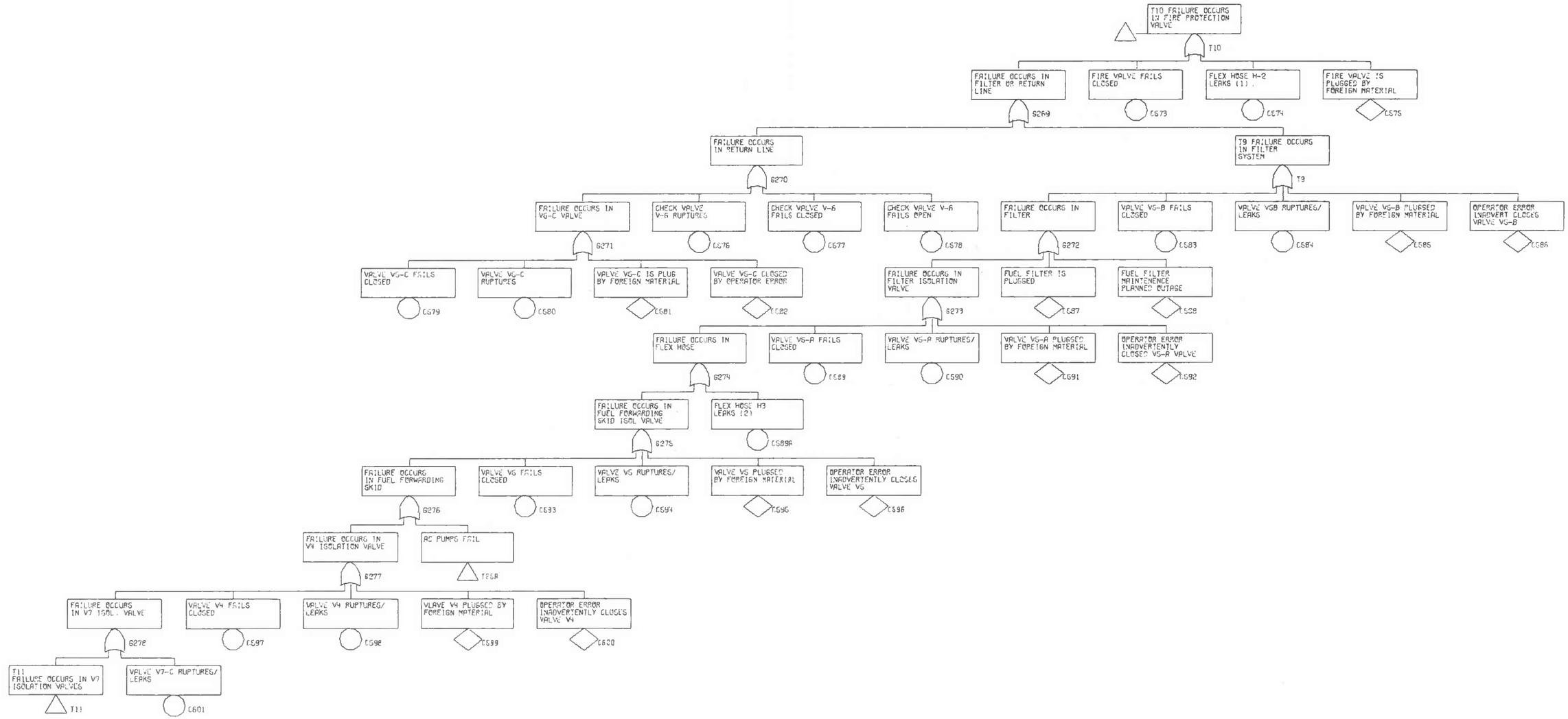

FIGURE B-12

T10 FAILURE OCCURS IN FIRE PROTECTION VALVE

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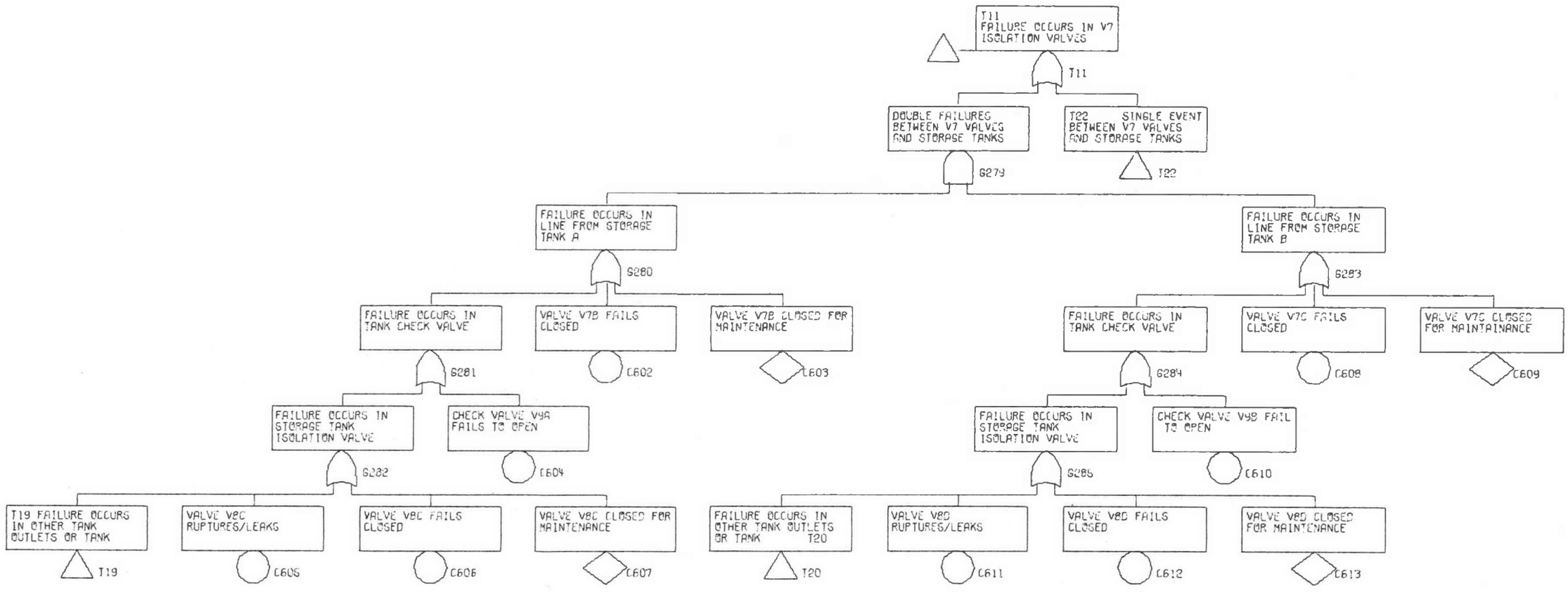

FIGURE B-13

T11 FAILURE OCCURS
IN V7 ISOLATION
VALVES

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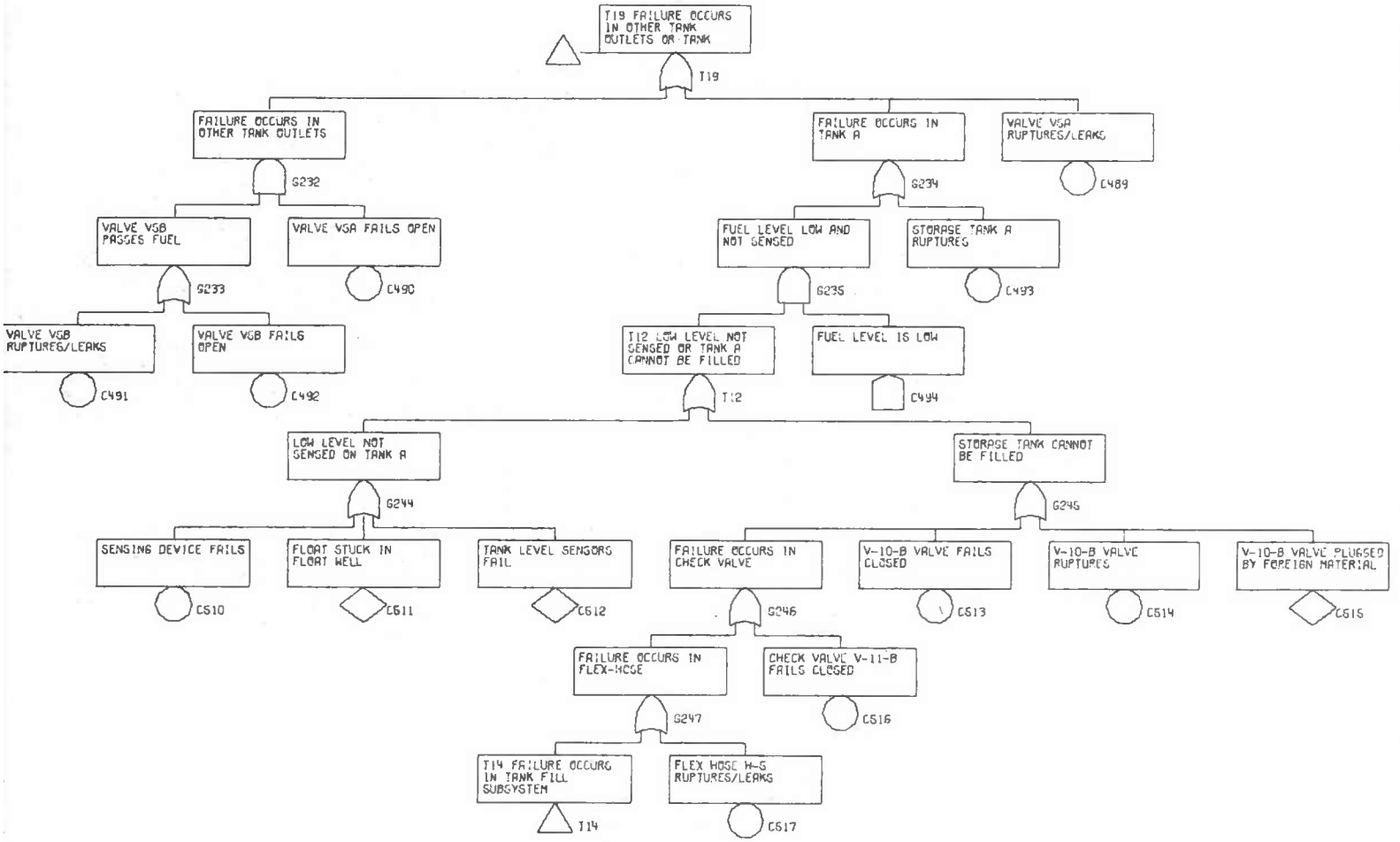

FIGURE B-14

T19 FAILURE OCCURS
IN OTHER TANK
OUTLETS OR TANK

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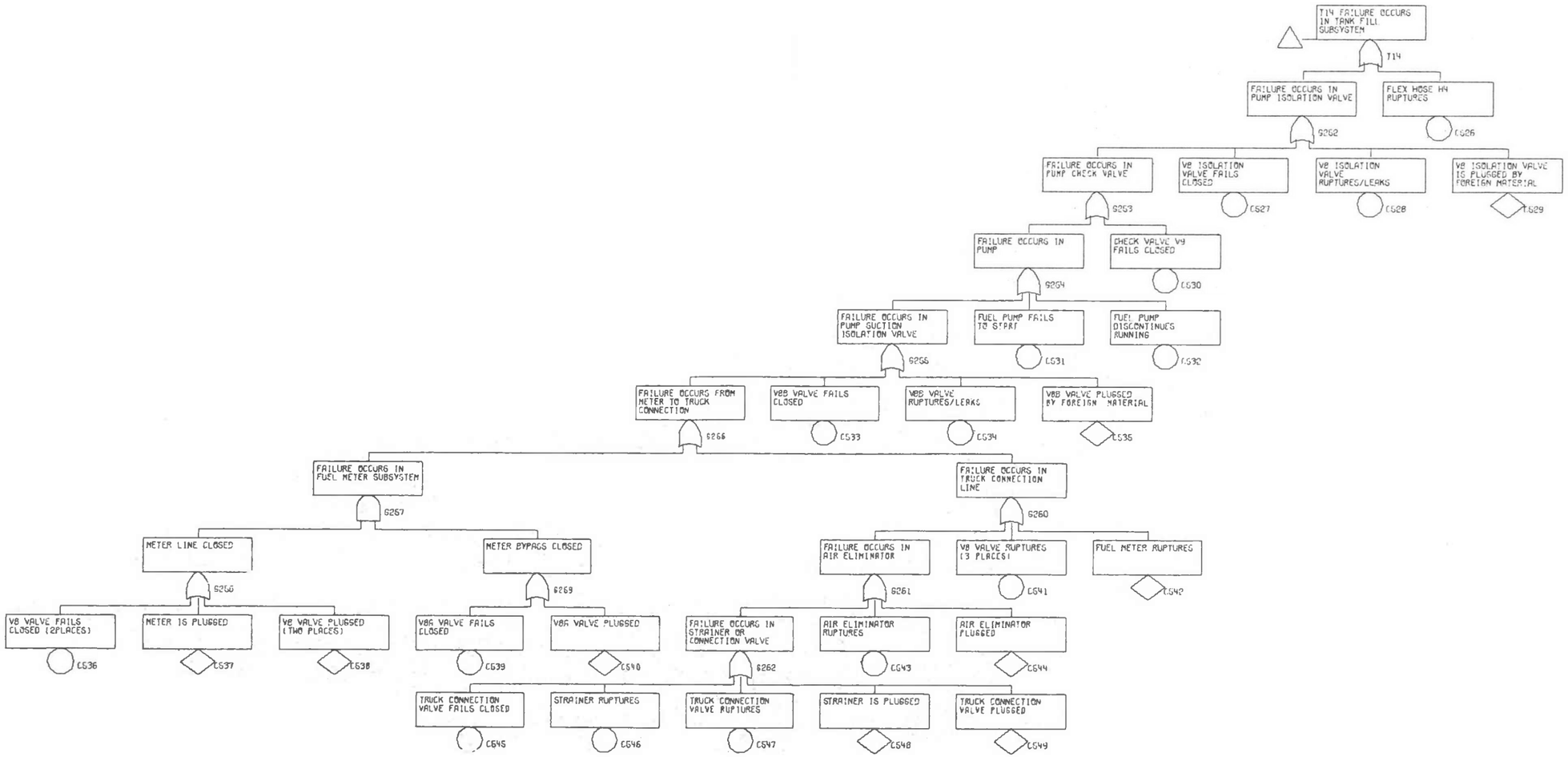

FIGURE B-15

T14 FAILURE OCCURS
1N TANK FILL
SUBSYSTEM

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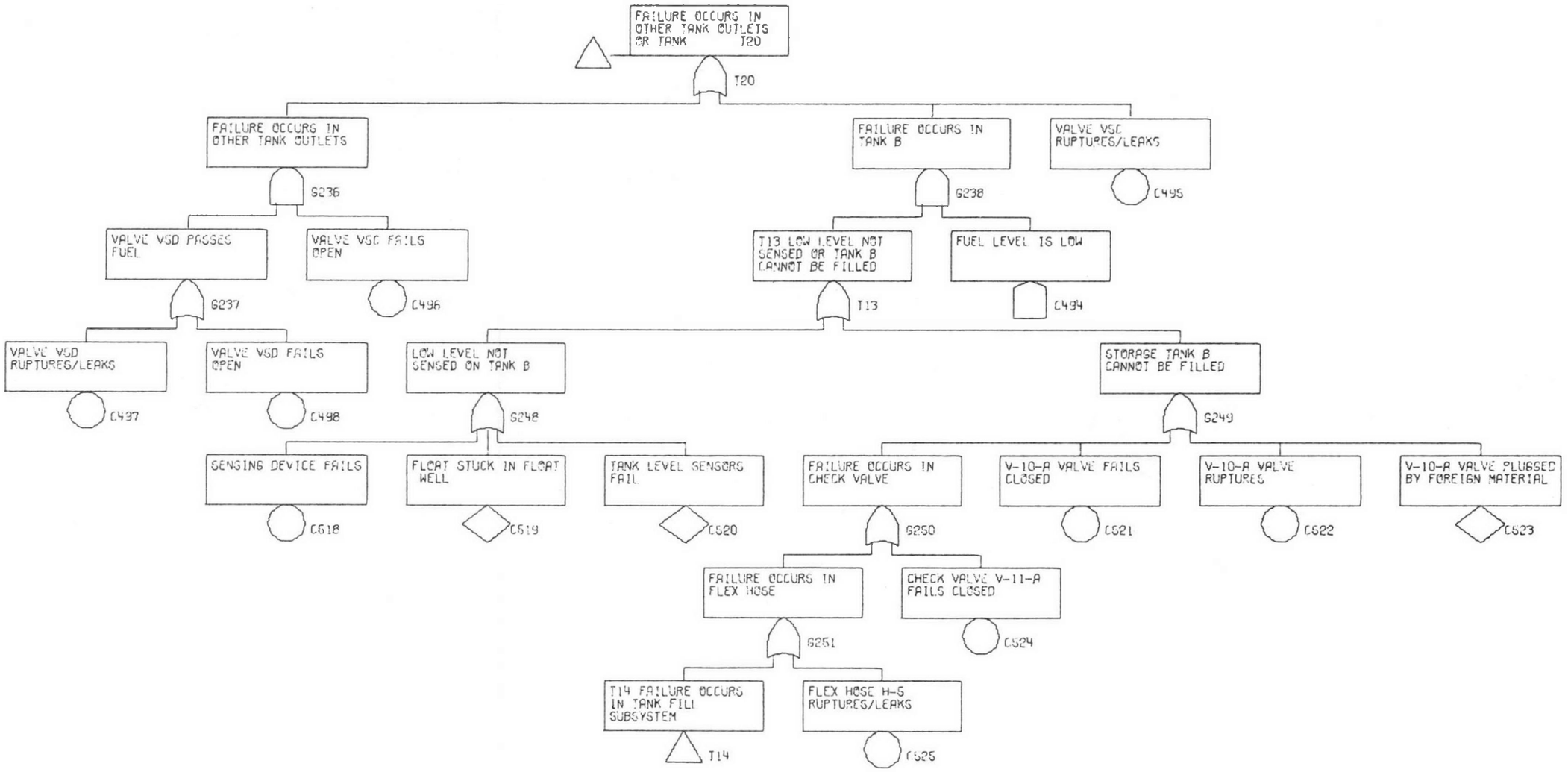

FIGURE B-16

FAILURE OCCURS IN
OTHER TANK OUTLETS
OR TANK T20

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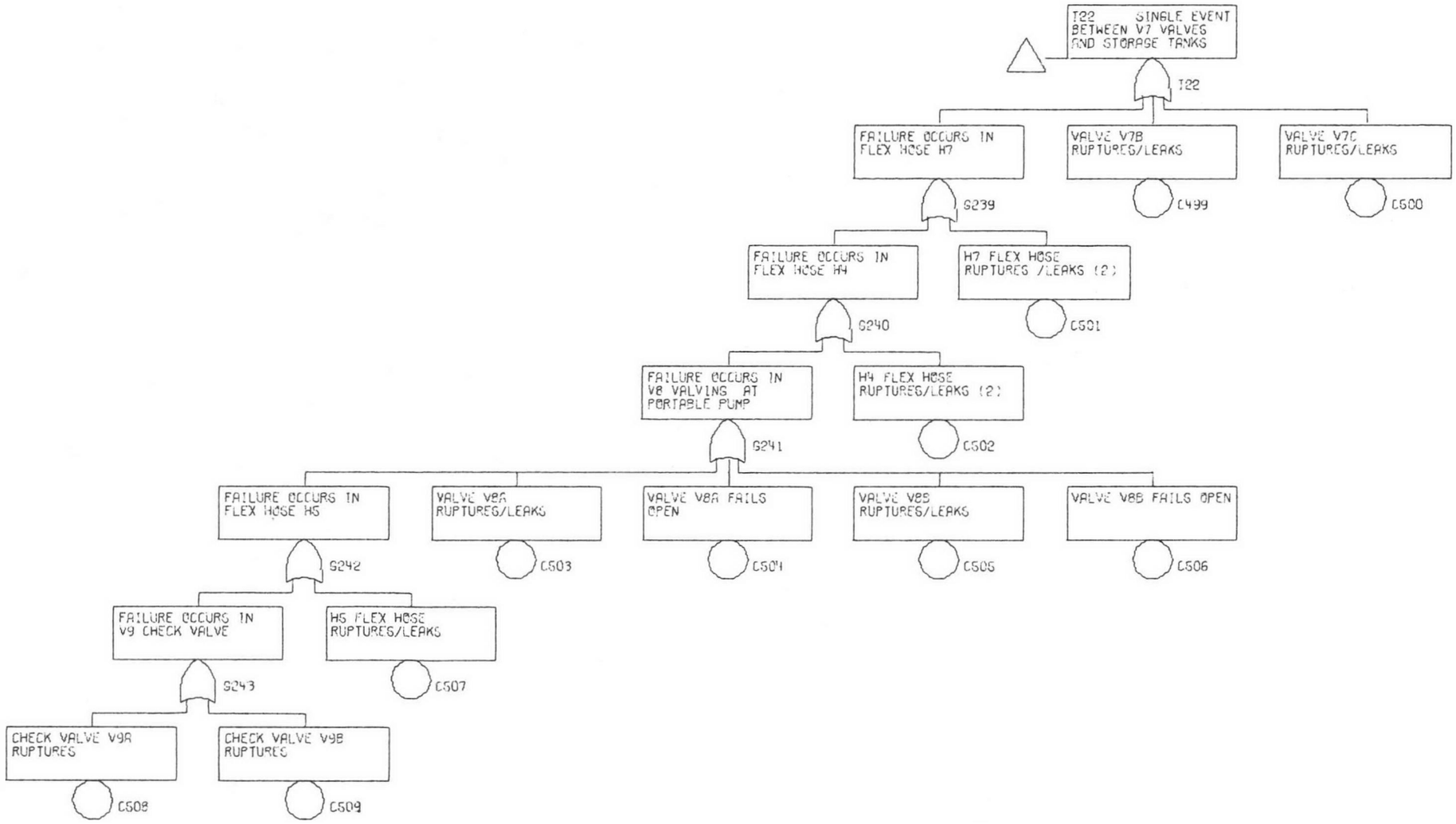

FIGURE B-17

T22 SINGLE EVENT BETWEEN V7 VALVES AND STORAGE TANKS

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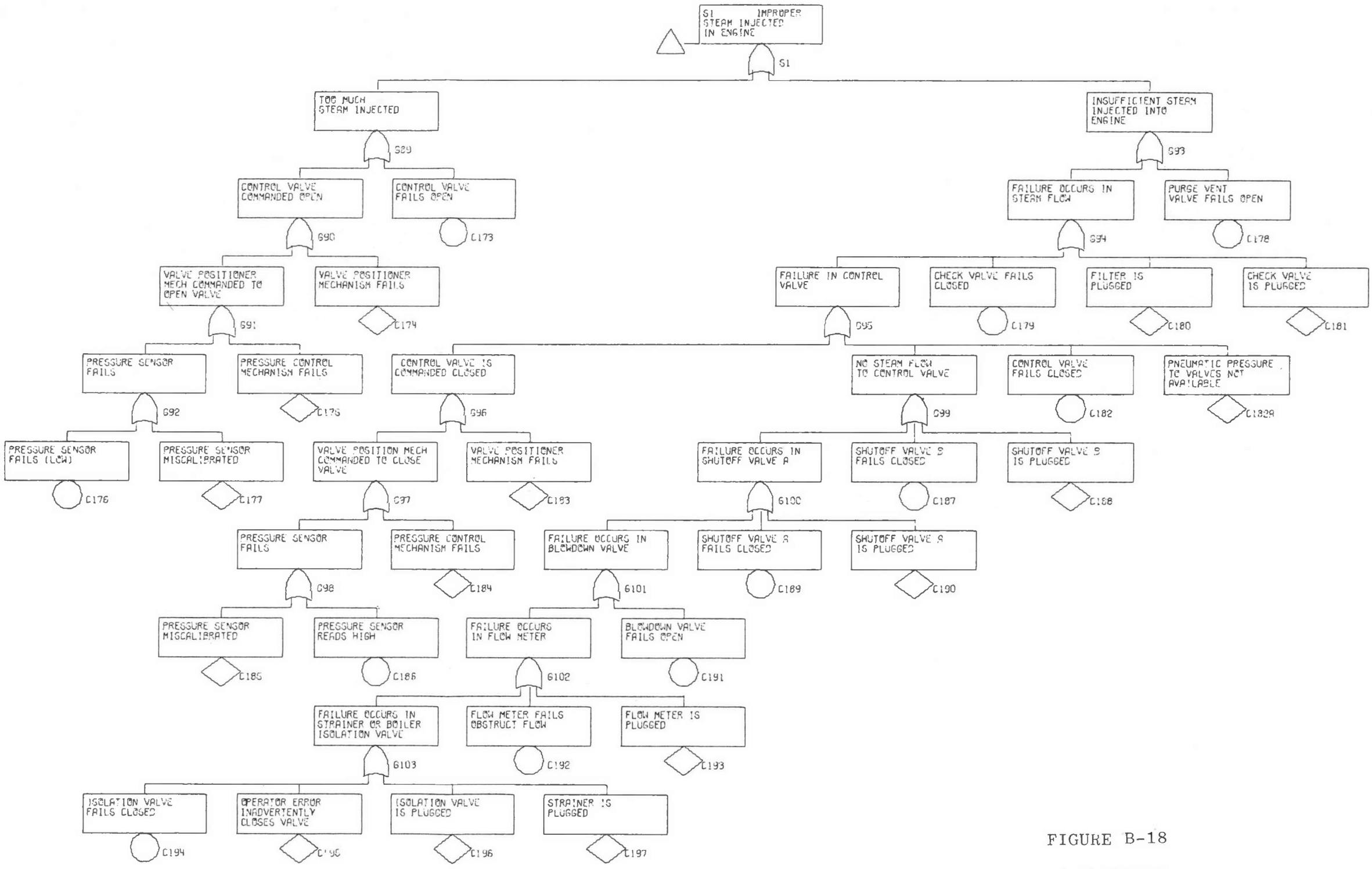

FIGURE B-18

S1 IMPROPER
STEAM INJECTED
IN ENGINE

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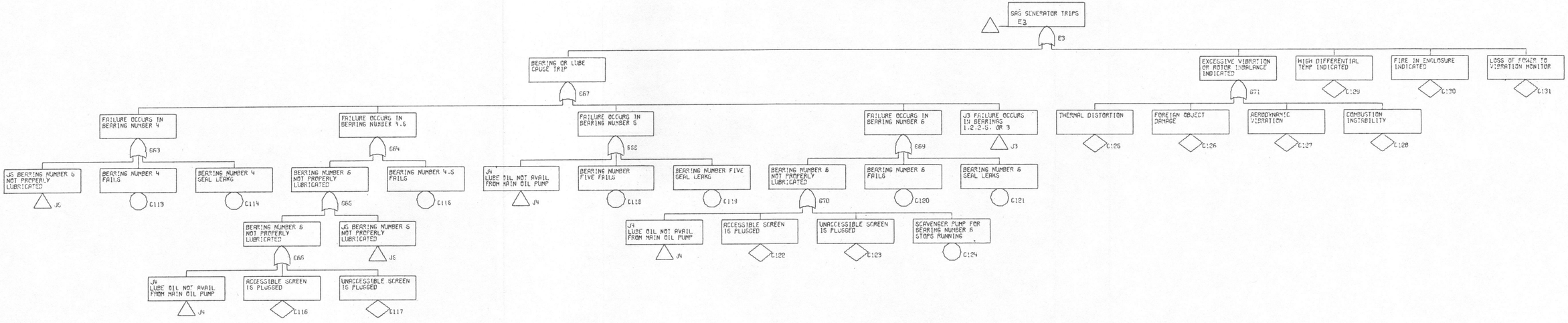

FIGURE B-19

GAS GENERATOR TRIPS E3

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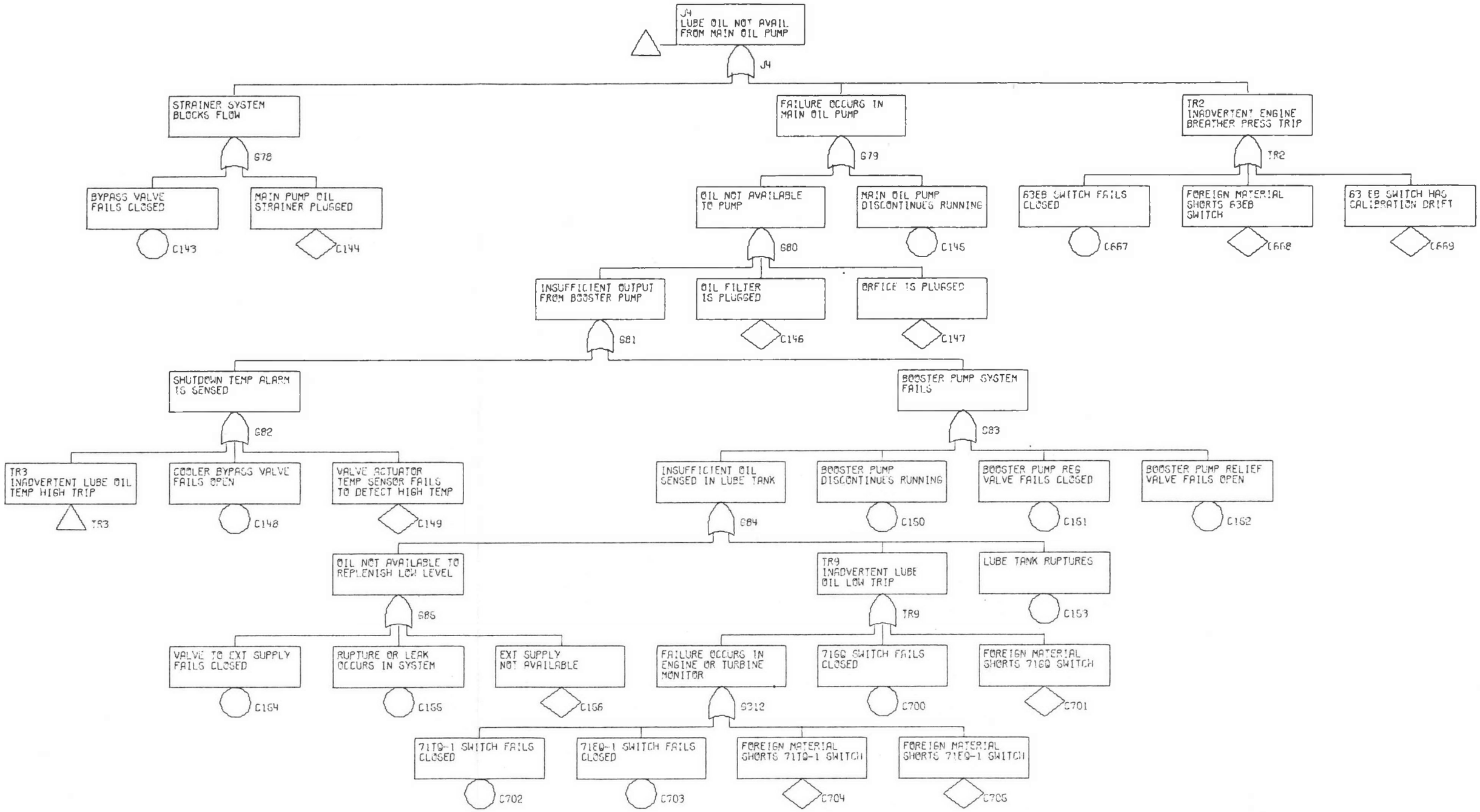

FIGURE B-20

J4 LUBE OIL NOT AVAILABLE FROM MAIN OIL PUMP

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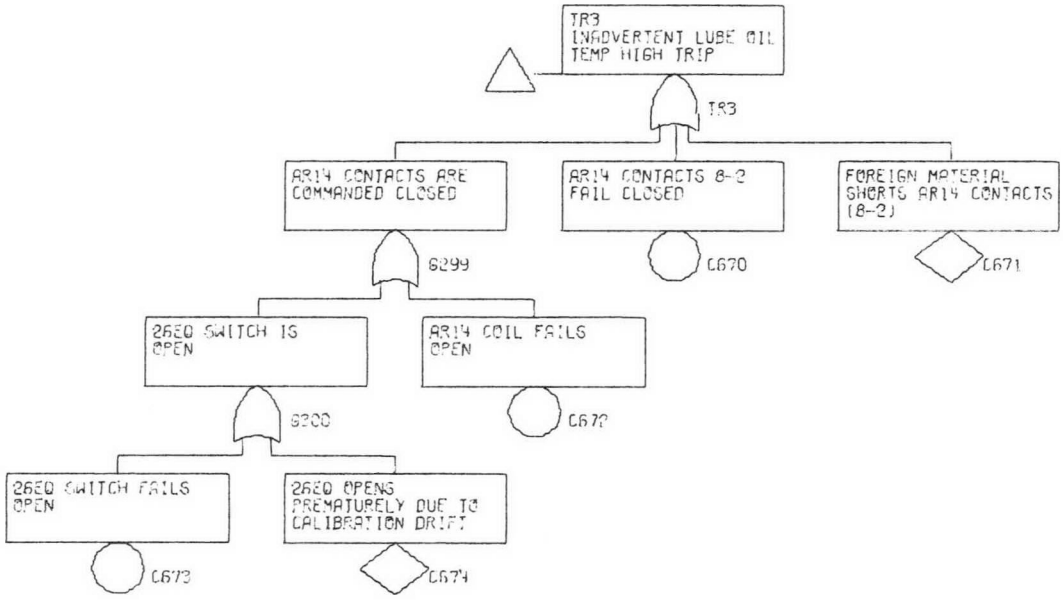

FIGURE B-21

TR3 INADVERTENT
LUBE OIL TEMPERATURE
HIGH TRIP

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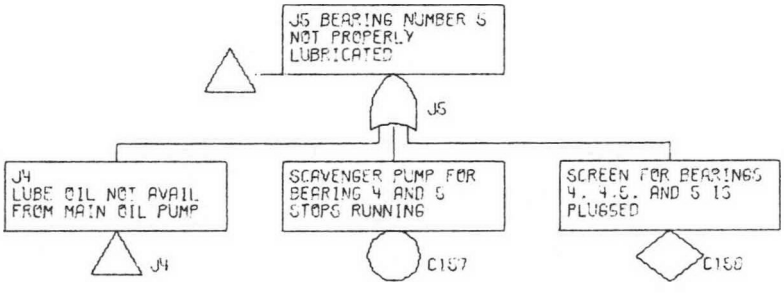

FIGURE B-22

J5 BEARING NUMBER 5
NOT PROPERLY
LUBRICATED

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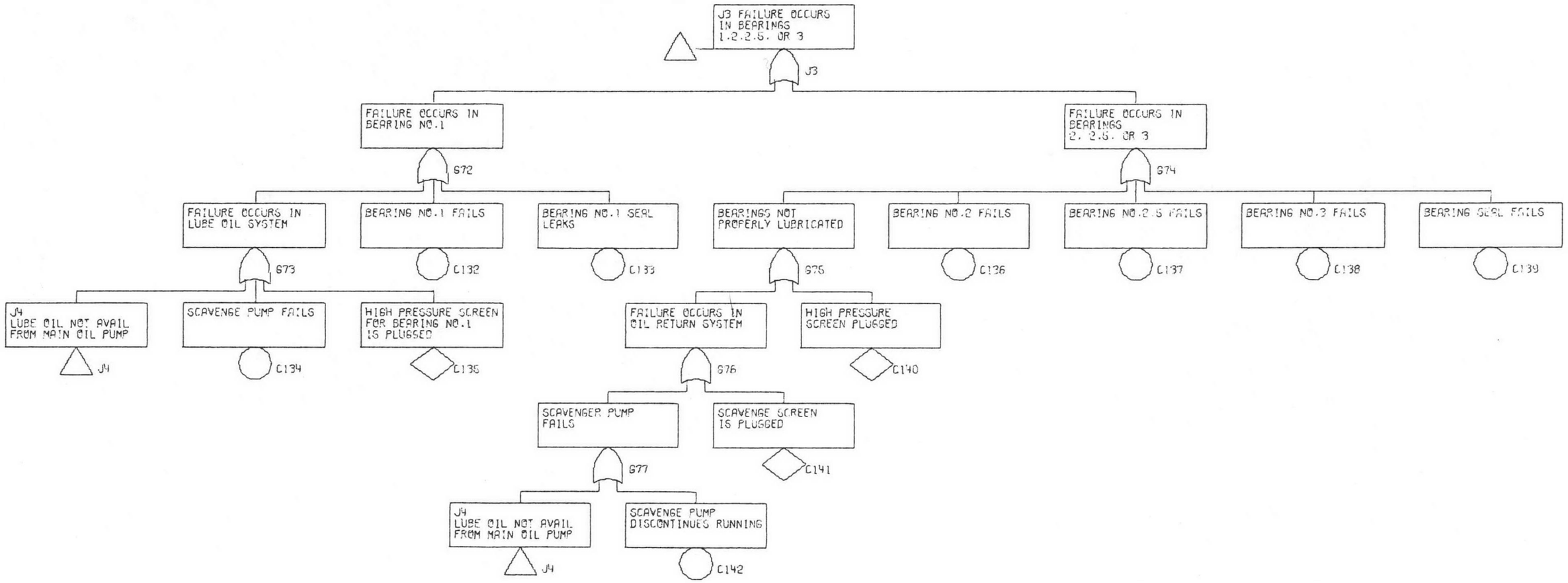

FIGURE B-23

J3 FAILURE
OCCURS IN BEARINGS
1, 2, 2, 5 or 3

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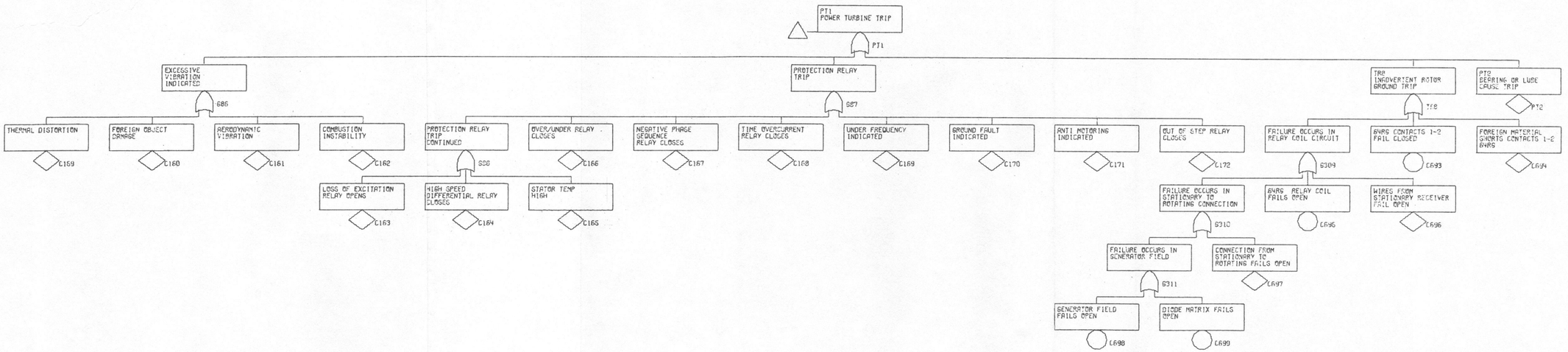

FIGURE B-24

PT1 POWER TURBINE TRIP

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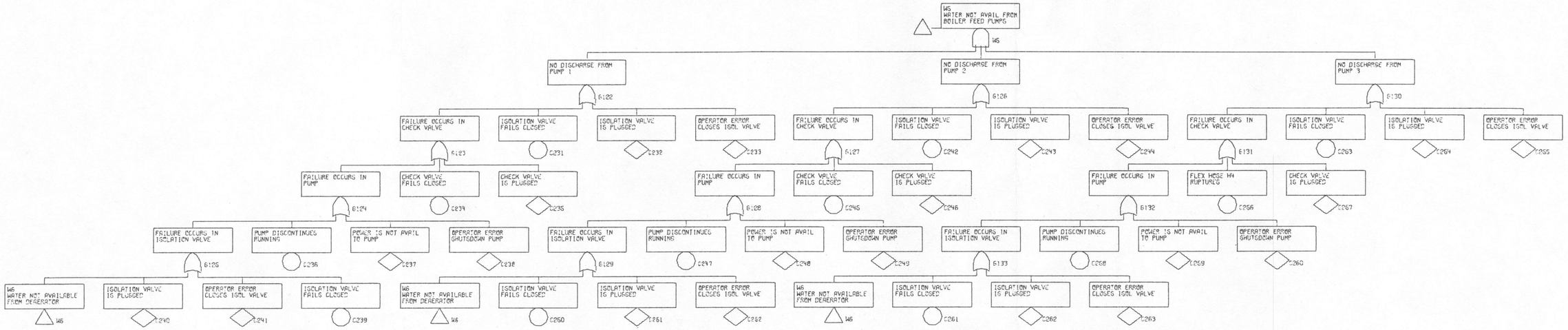

FIGURE B-25

W5 WATER NOT
AVAILABLE FROM
BOILER FEED PUMPS

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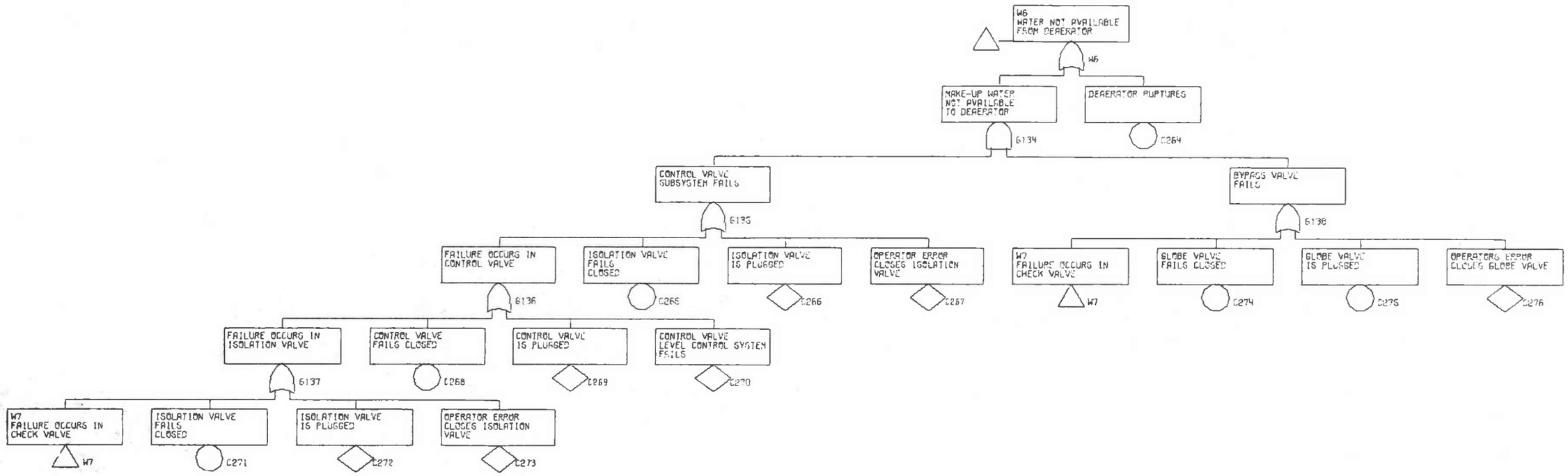

FIGURE B-26

W6 WATER
NOT AVAILABLE
FROM DEAERATOR

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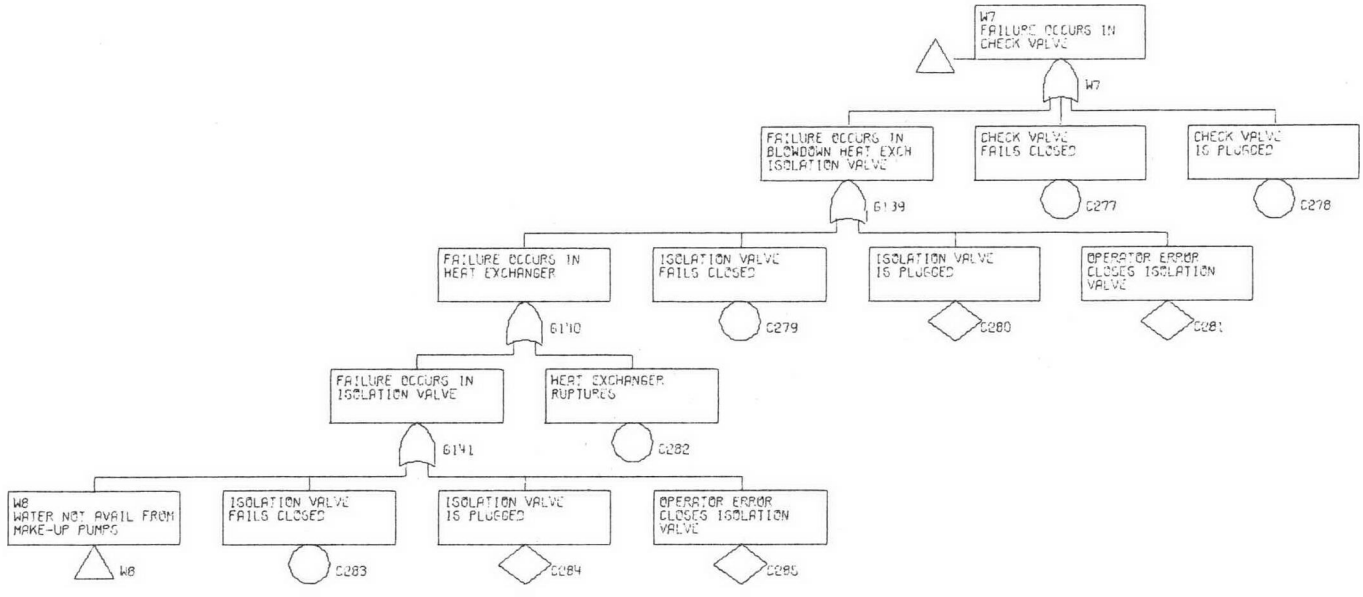

FIGURE B-27

W7 FAILURE
OCCURS IN
CHECK VALVE

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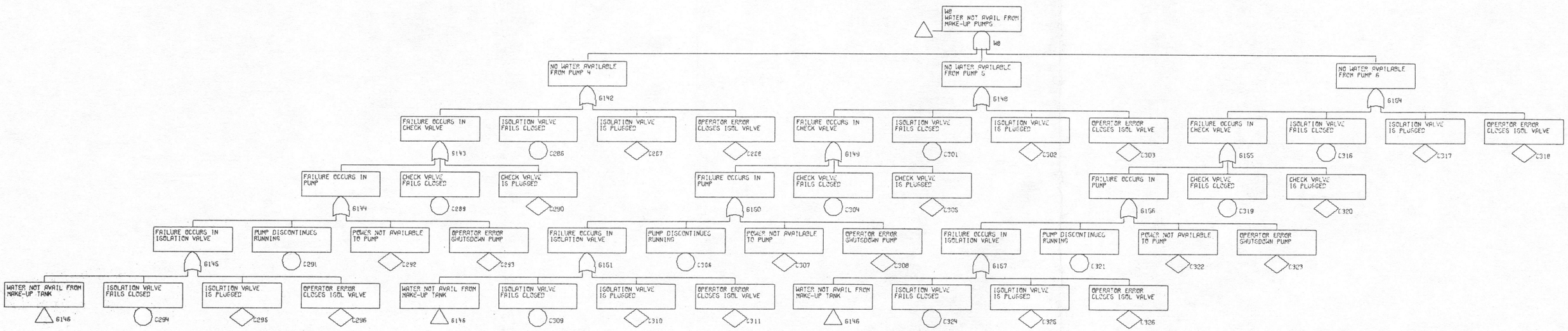

FIGURE B-28

W8 WATER
NOT AVAILABLE
FROM MAKE-UP
PUMPS

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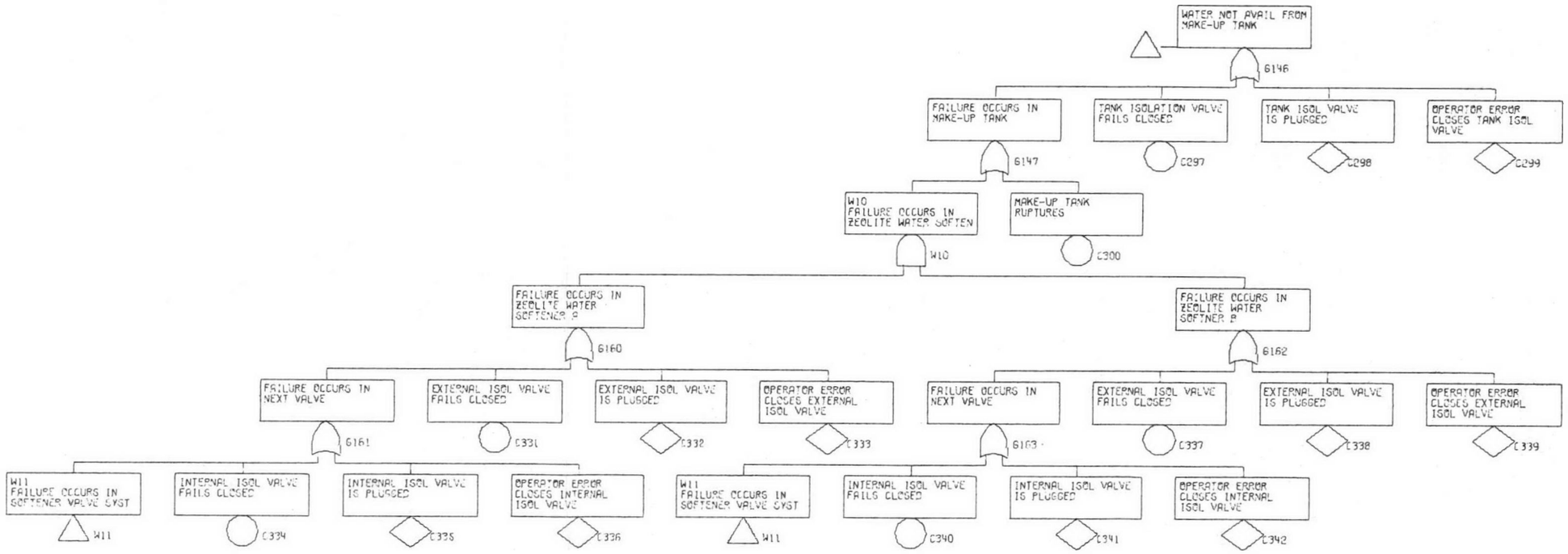

FIGURE B-29

WATER NOT AVAILABLE
FROM MAKE-UP TANK

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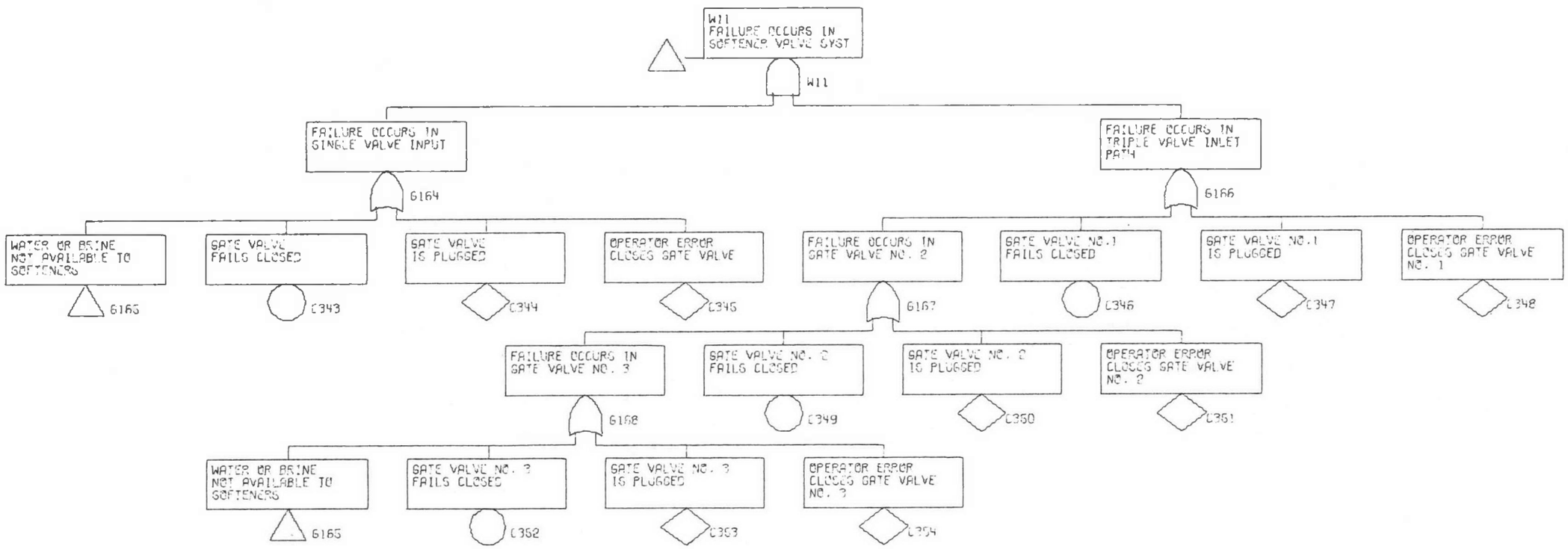

FIGURE B-30

W11 FAILURE
OCCURS IN SOFTENER
VALVE SYSTEM

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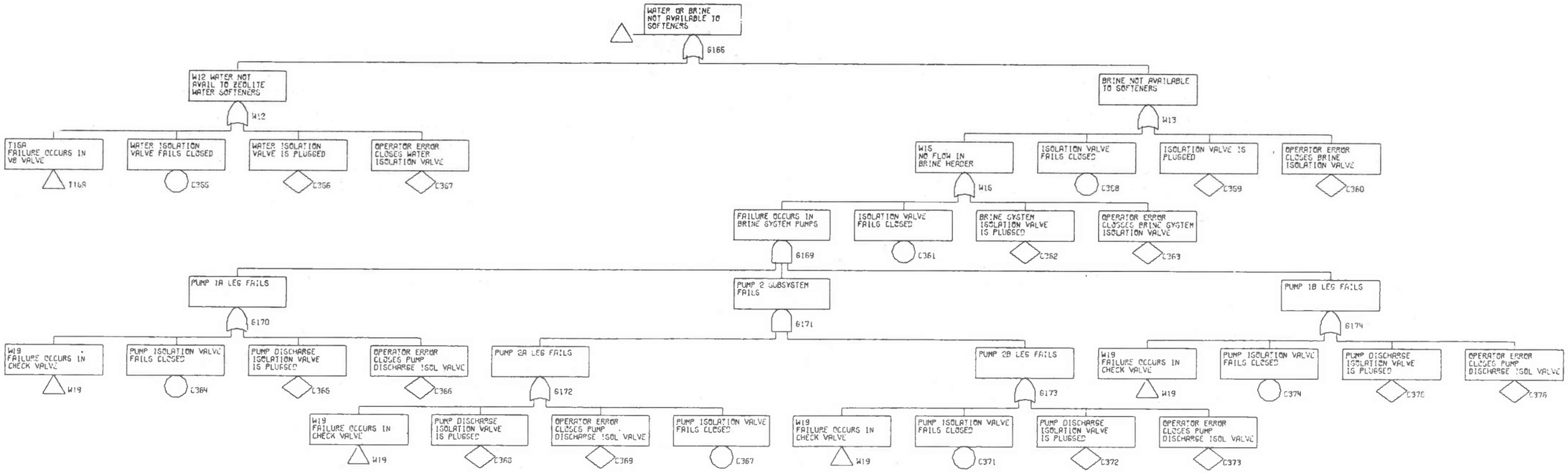

FIGURE B-31

WATER OR BRINE
NOT AVAILABLE TO
SOFTENERS

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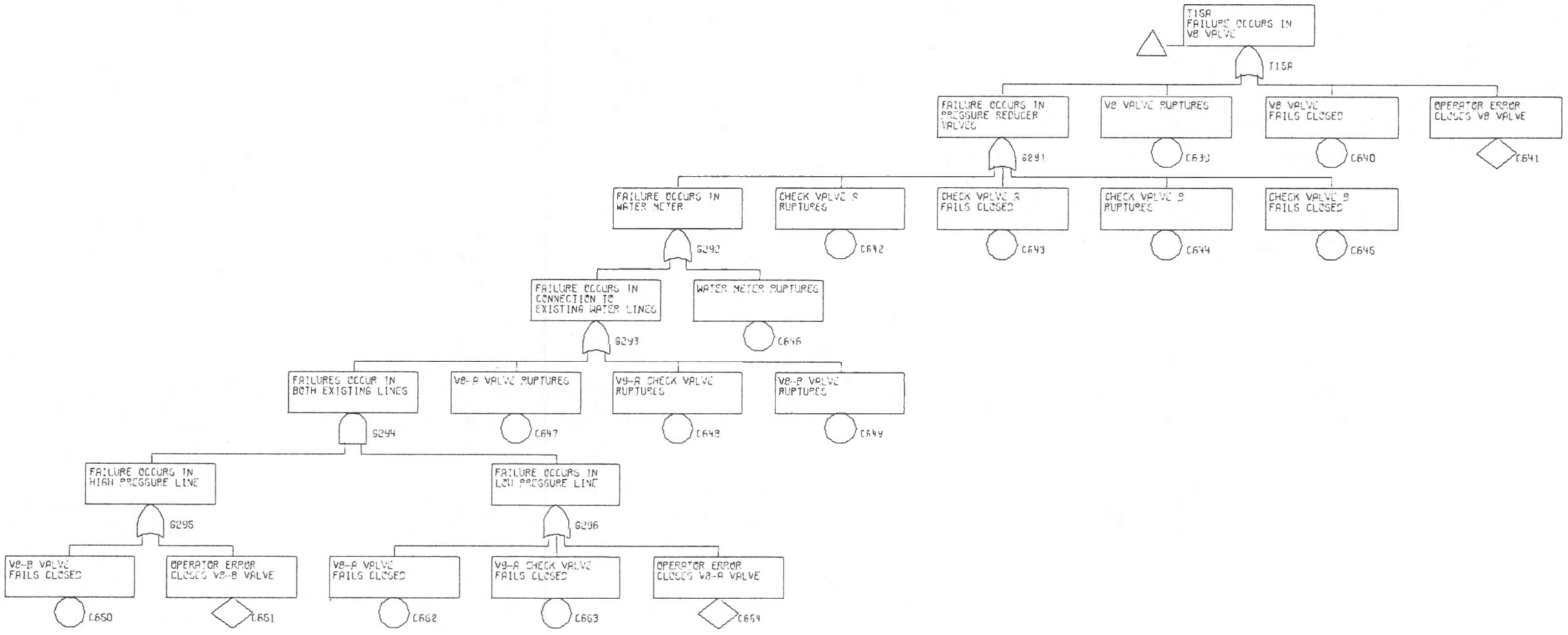

FIGURE B-32

T15A FAILURE OCCURS
IN V8 VALVE

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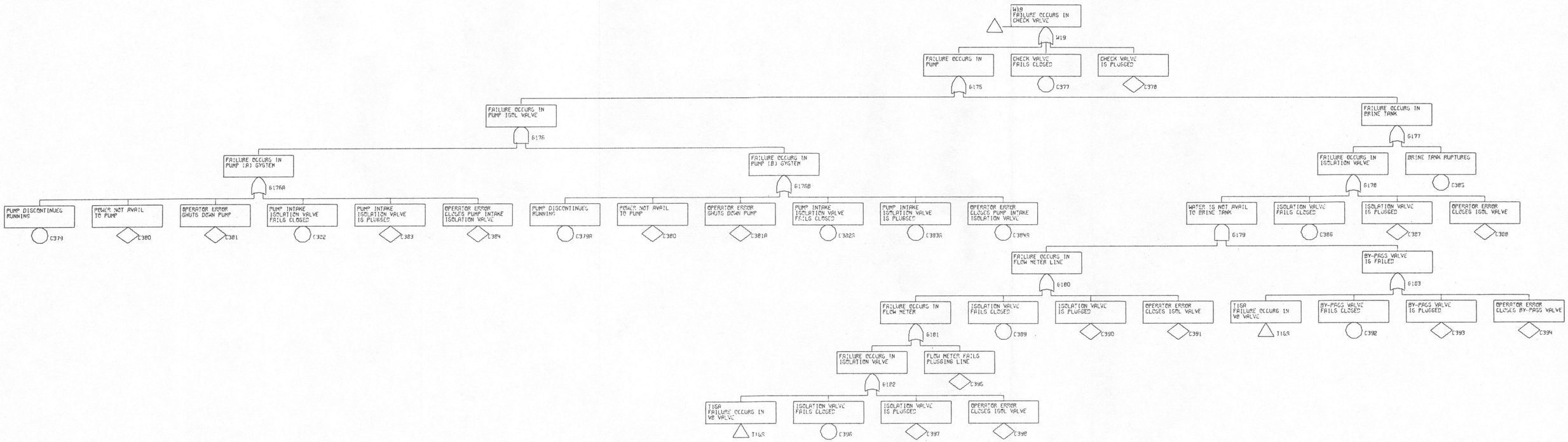

FIGURE B-33

W19 FAILURE OCCURS
IN CHECK VALVE

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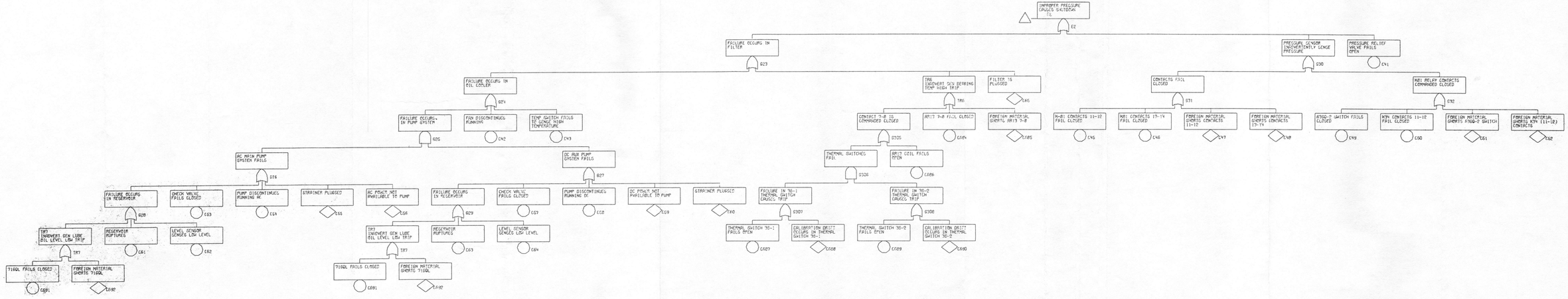

FIGURE B-34

IMPROPER PRESSURE CAUSES SHUTDOWN E2

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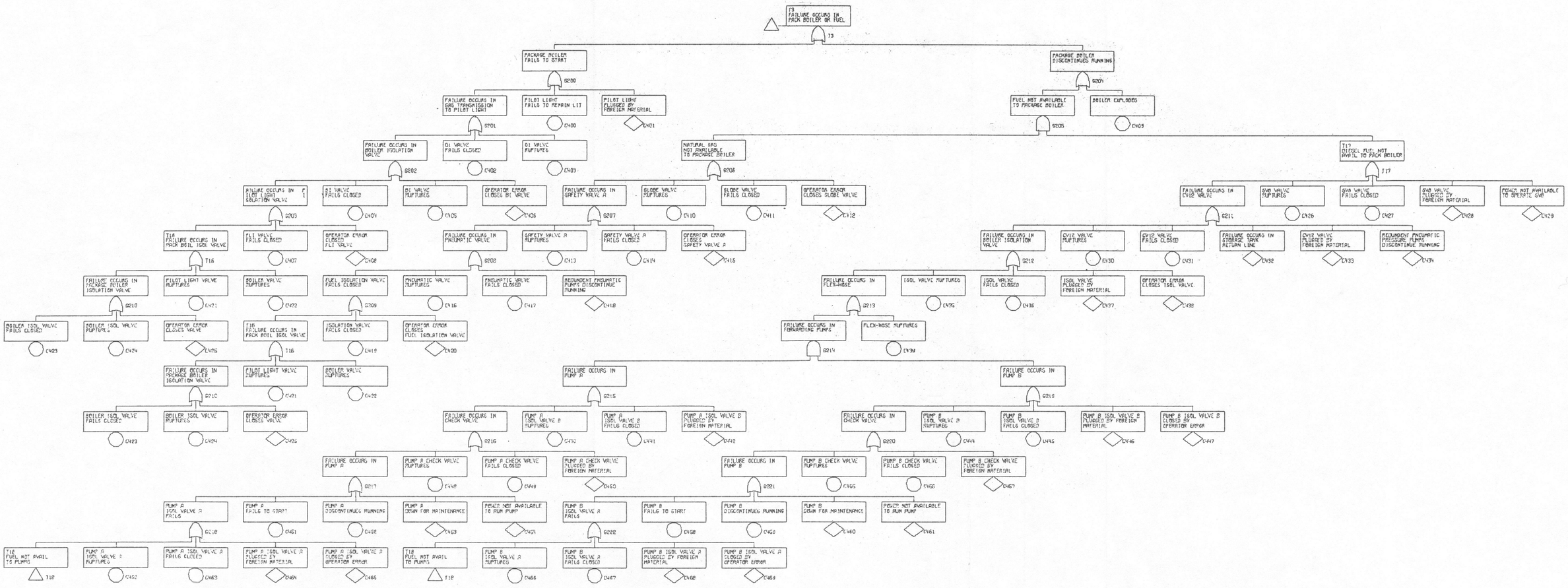

FIGURE B-35

T3 FAILURE OCCURS IN PACK BOILER OR FUEL

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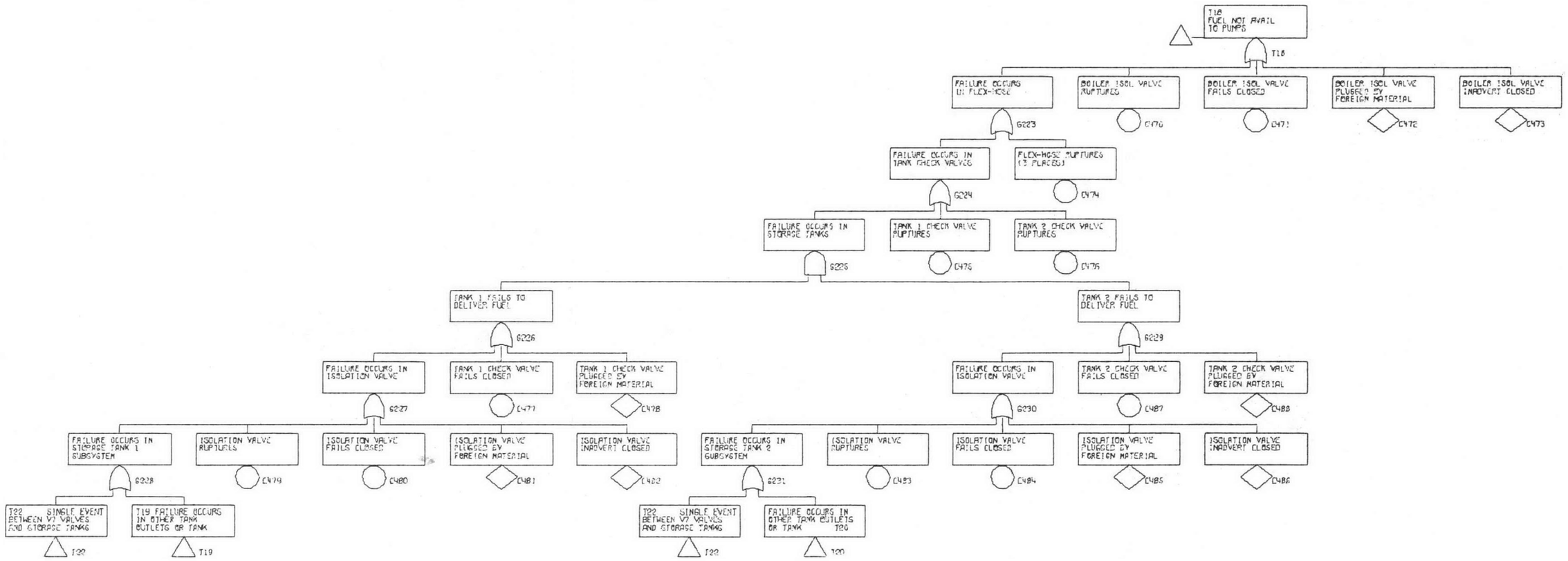

FIGURE B-36

T18 FUEL NOT
AVAILABLE TO PUMPS

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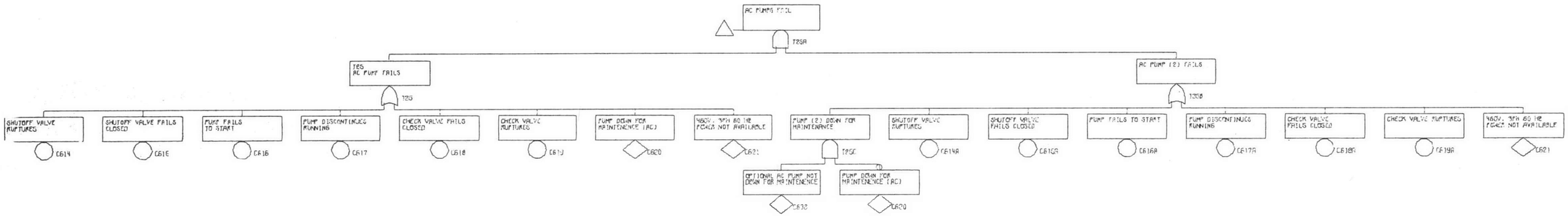

FIGURE B-37

AC PUMPS FAIL