A STUDY OF MASS TRANSFER FROM LARGE OSCILLATING DROPS

by

TARIQ SADIK AL-HASSAN

A Thesis submitted to
The University of Aston in Birmingham
for the Degree of
Doctor of Philosophy

VOLUME II

Department of Chemical Engineering
University of Aston in Birmingham

September 1979

CONTENTS

APPENDIX G

ILLUSTRATIONS OF THE EXPERIMENTS OF THE N-HEPTANE-ACETONE-WATER

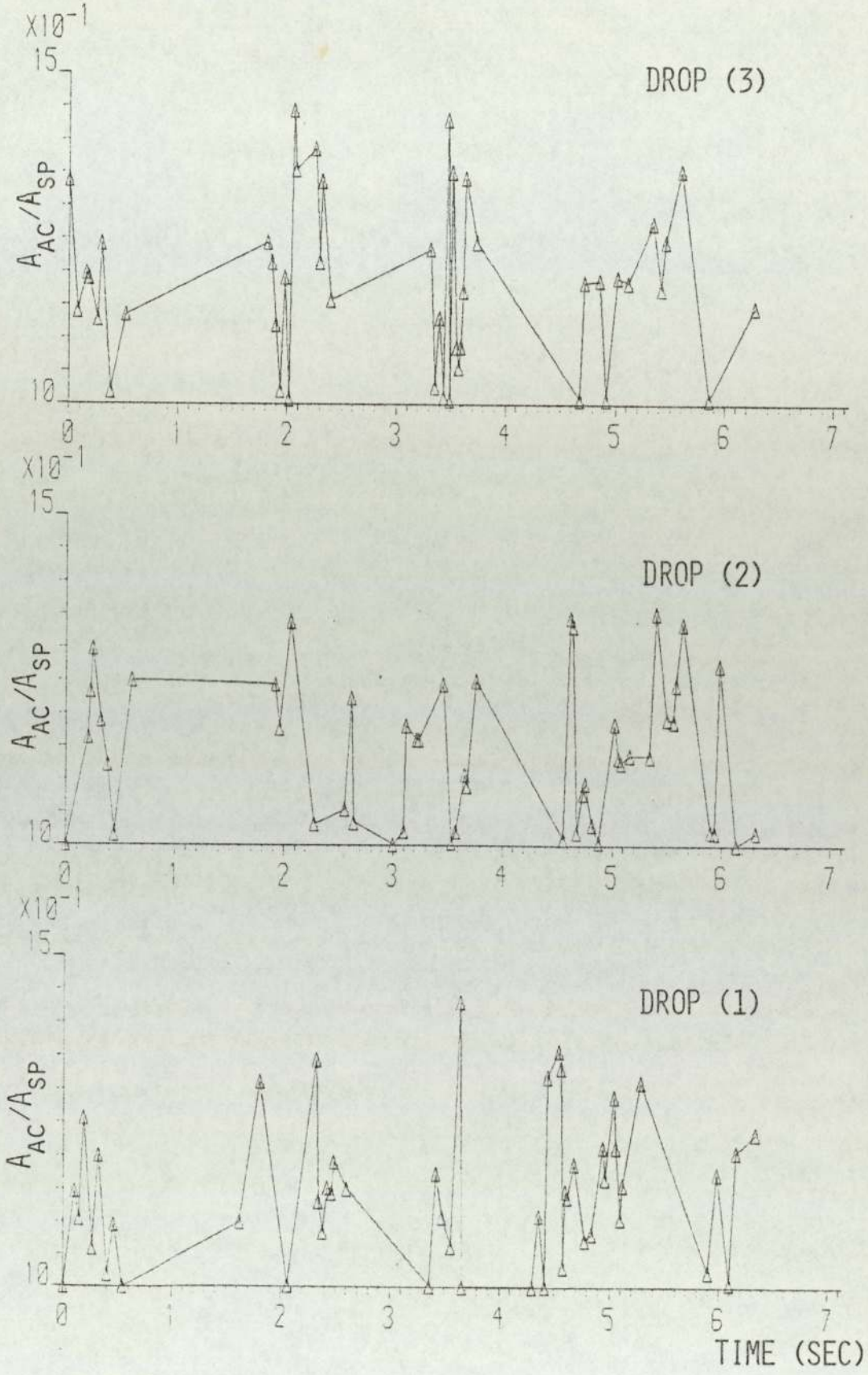

FIG. G.1 AREA RATIO VS. TIME, RUN-30.

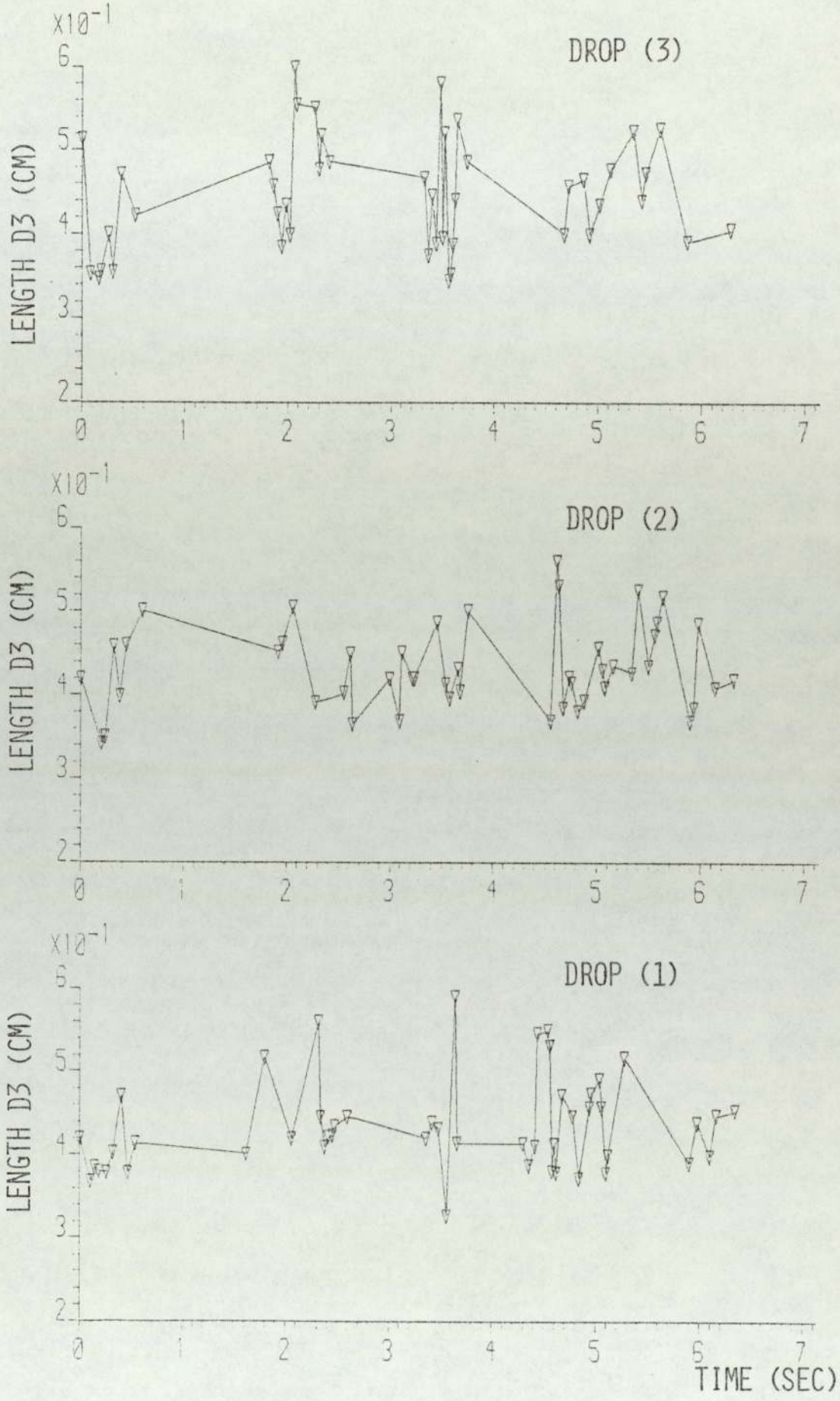

FIG. G.2 LENGTH D3 VS. TIME, RUN-30.

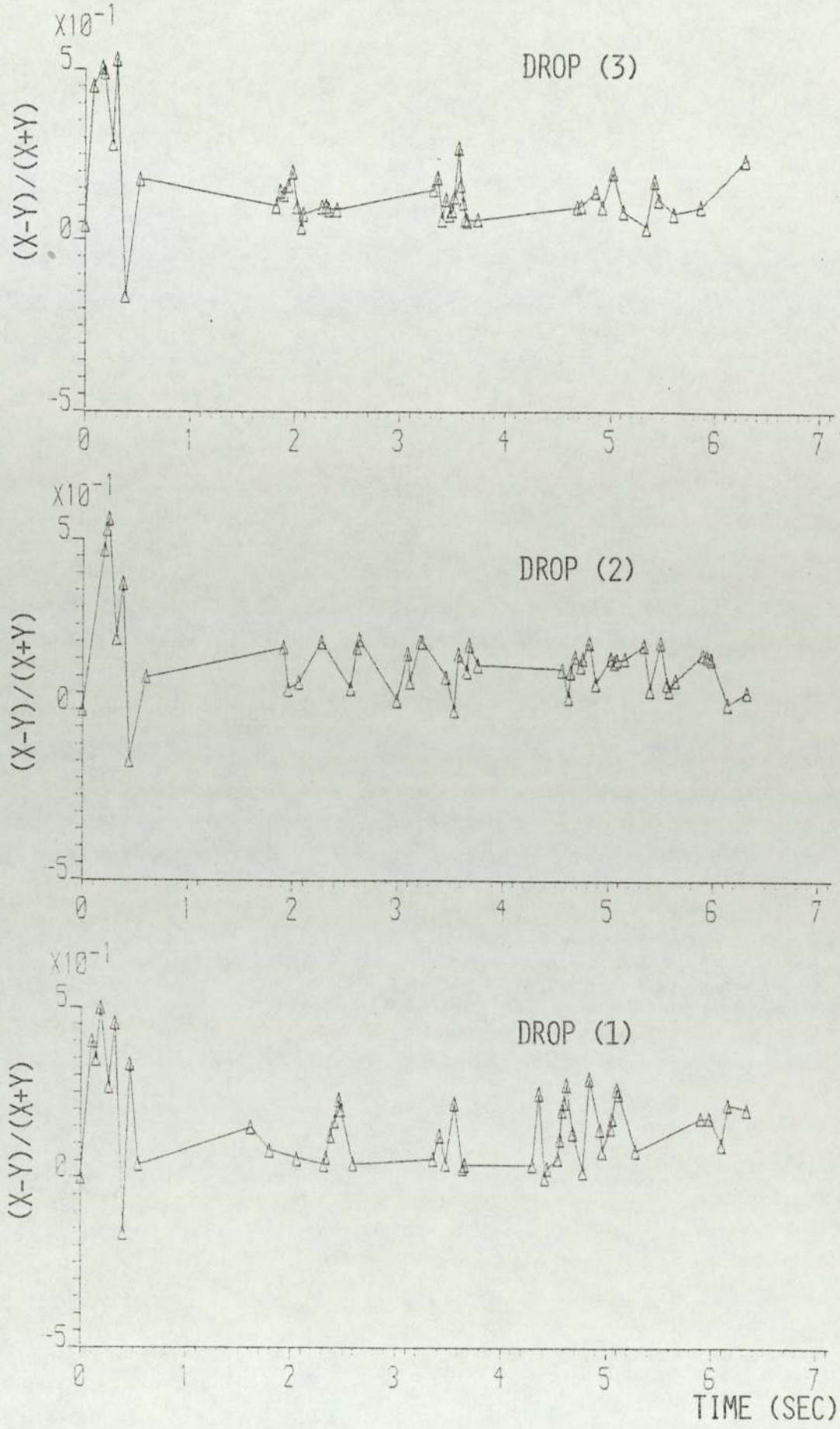

FIG. G.3 DEFORMATION RATIO VS. TIME, RUN-30.

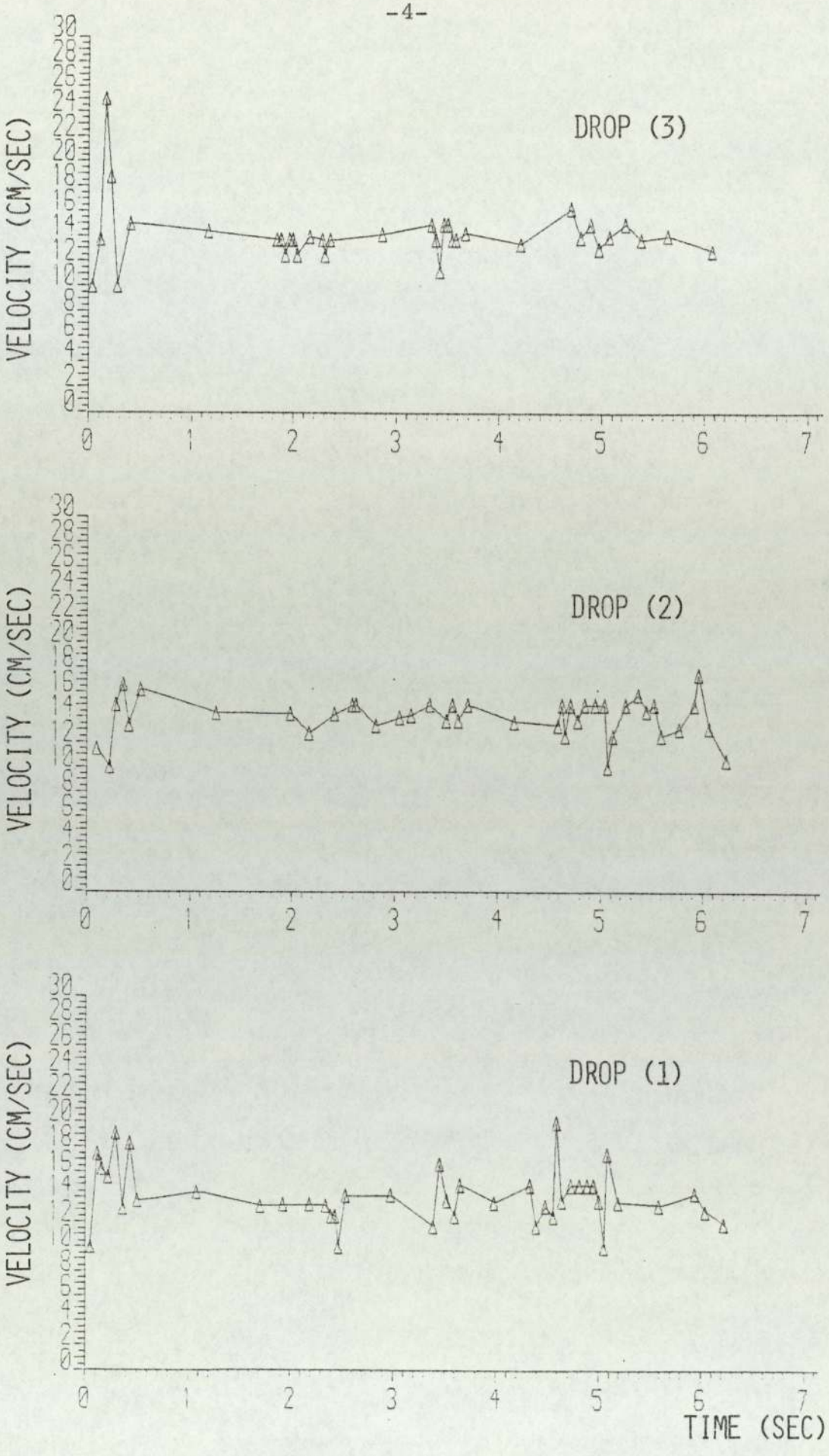

FIG. G.4 INSTANTANEOUS VELOCITY VS. AVERAGE TIME, RUN-30.

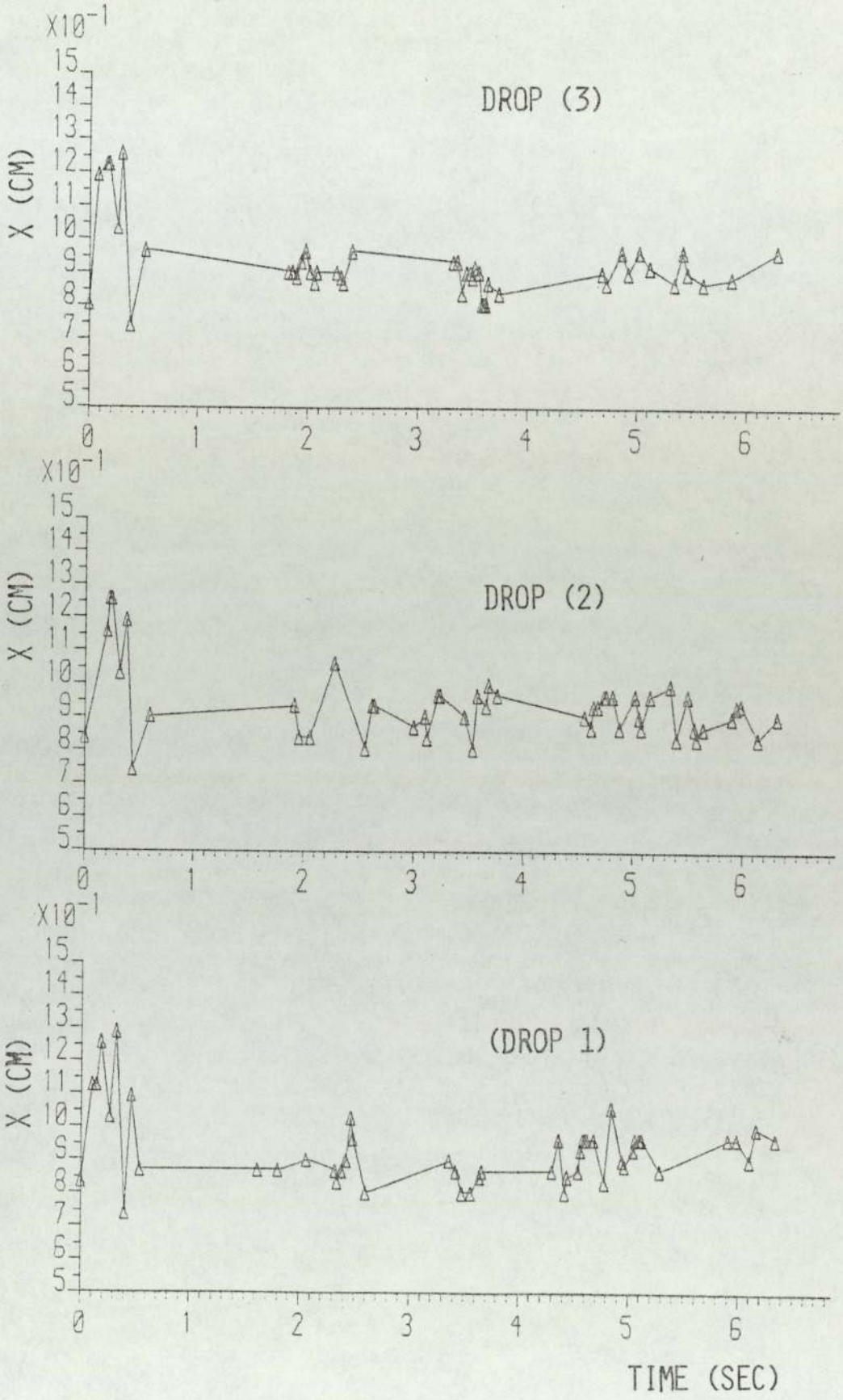

FIG. G.5 X VS. TIME, RUN-30.

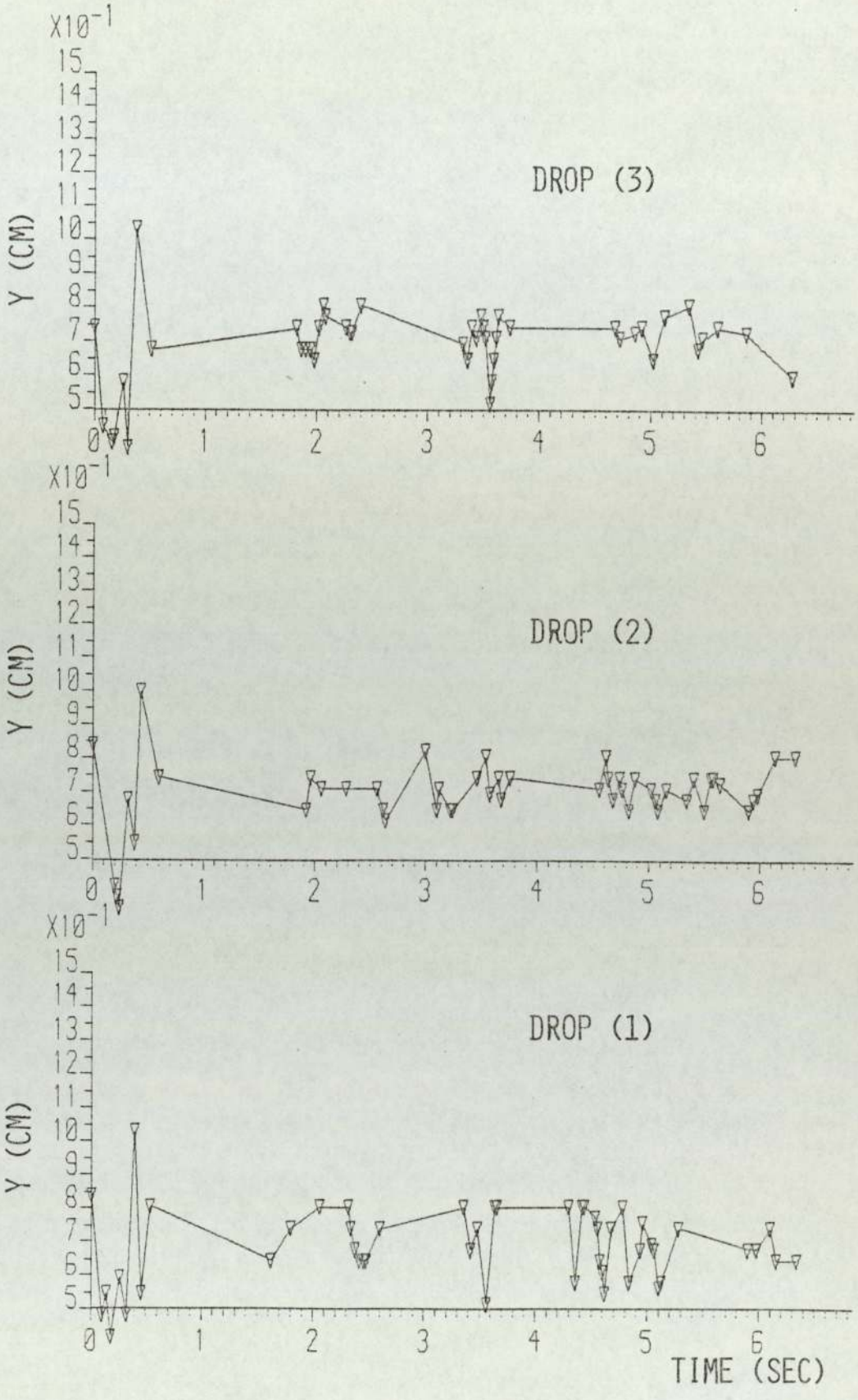

FIG. G.6 Y VS. TIME, RUN-30.

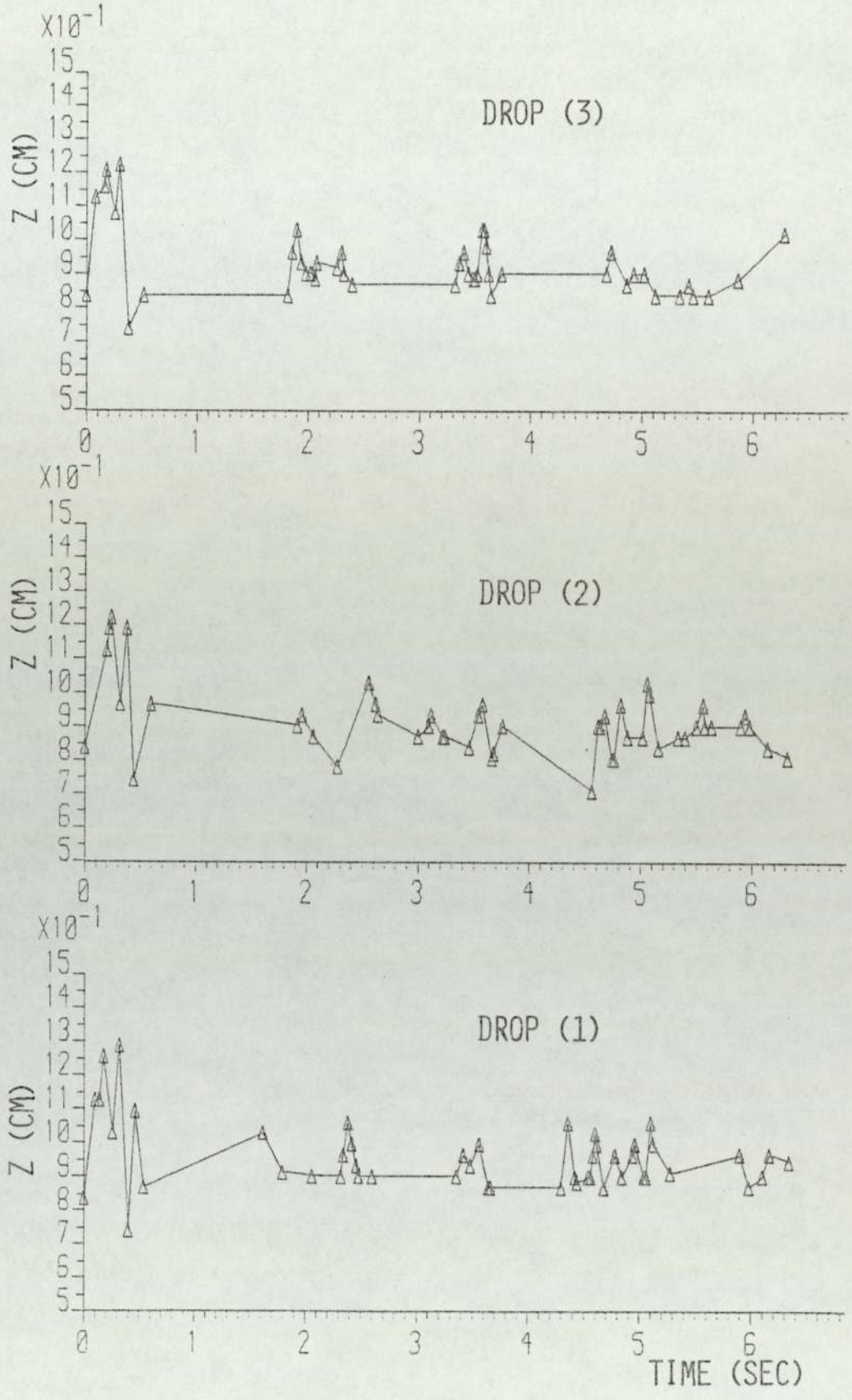

FIG.G.7 Z VS. TIME, RUN-30.

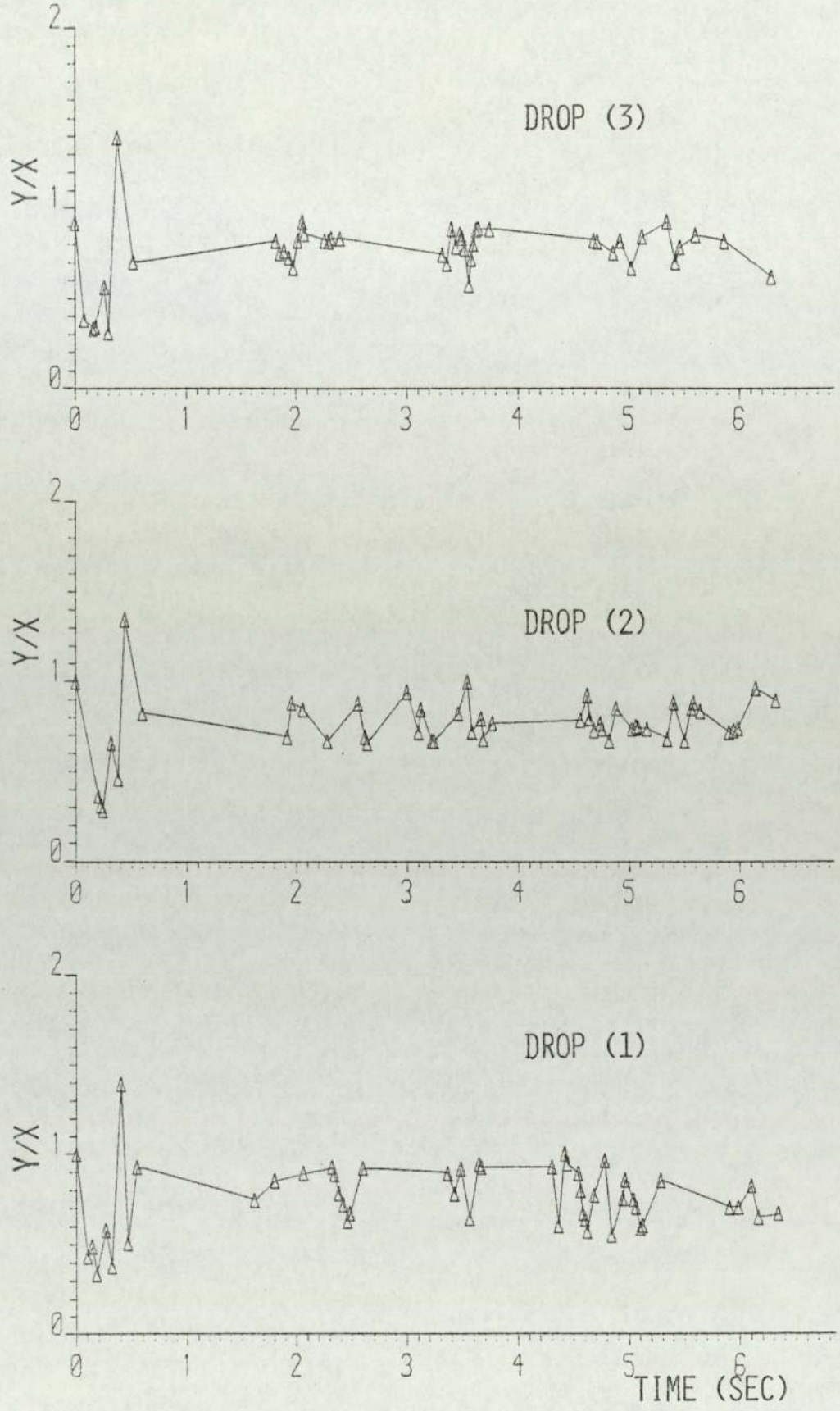

FIG. G.8 AXES RATIO VS. TIME, RUN-30.

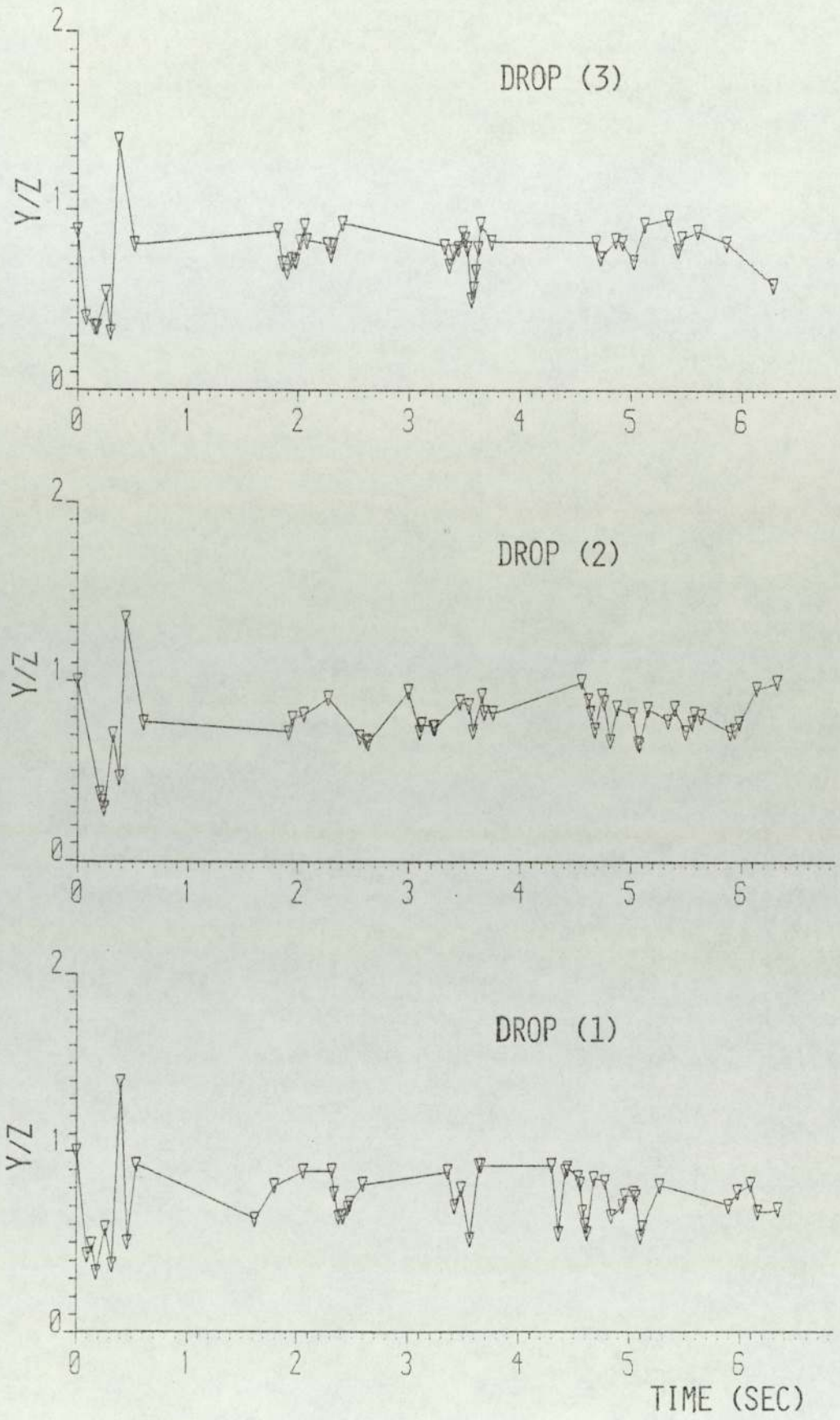

FIG. G.9 AXES RATIO VS. TIME, RUN-30.

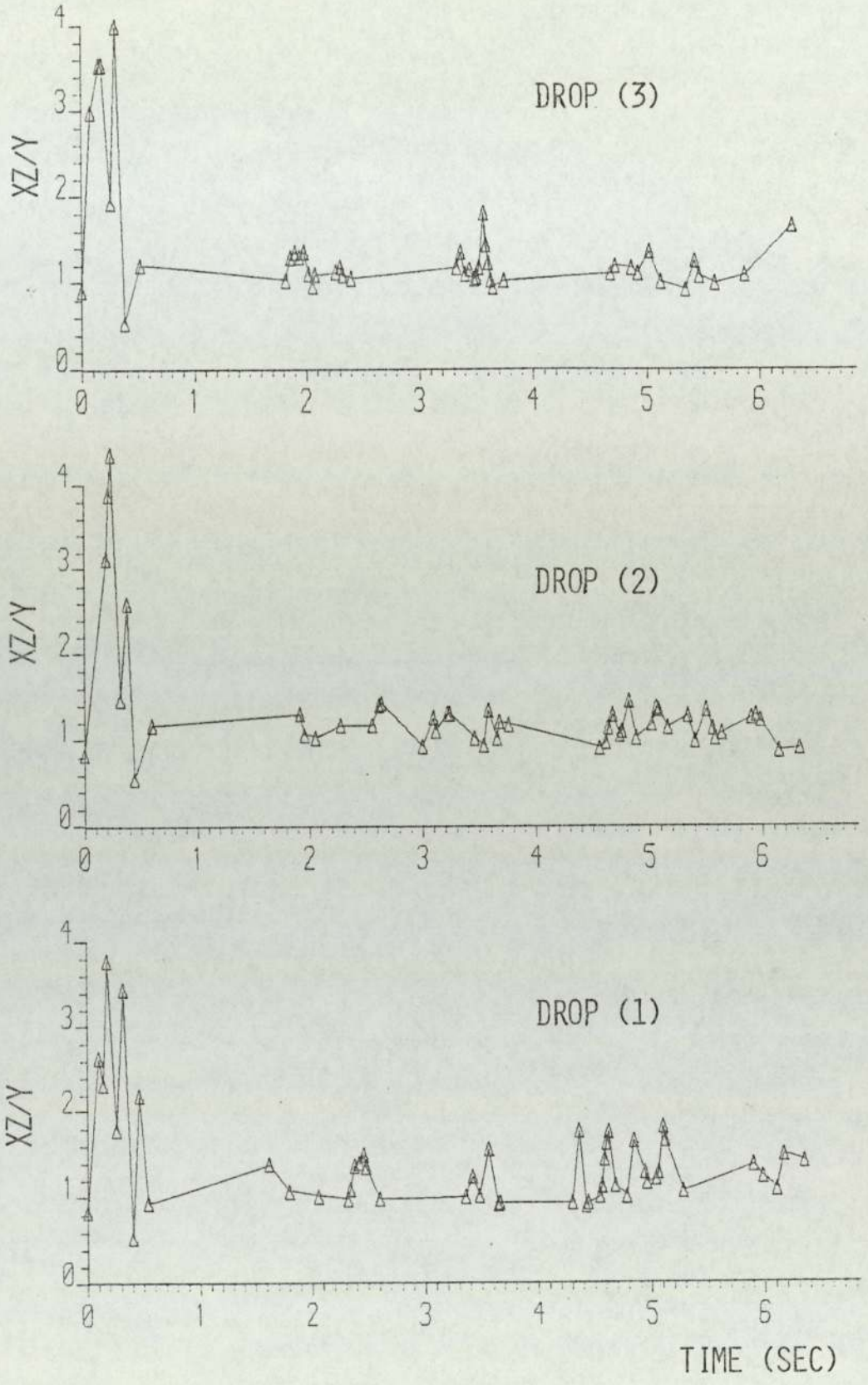

FIG.G.10 AXES RATIO VS. TIME, RUN-30

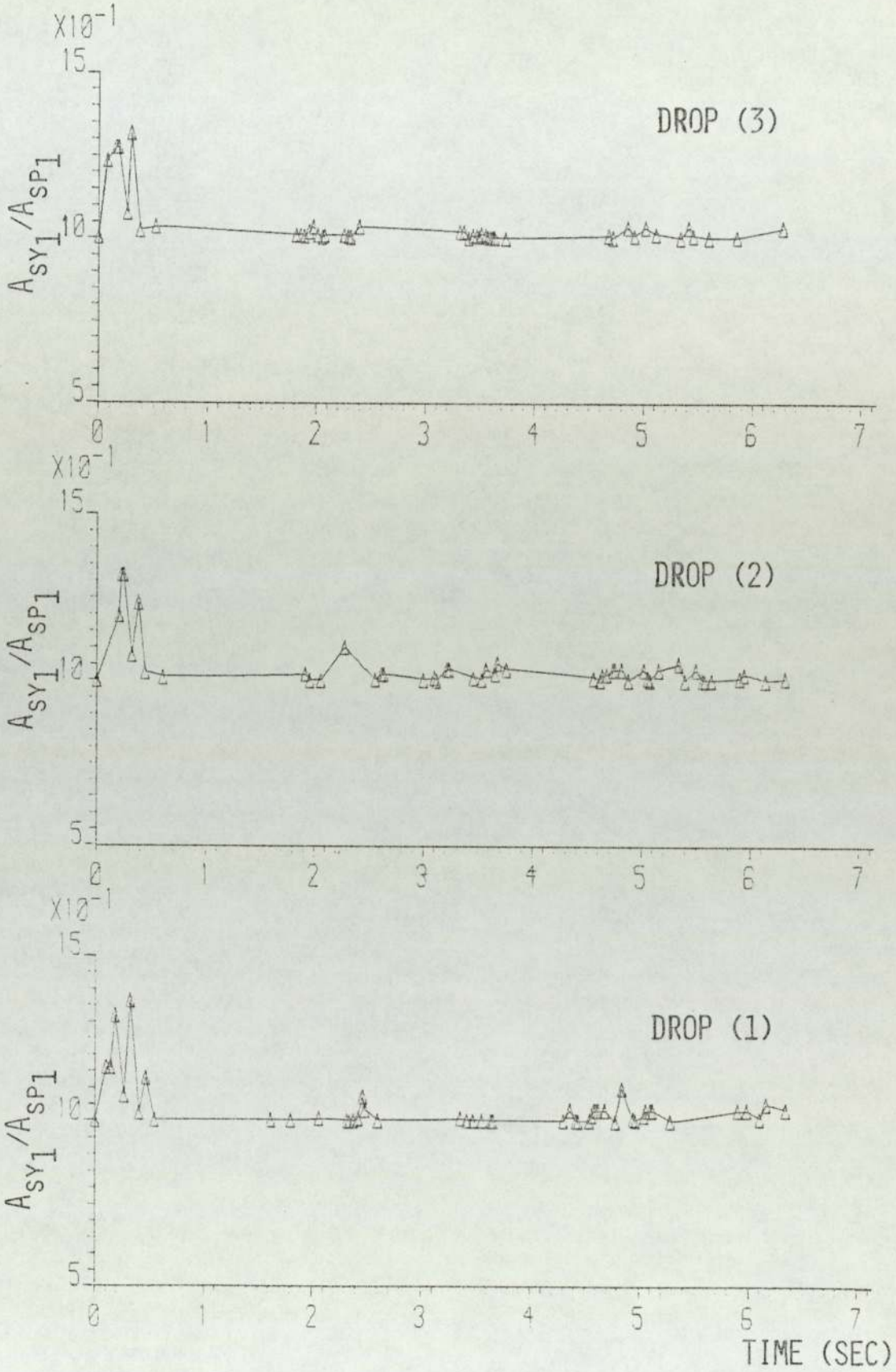

FIG. C.13 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-30, BASED ON DISPLACED VOLUME.

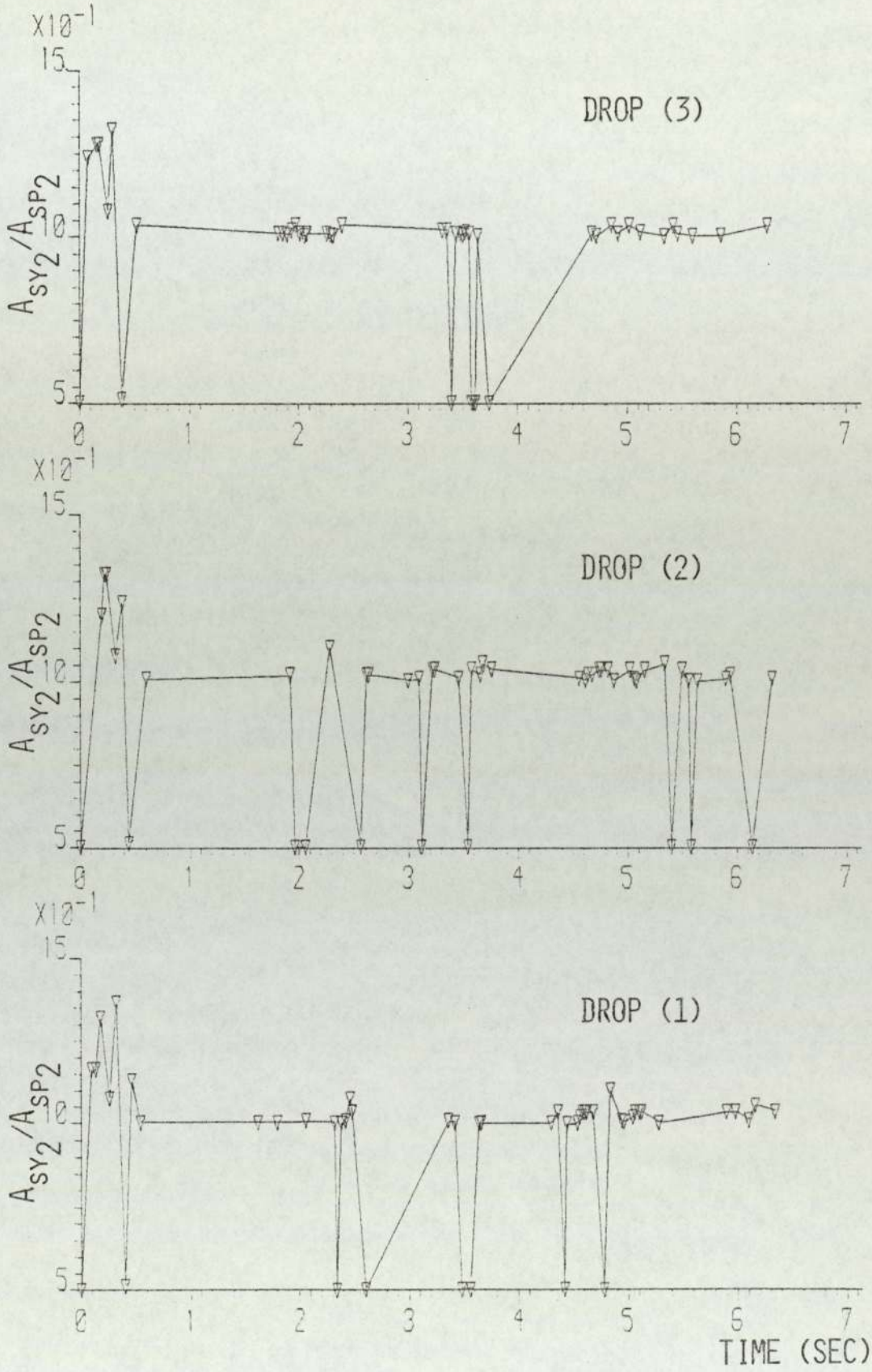

FIG. G.14 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-30, BASED ON MEAN VOLUME.

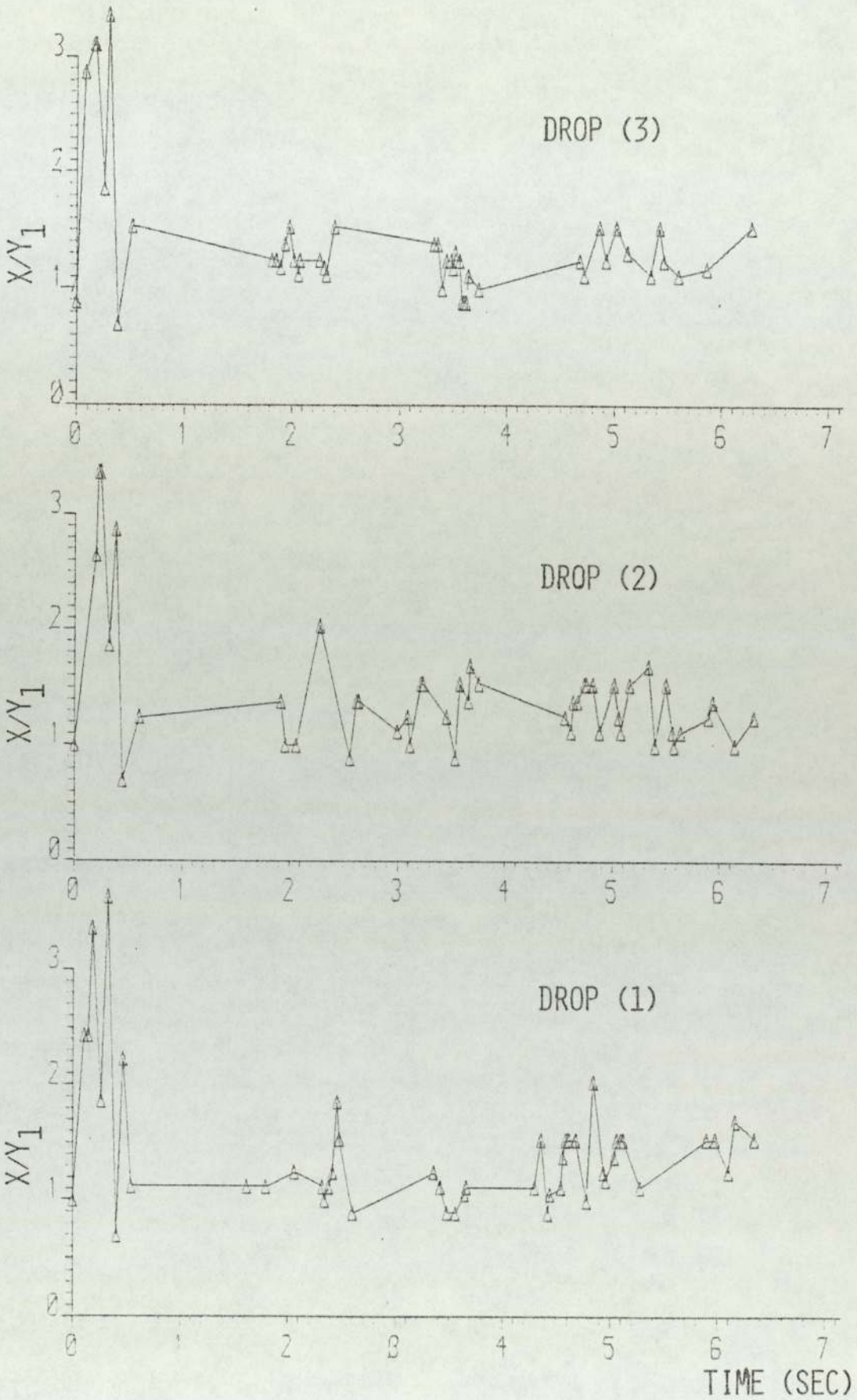

FIG. 6.15 AXES RATIO VS. TIME, RUN-30.

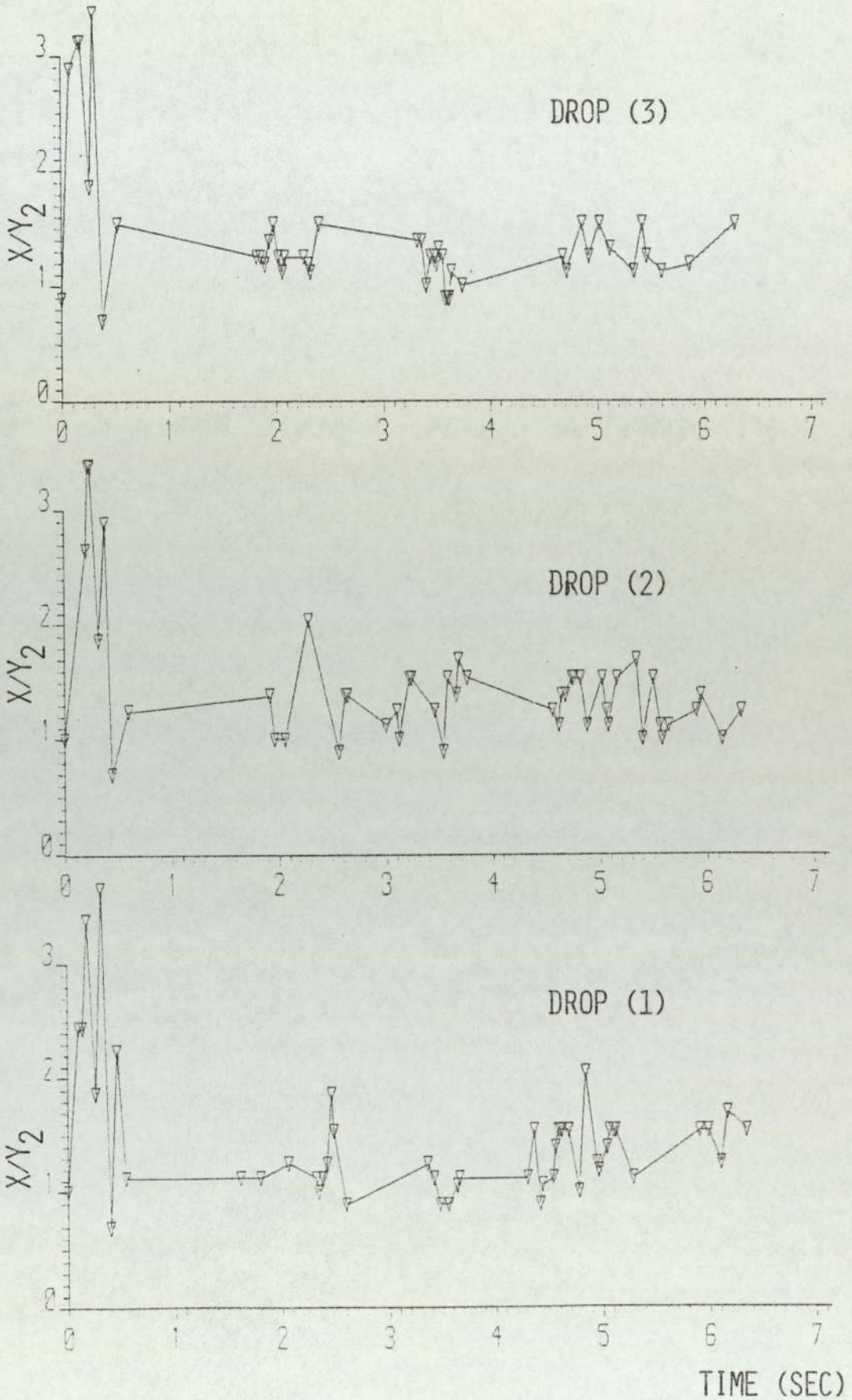

FIG. G.1E AXES RATIO VS. TIME, RUN-30.

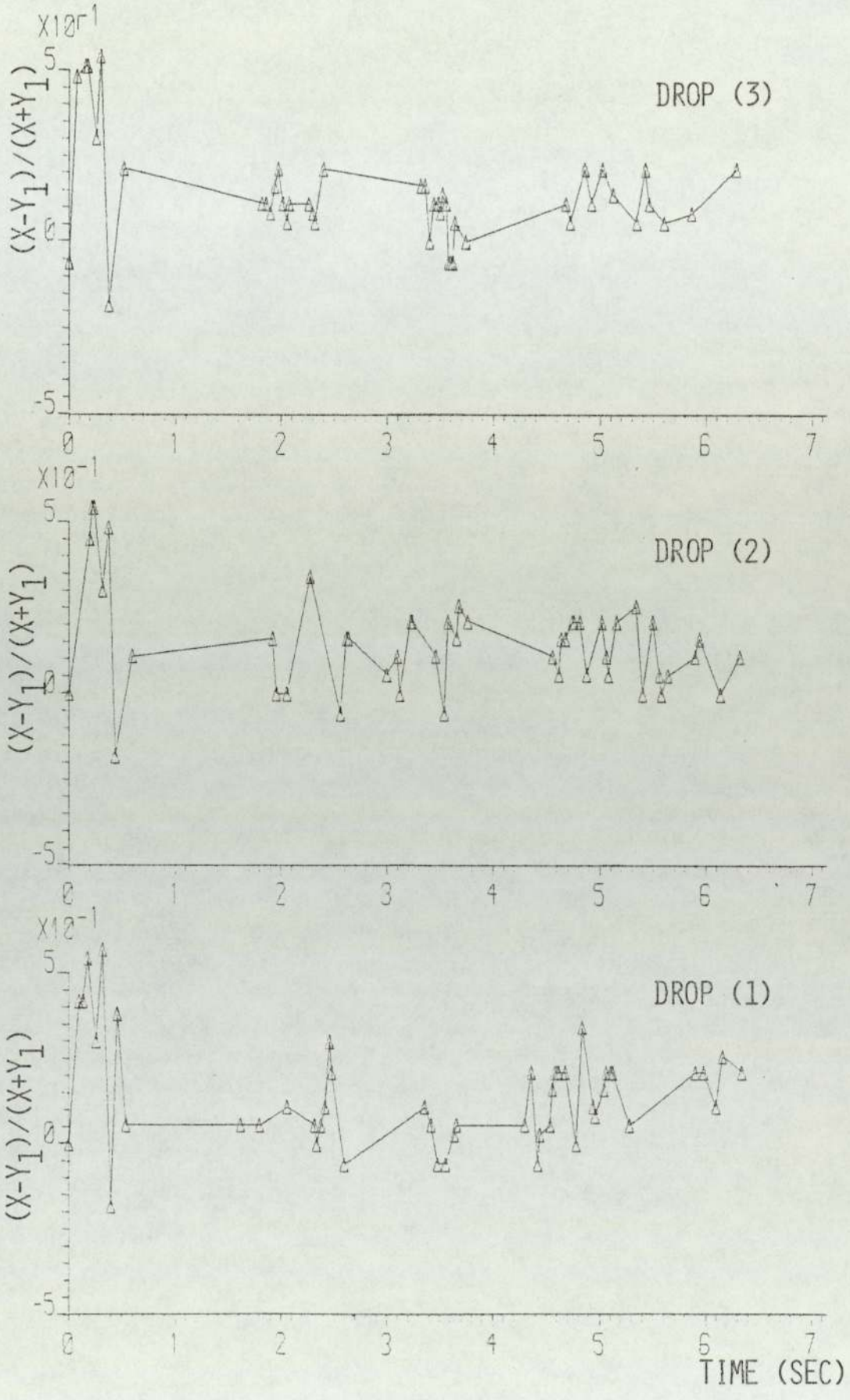

FIG. G.17 DEFORMATION RATIO VS. TIME, RUN-30.

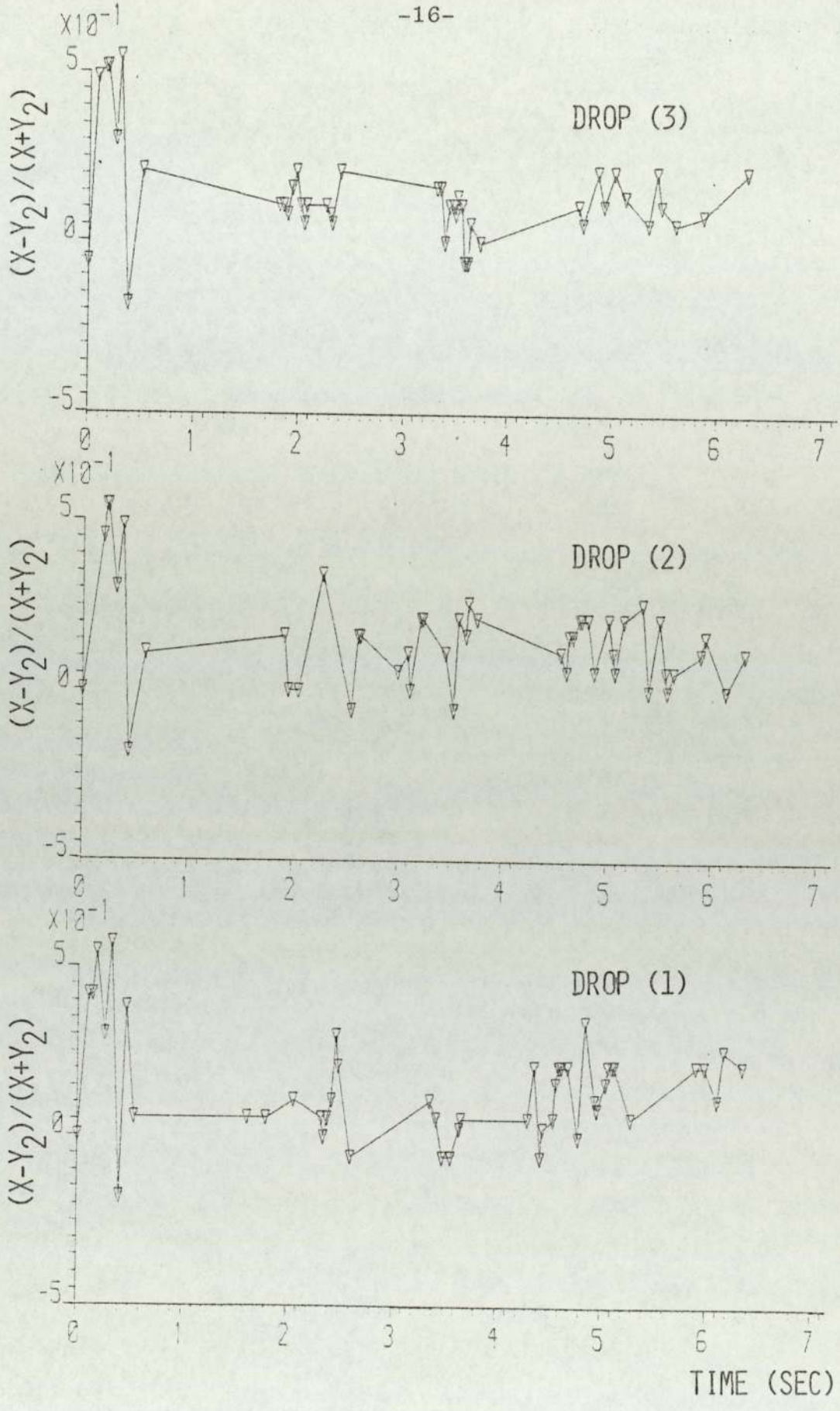

FIG. G.18 DEFORMATION RATIO VS. TIME, RUN-30.

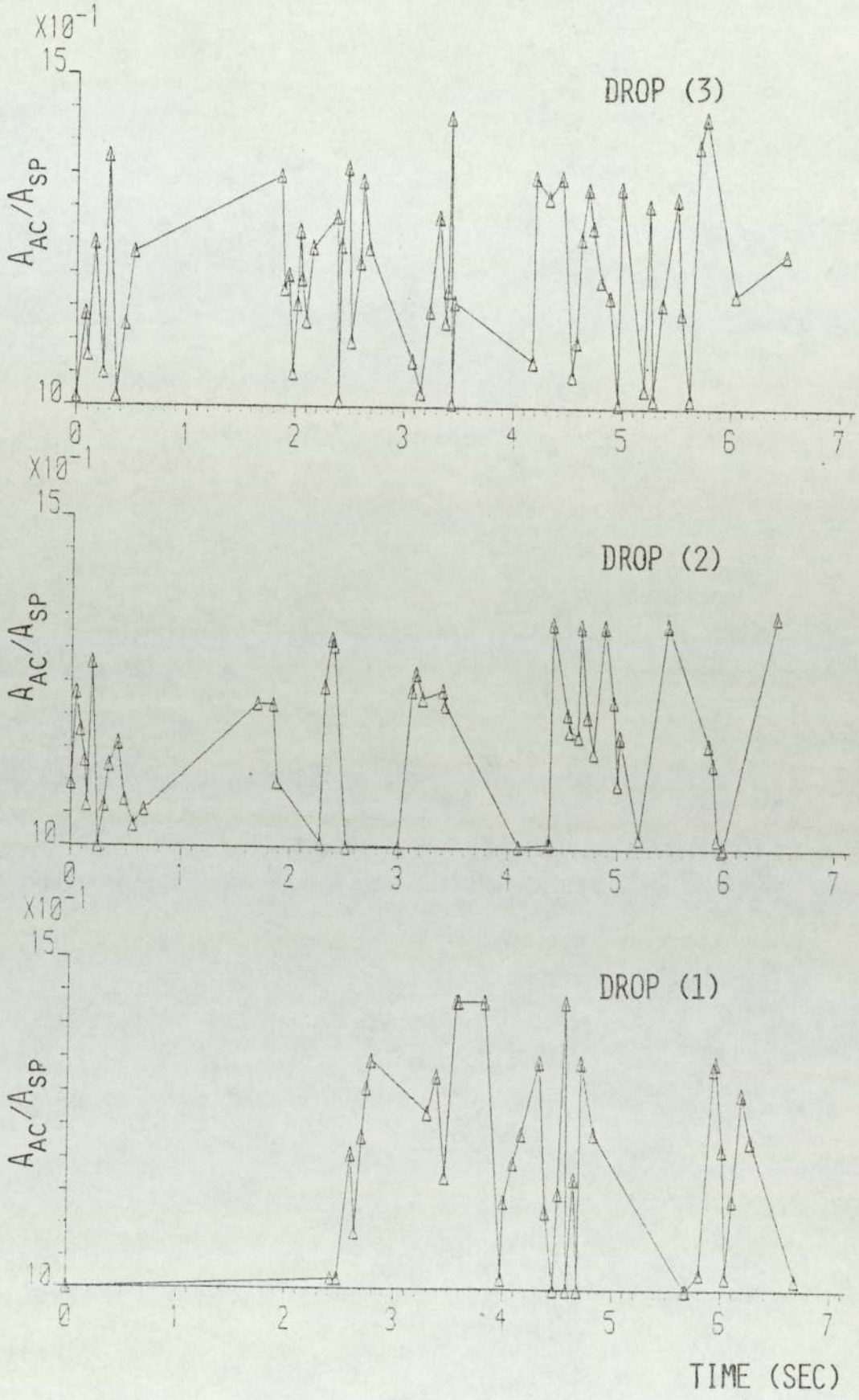

FIG. G.19 AREA RATIO VS. TIME, RUN-31.

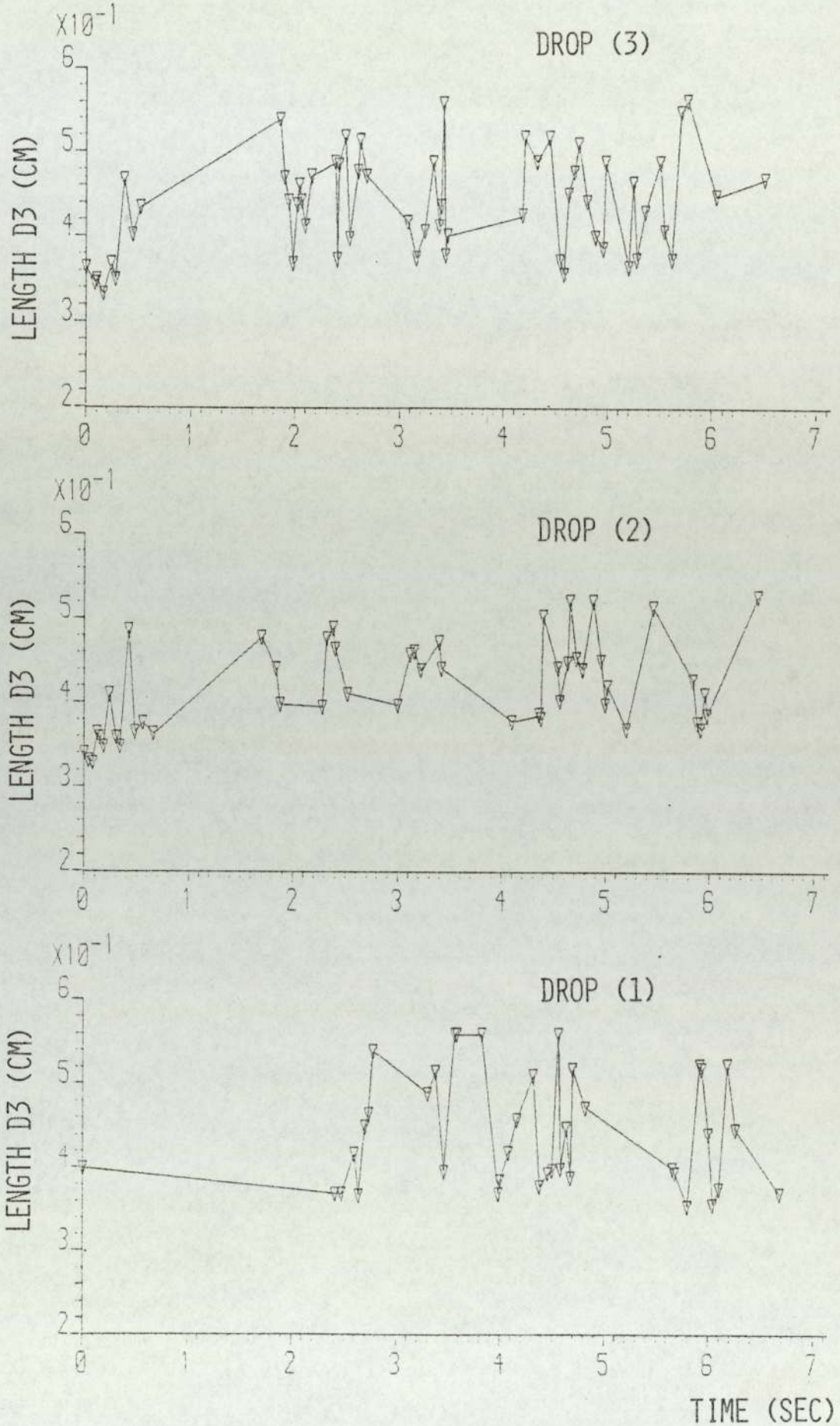

FIG. G.20 LENGTH D3 VS. TIME, RUN-31.

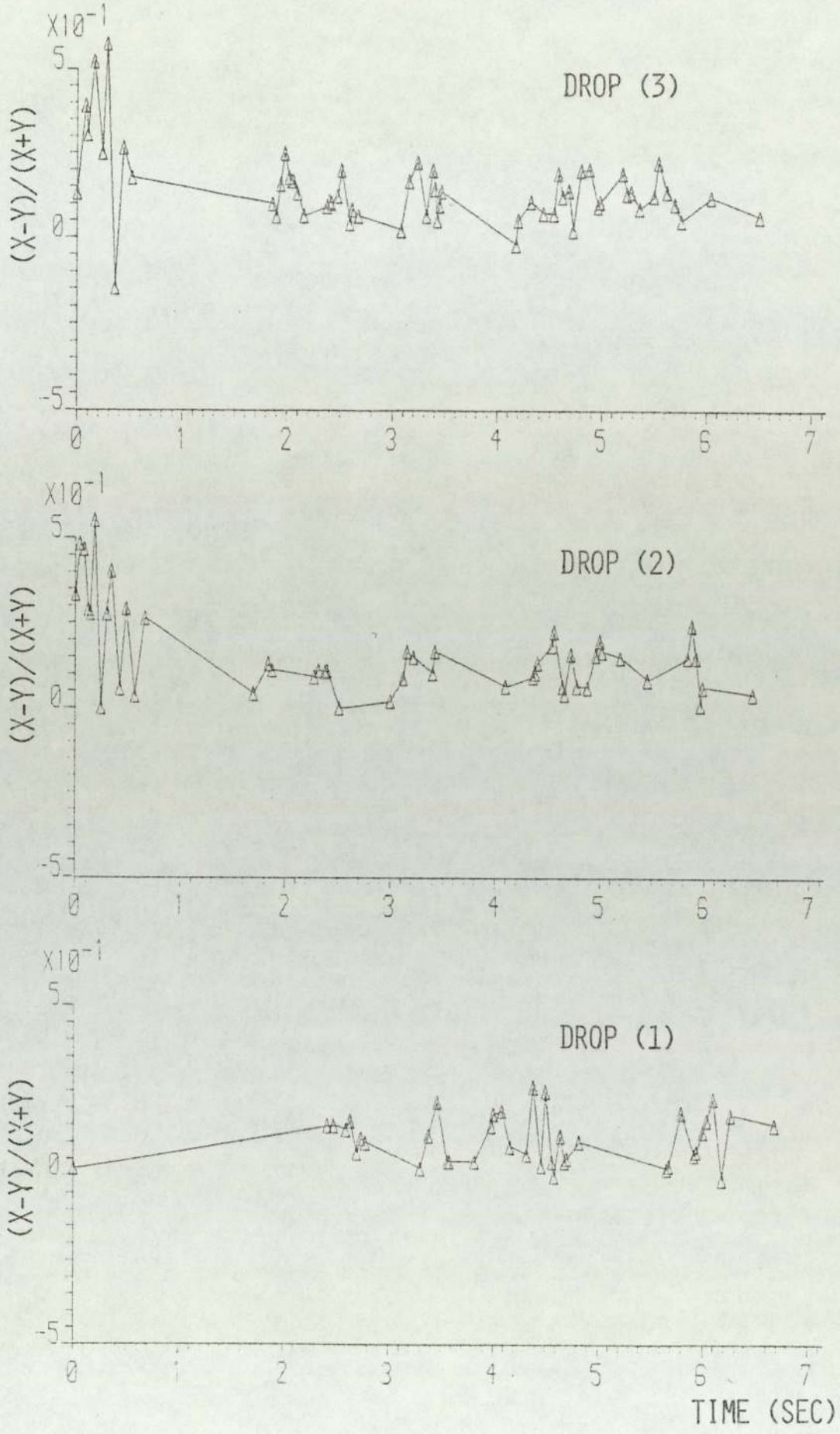

FIG. G.21 DEFORMATION RATIO VS. TIME, RUN-31.

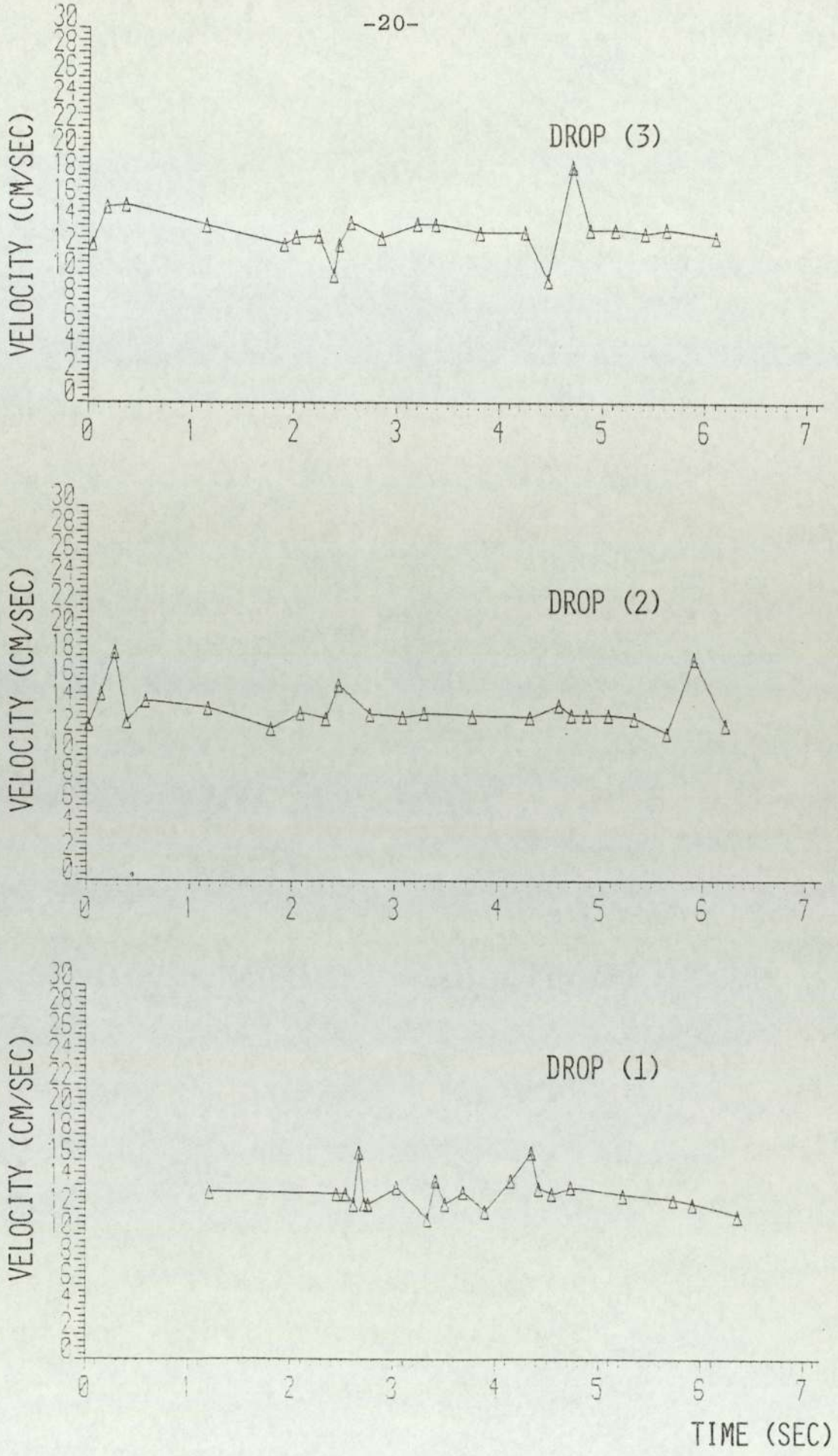

FIG. G.22 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-31.

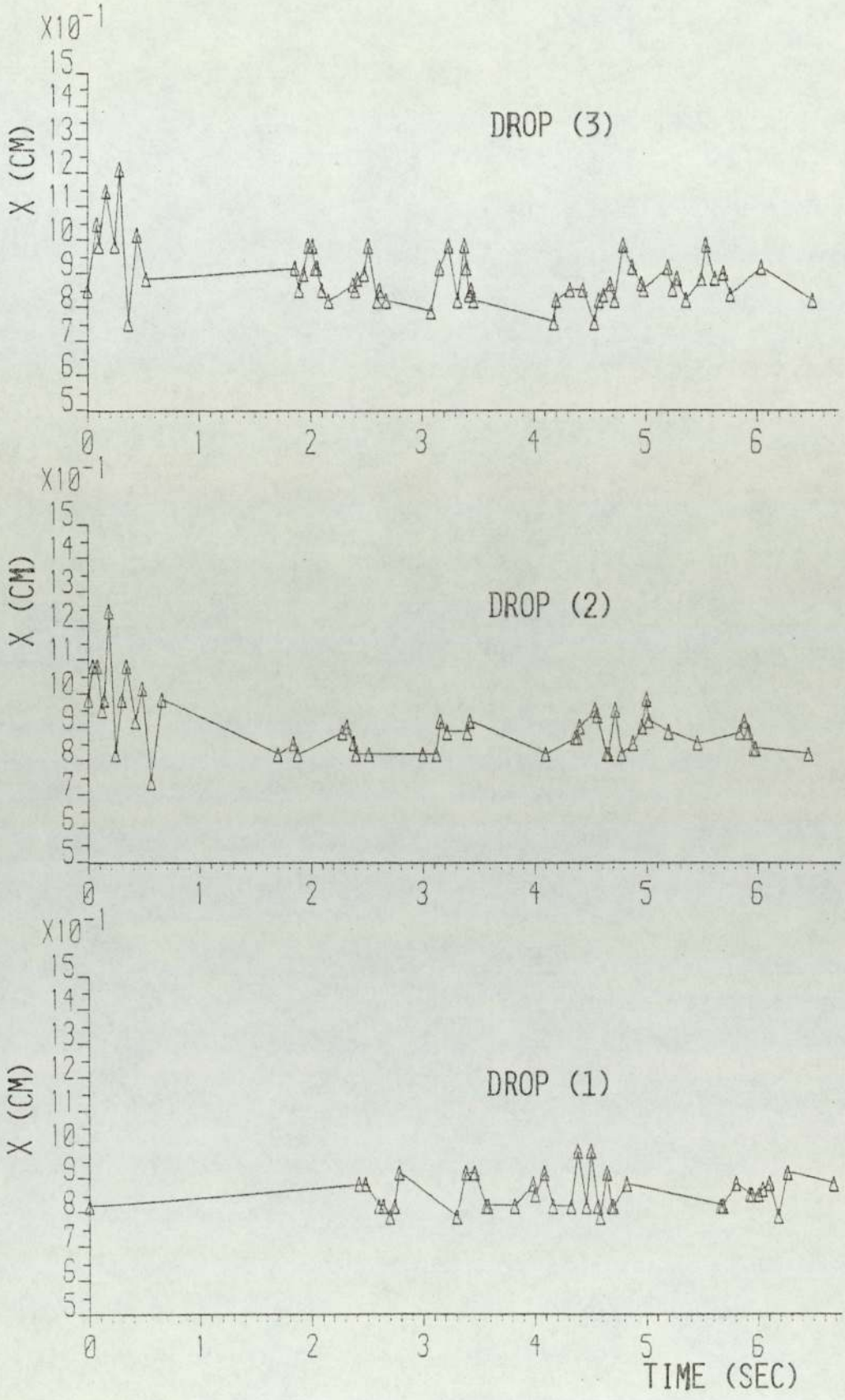

FIG. G.23 X VS. TIME, RUN-31.

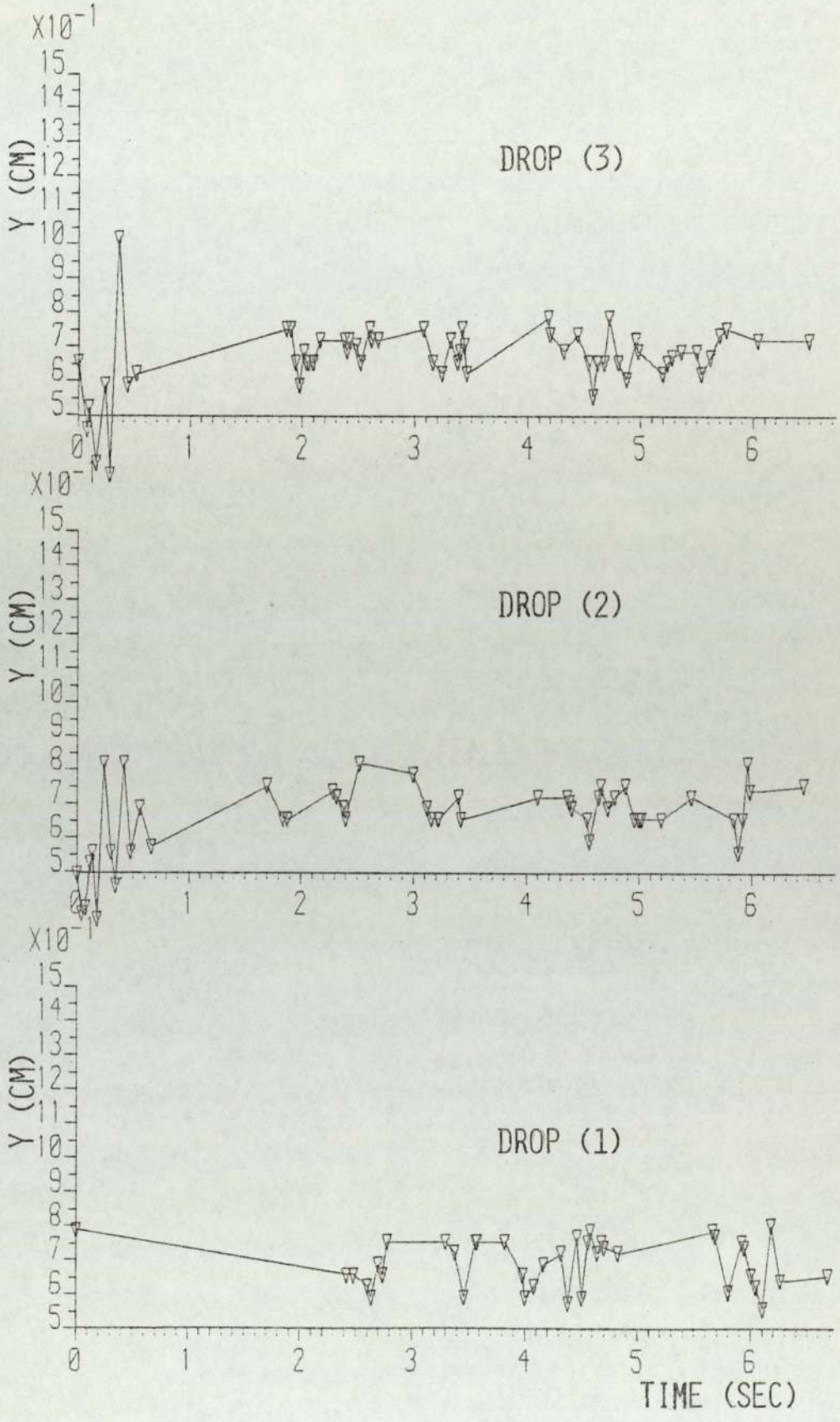

FIG. G.24 Y VS. TIME, RUN-31.

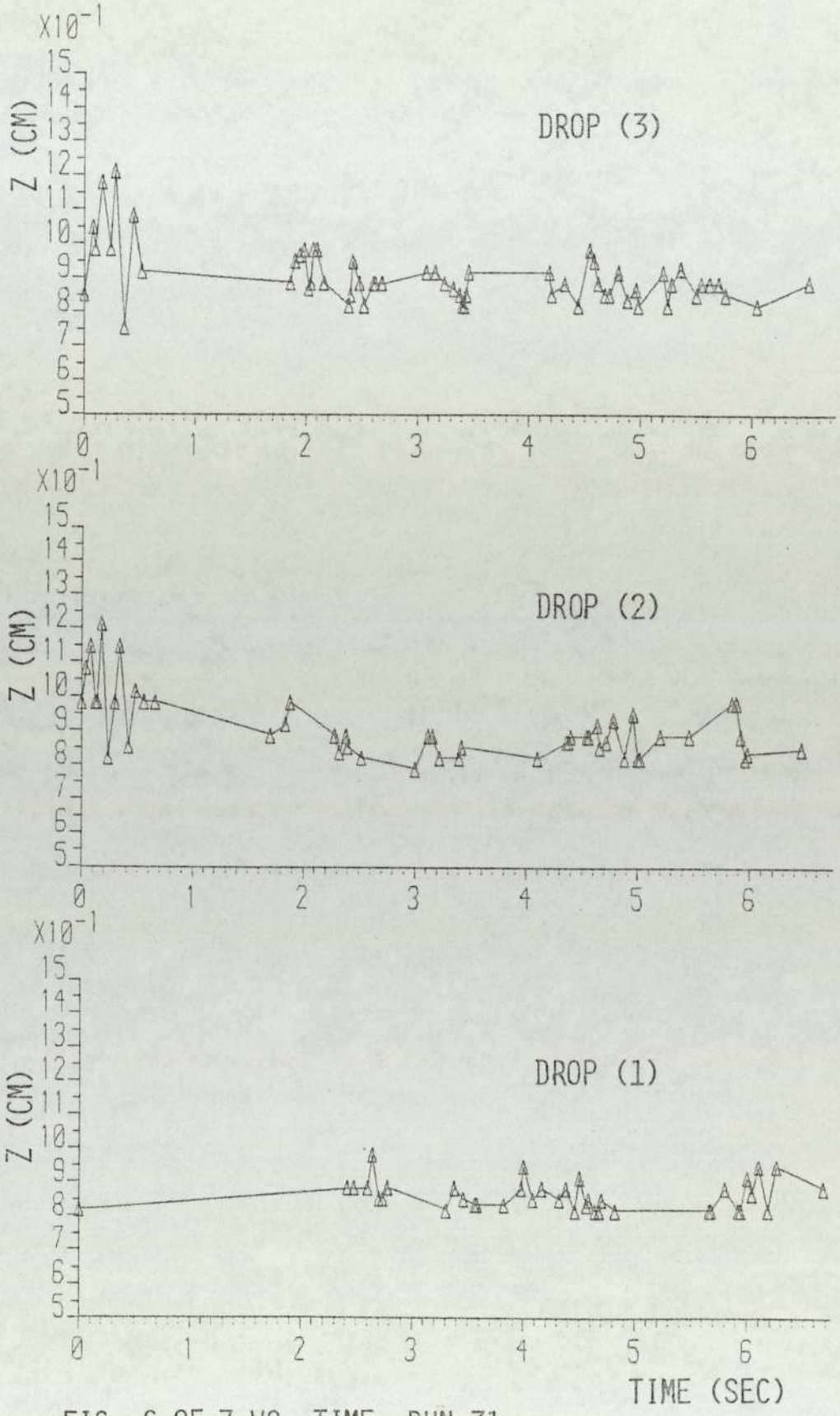

FIG. G.25 Z VS. TIME, RUN-31.

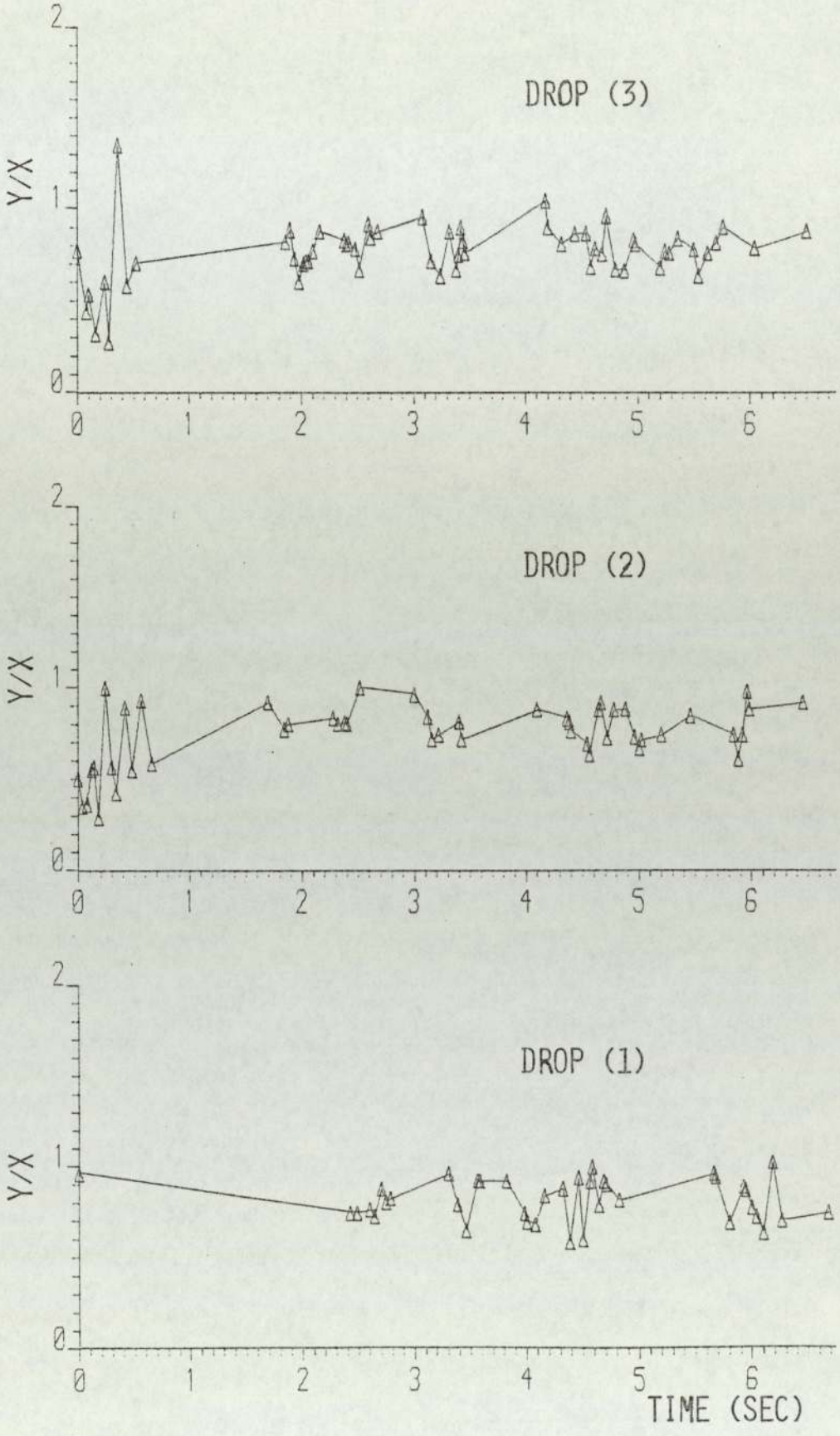

FIG. G.26 AXES RATIO VS. TIME, RUN-31.

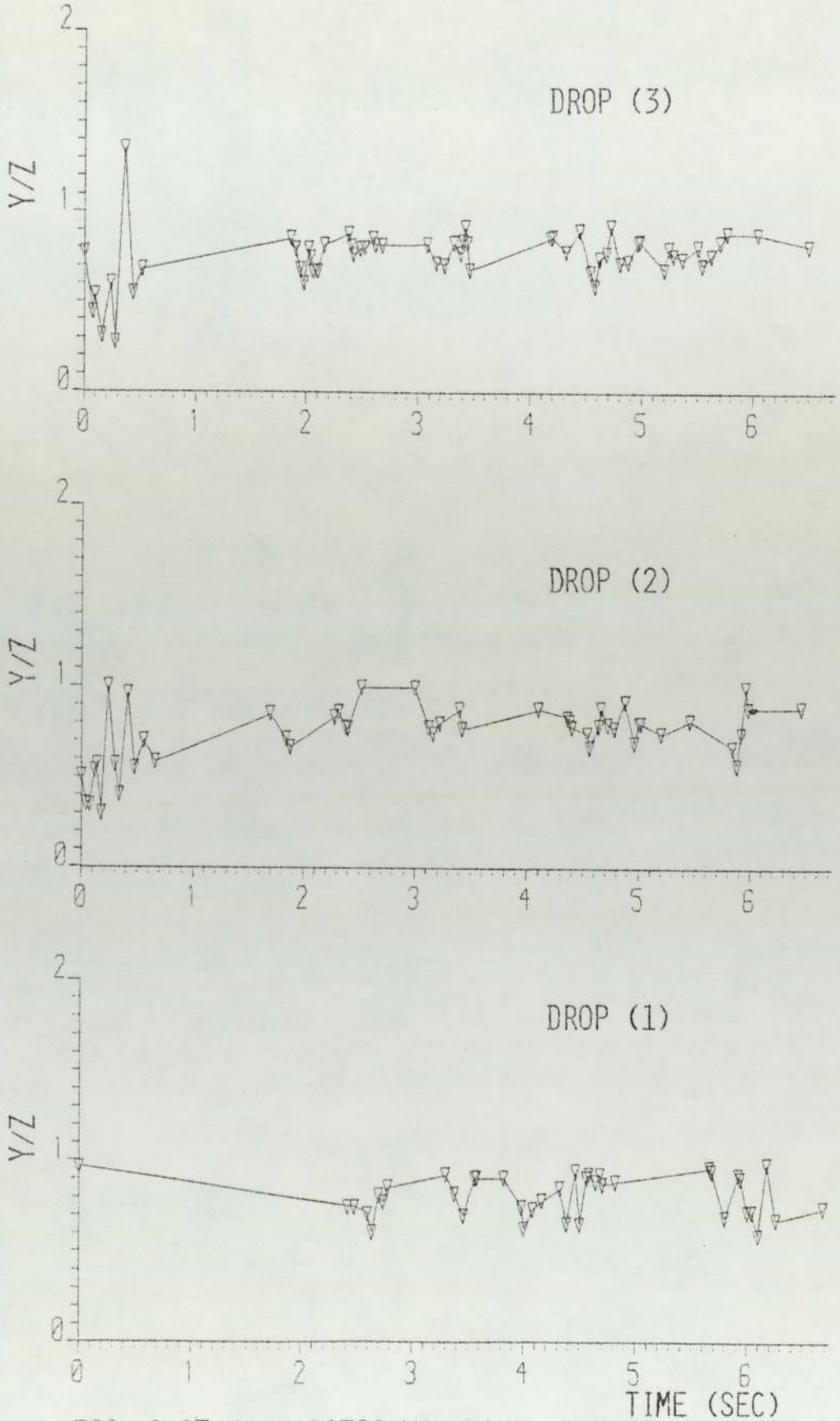

FIG. G.27 AXES RATIO VS. TIME, RUN-31.

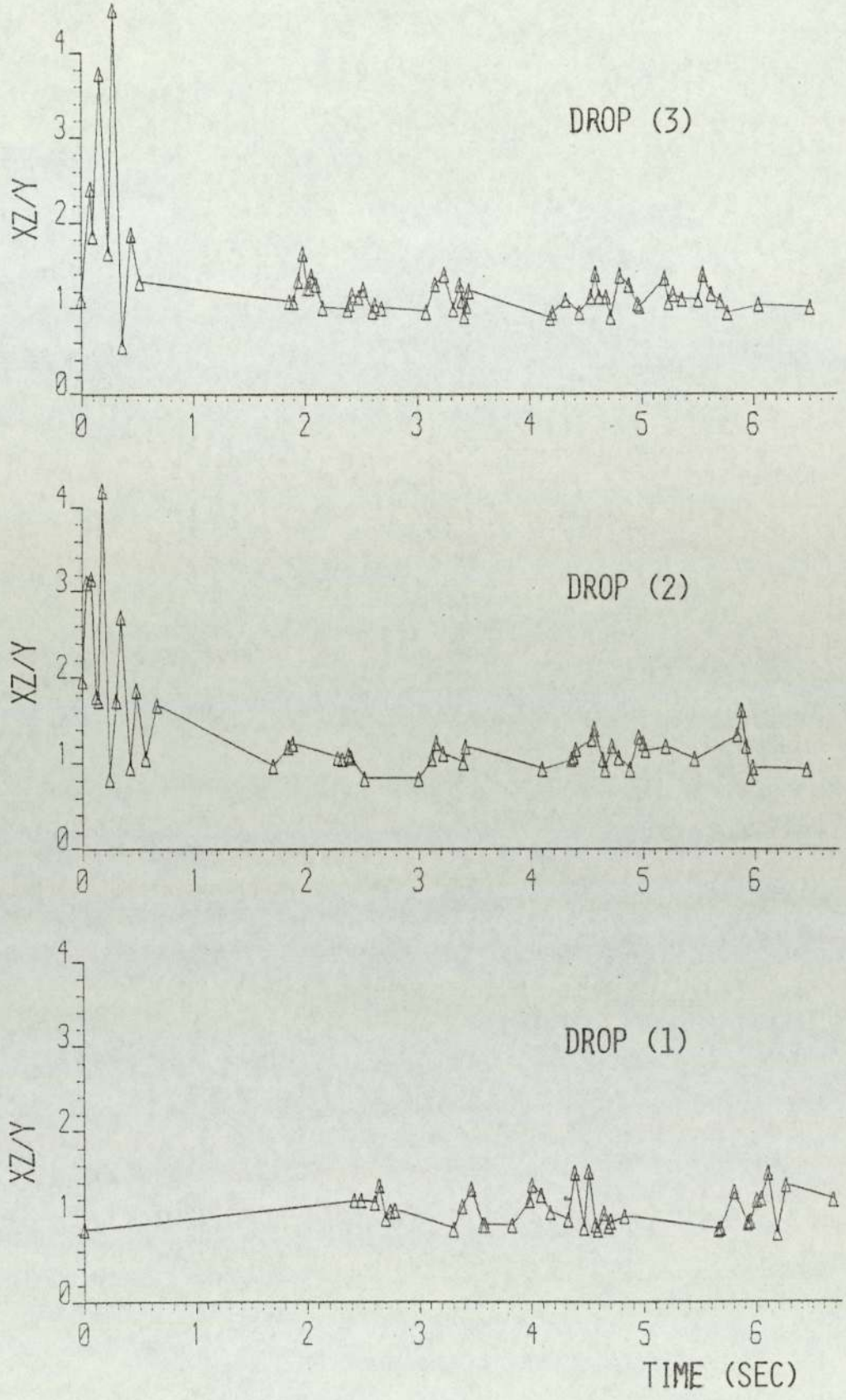

FIG. G.28 AXES RATIO VS. TIME, RUN-31.

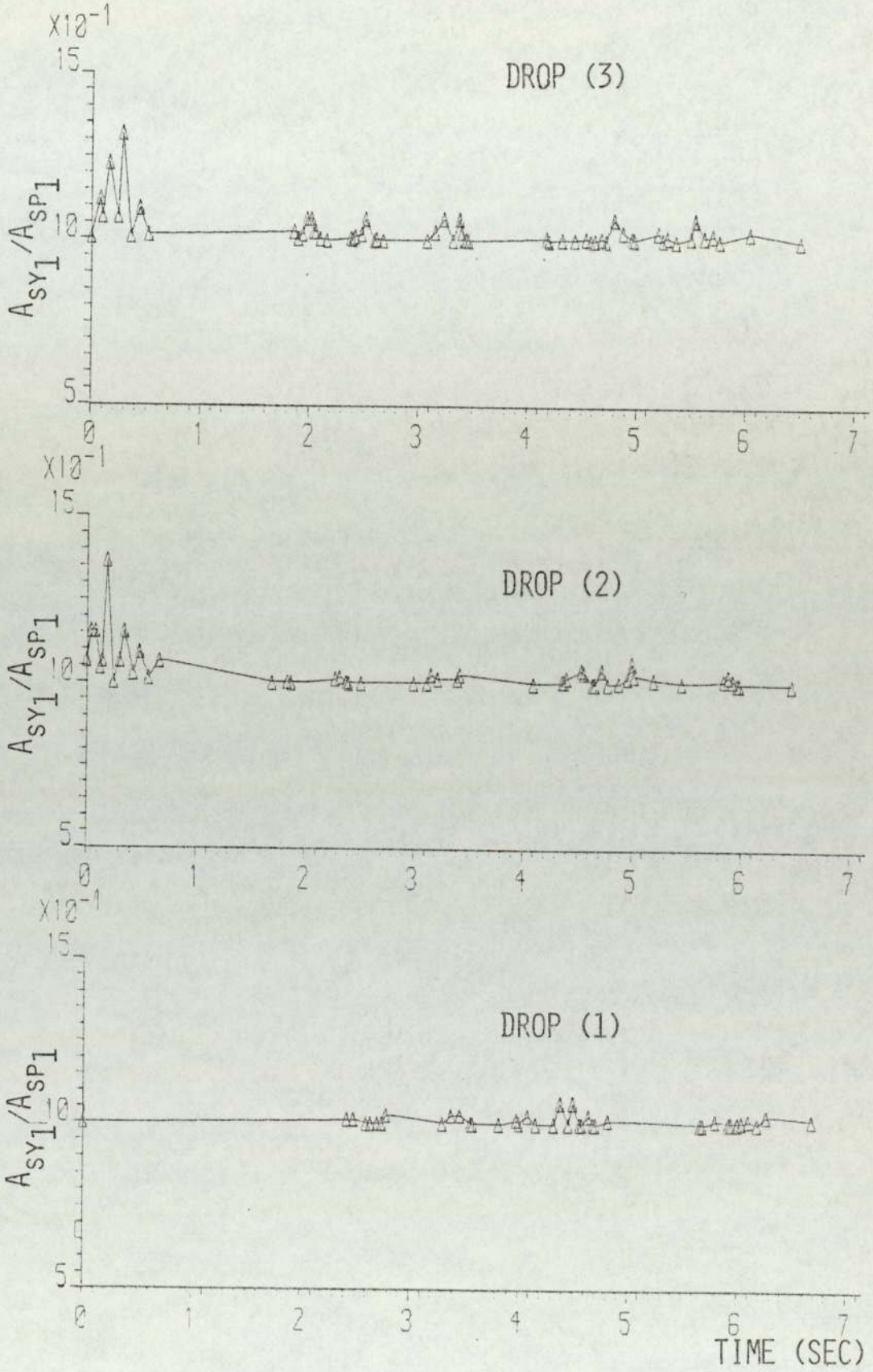

FIG. G.29 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-31, BASED ON DISPLACED VOLUME.

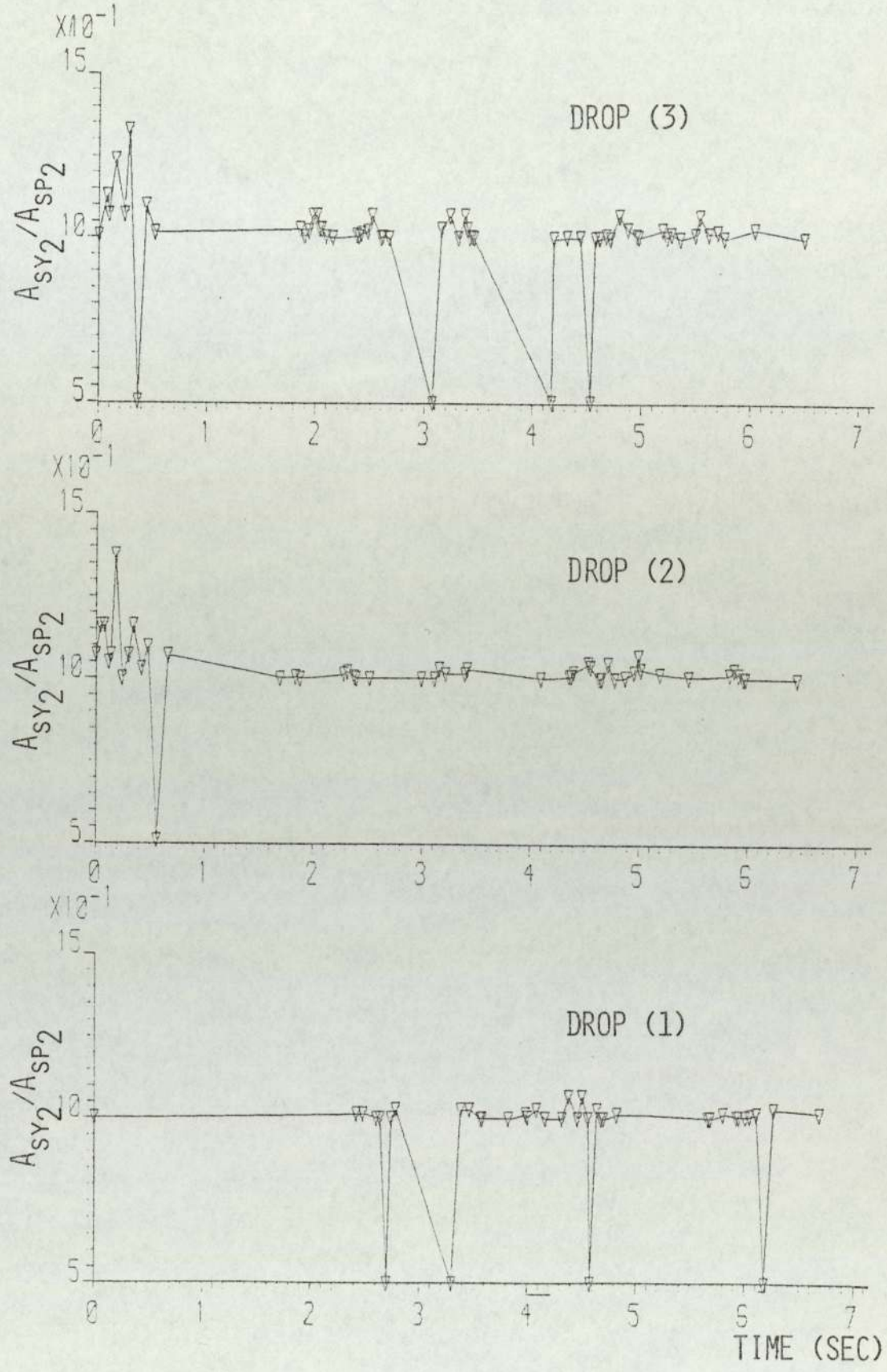

FIG. G.30 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-31, BASED ON MEAN VOLUME.

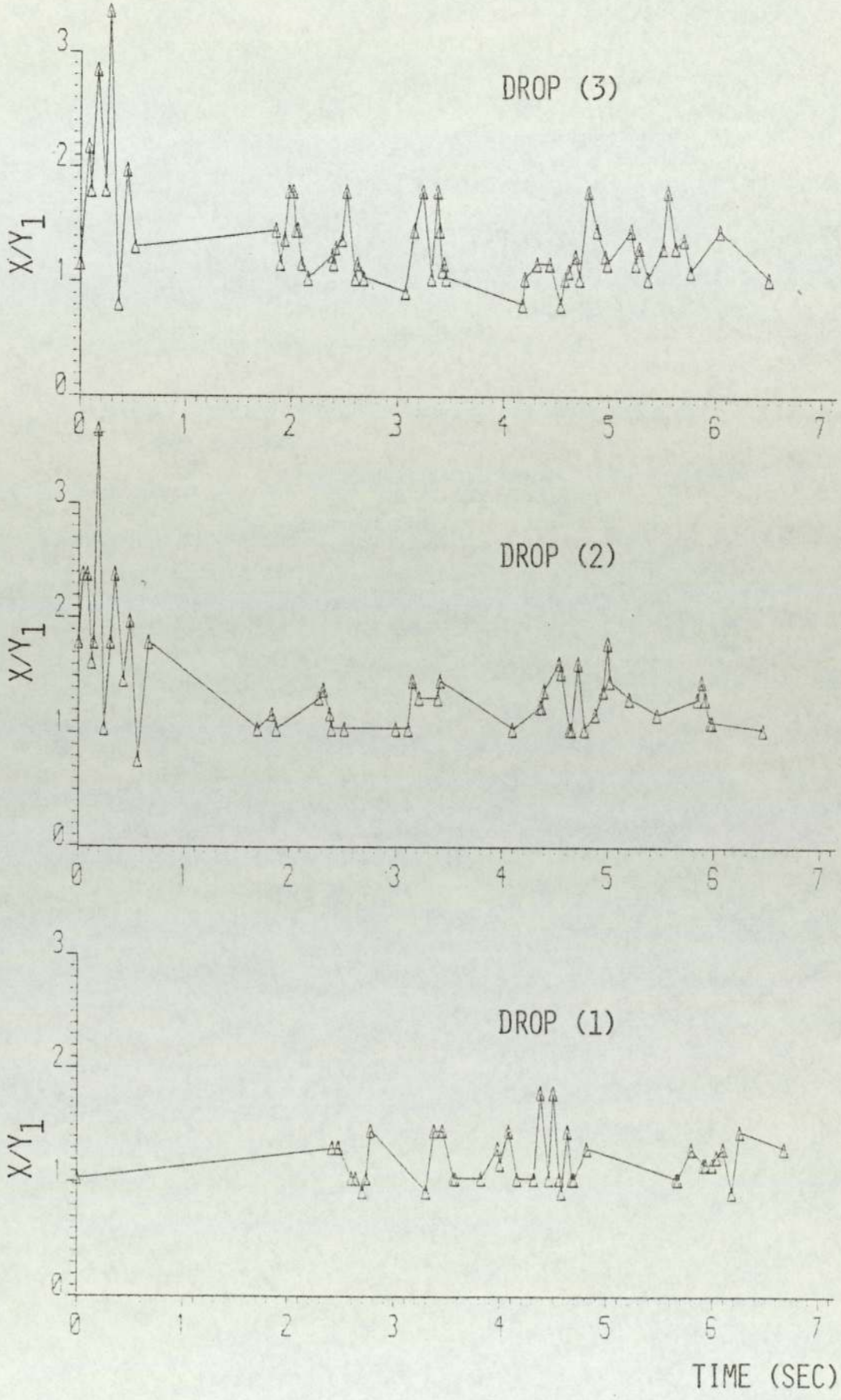

FIG.G.31 AXES RATIO VS. TIME, RUN-31.

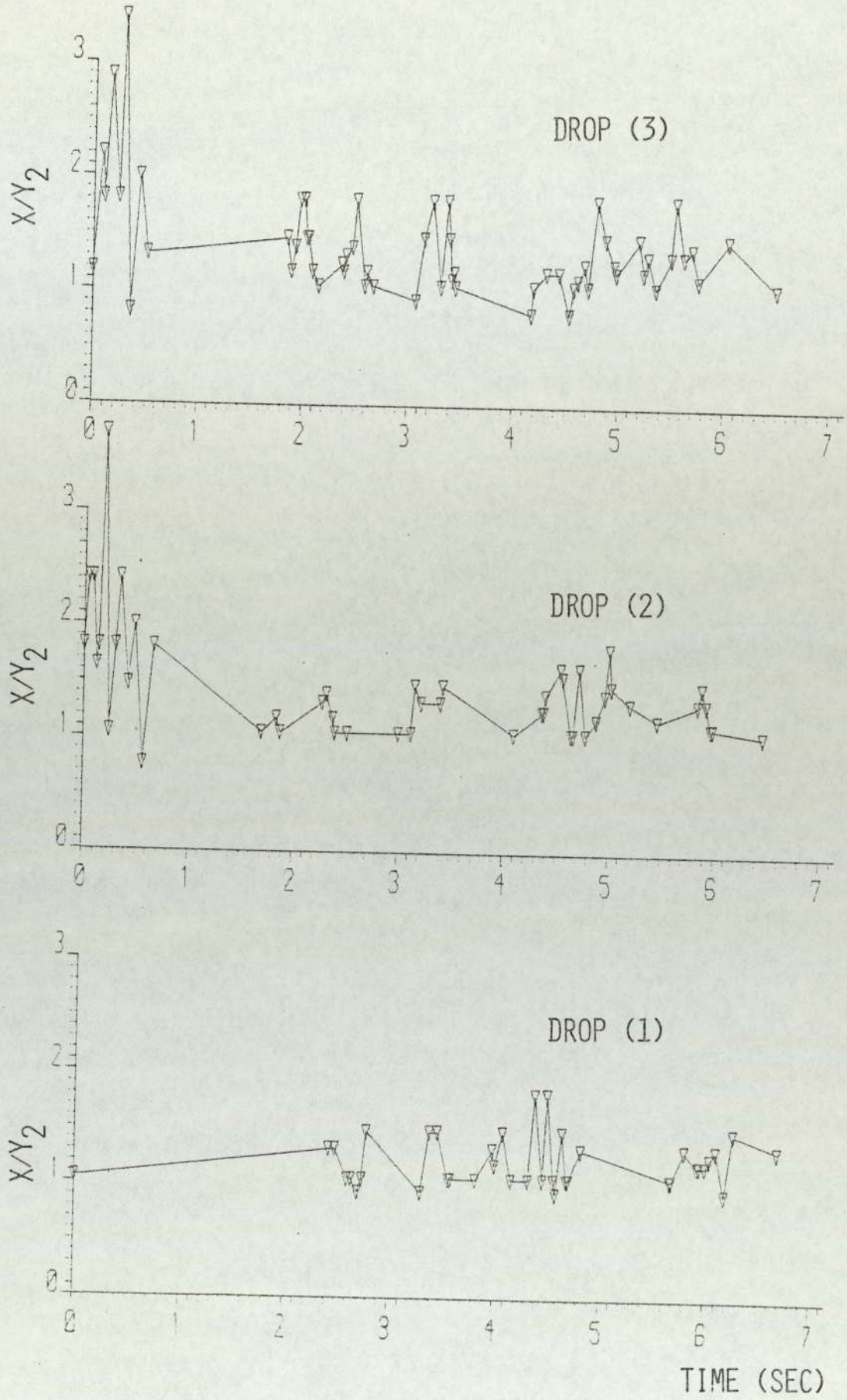

FIG. G.32 AXES RATIO VS. TIME, RUN-31.

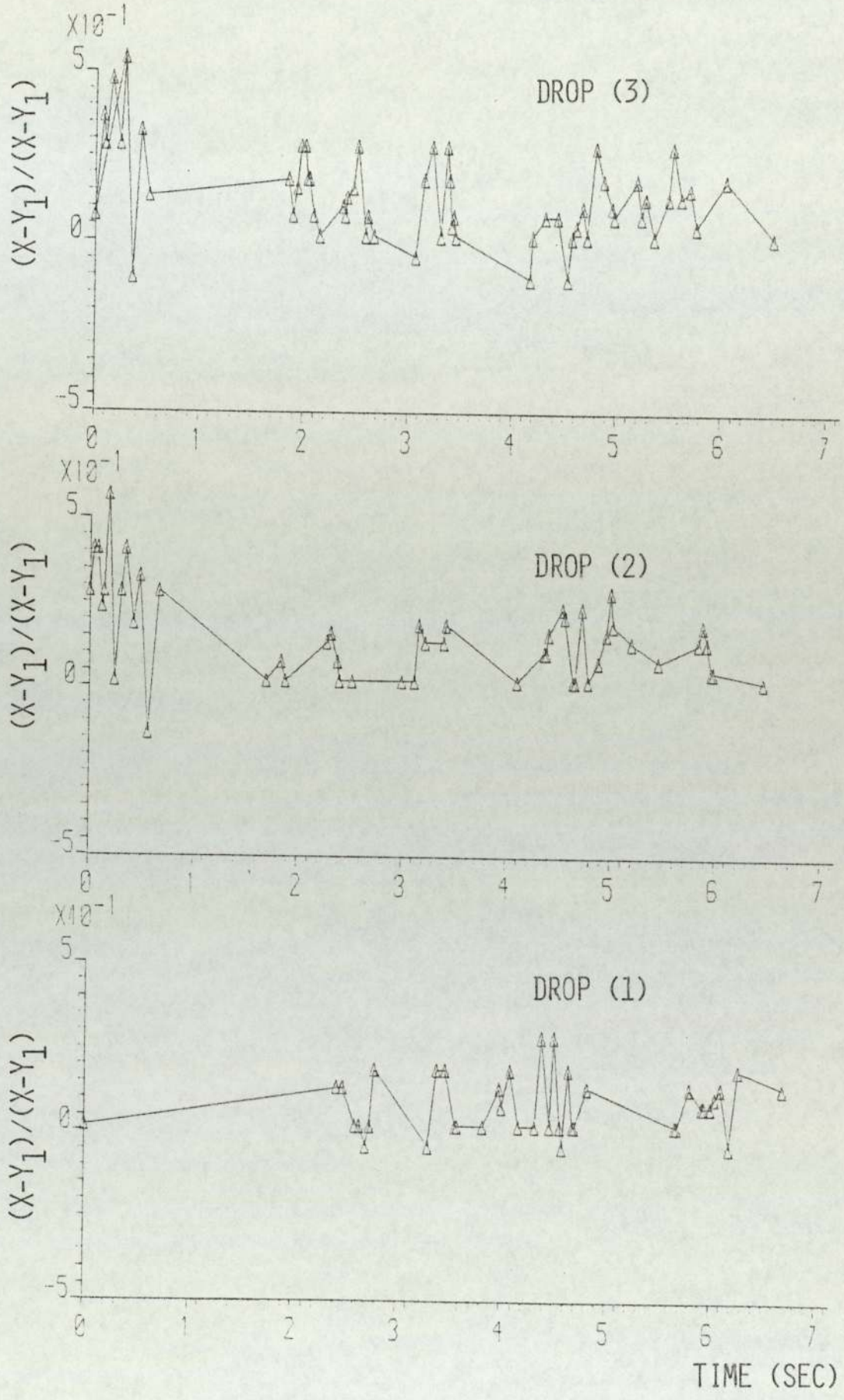

FIG. G.33 DEFORMATION RATIO VS. TIME, RUN-31.

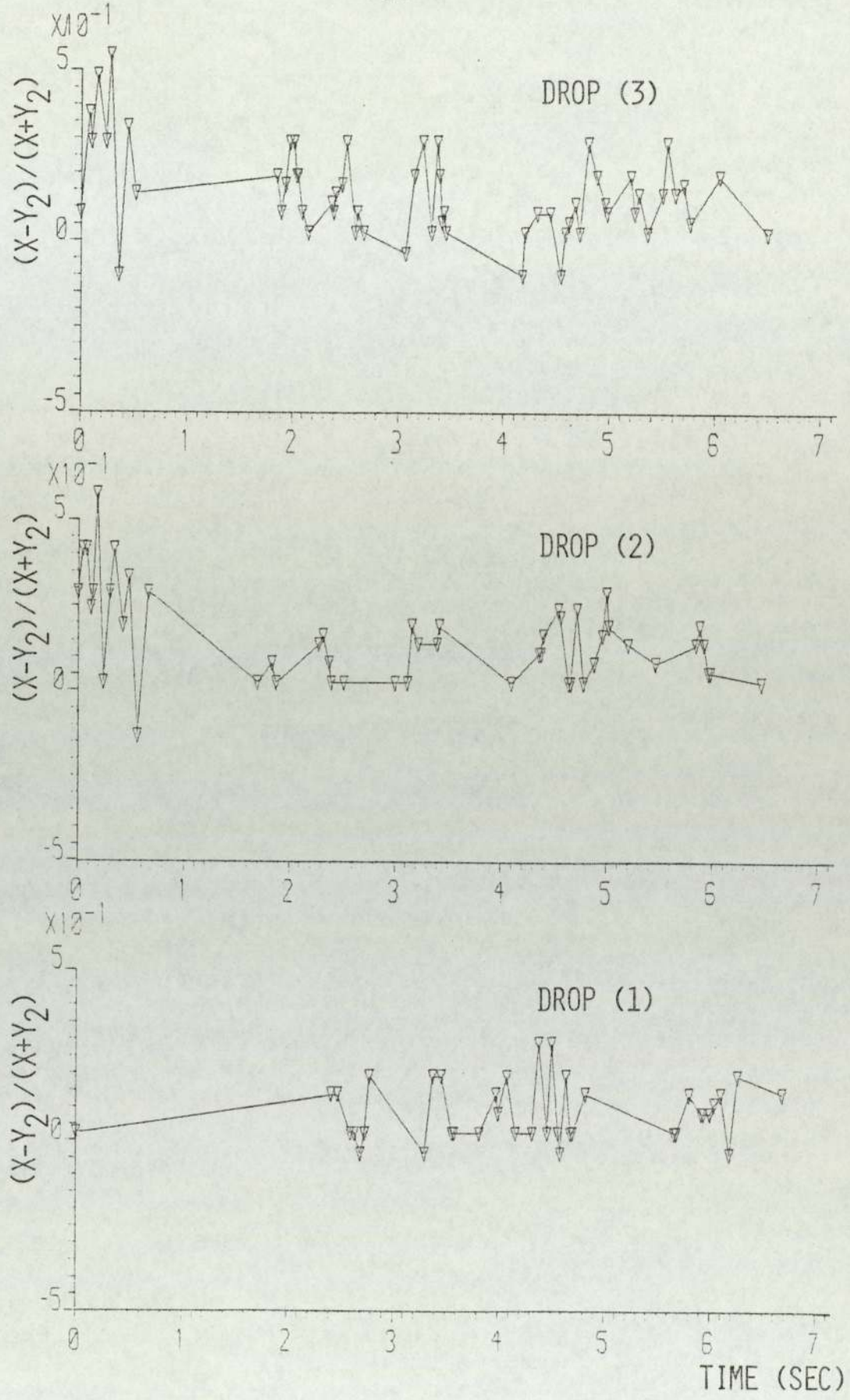

FIG. G.34 DEFORMATION RATIO VS. TIME, RUN-31.

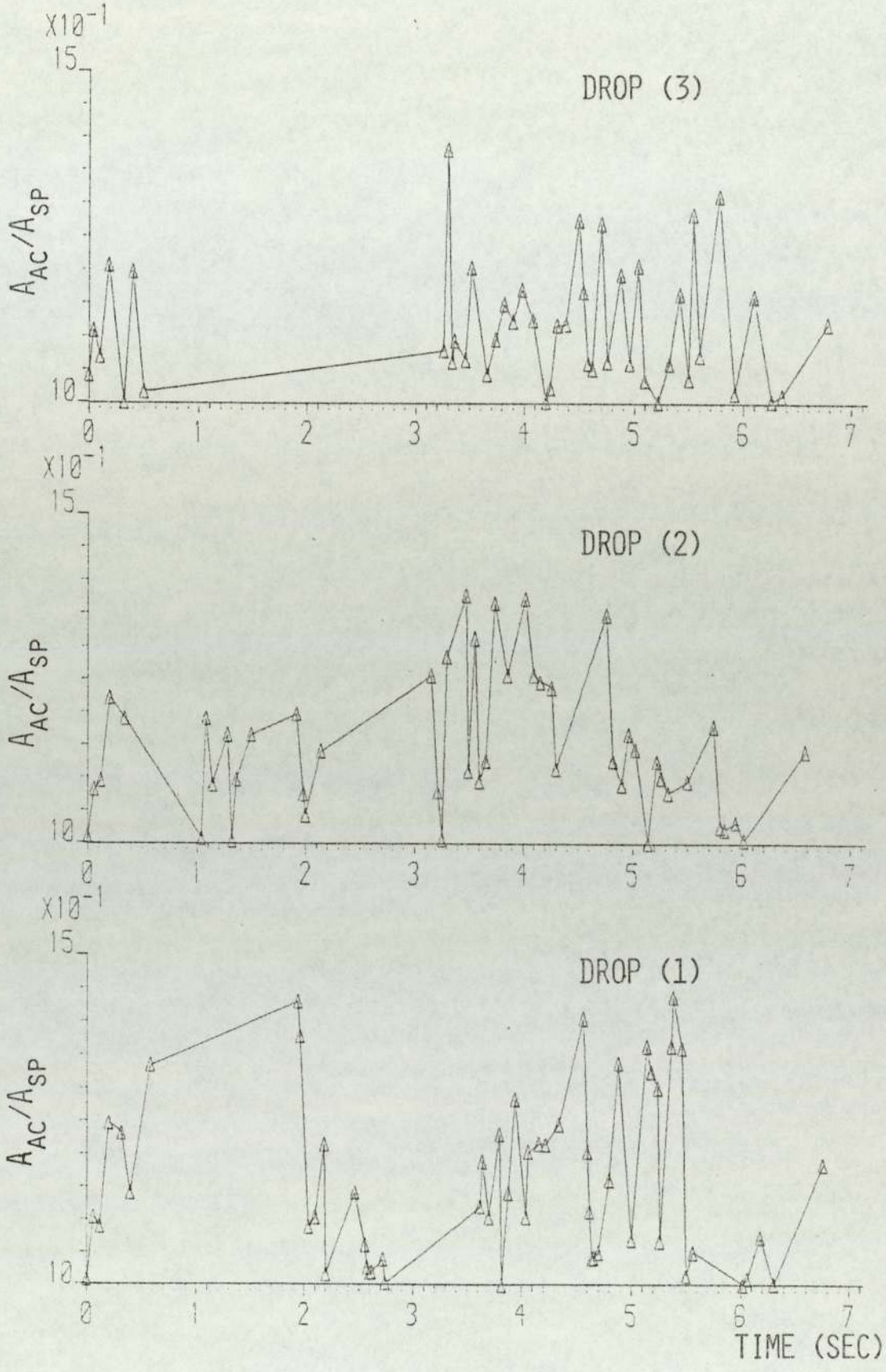

FIG. G.35 AREA RATIO VS. TIME, RUN-32 .

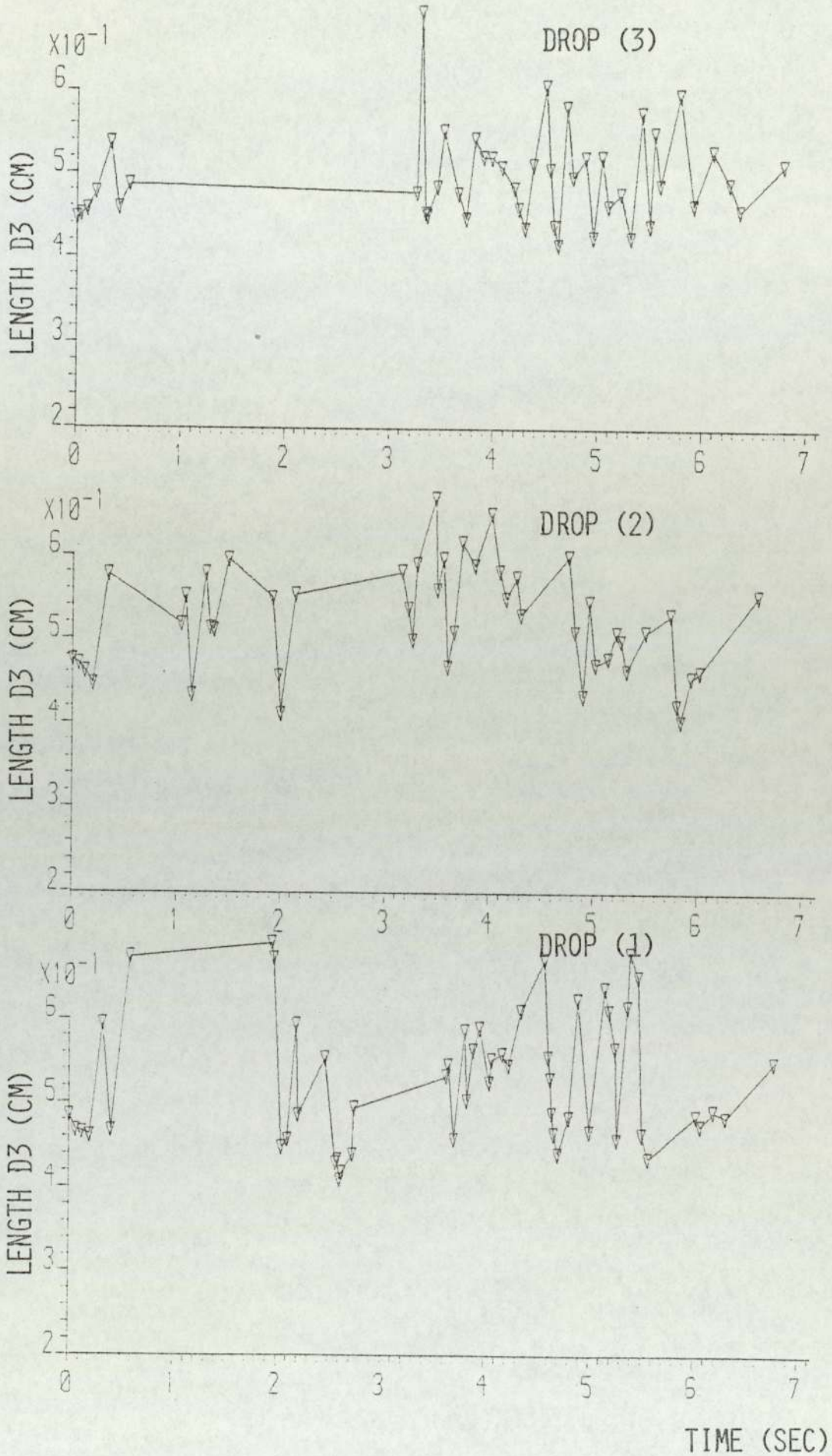

FIG.G.36 LENGTH D3 VS. TIME, RUN-32.

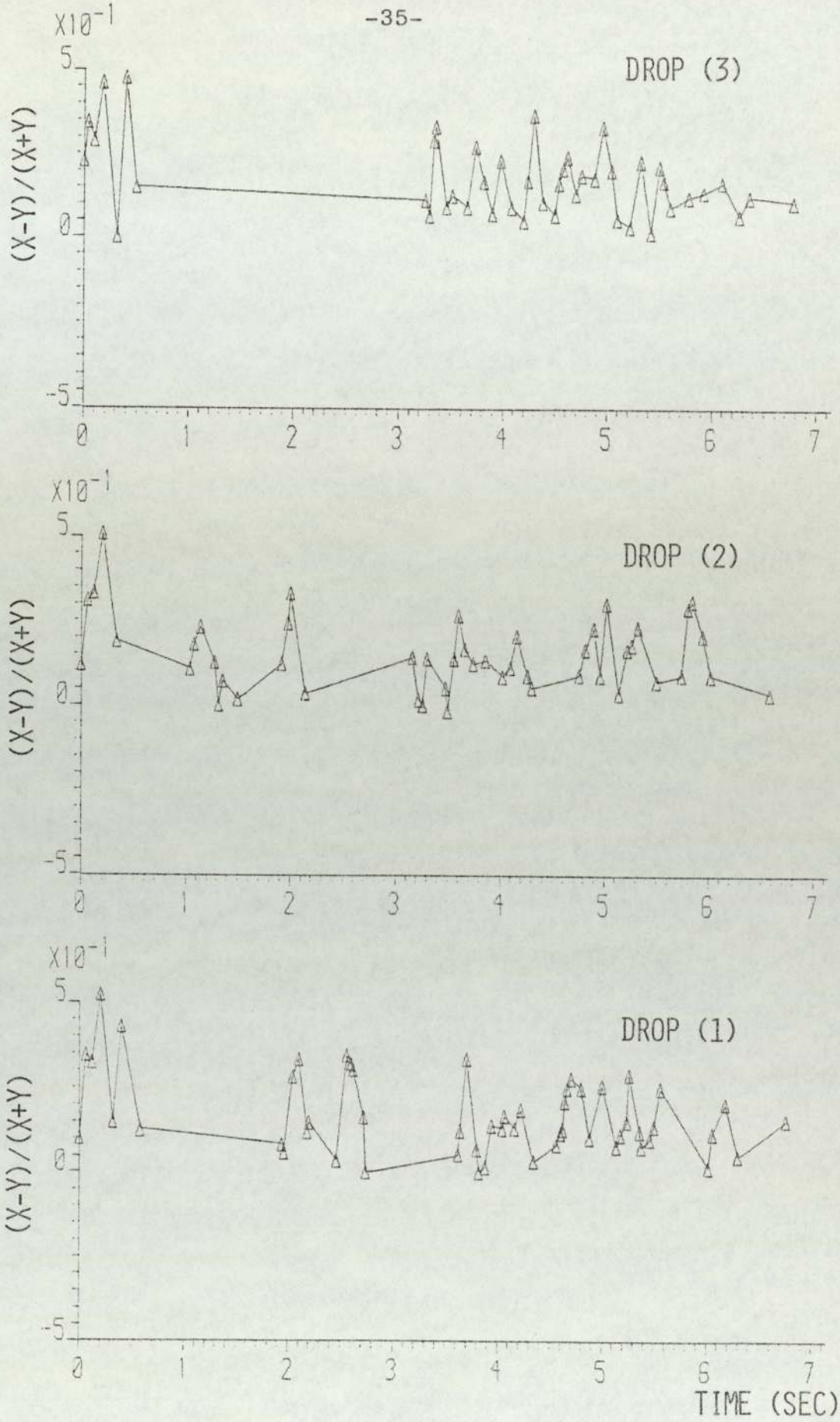

FIG. G.37 DEFORMATION RATIO VS. TIME, RUN-32.

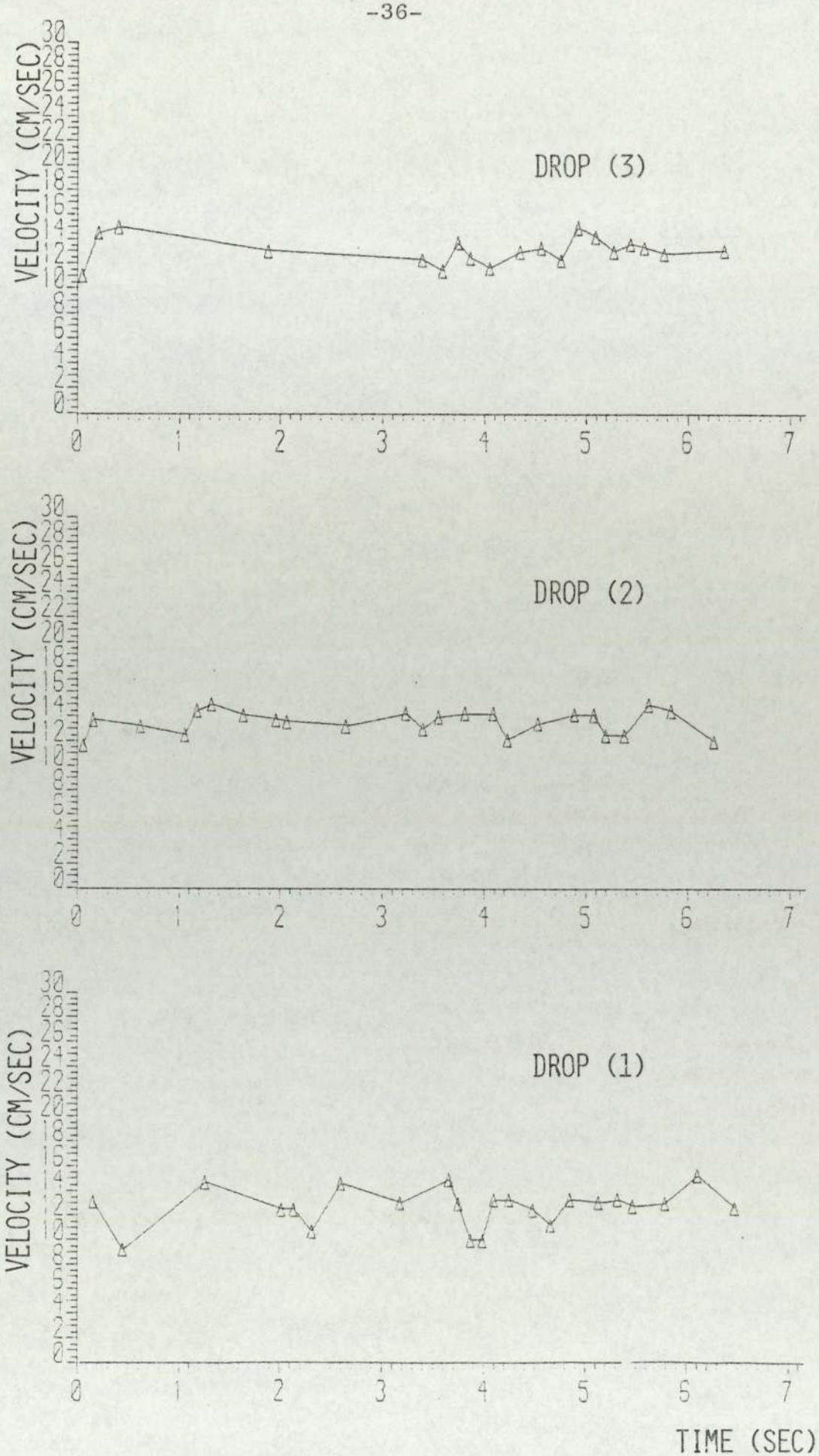

FIG. G.38 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-32.

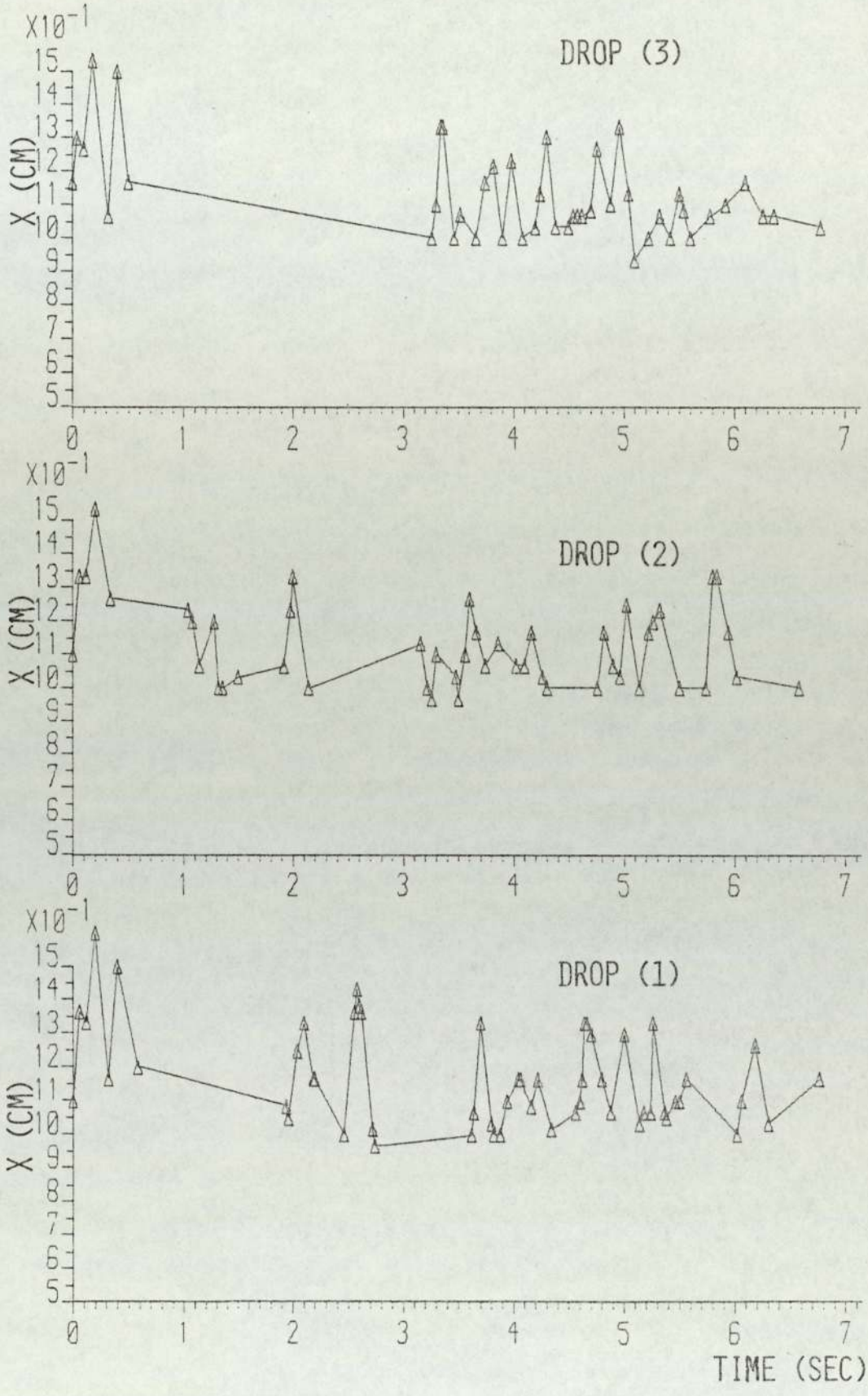

FIG. G.39 X VS. TIME, RUN-32.

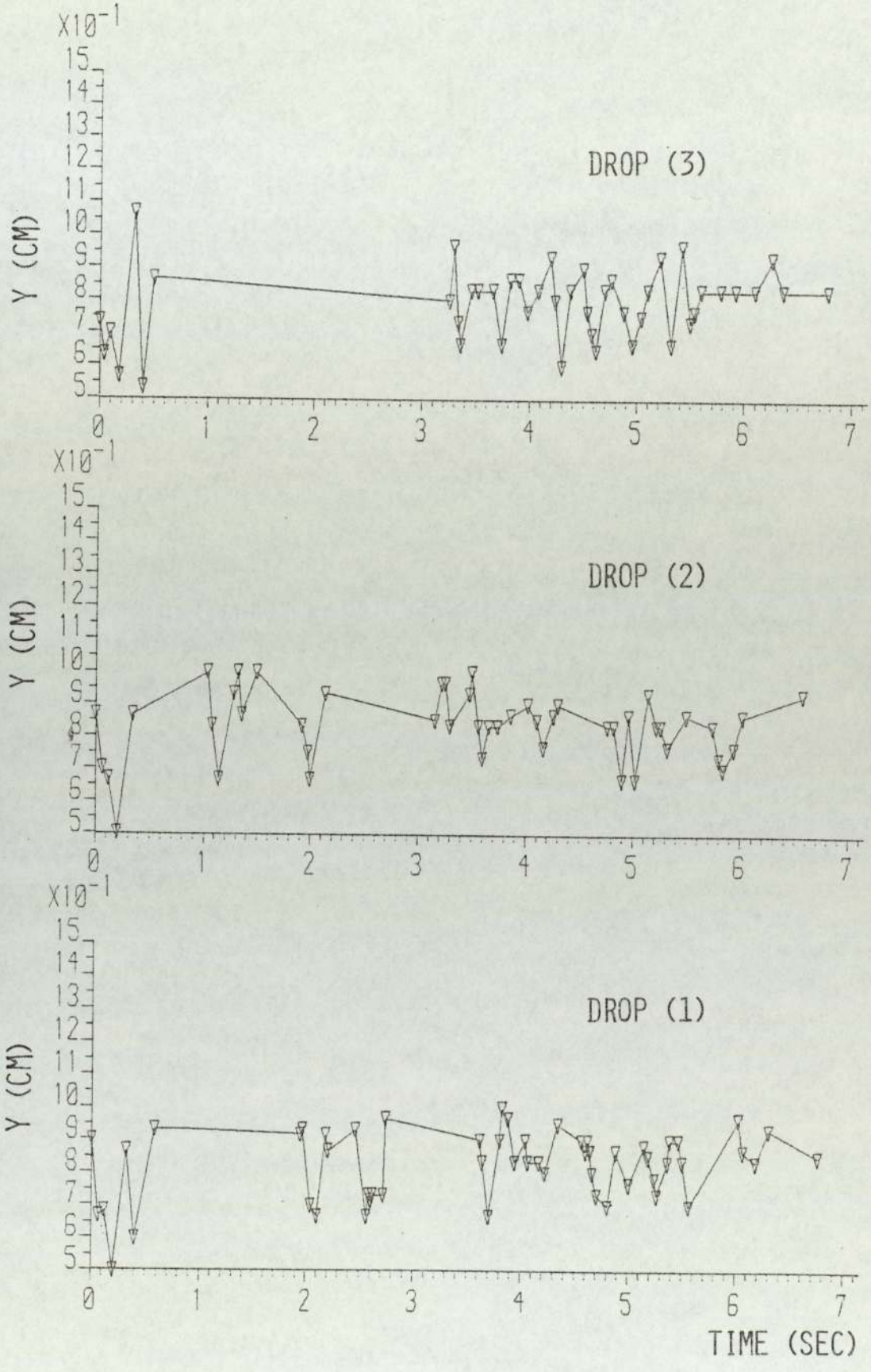

FIG. G.40 Y VS. TIME, RUN-32.

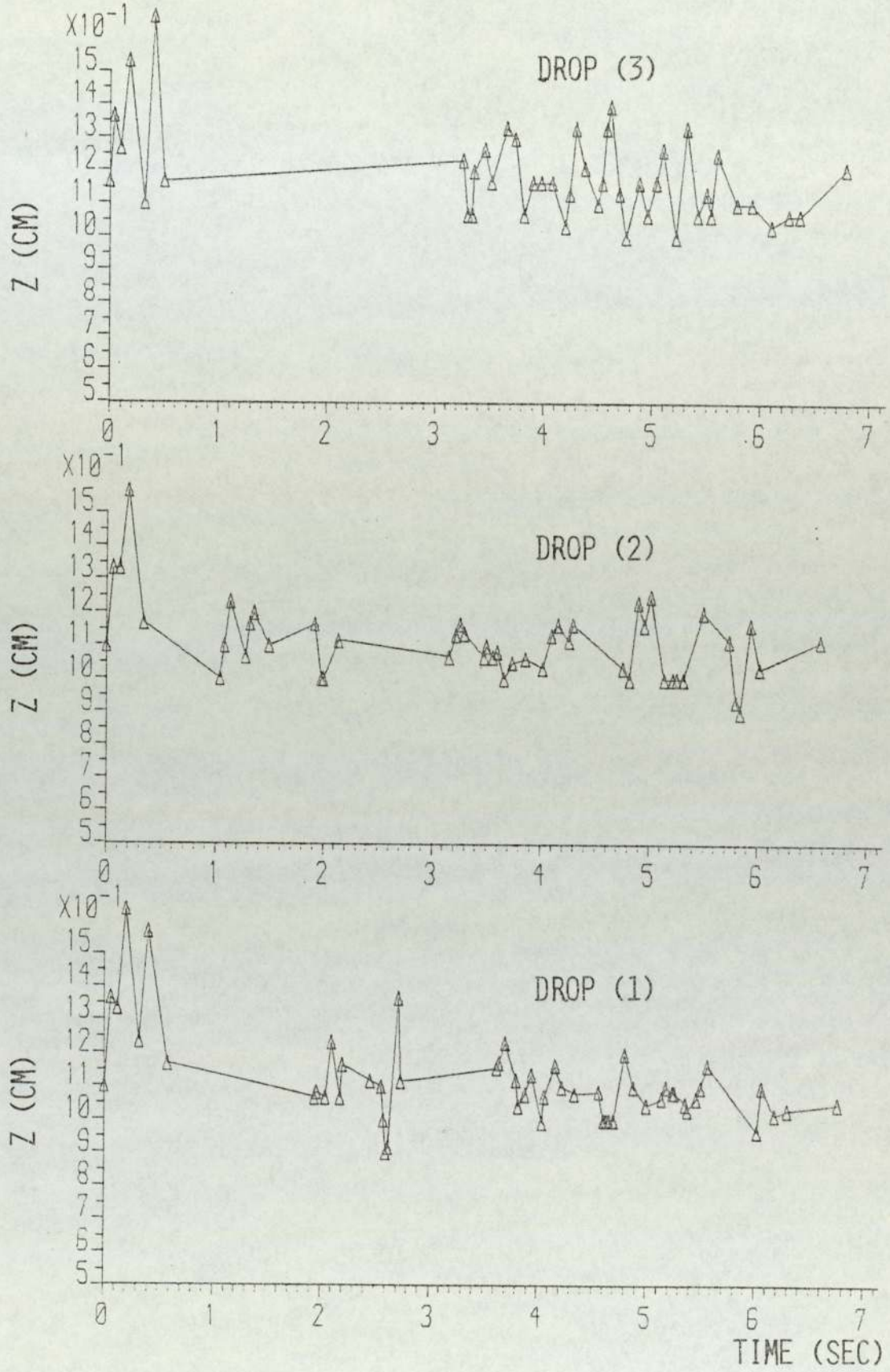

FIG. G.41 Z VS. TIME, RUN-32.

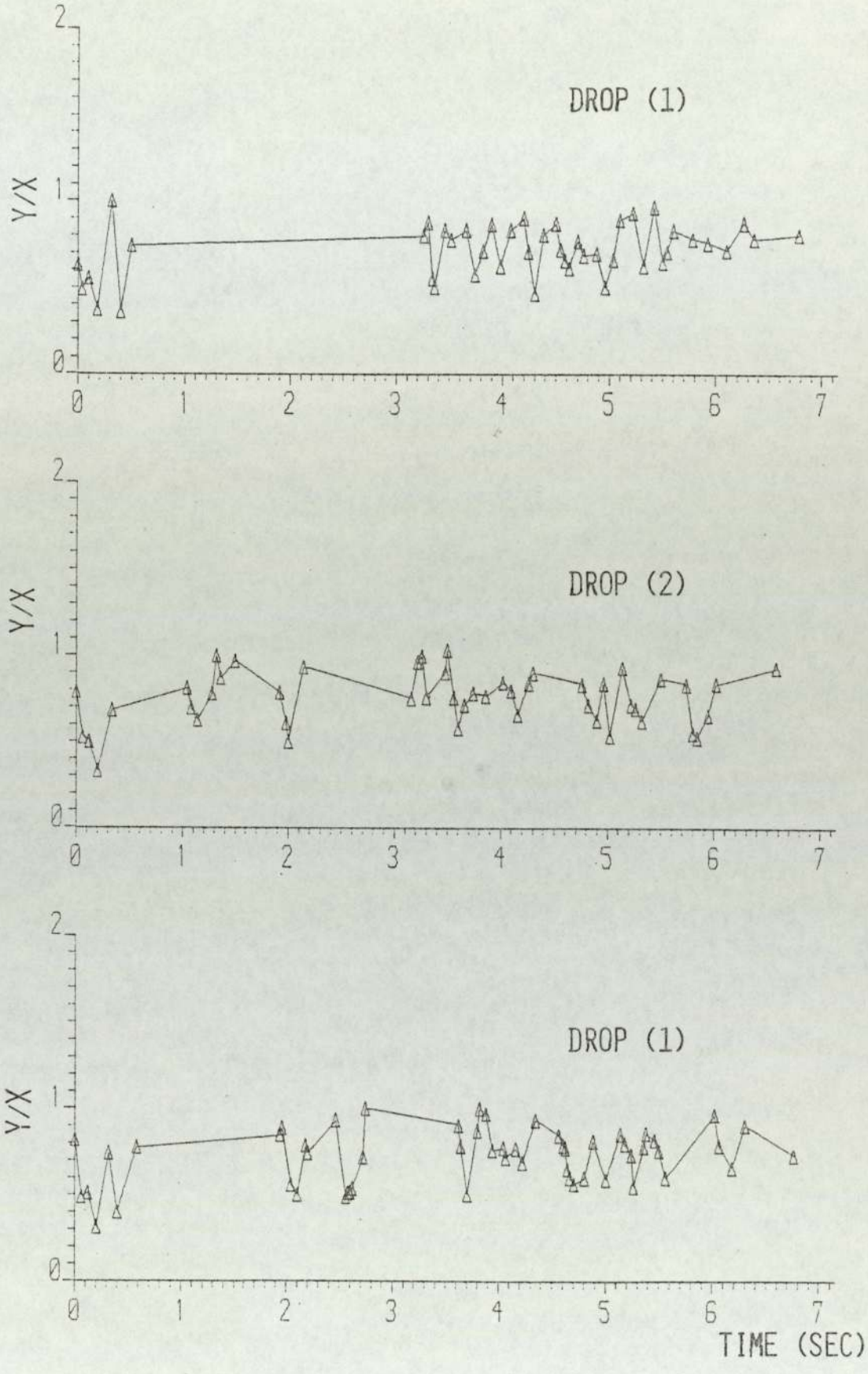

FIG. G.42 AXES RATIO VS. TIME, RUN-32.

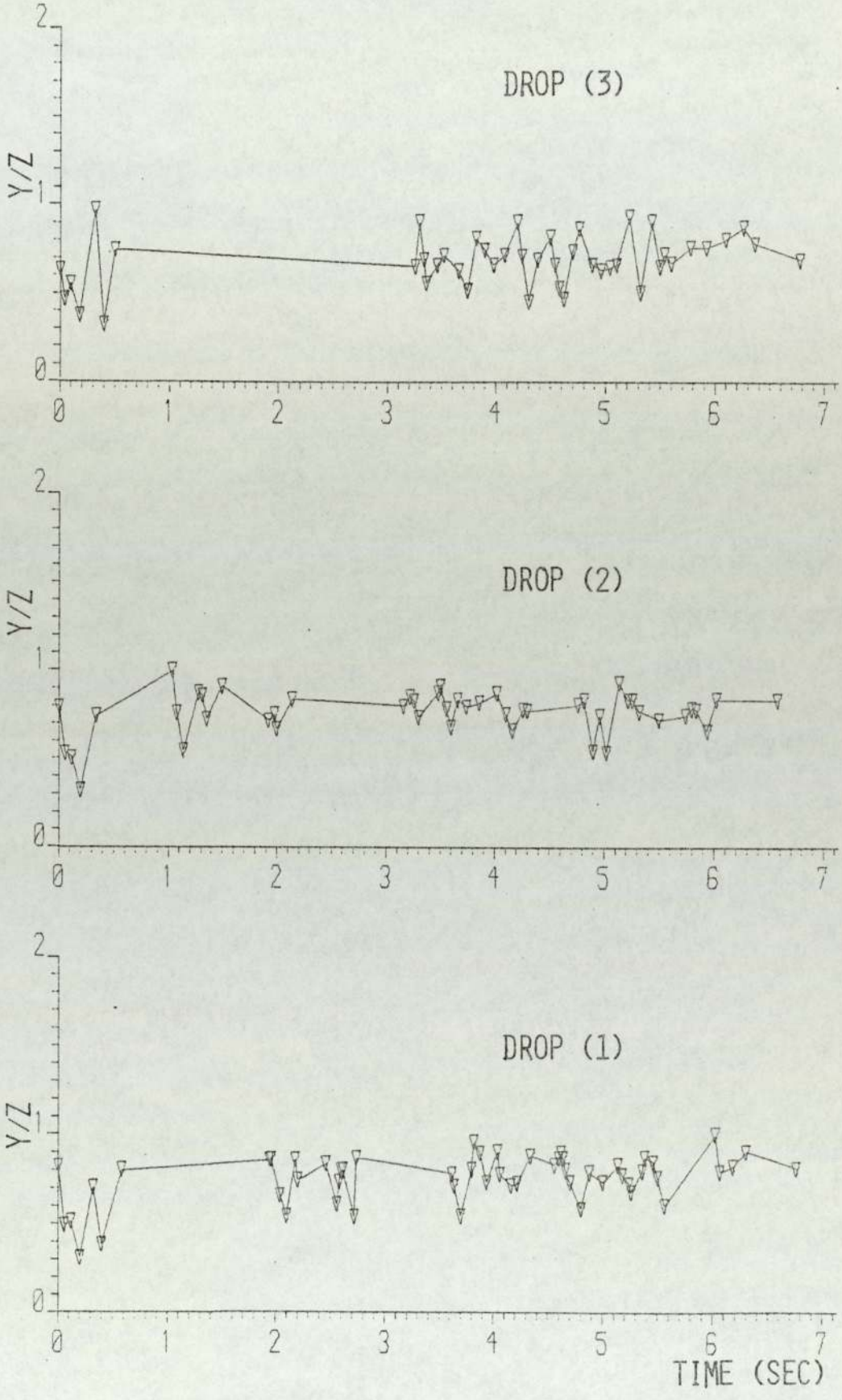

FIG. G.43 AXES RATIO VS. TIME, RUN-32.

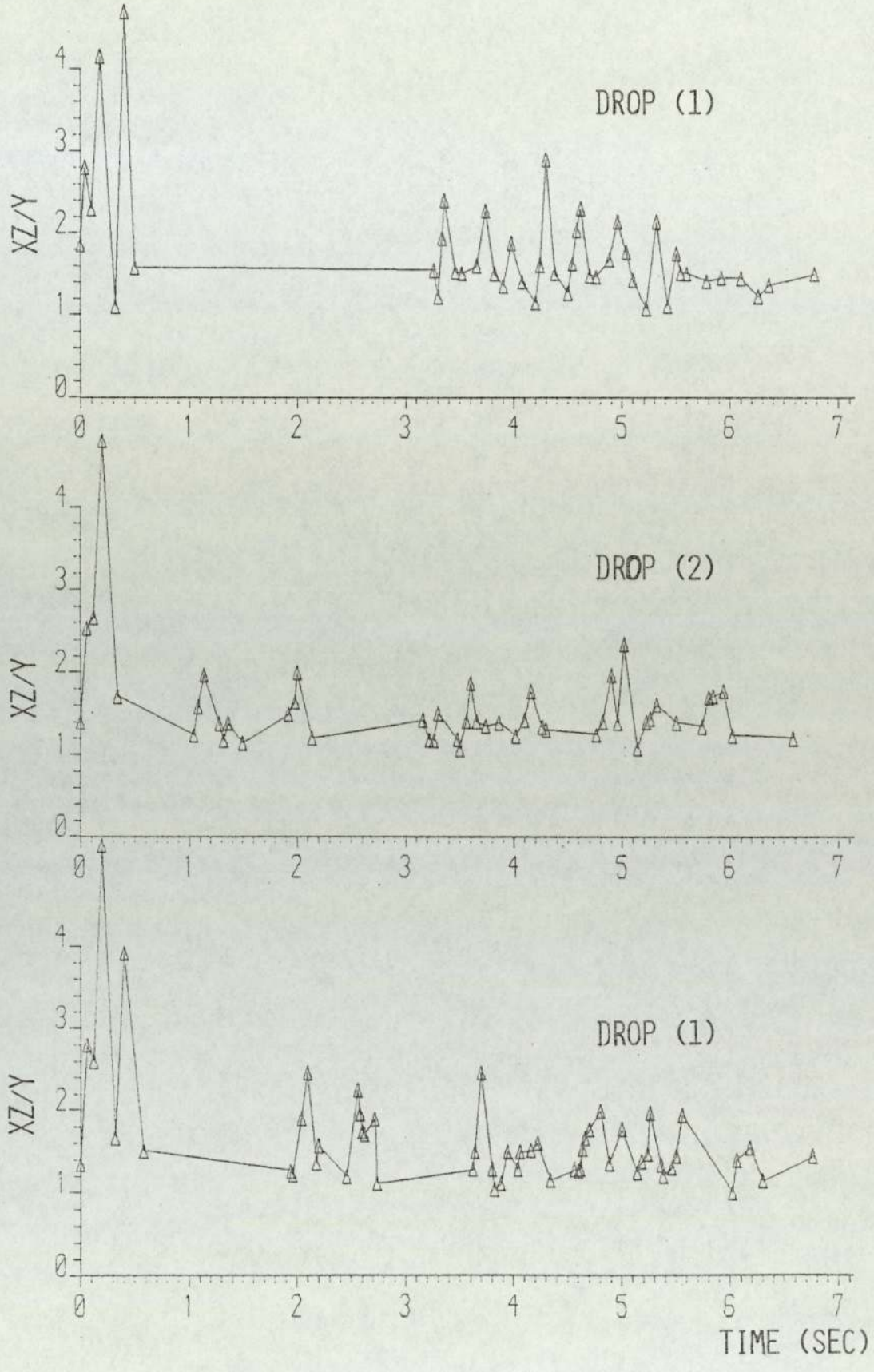

FIG. G.44 AXES RATIO VS. TIME, RUN-32.

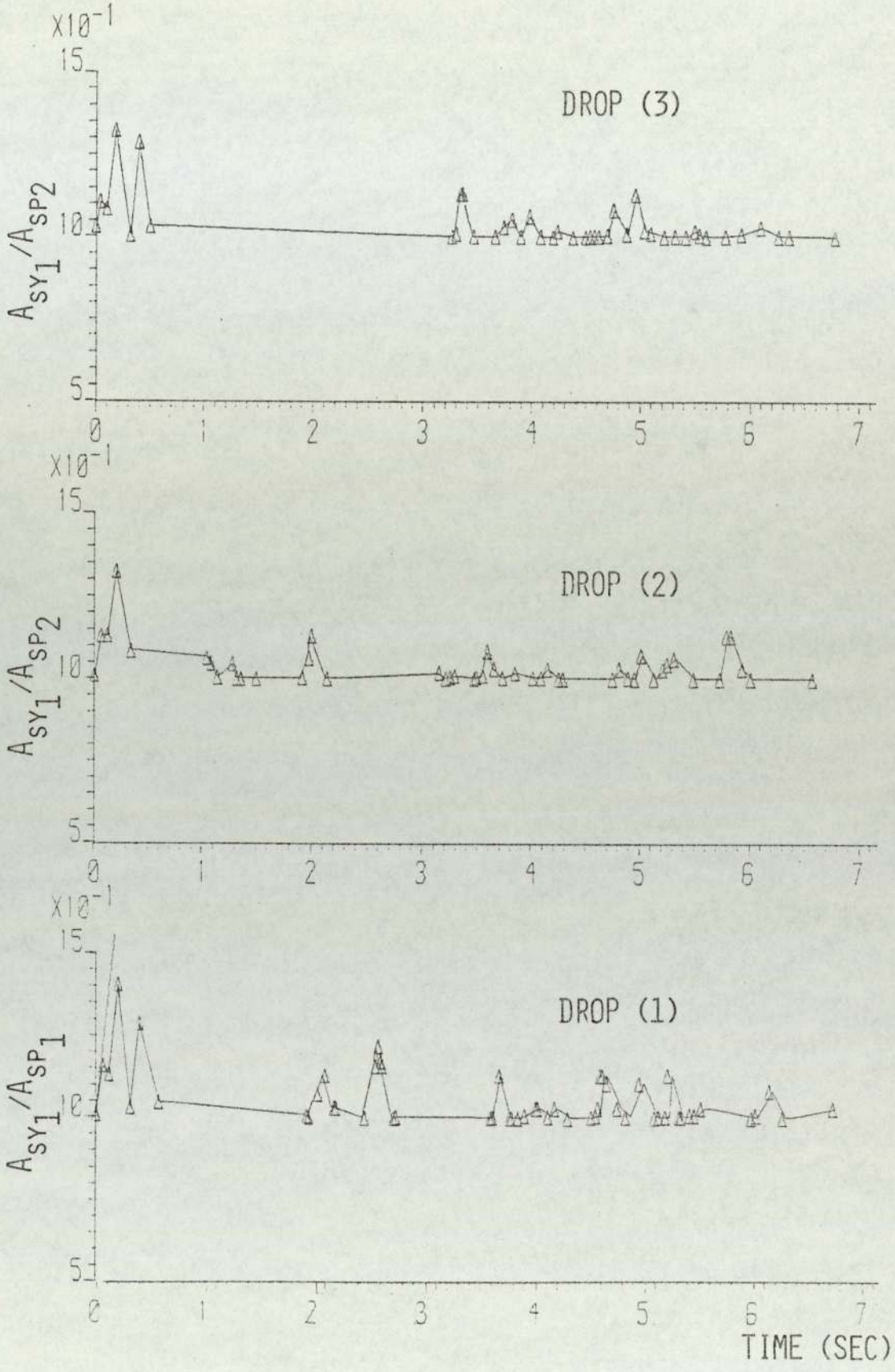

FIG. G.45 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-32, BASED ON DISPLACED VOLUME.

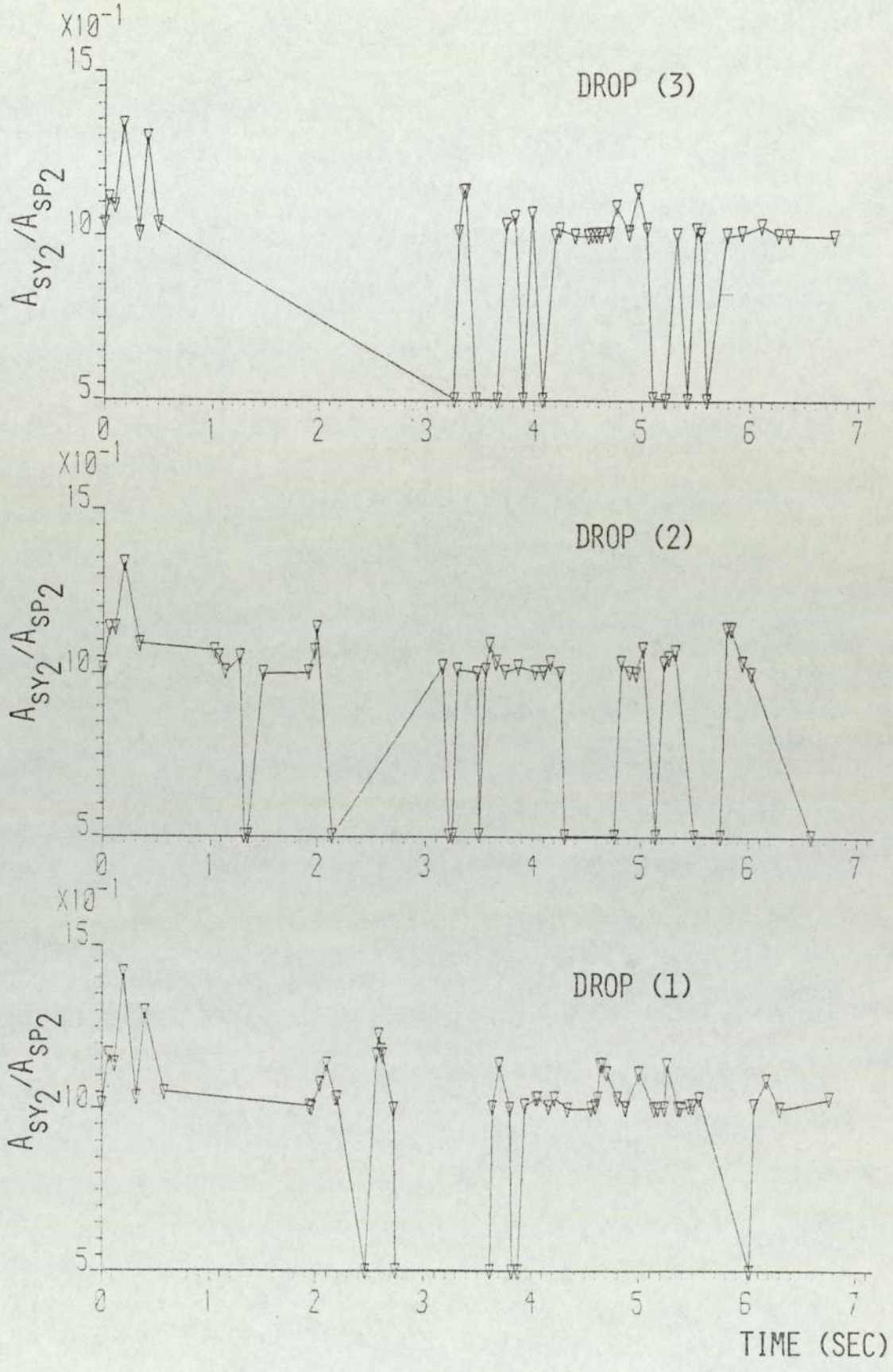

FIG. G.46 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-32, BASED ON MEAN VOLUME.

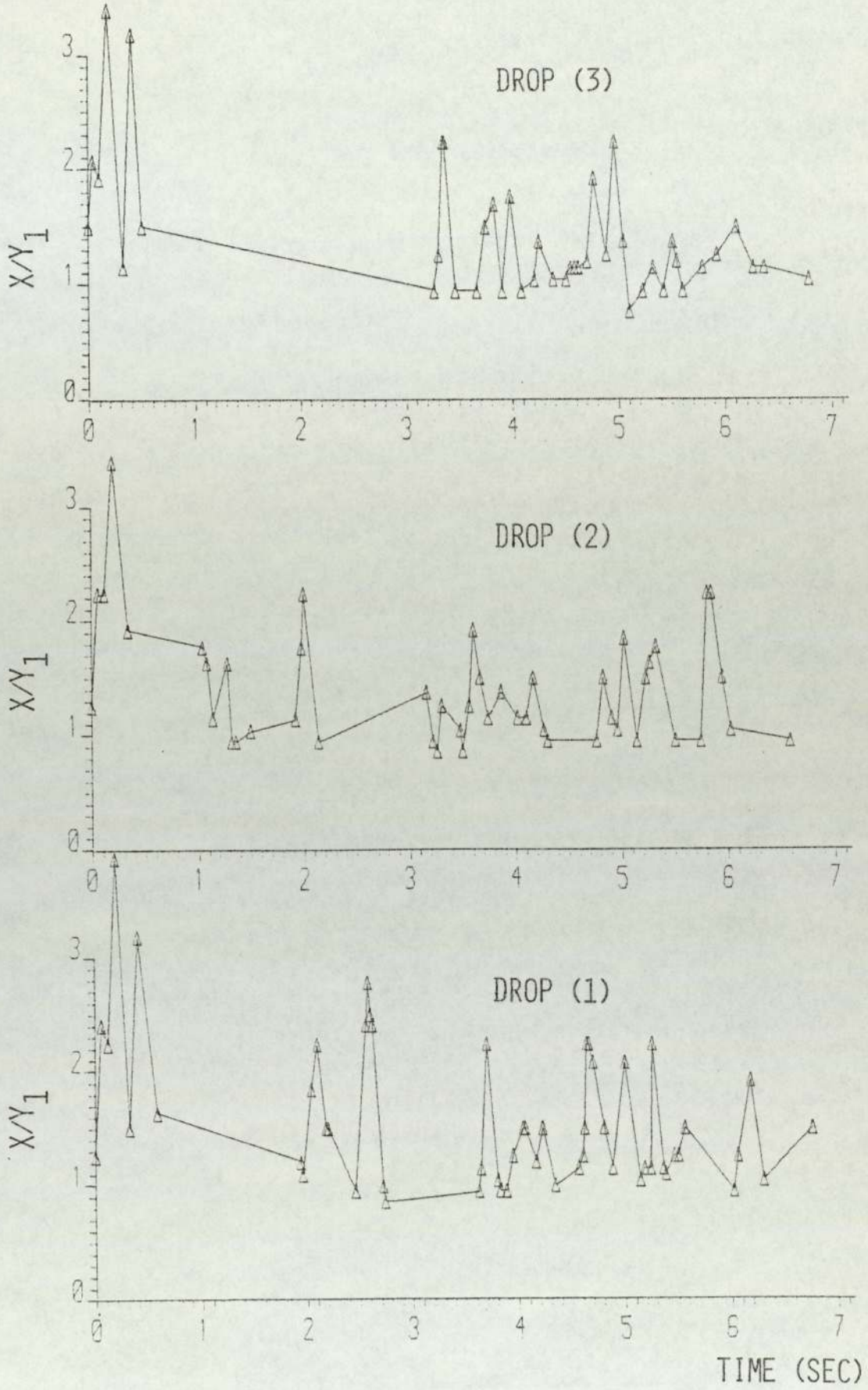

FIG. G.47 AXES RATIO VS. TIME, RUN-32.

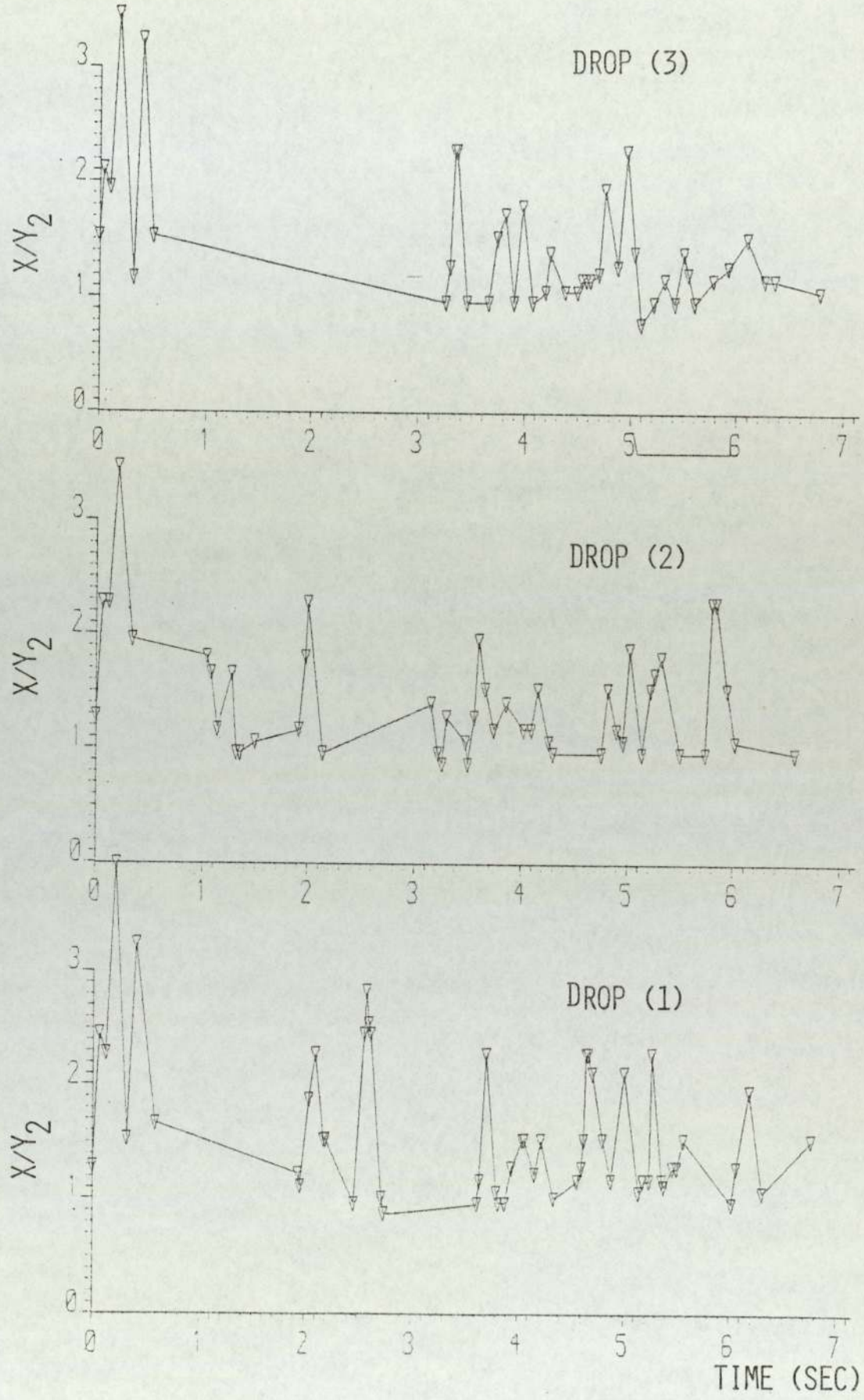

FIG. G.48 AXES RATIO VS. TIME, RUN-32.

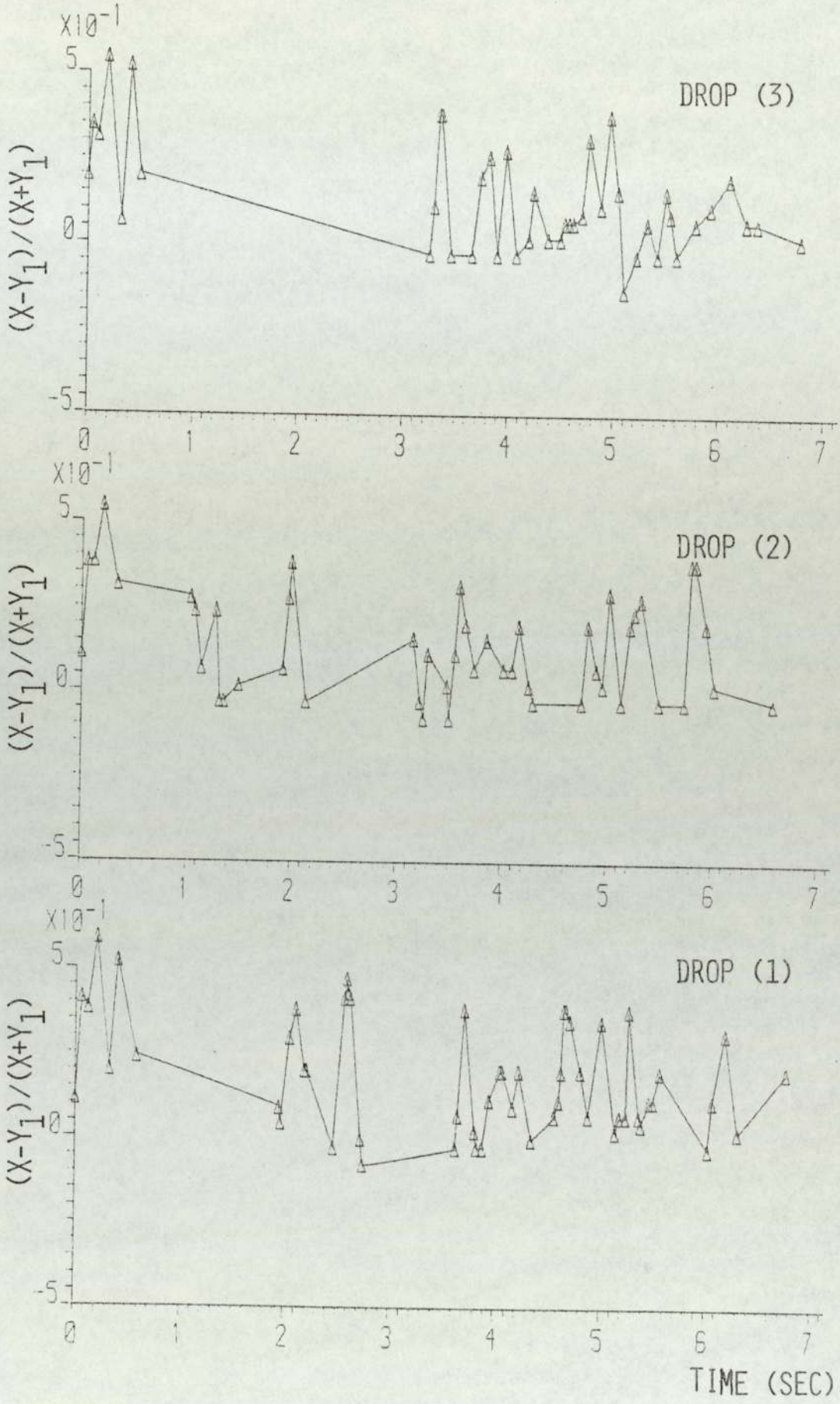

FIG. G.49 DEFORMATION RATIO VS. TIME, RUN-32.

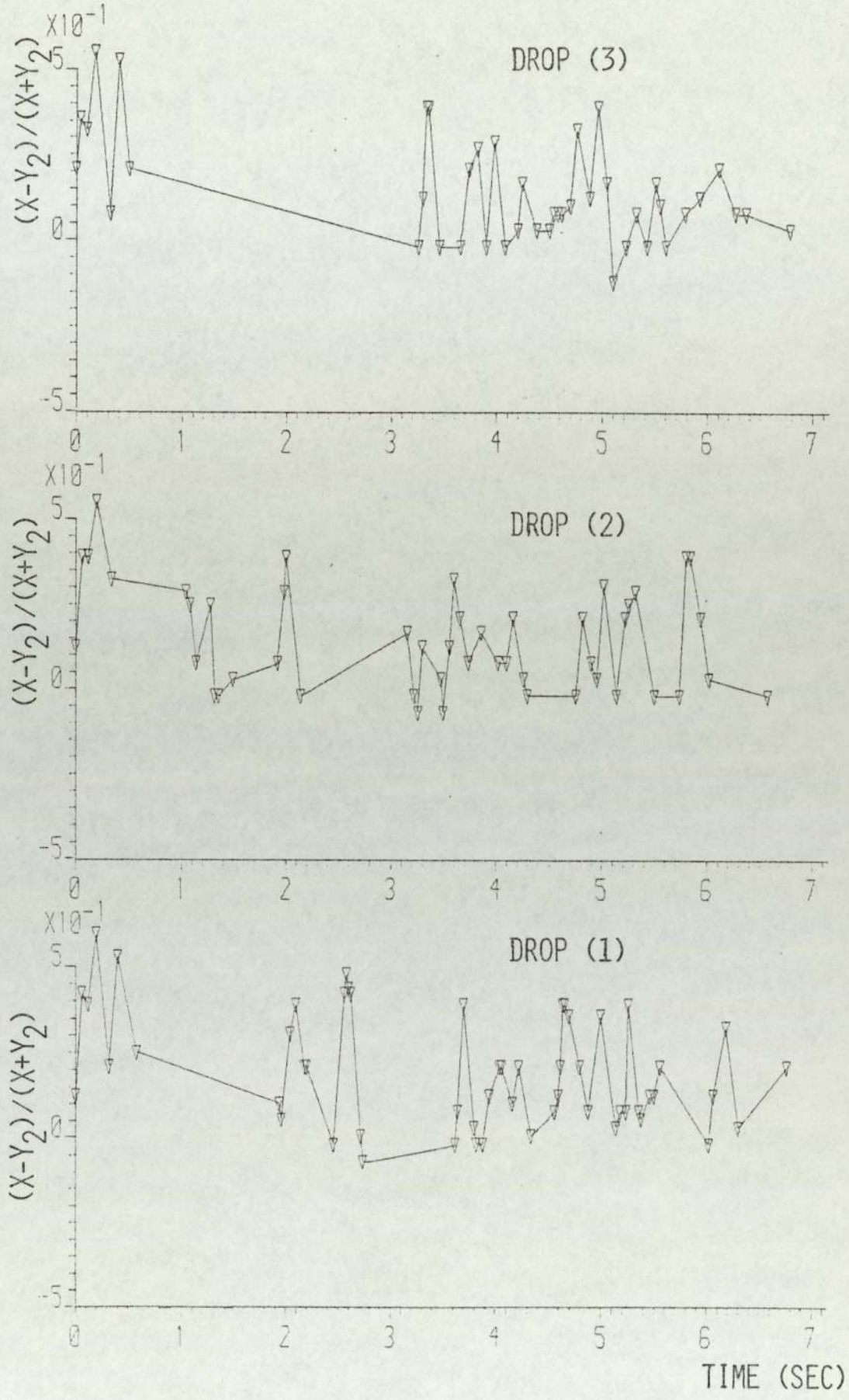

FIG. G.50 DEFORMATION RATIO VS. TIME, RUN-32.

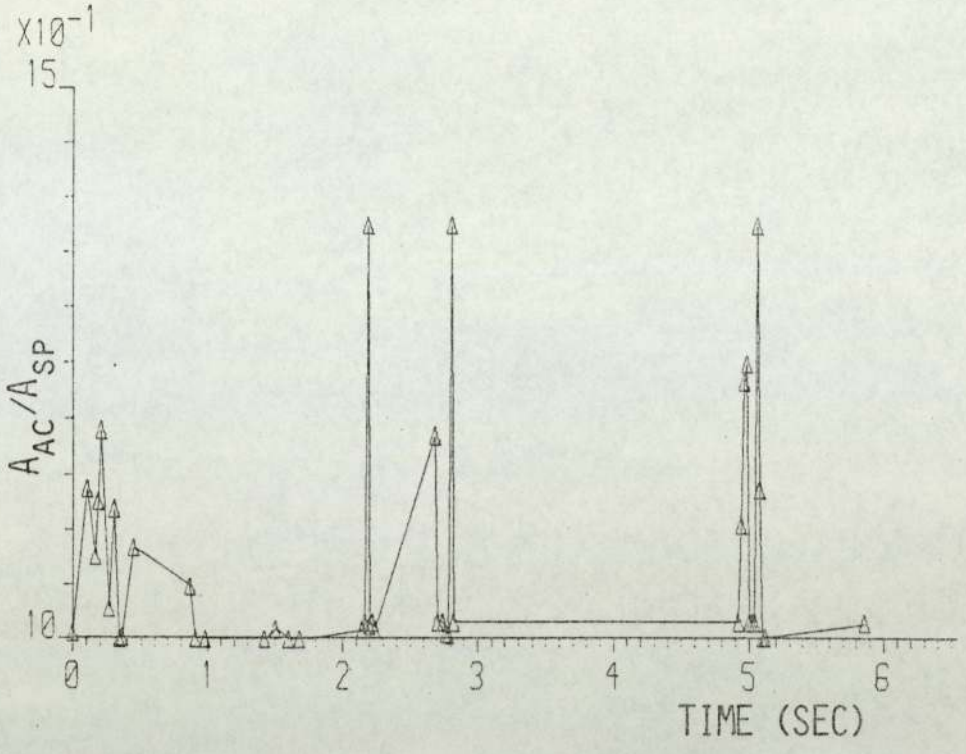

FIG. G.51 AREA RATIO VS. TIME, RUN-34.

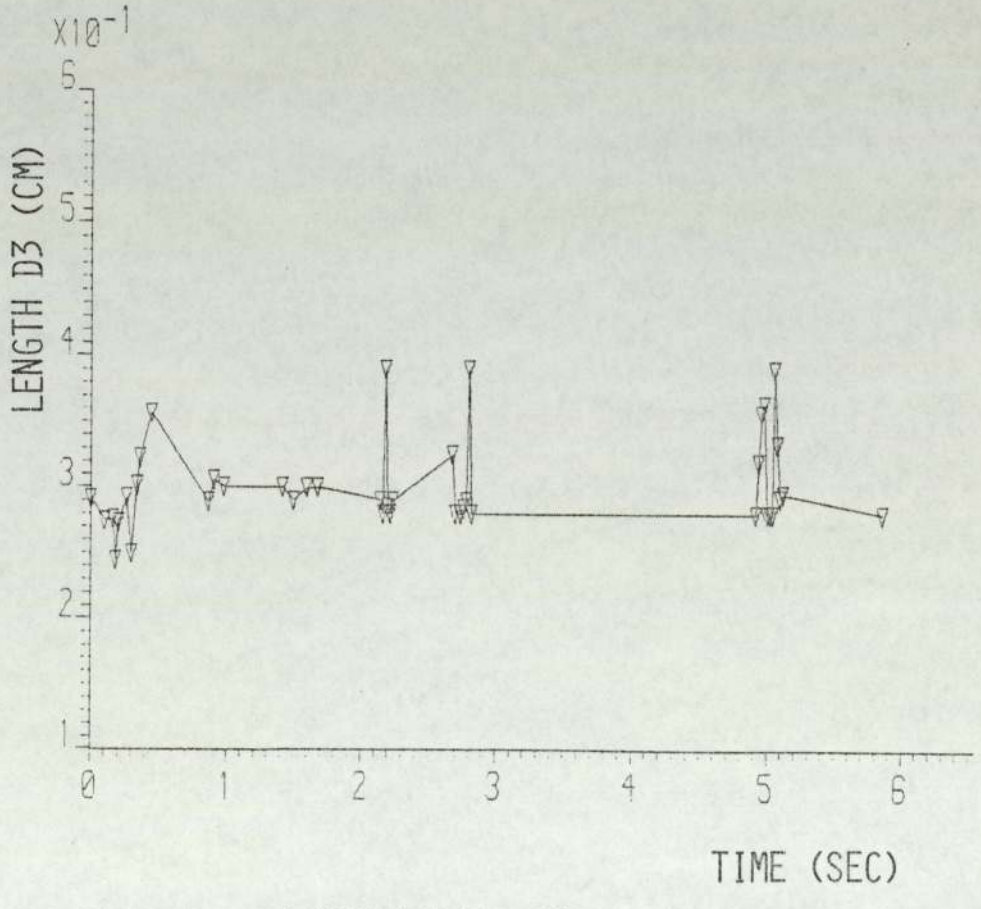

FIG. G.52 LENGTH D3 VS. TIME, RUN-34.

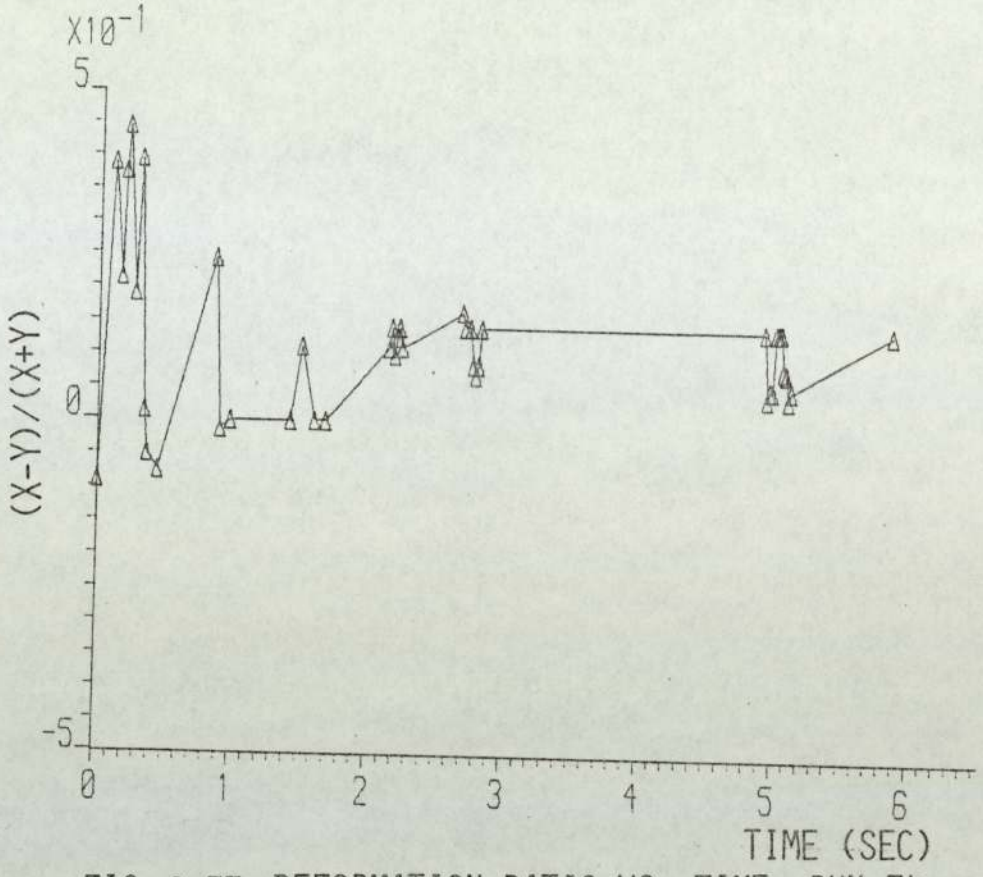

FIG. G.53 DEFORMATION RATIO VS. TIME, RUN-34.

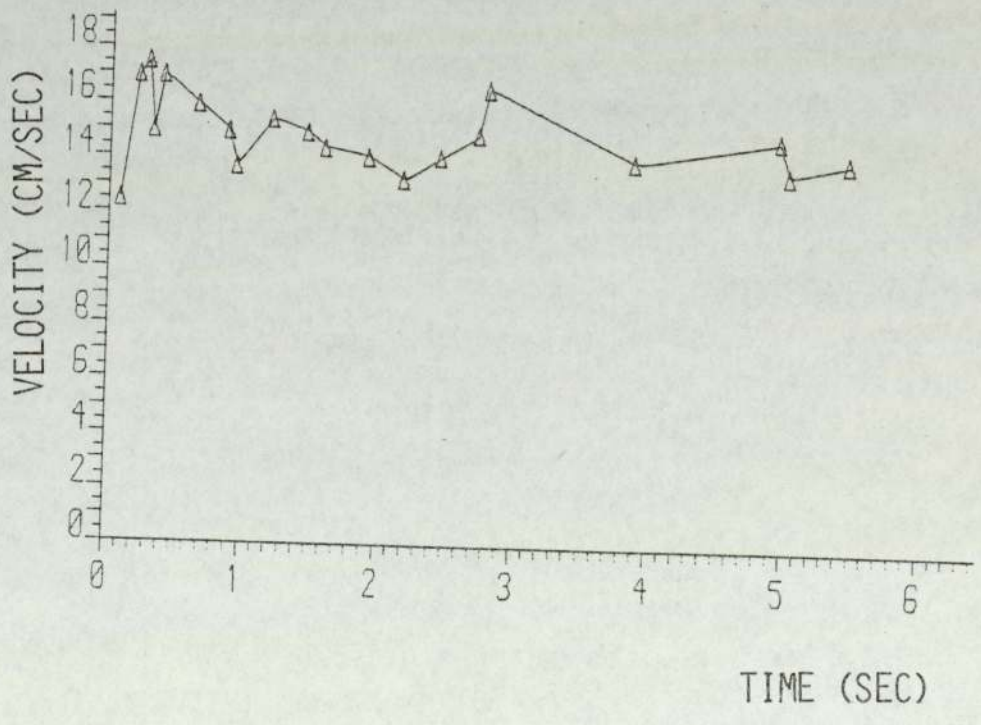

FIG. G.54 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-34.

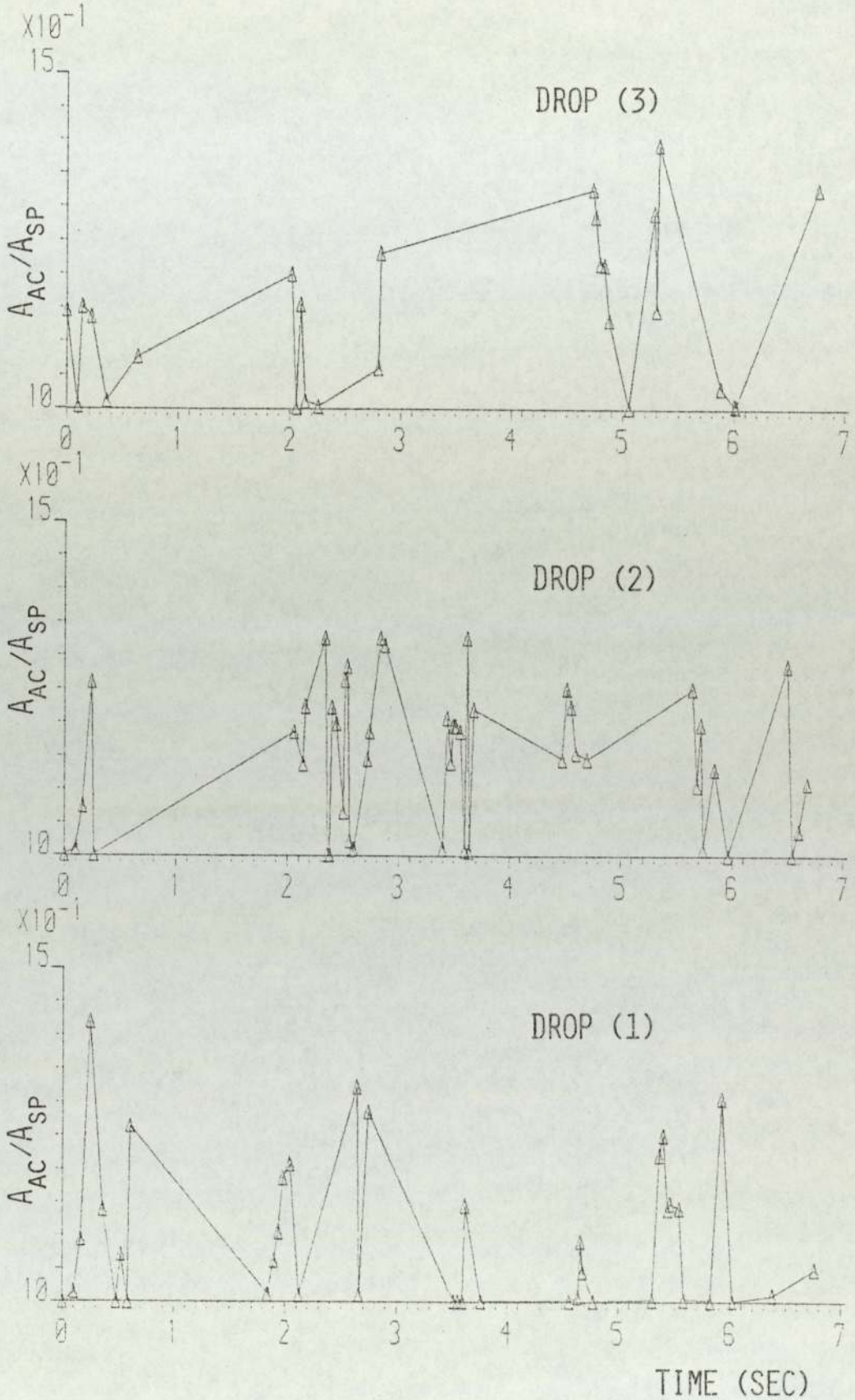

FIG. G.55 AREA RATIO VS. TIME, RUN-37.

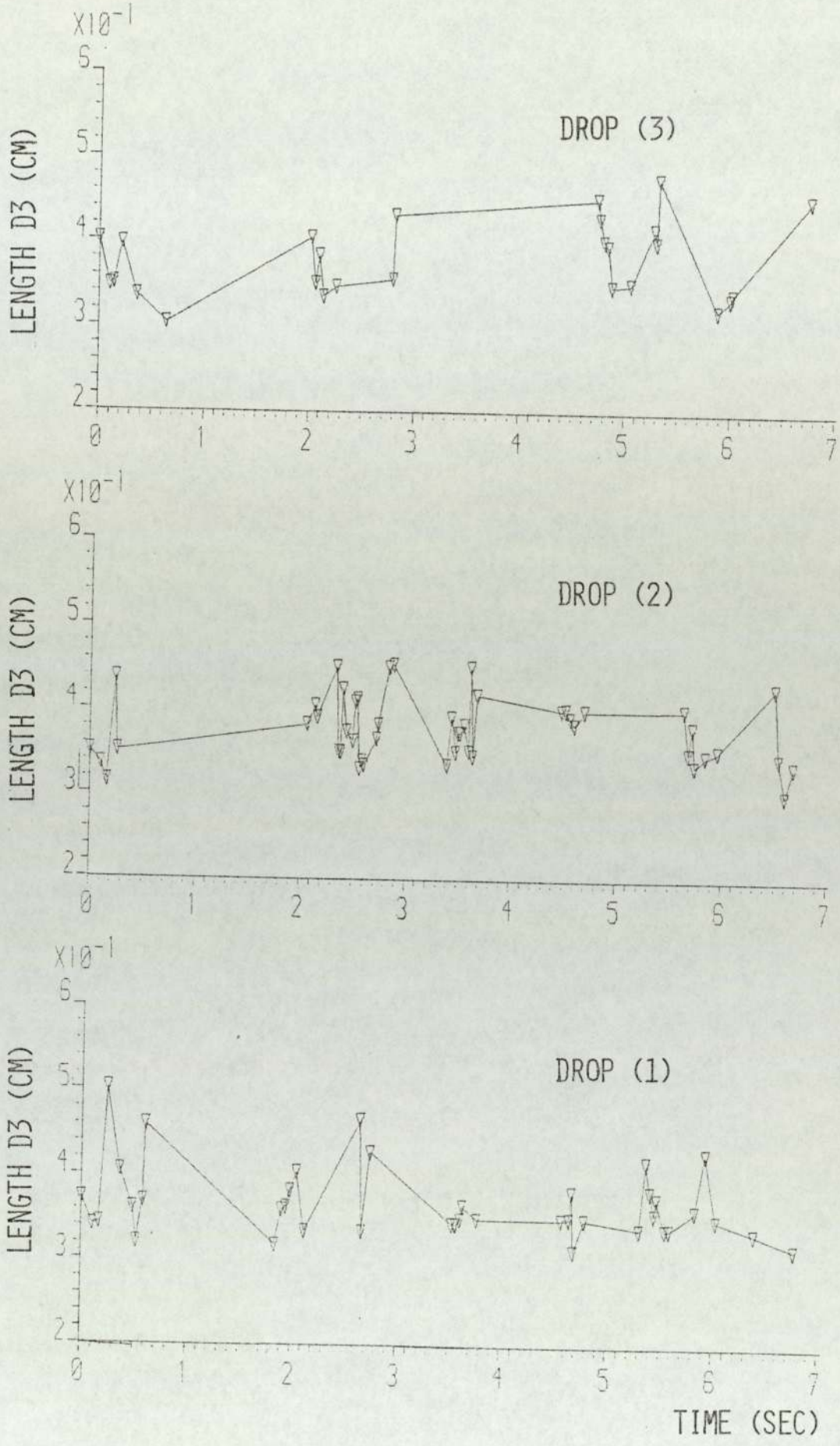

FIG. G.56 LENGTH D3 VS. TIME, RUN-37.

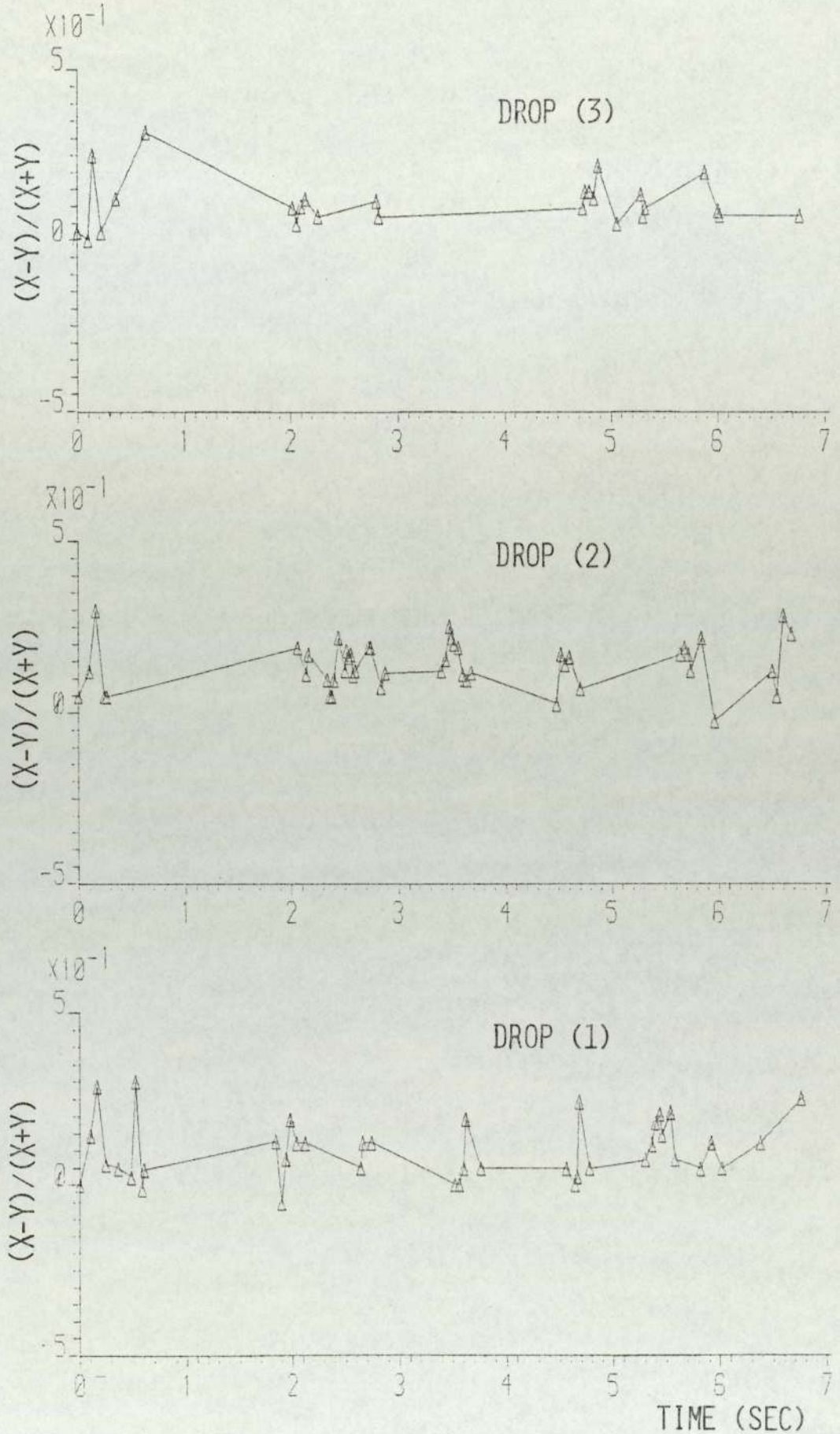

FIG. G.57 DEFORMATION RATIO VS. TIME, RUN-37.

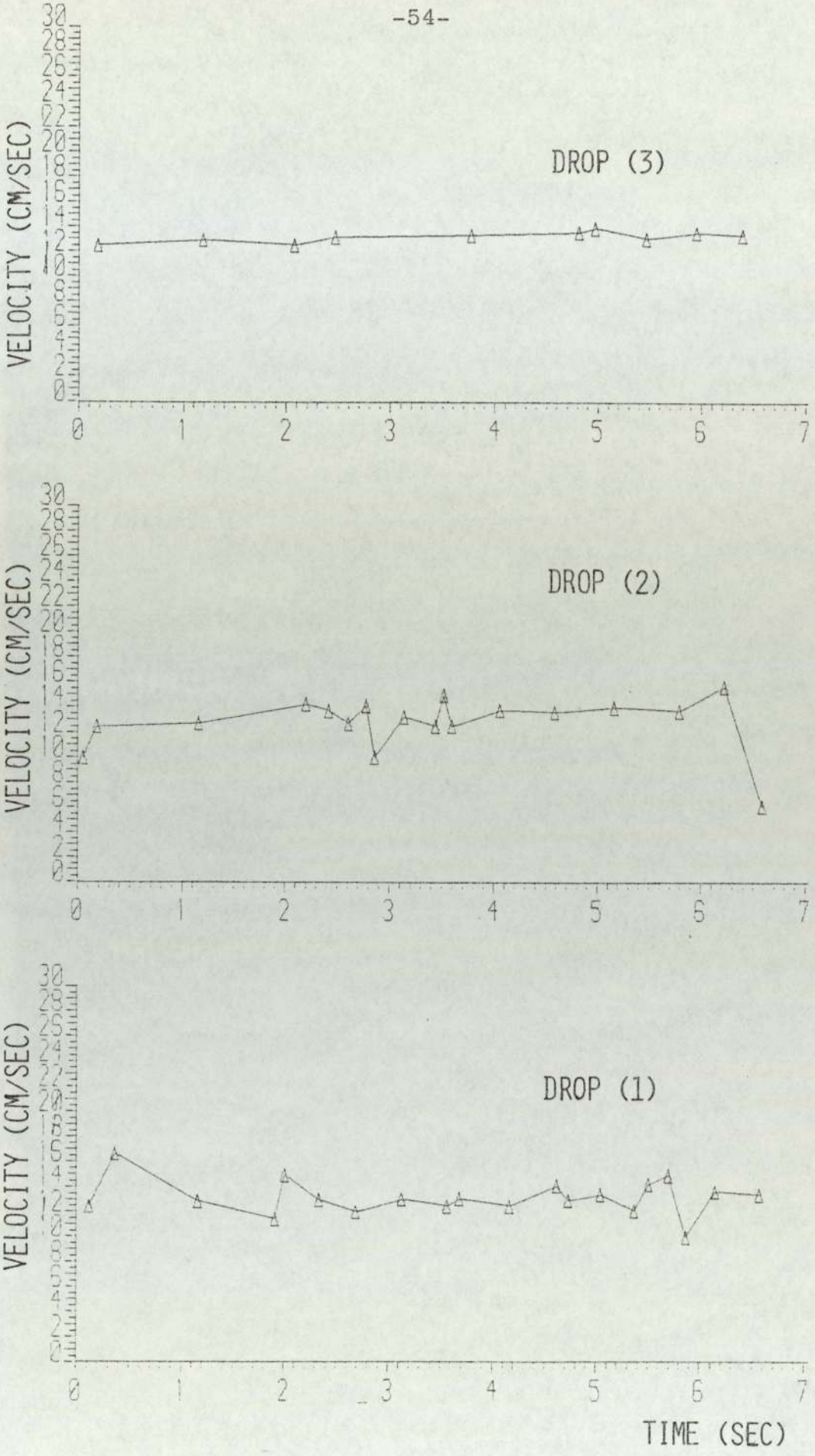

FIG. G.58 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-37.

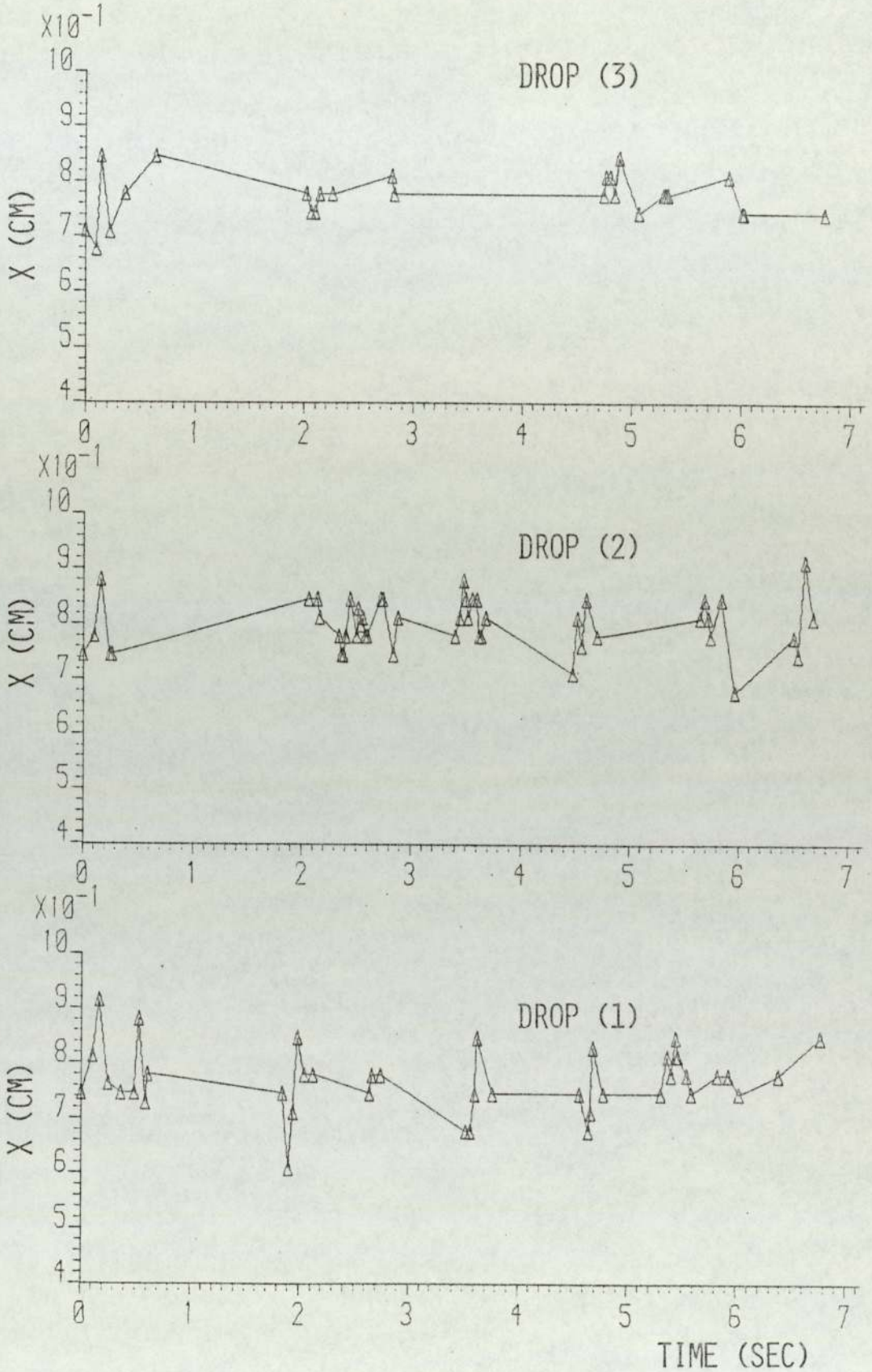

FIG.G.59 X VS. TIME, RUN-37.

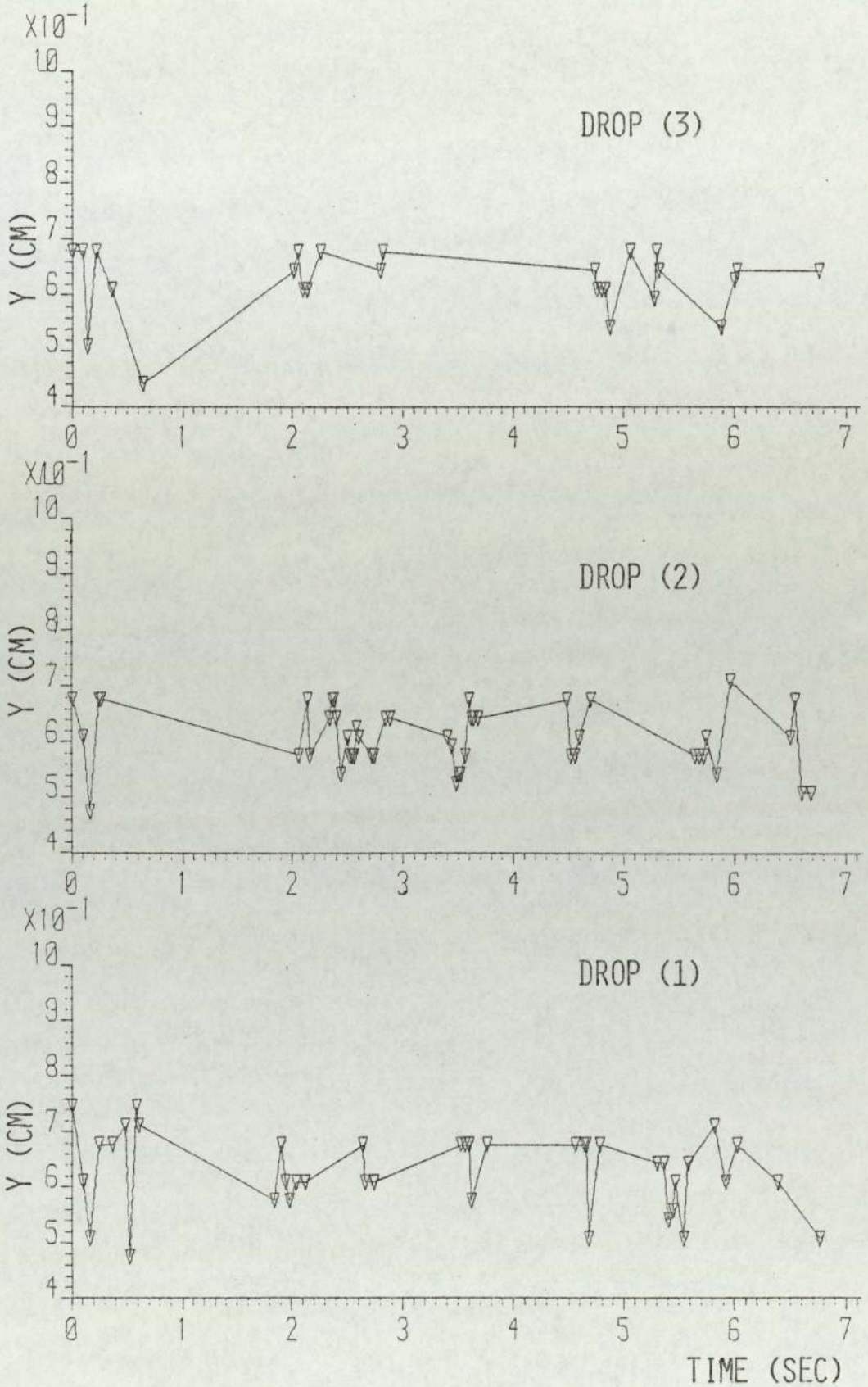

FIG. G.60 Y VS. TIME, RUN-37.

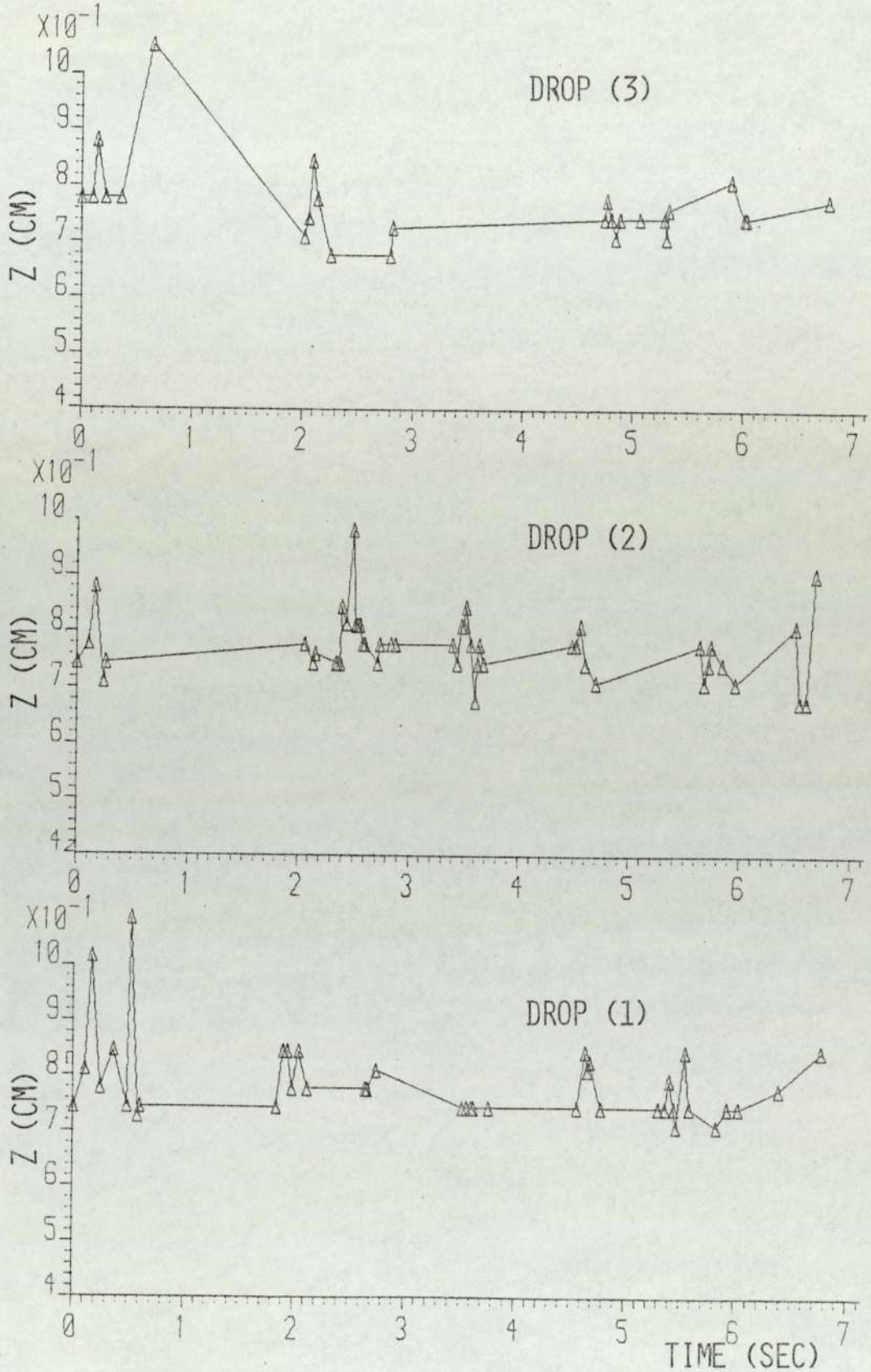

FIG. G.61 Z VS. TIME, RUN-37.

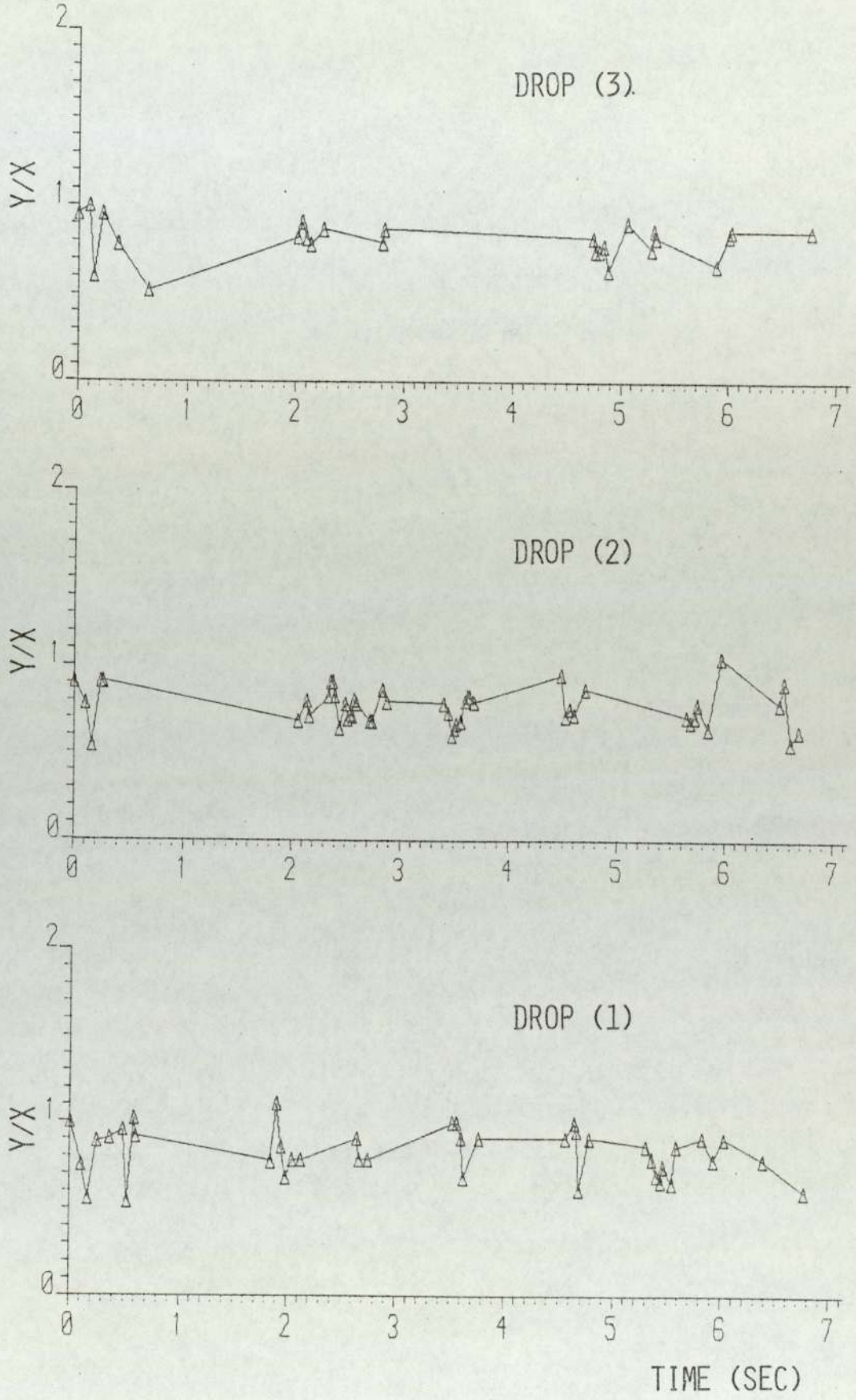

FIG. G.62 AXES RATIO VS. TIME, RUN-37.

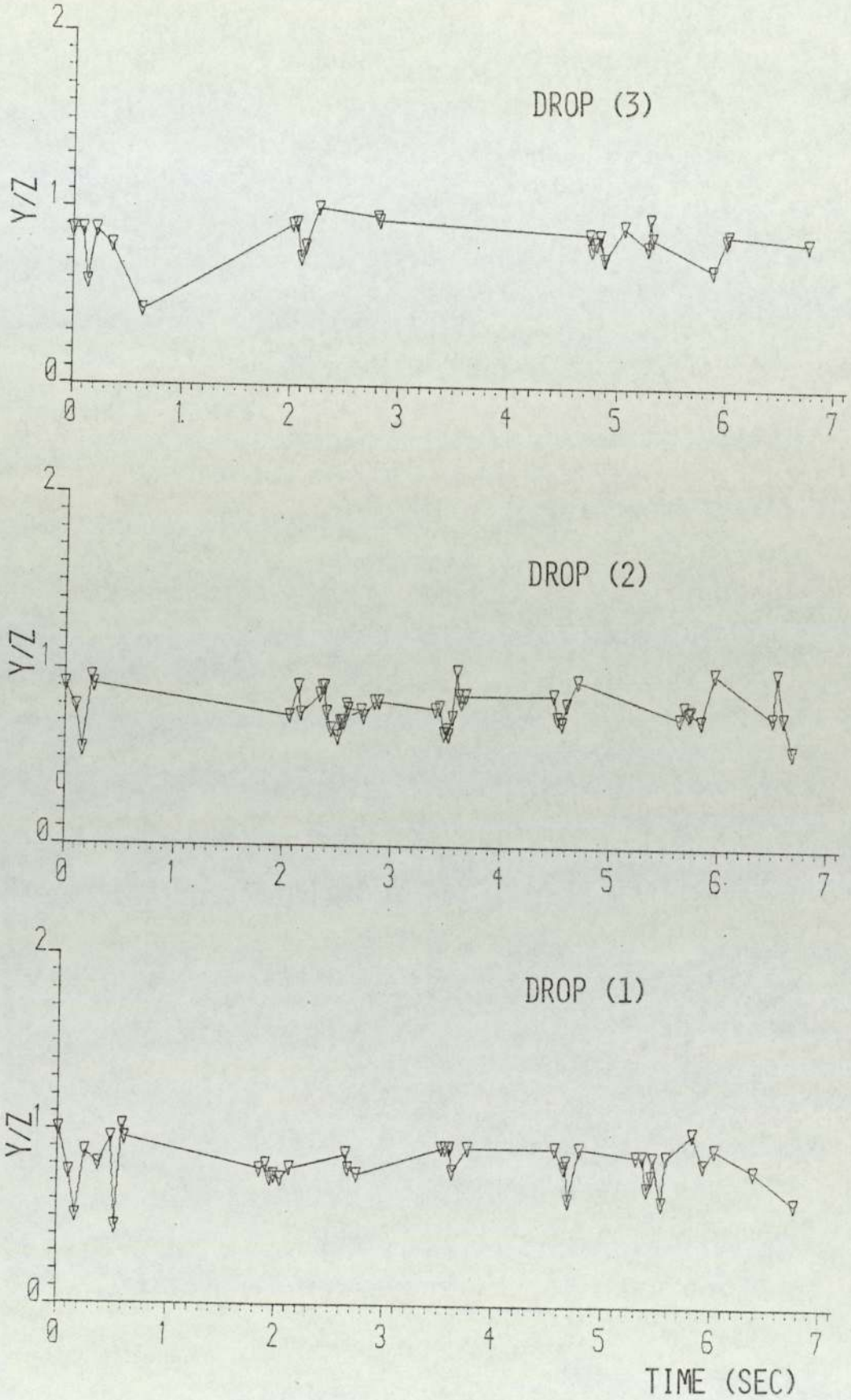

FIG. G.63 AXES RATIO VS. TIME, RUN-37.

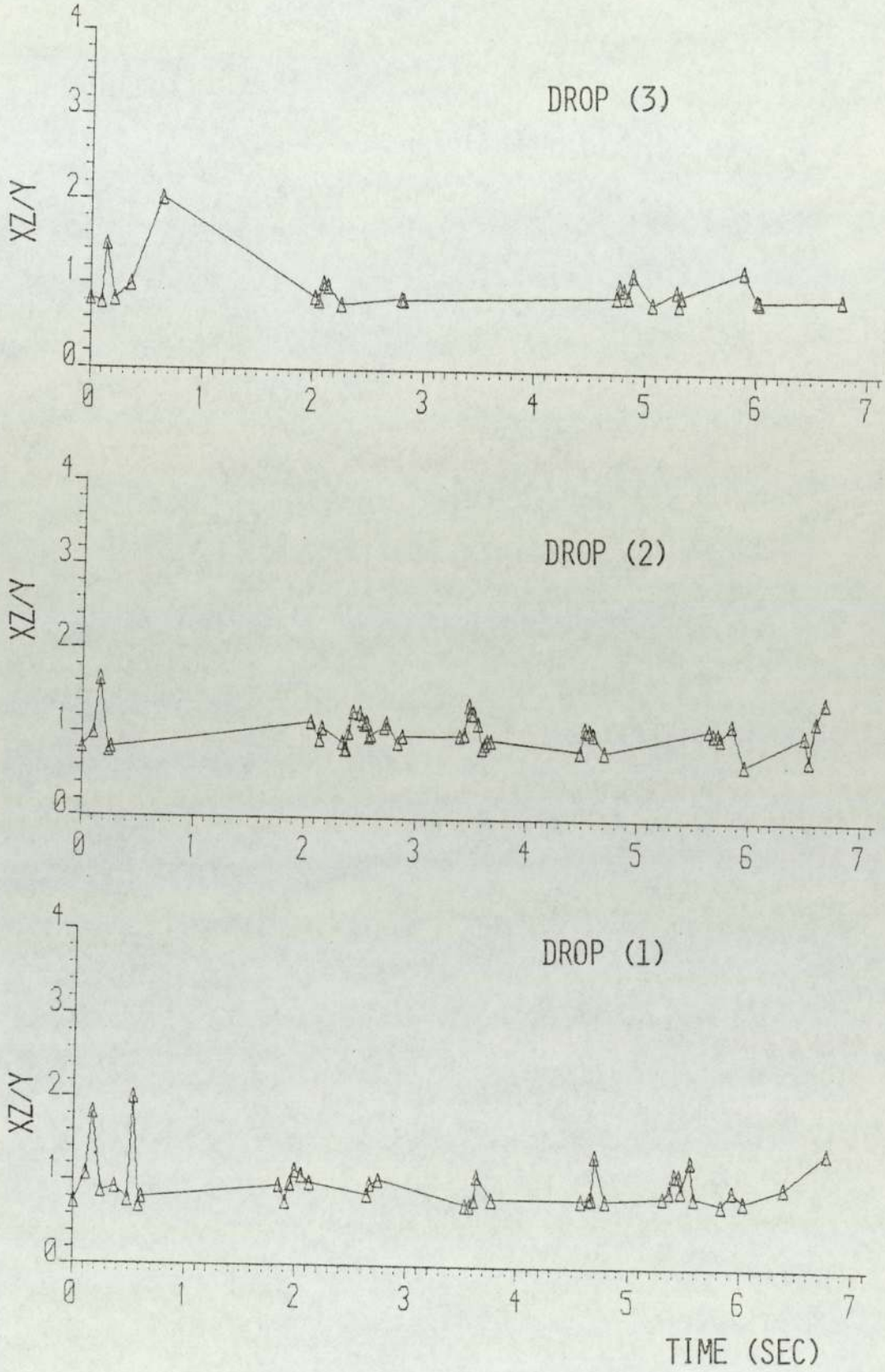

FIG. G.64 AXES RATIO VS. TIME, RUN-37.

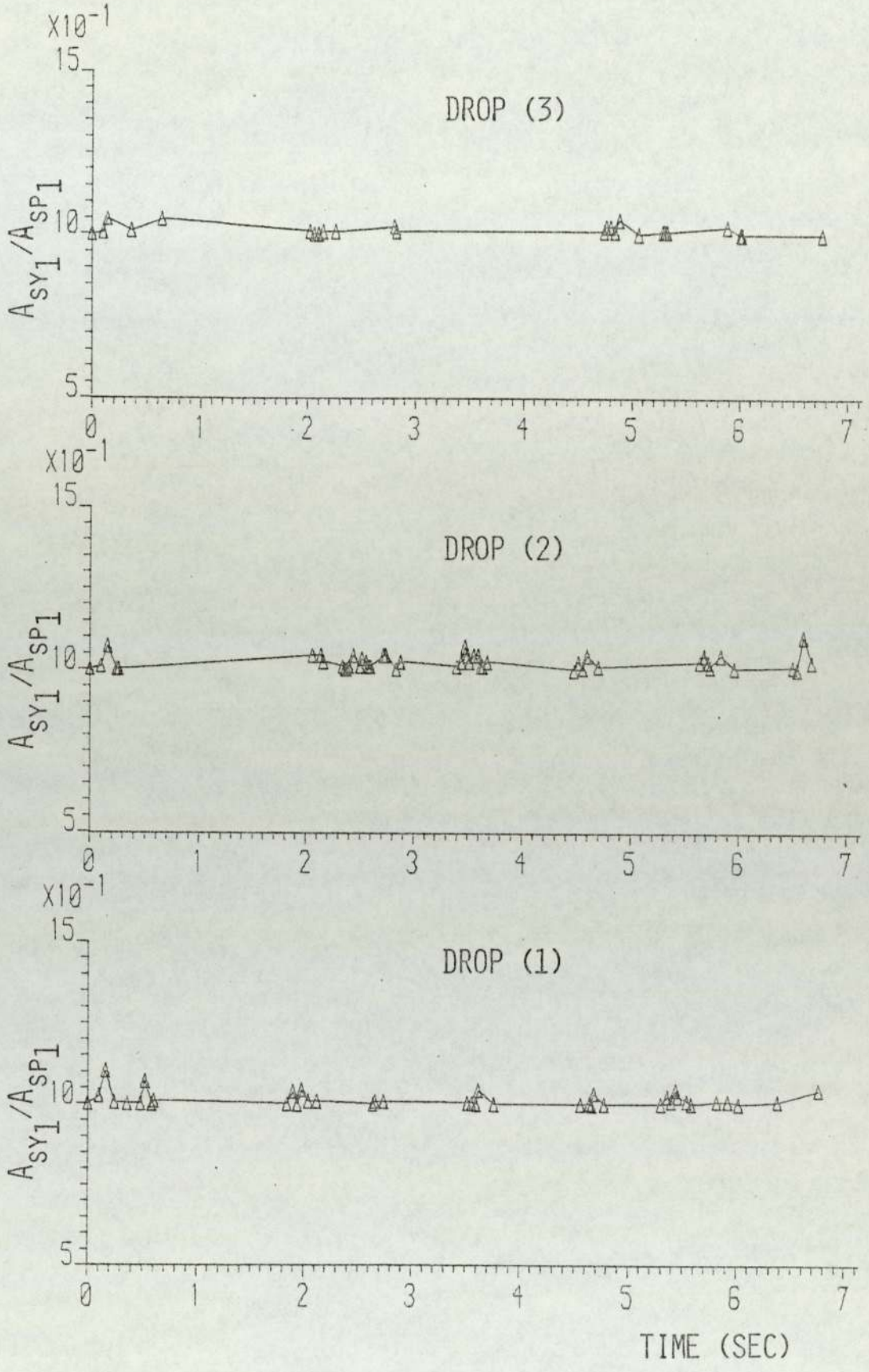

FIG. G.65 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-37, BASED ON DISPLACED VOLUME.

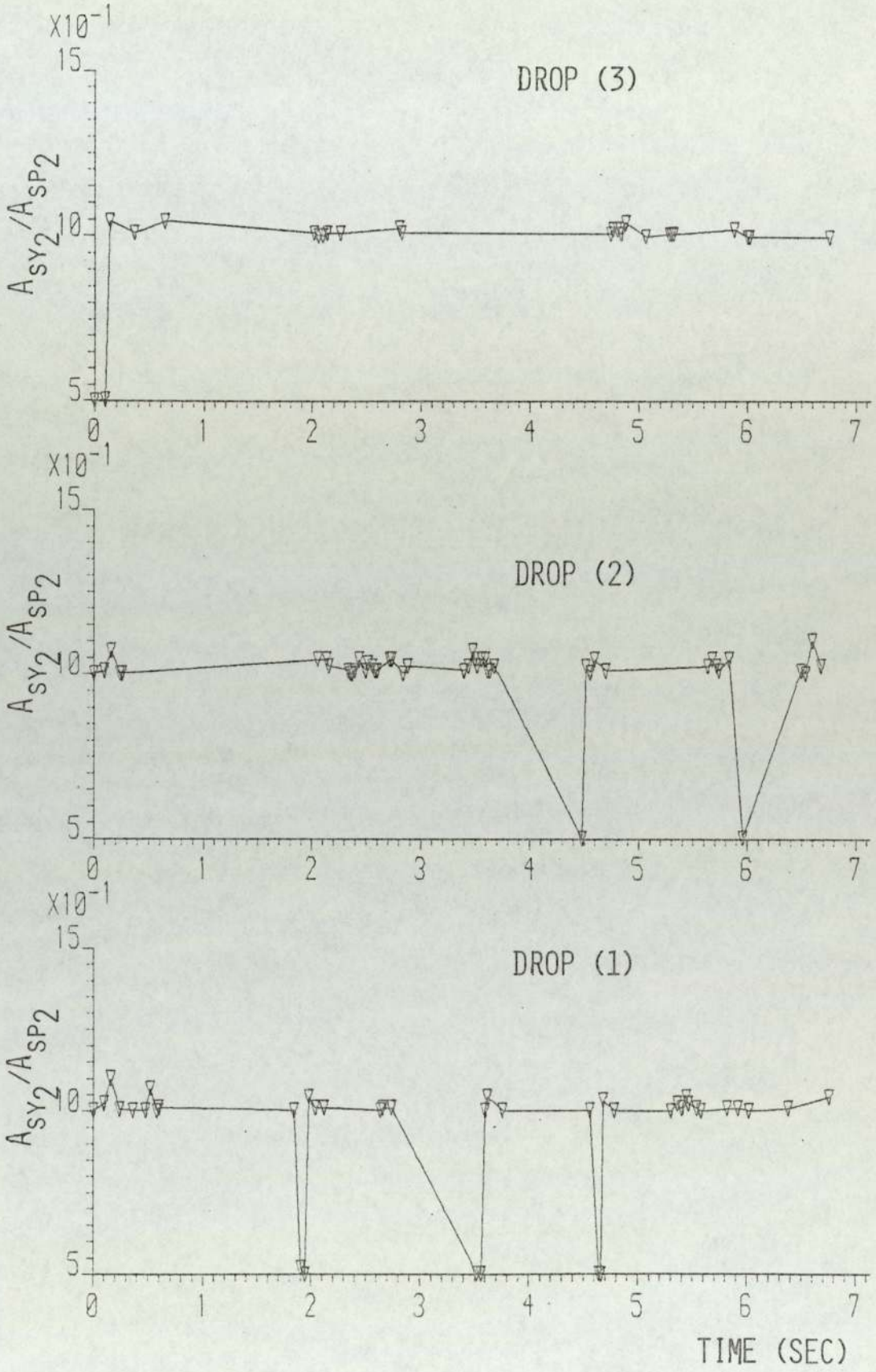

FIG. G.66 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-37, BASED ON MEAN VOLUME.

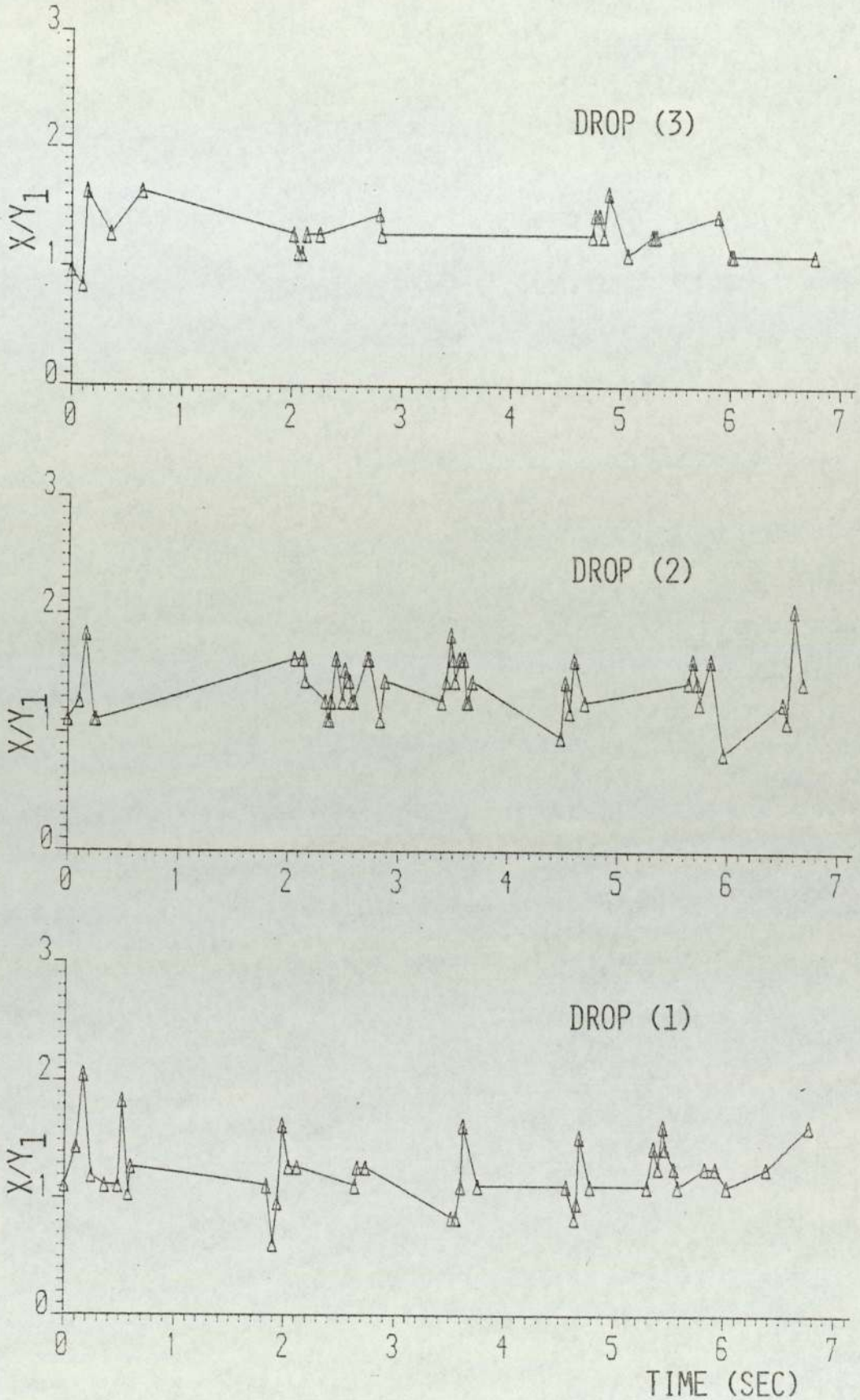

FIG. G.67 AXES RATIO VS. TIME, RUN-37.

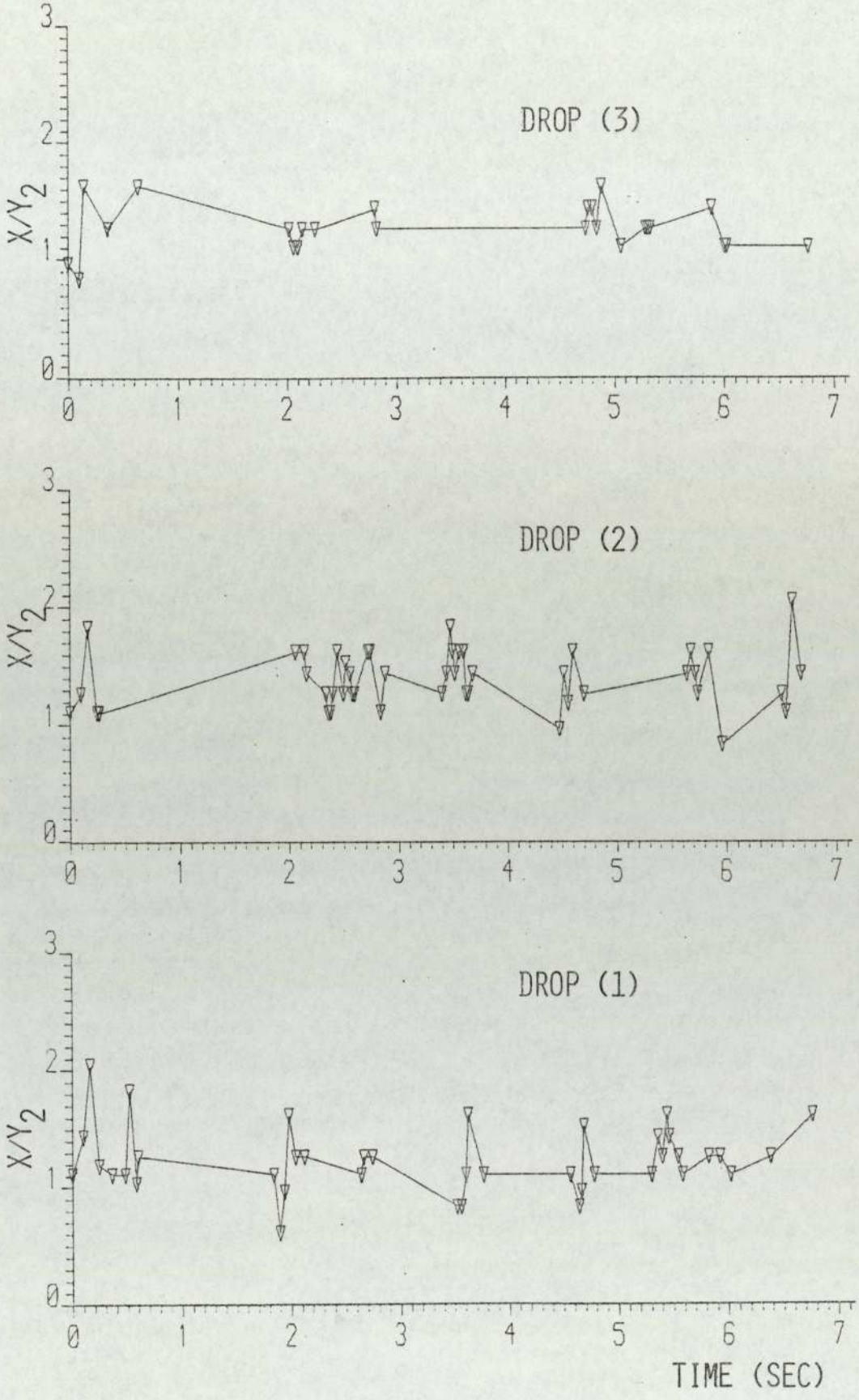

FIG. G.68 AXES RATIO VS. TIME, RUN-37.

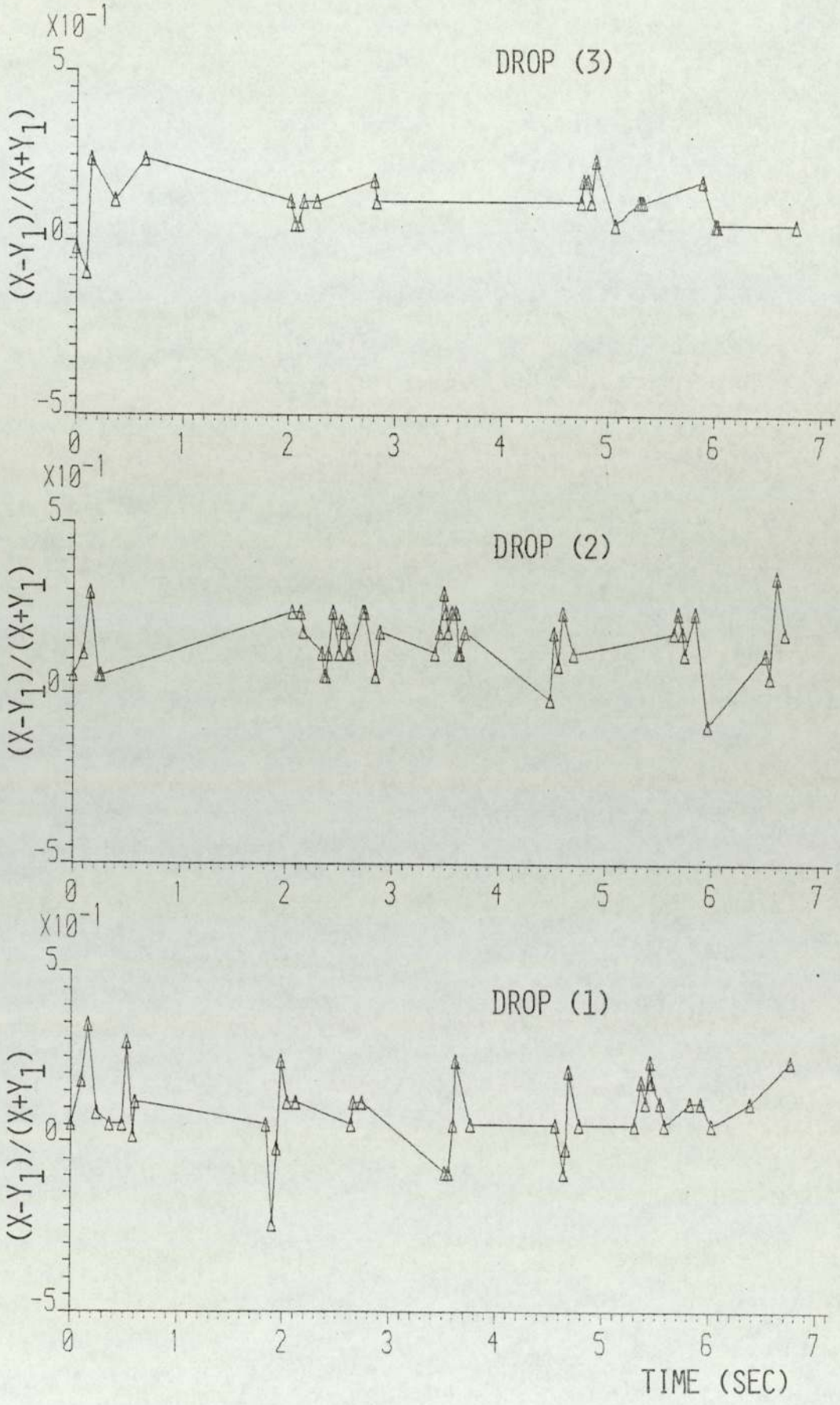

FIG. G.69 DEFOPMATION RATIO VS. TIME, RUN-37.

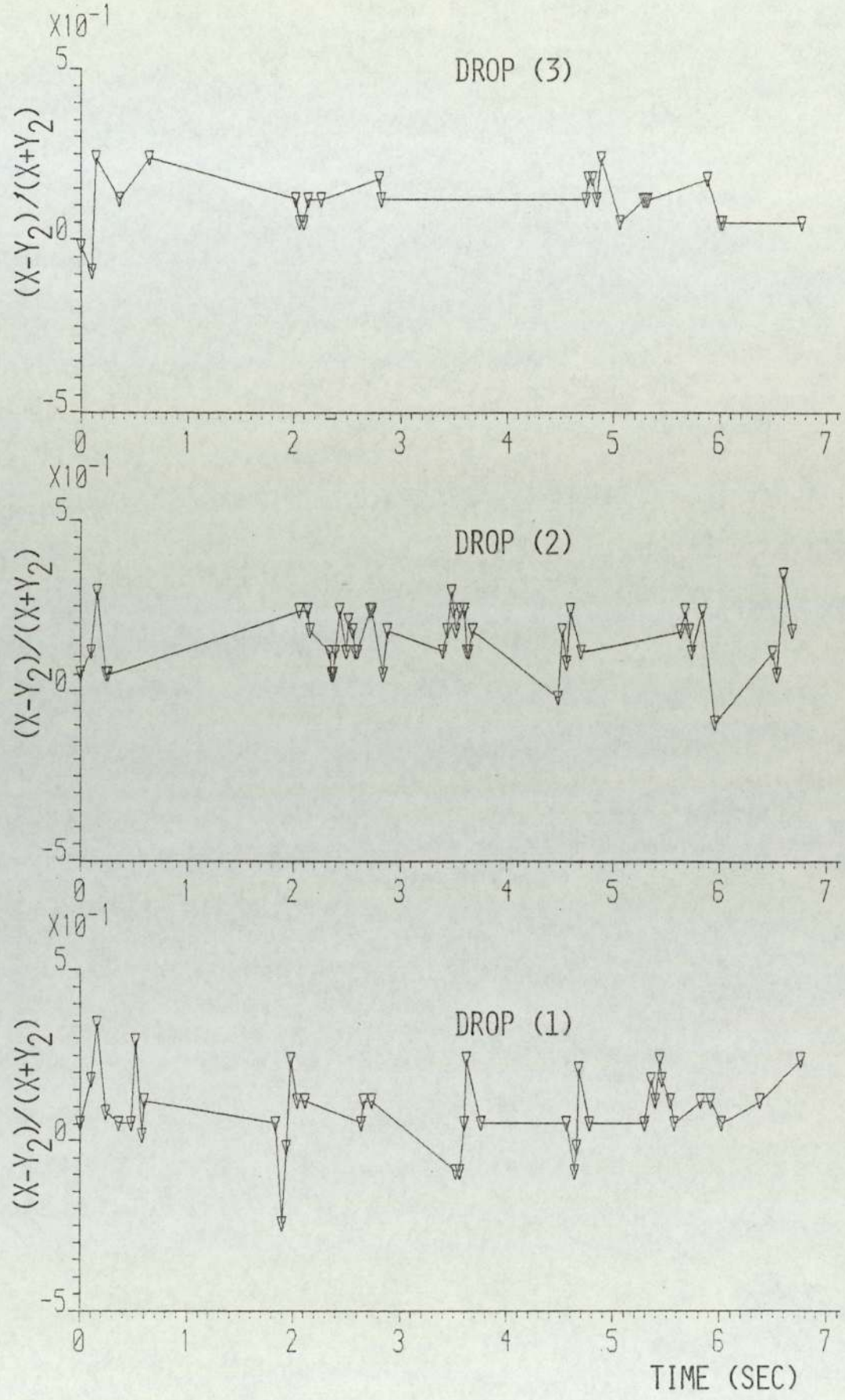

FIG. G.70 DEFORMATION RATIO VS. TIME, RUN-37.

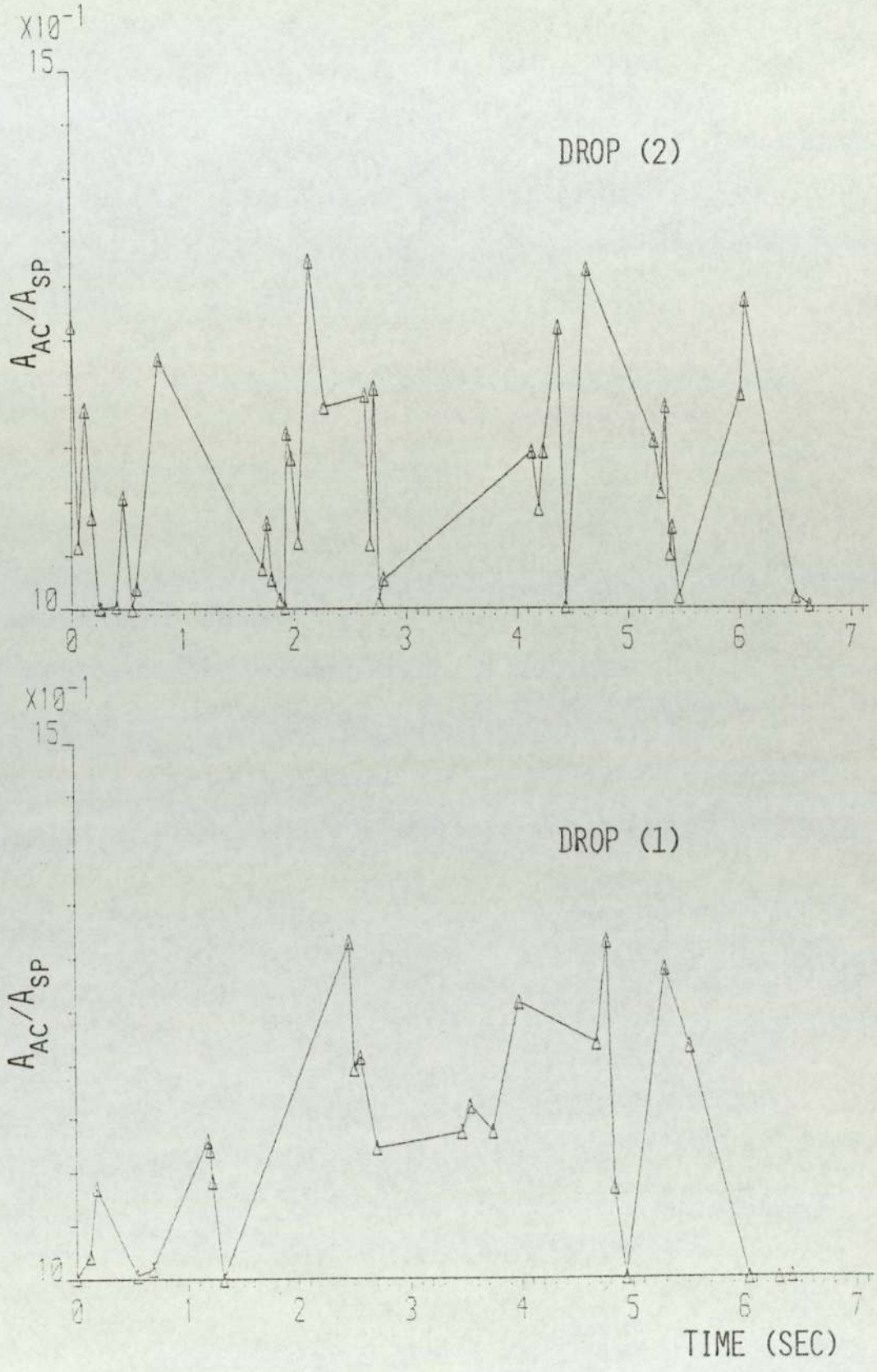

FIG. G.71 AREA RATIO VS. TIME, RUN-38.

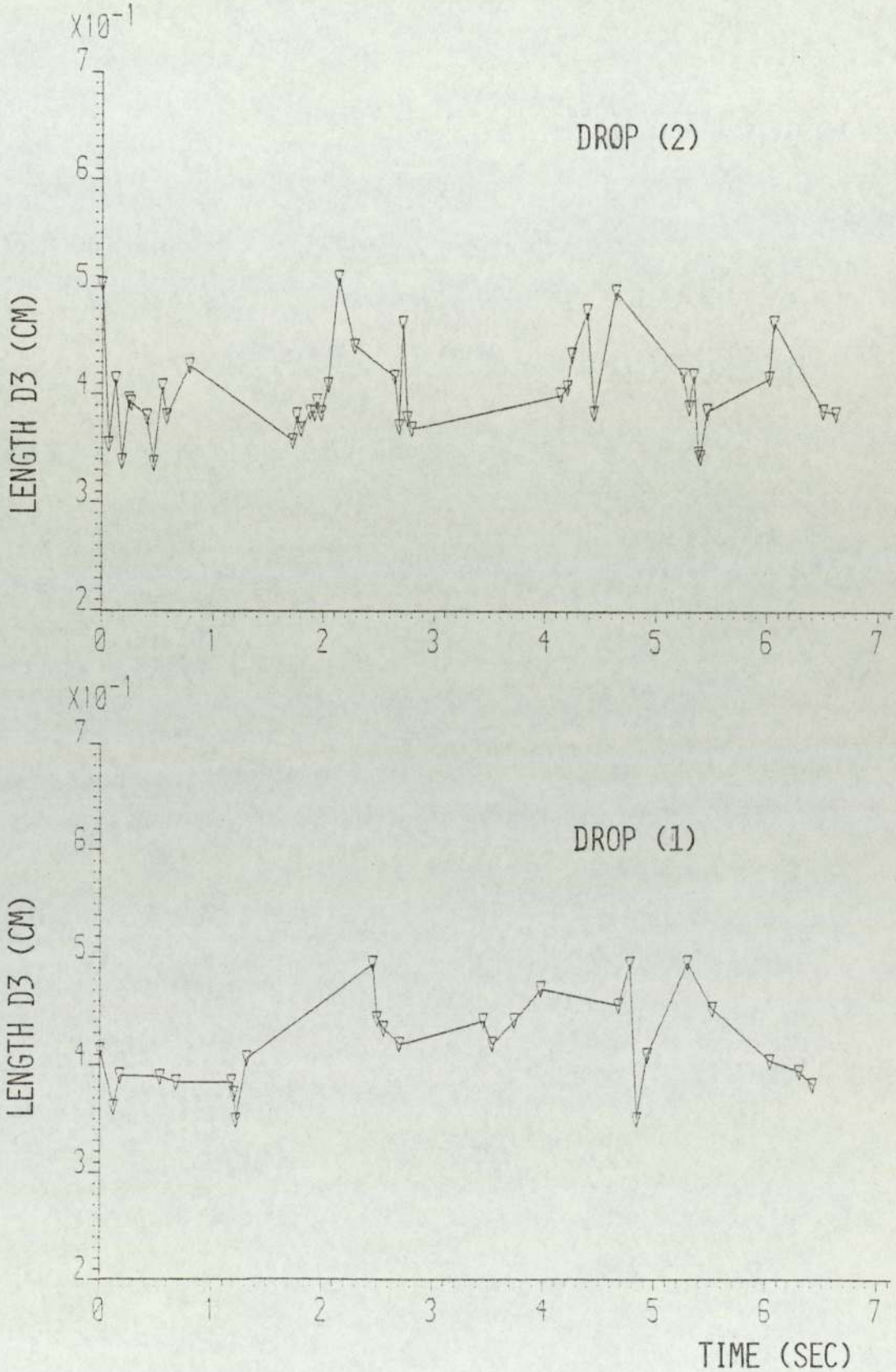

FIG. G.72 LENGTH D3 VS. TIME, RUN-38.

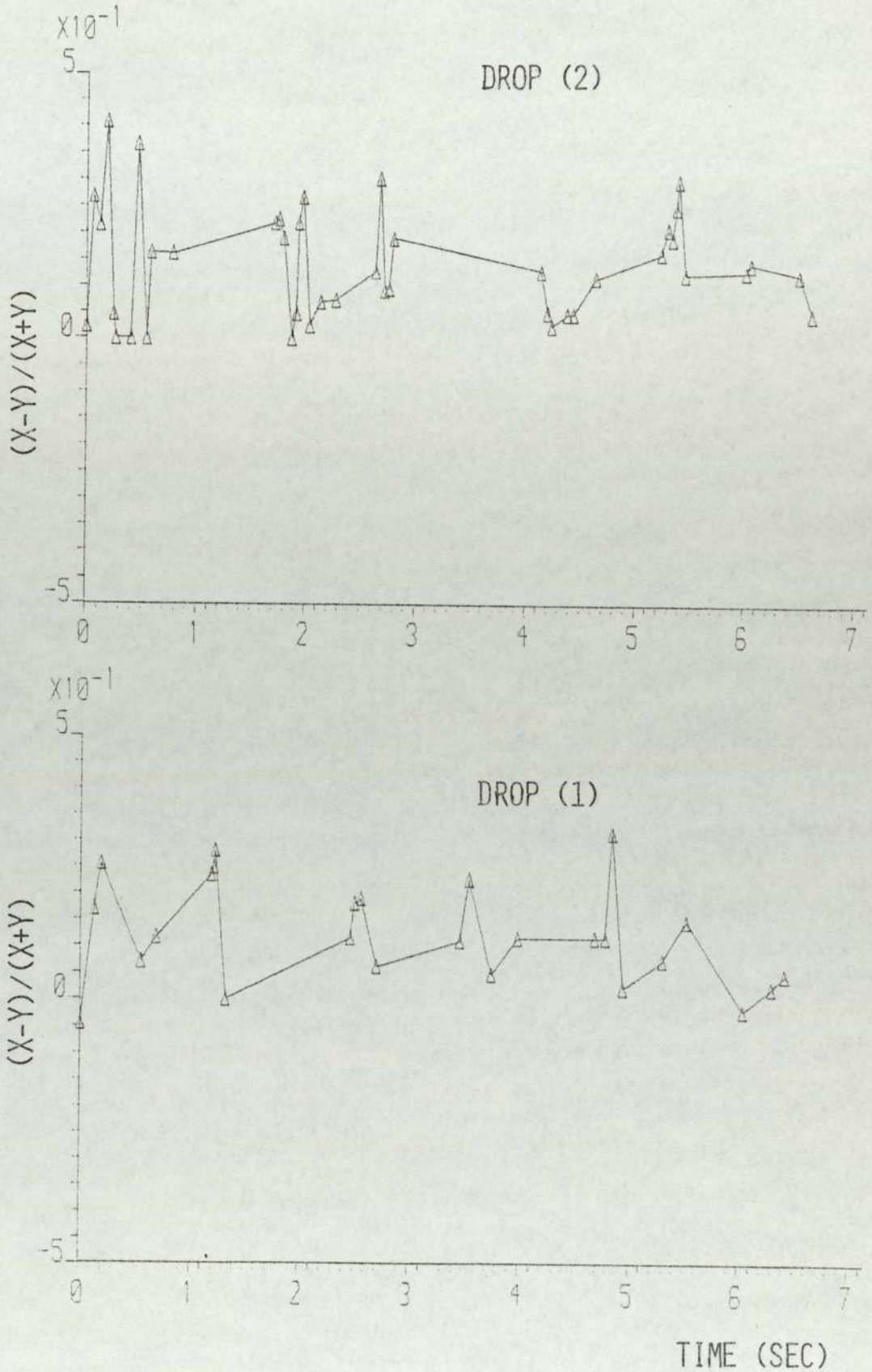

FIG. G.73 DEFORMATION RATIO VS. TIME, RUN-38.

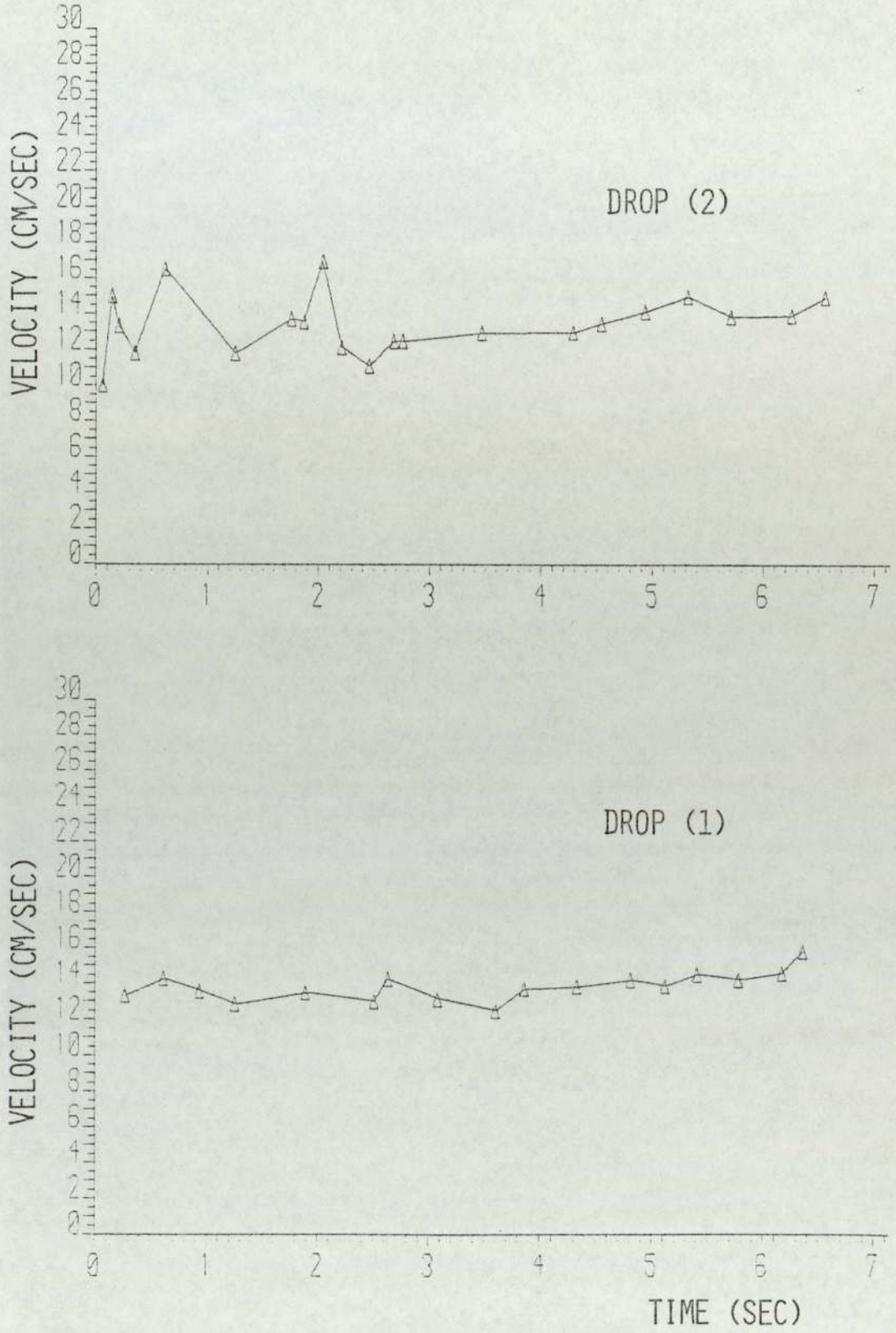

FIG. G.74 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-38.

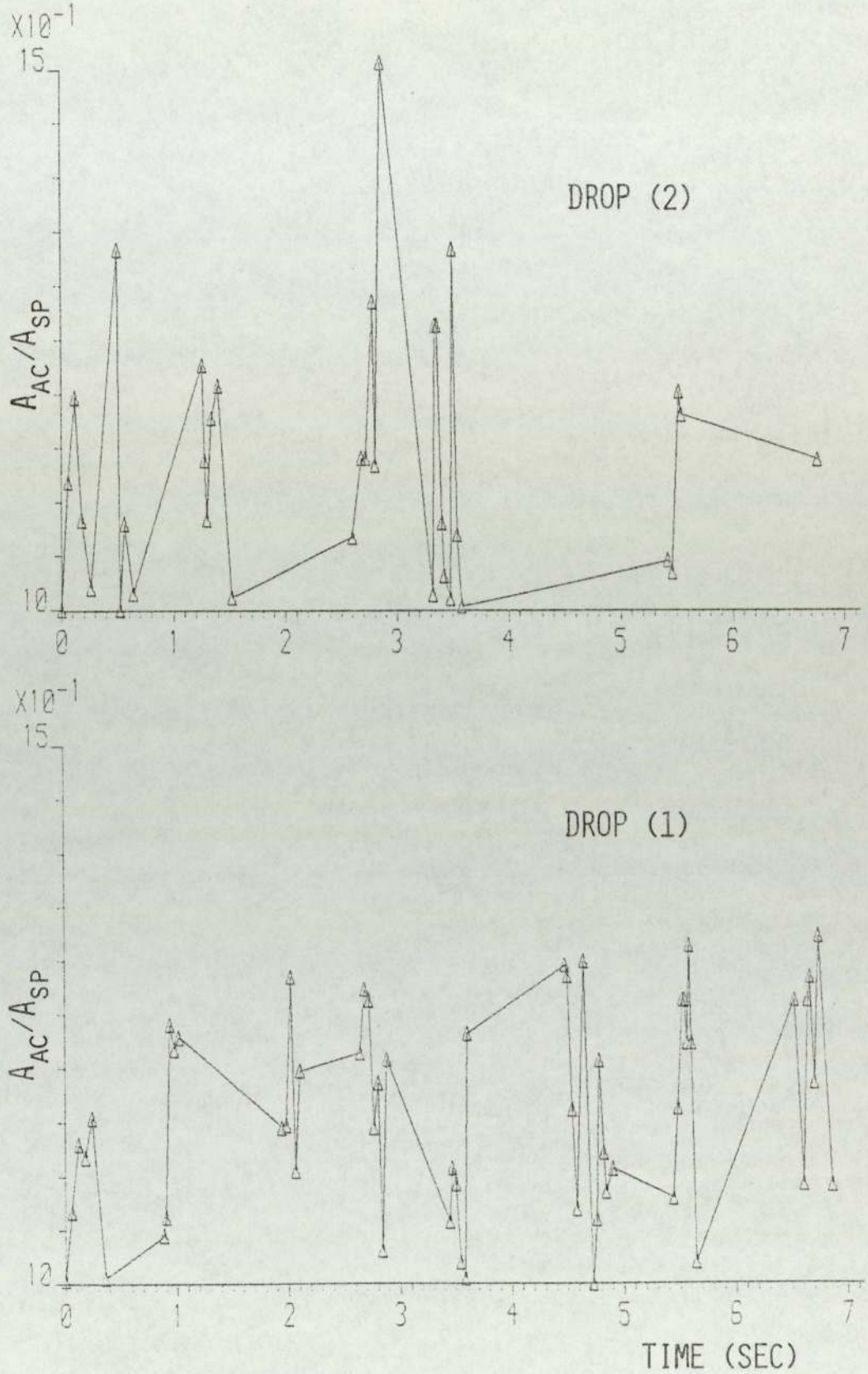

FIG. G.75 AREA RATIO VS. TIME, RUN-41.

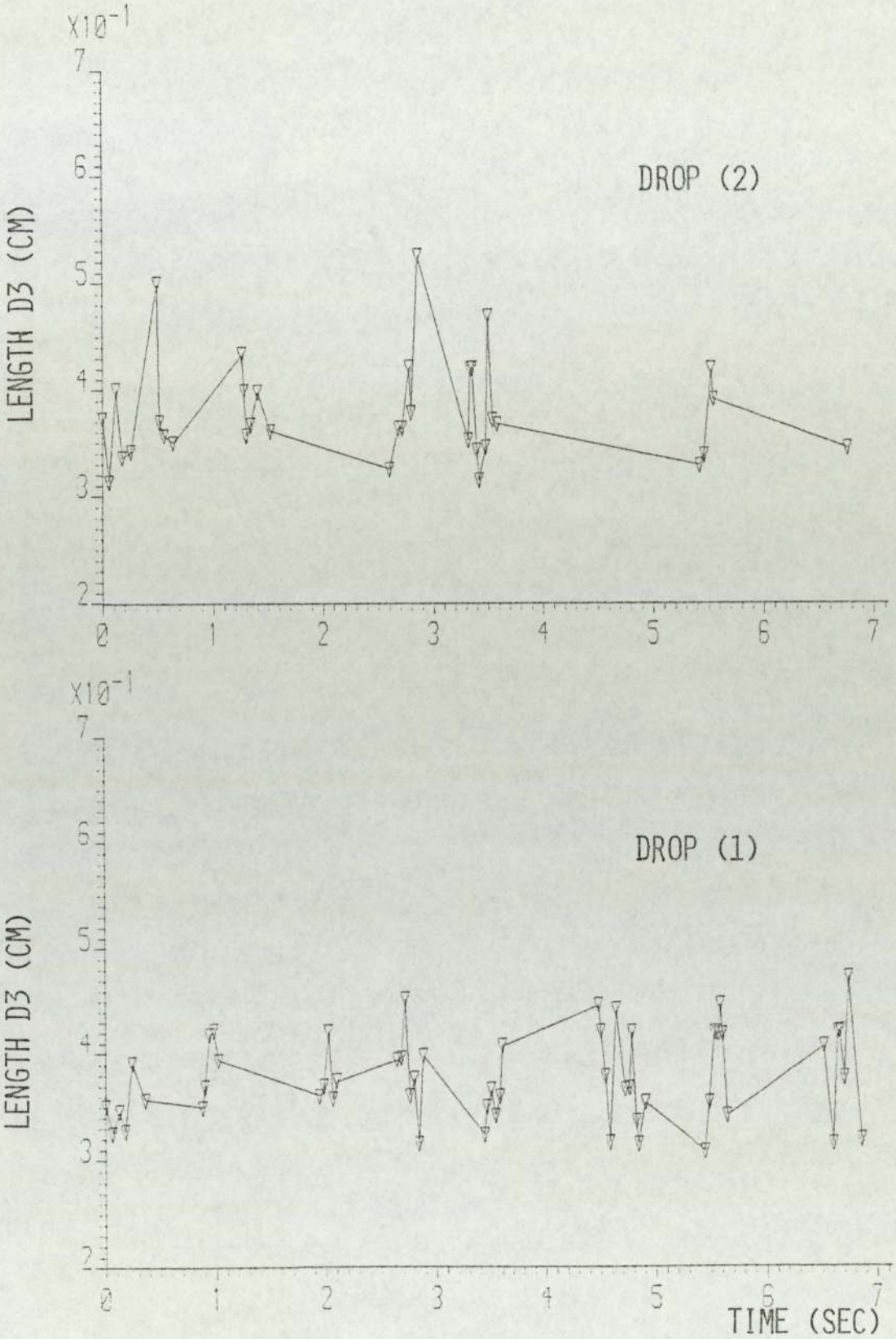

FIG. G.76 LENGTH D3 VS. TIME, RUN-41.

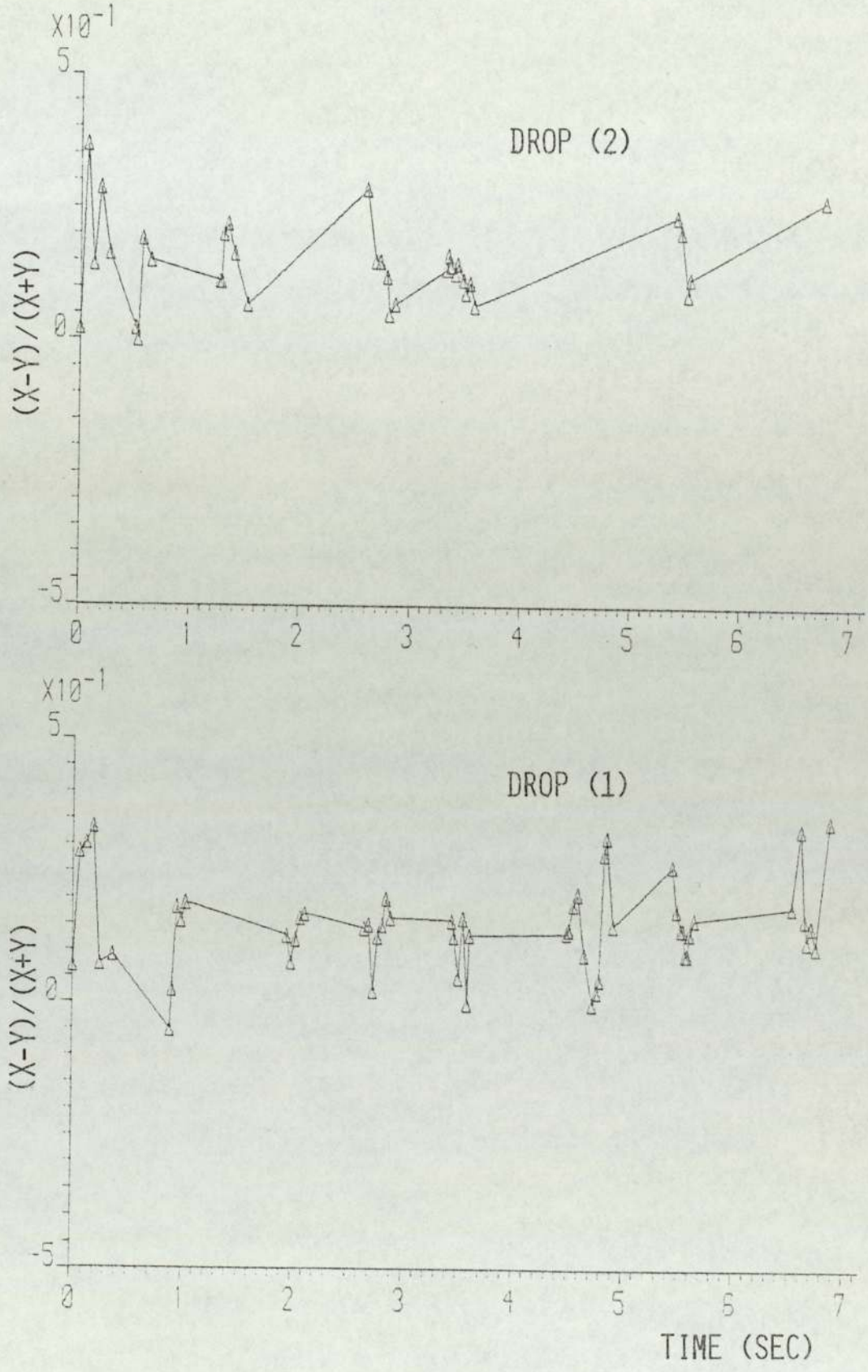

FIG. G.77 DEFORMATION RATIO VS. TIME, RUN-41.

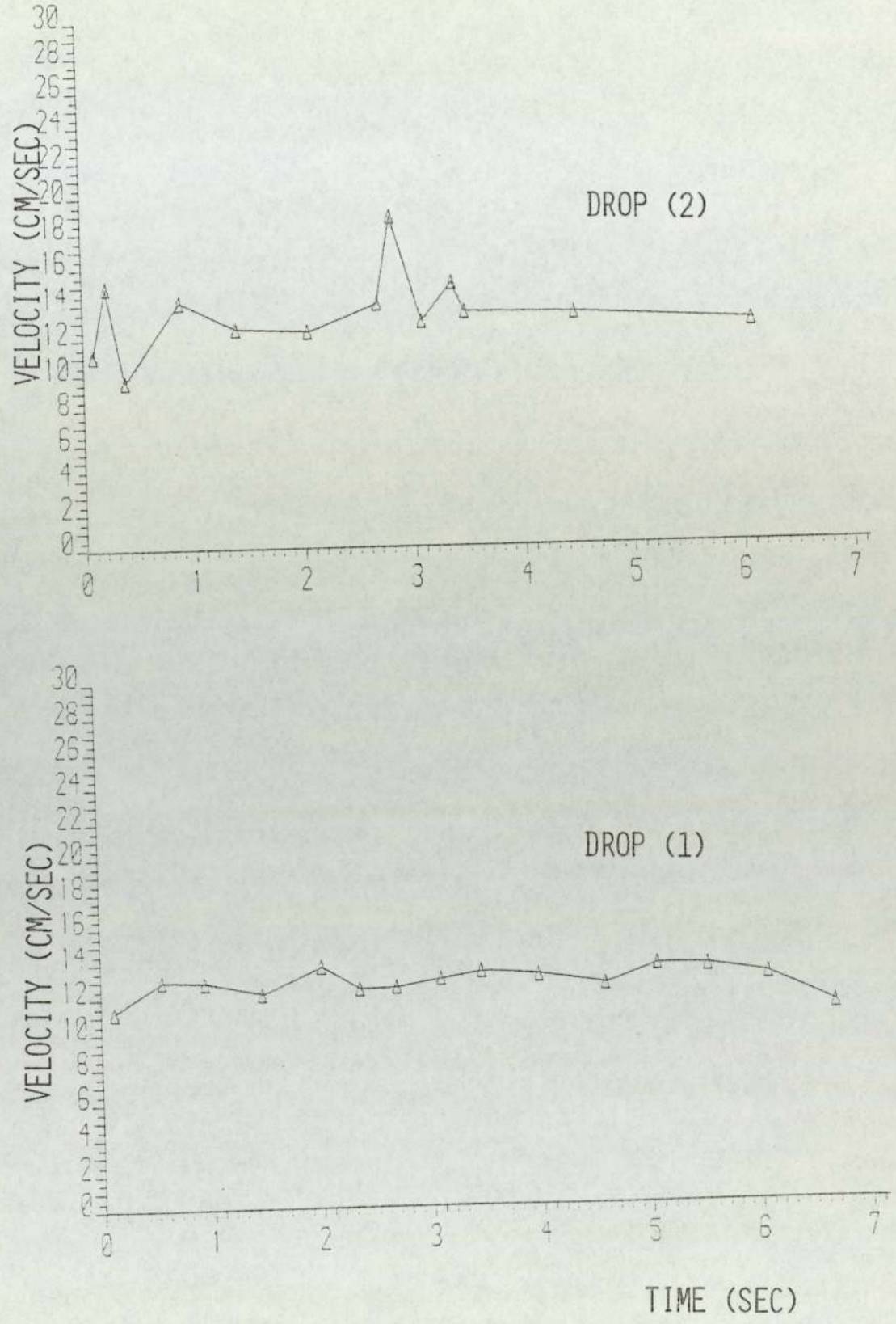

FIG. G.78 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-41.

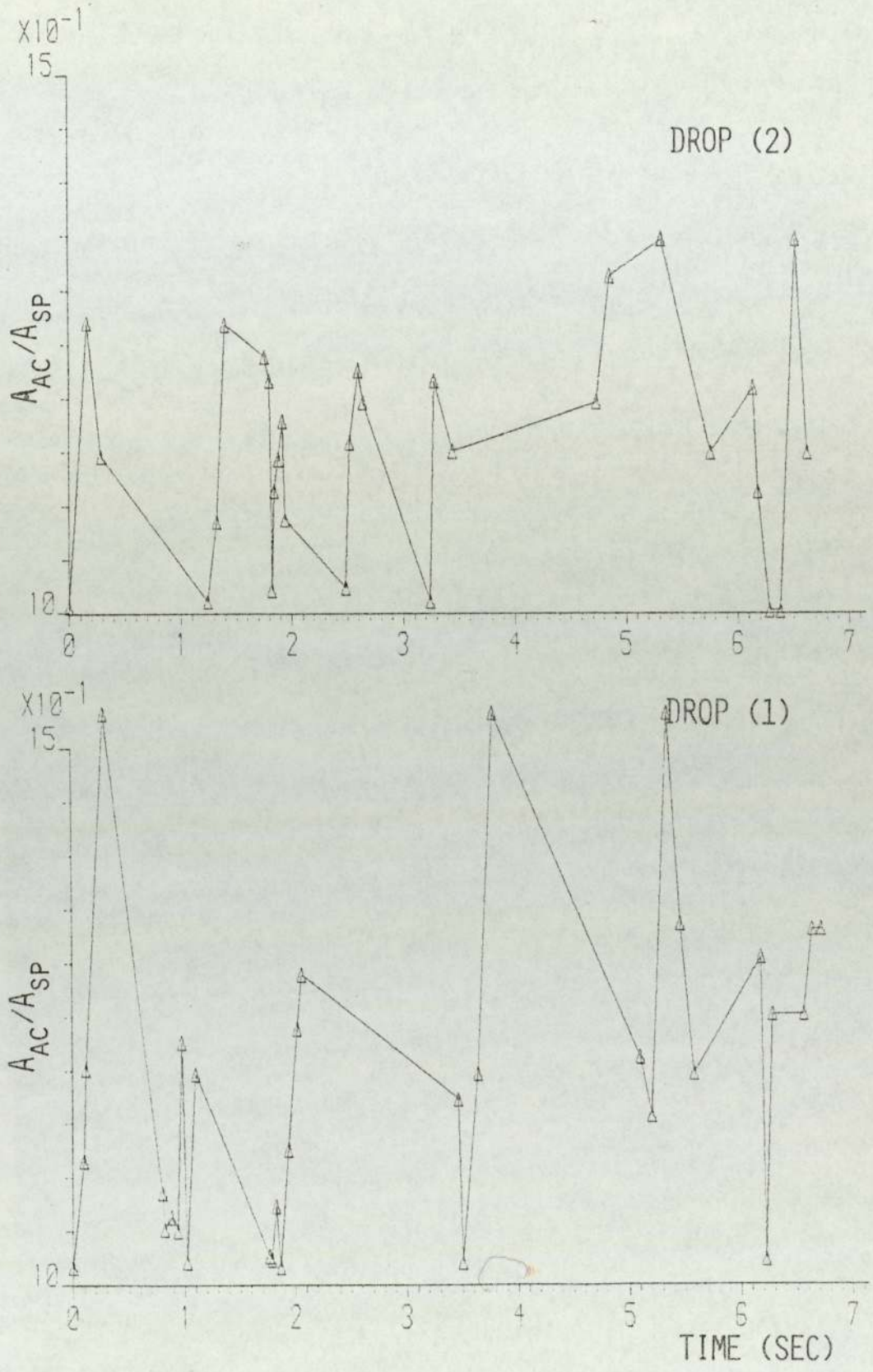

FIG. G.79 AREA RATIO VS. TIME, RUN-42.

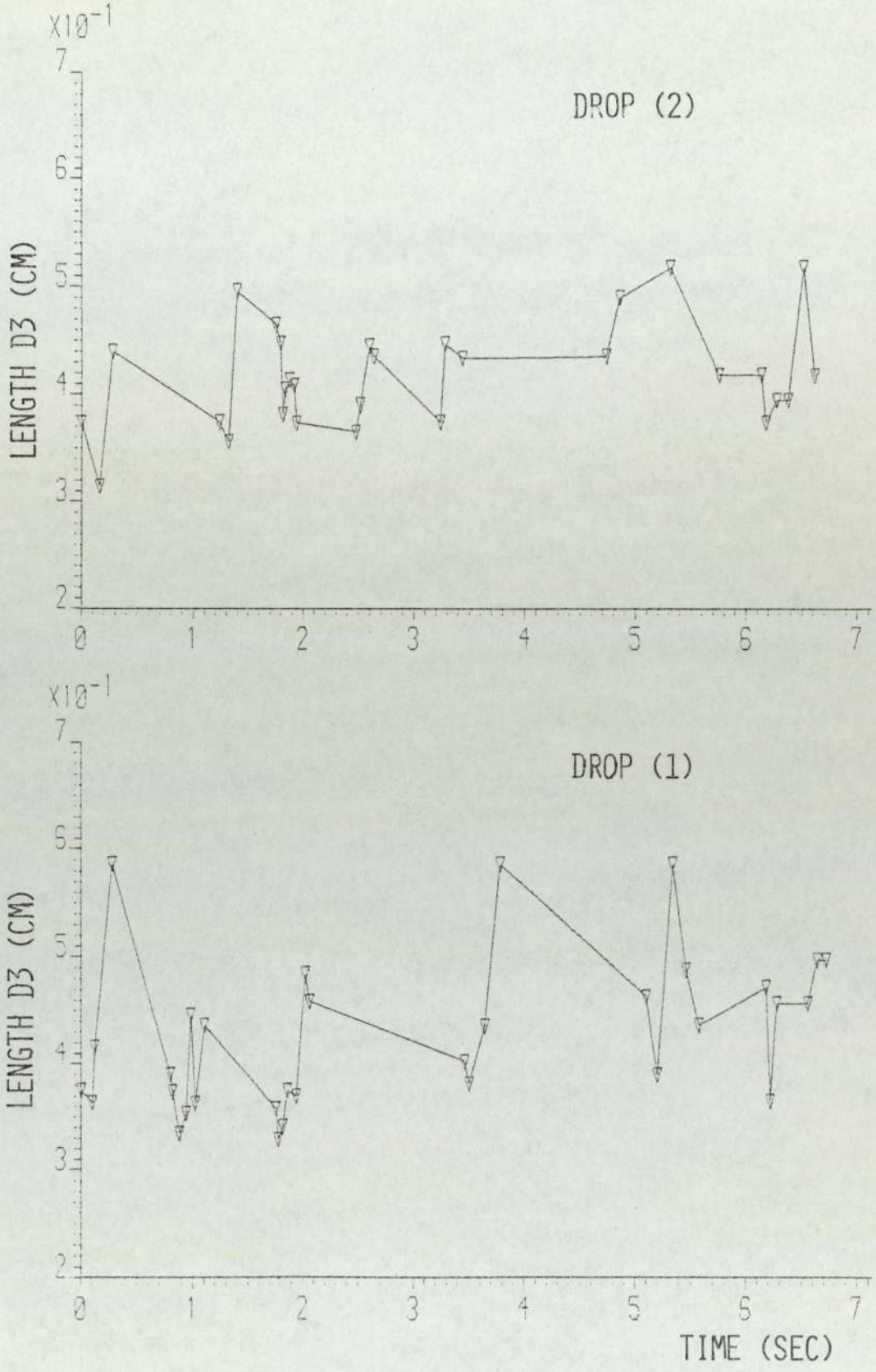

FIG. G.80 LENGTH D3 VS. TIME, RUN-42.

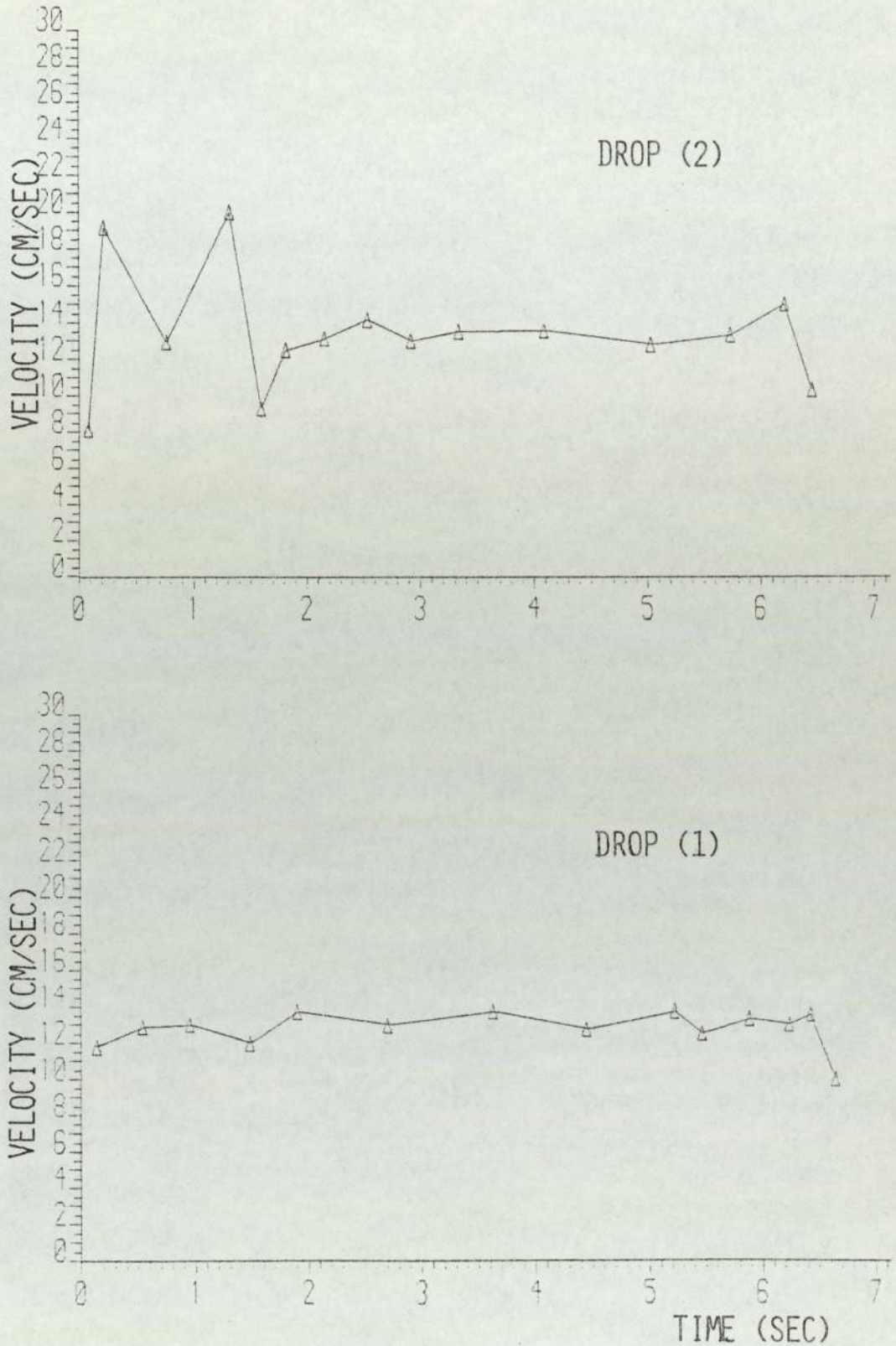

FIG. G.81 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-42.

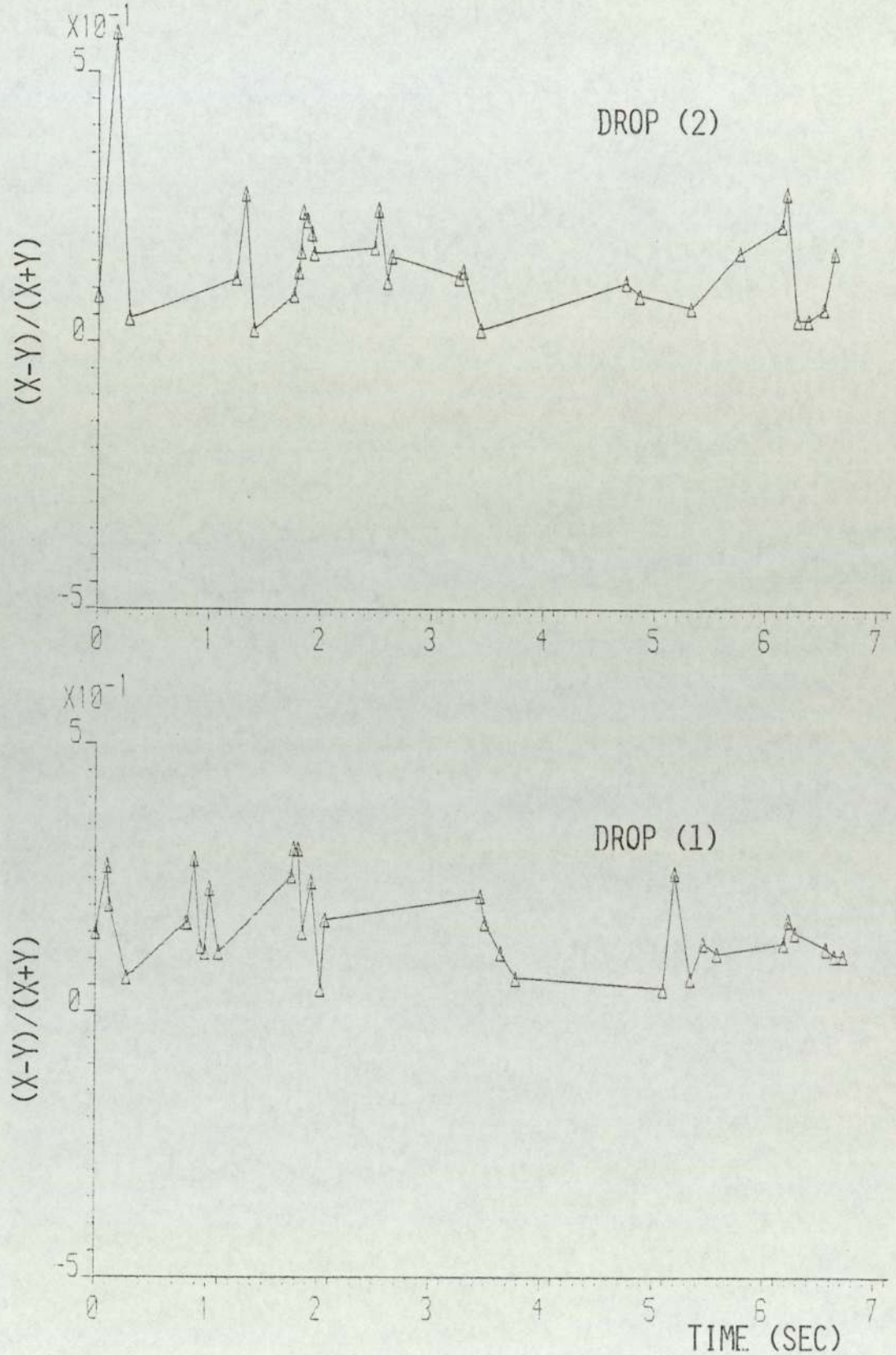

FIG. G.82 DEFORMATION RATIO VS. TIME, RUN-42.

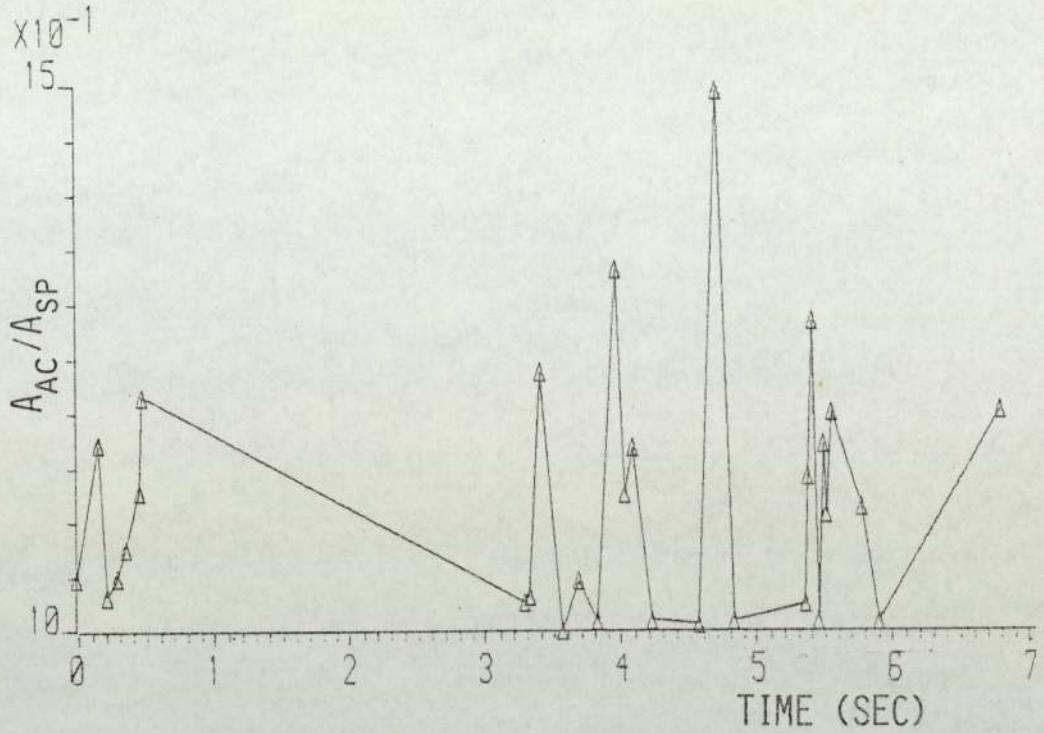

FIG. G.83 AREA RATIO VS. TIME, RUN-48.

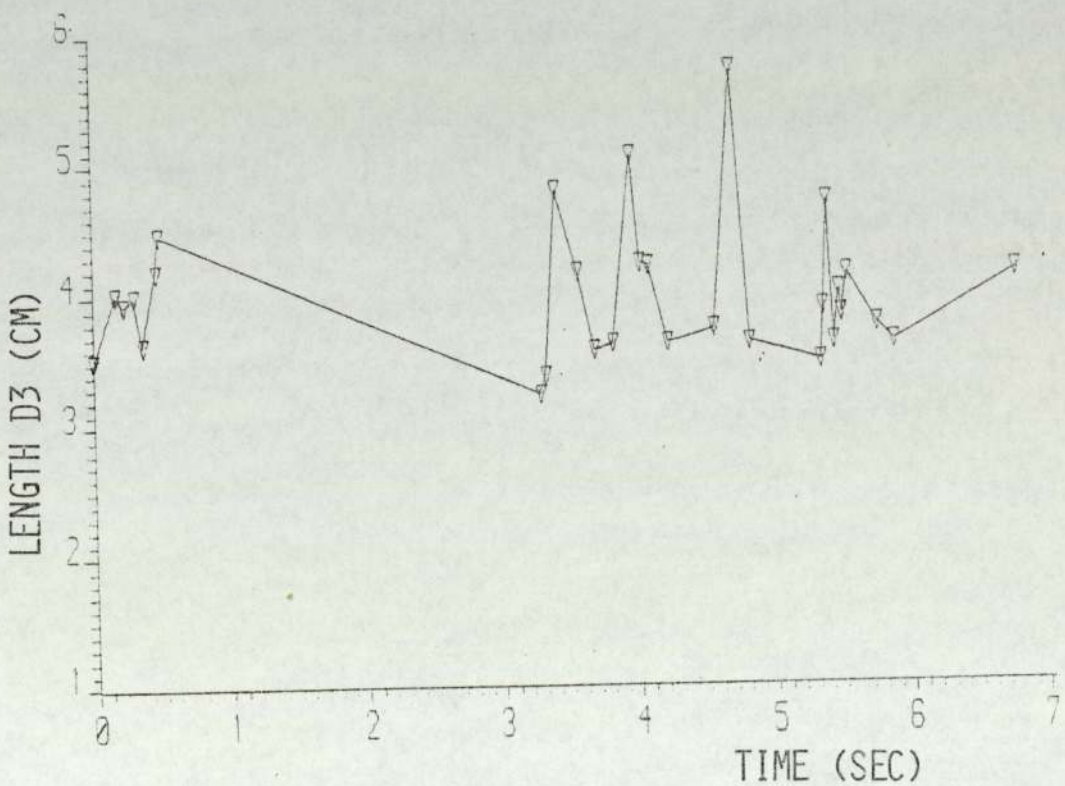

FIG. G.84 LENGTH D3 VS. TIME, RUN-48.

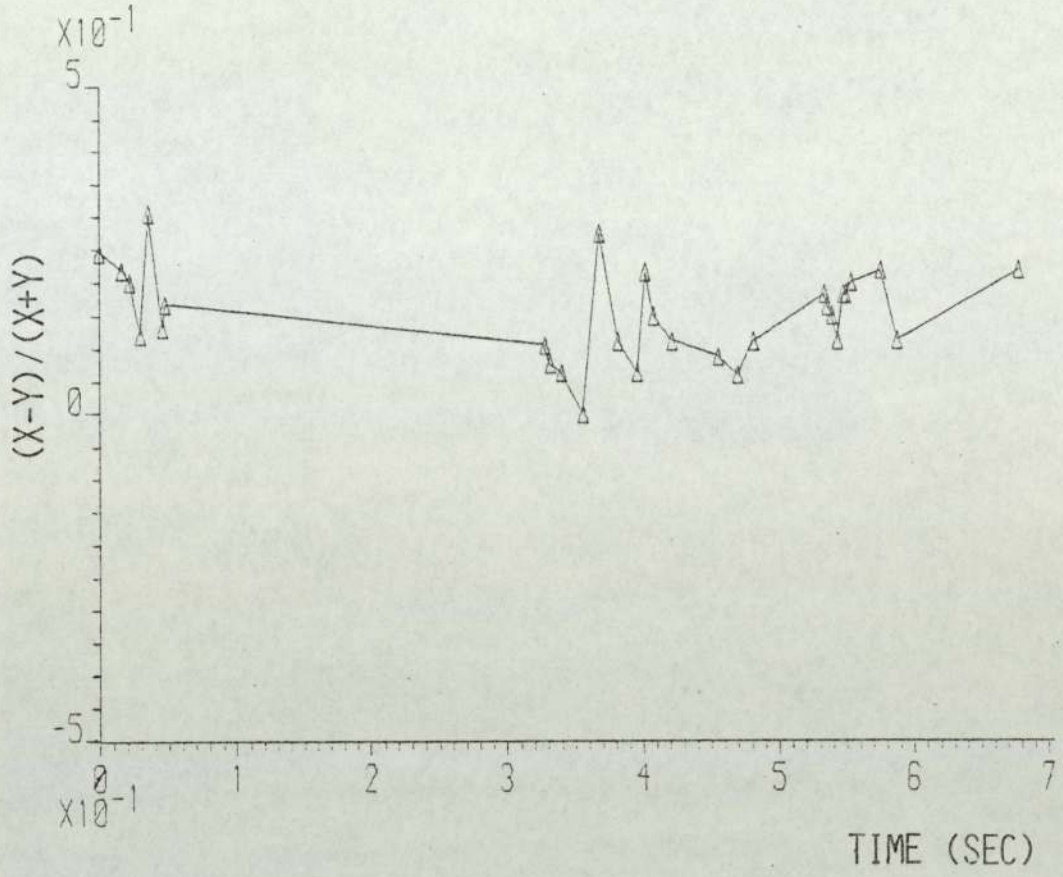

FIG. G.85 DEFORMATION RATIO VS. TIME, RUN-48.

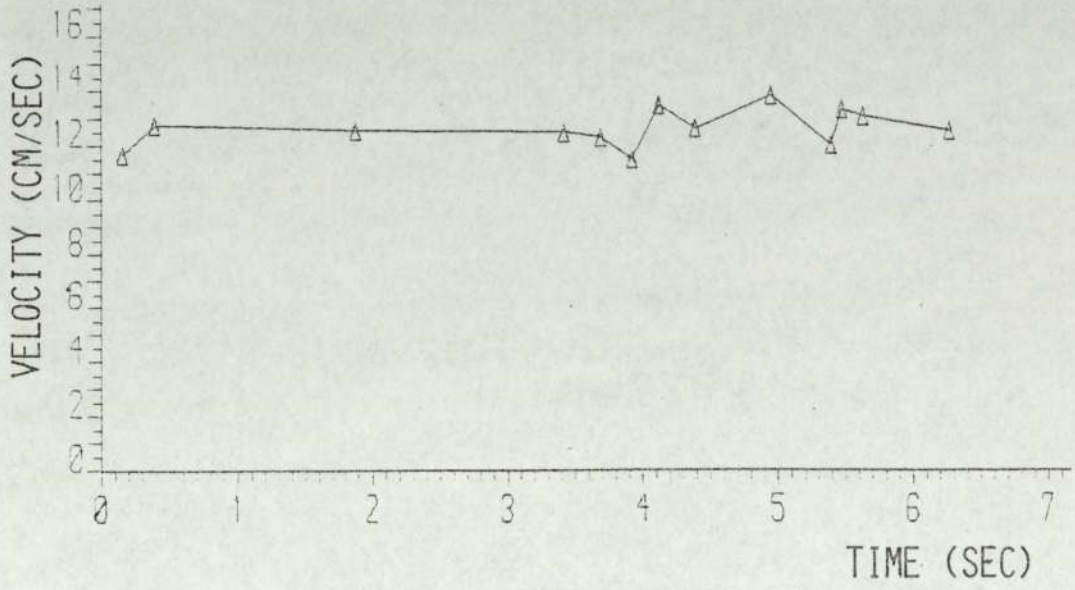

FIG. G.86 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-48.

APPENDIX H

ILLUSTRATIONS OF THE EXPERIMENTS OF THE TOLUENE-ACETONE-WATER SYSTEMS

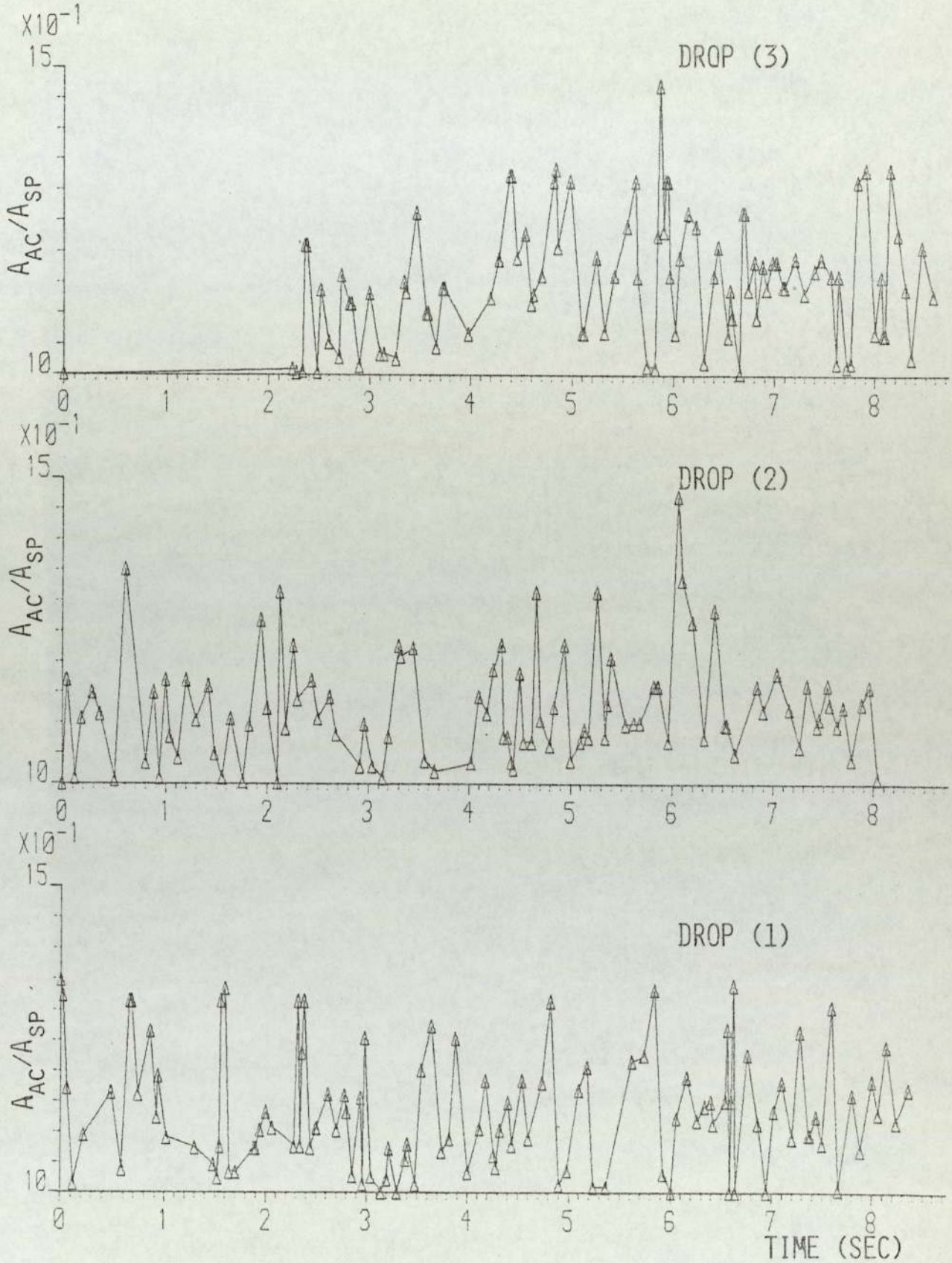

FIG. H.1 AREA RATIO VS. TIME, RUN-7.

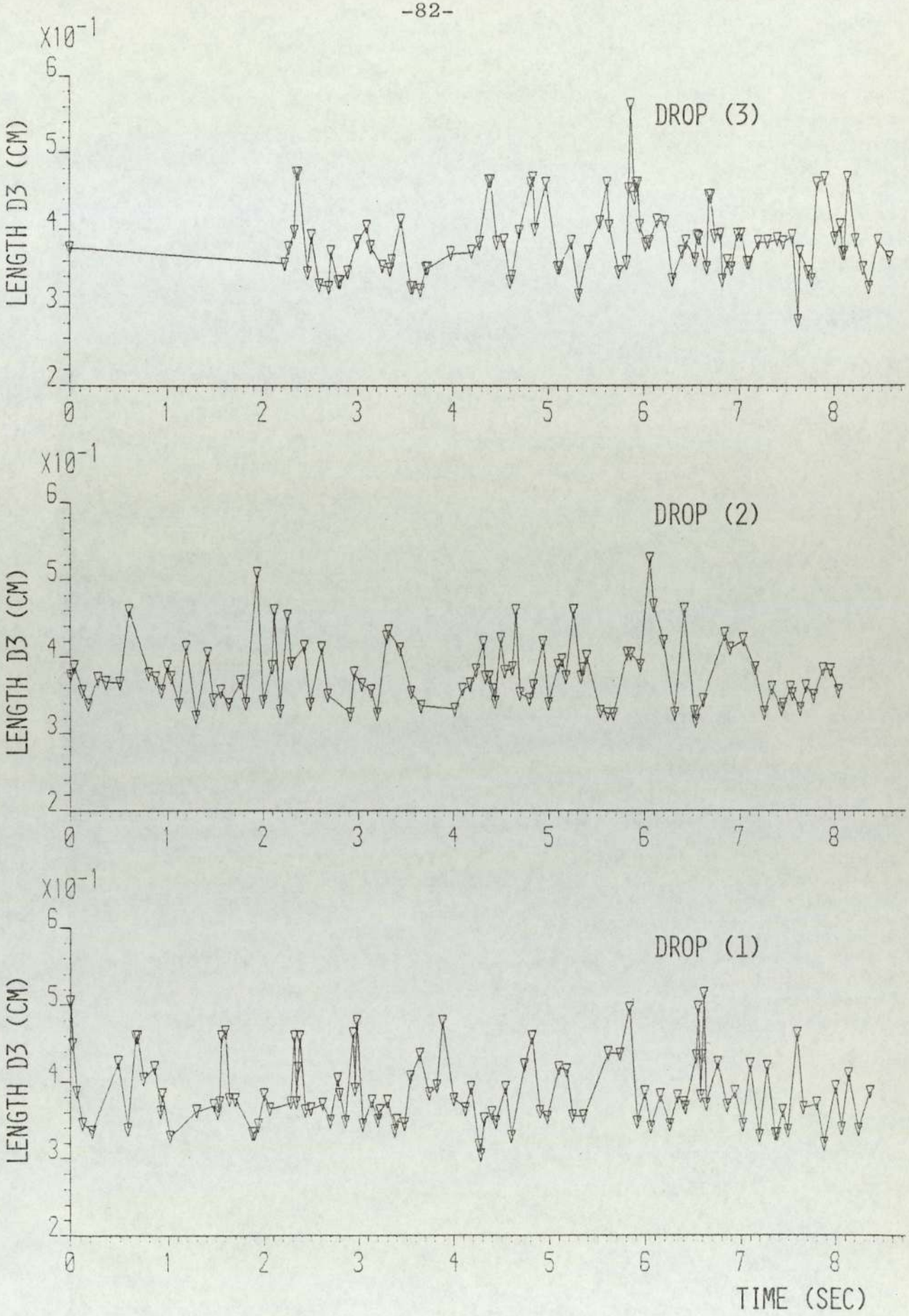

FIG. H.2 LENGTH D3 VS. TIME, RUN-7.

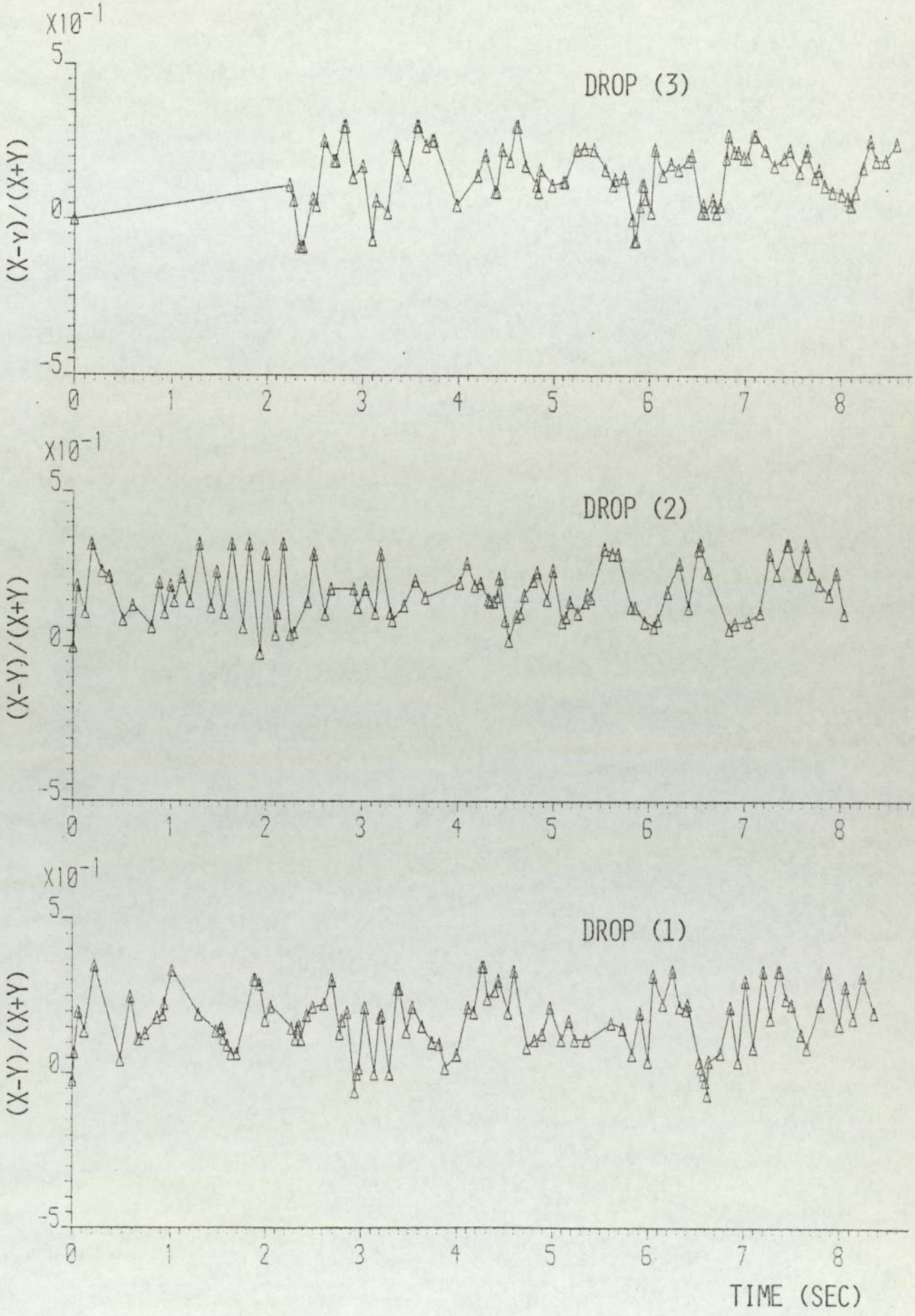

FIG. H.3 DEFORMATION RATIO VS. TIME, RUN-7.

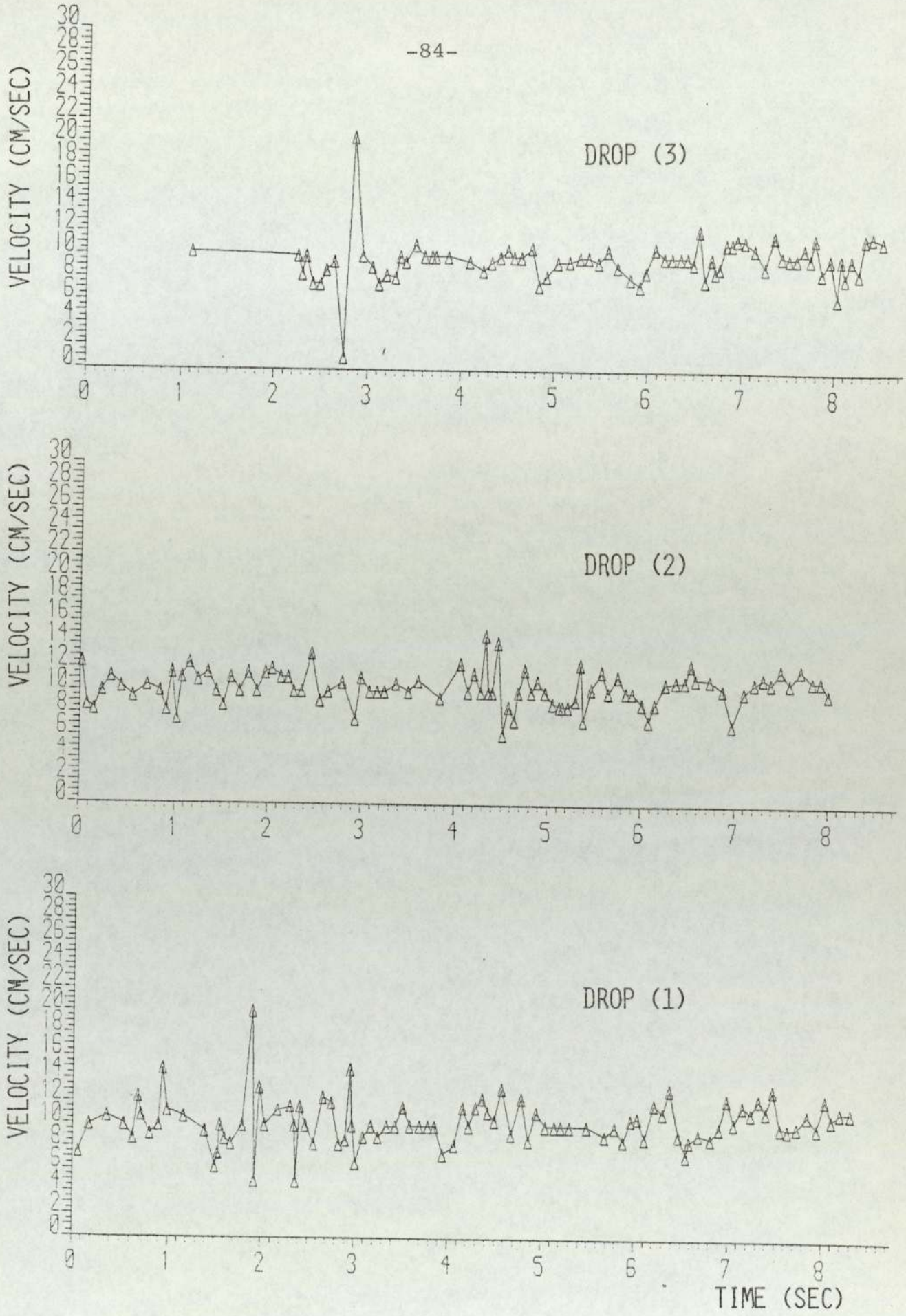

FIG. H.4 INSTANTANEOUS VELOCITY VS. AVERAGE TIME, RUN-7.

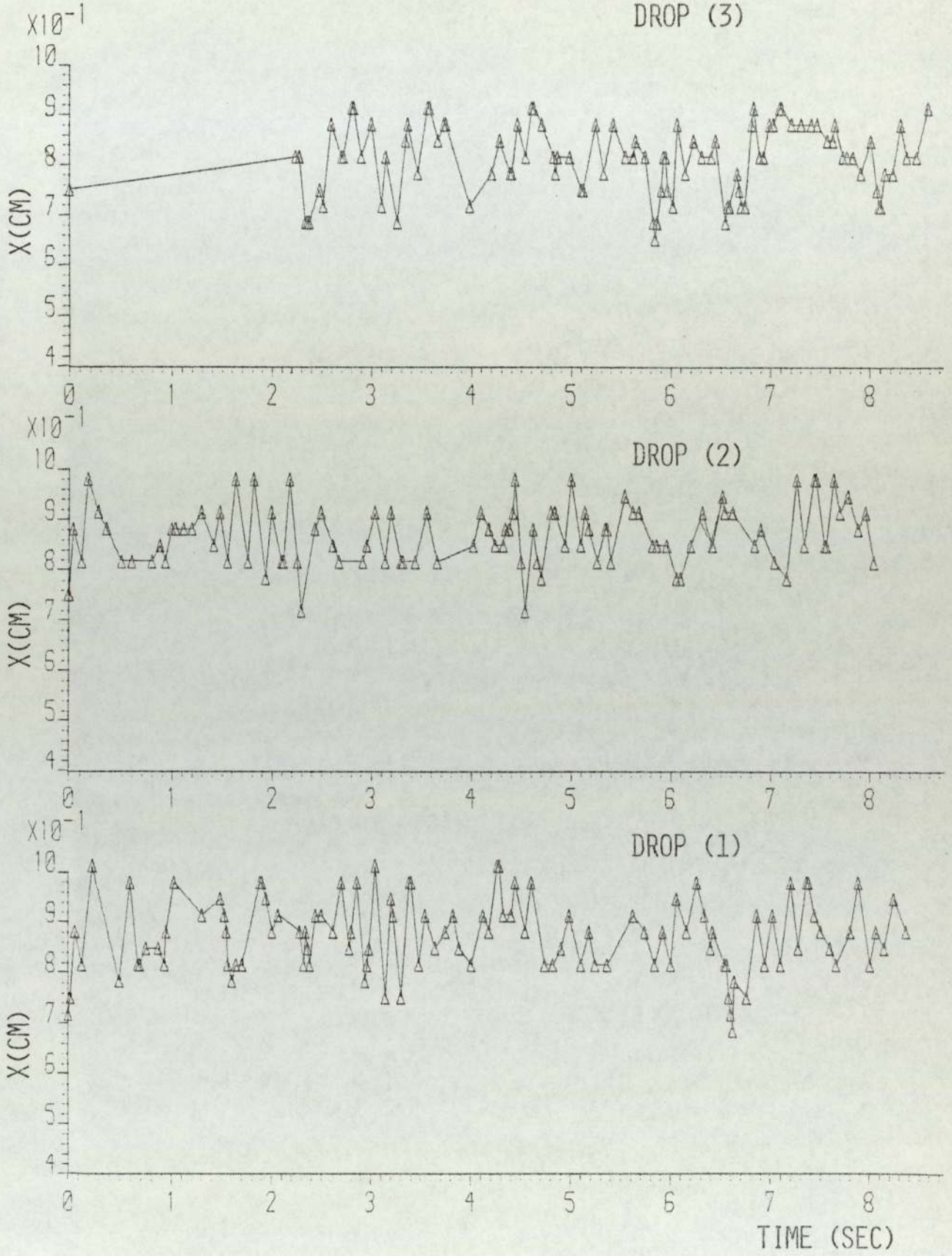

FIG. H.5 X VS. TIME, RUN-7.

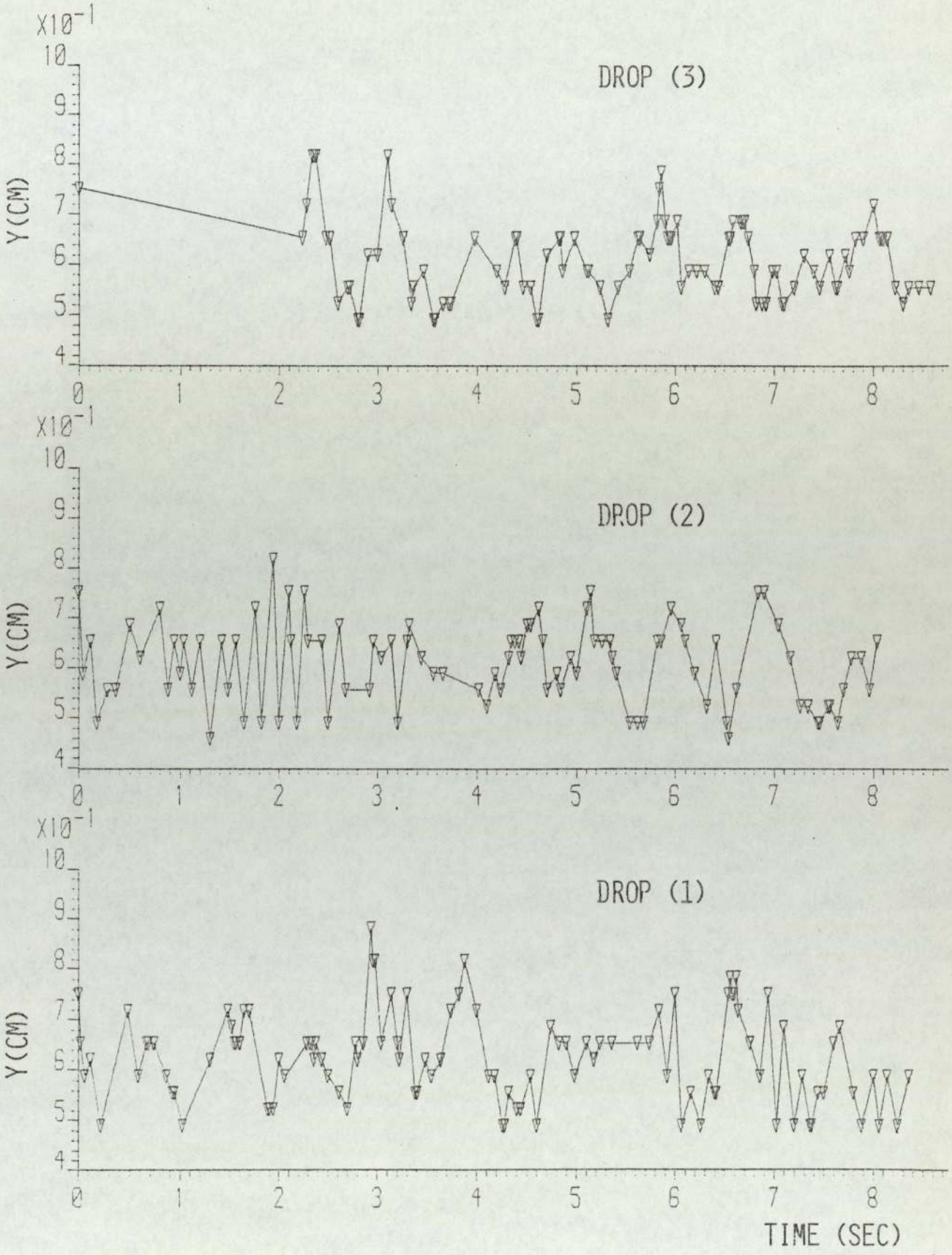

FIG. H.6 Y VS. TIME, RUN-7.

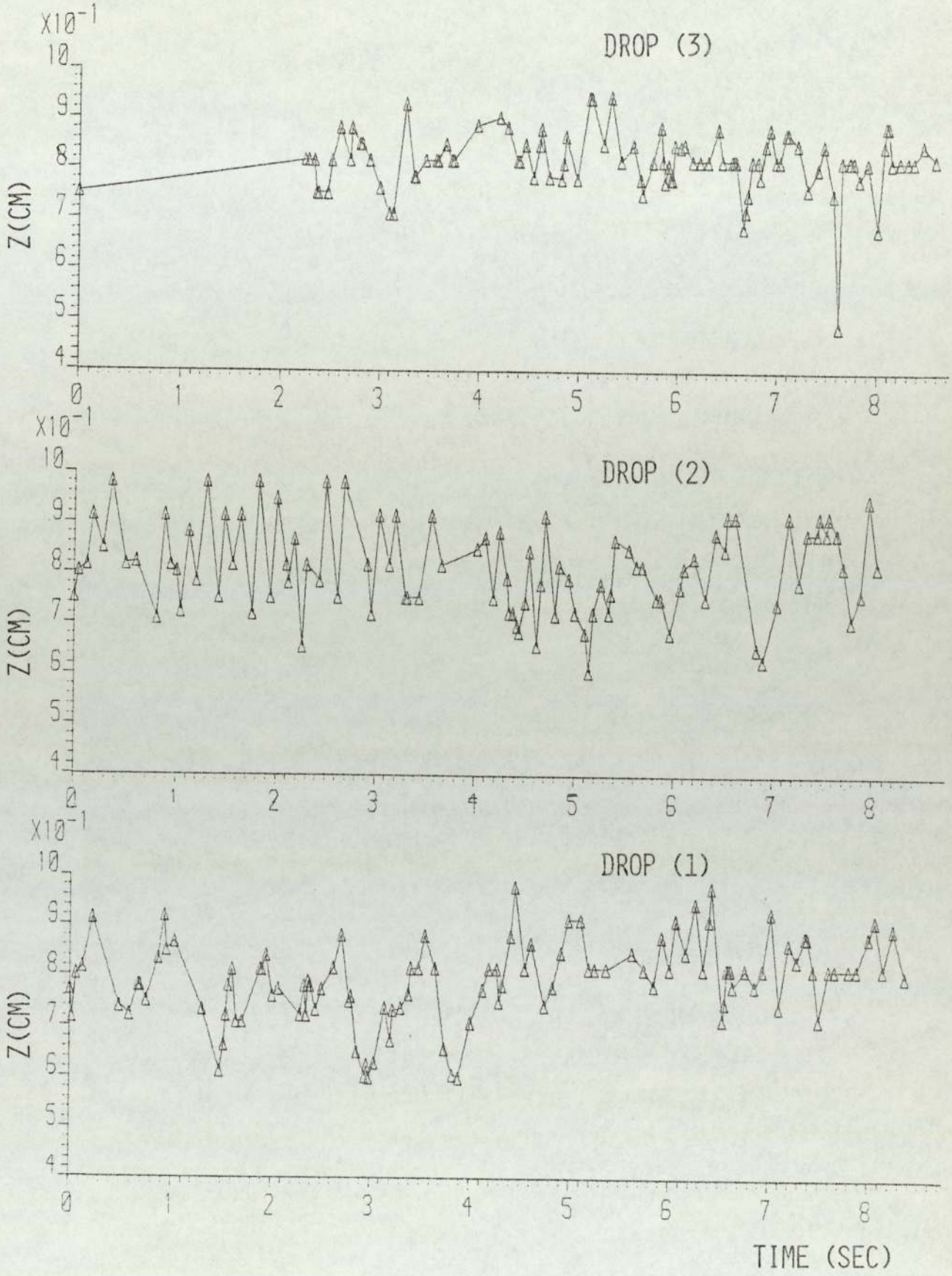

FIG. H.7 Z VS. TIME, RUN-7.

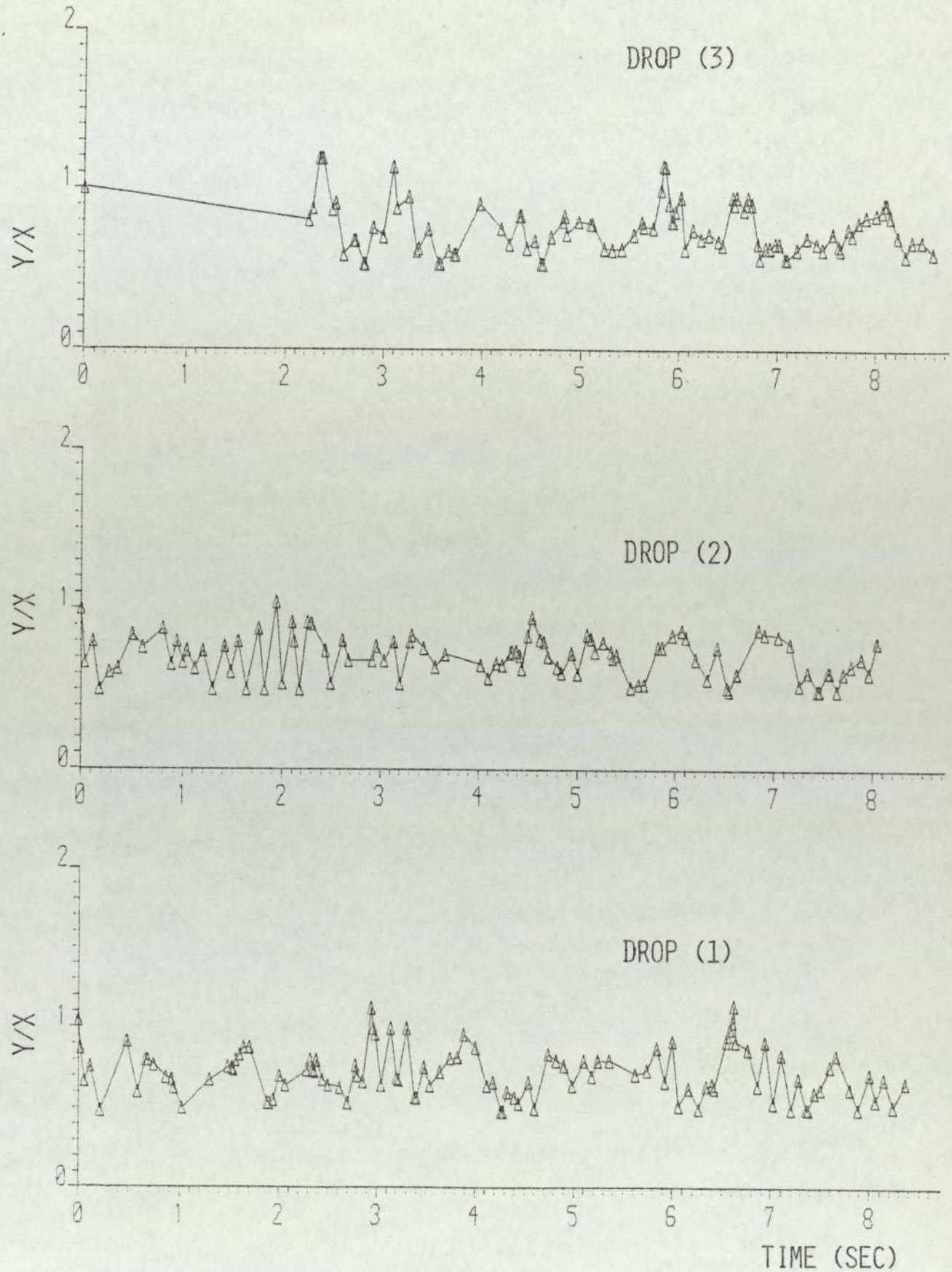

FIG. H.8 AXES RATIO VS. TIME, RUN-7.

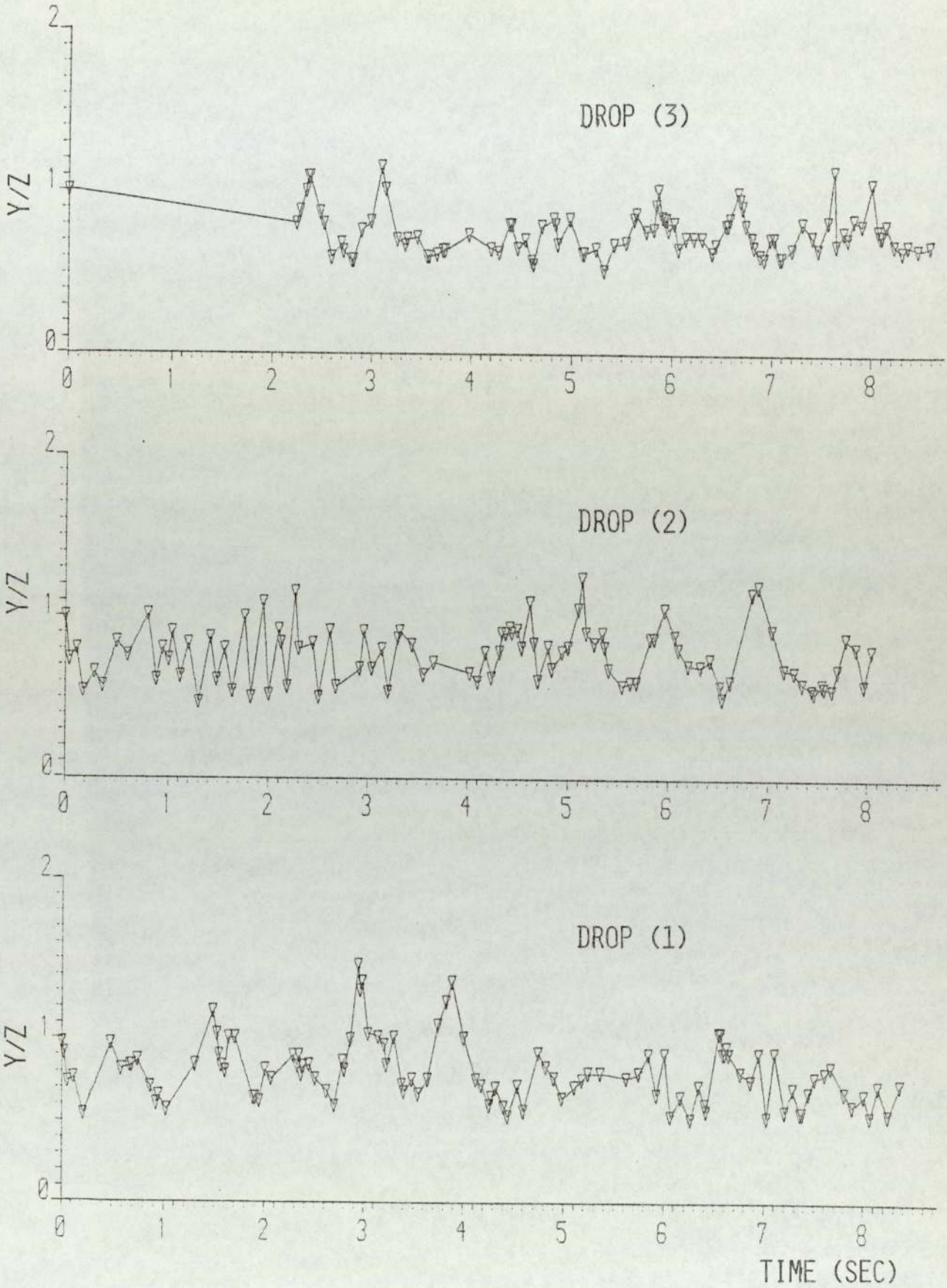

FIG. H.9 AXES RATIO VS. TIME, RUN-7.

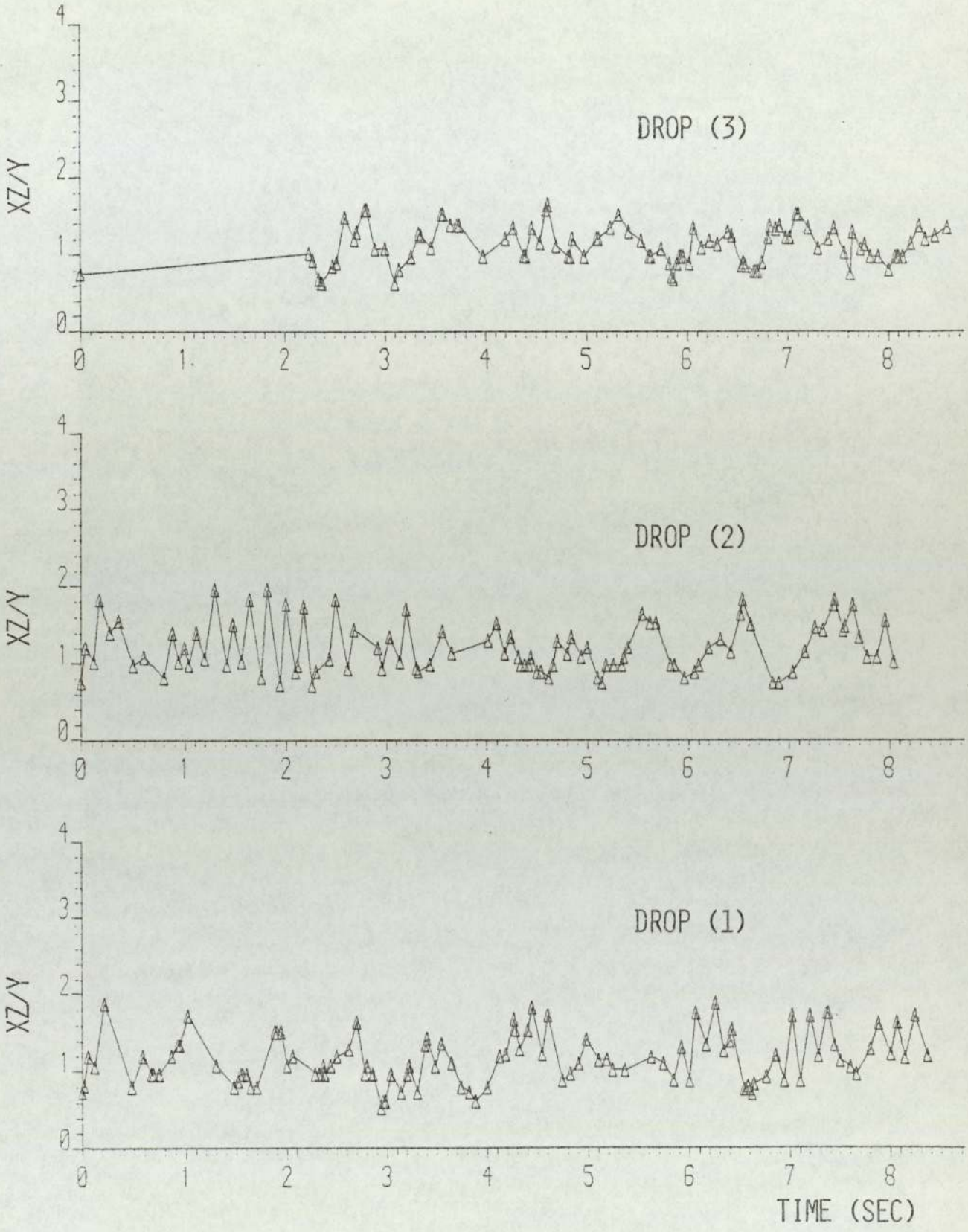

FIG. H.10 AXES RATIO VS. TIME, RUN-7.

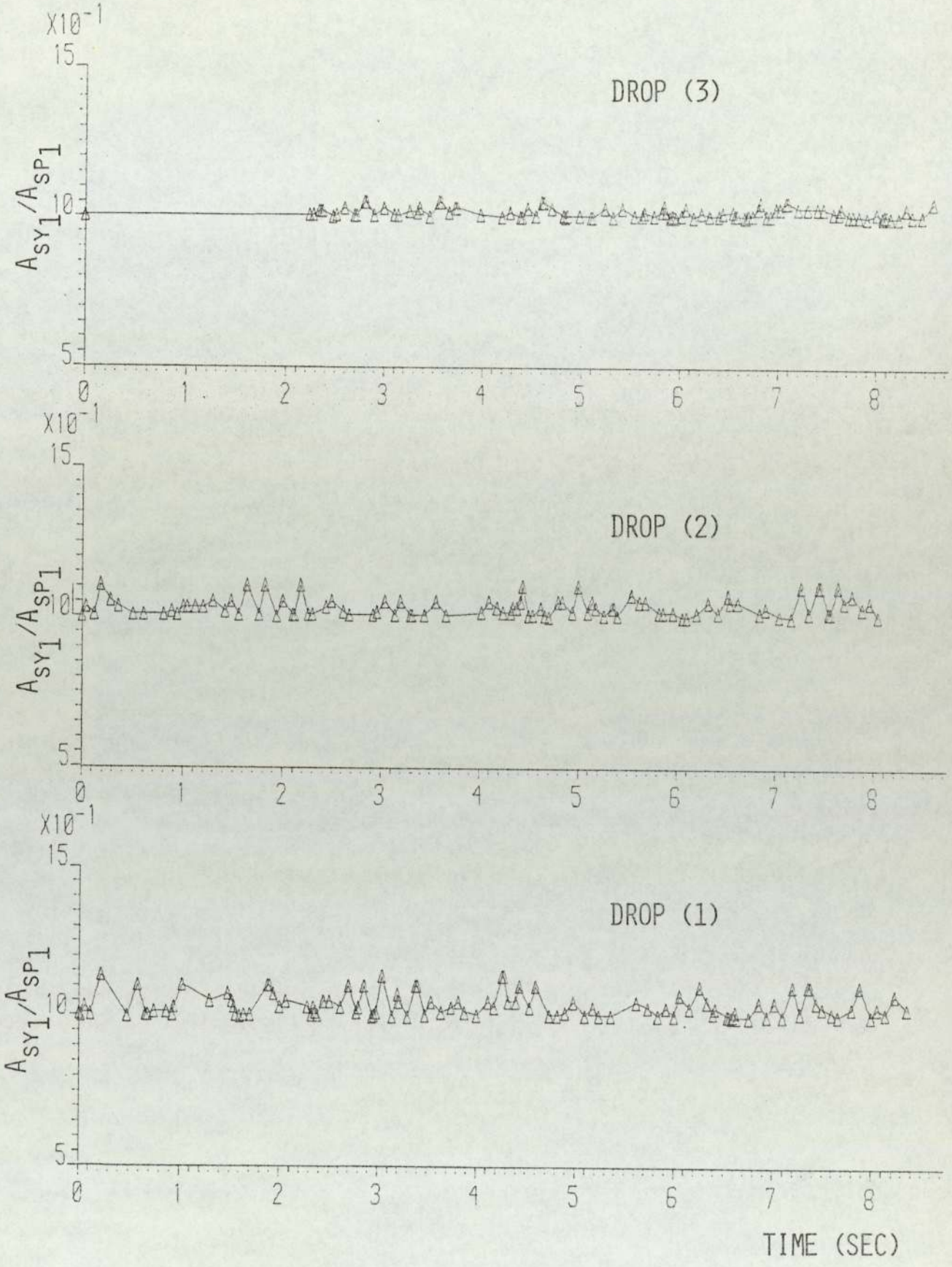

FIG. H.11 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-7, BASED ON DISPLACED VOLUME.

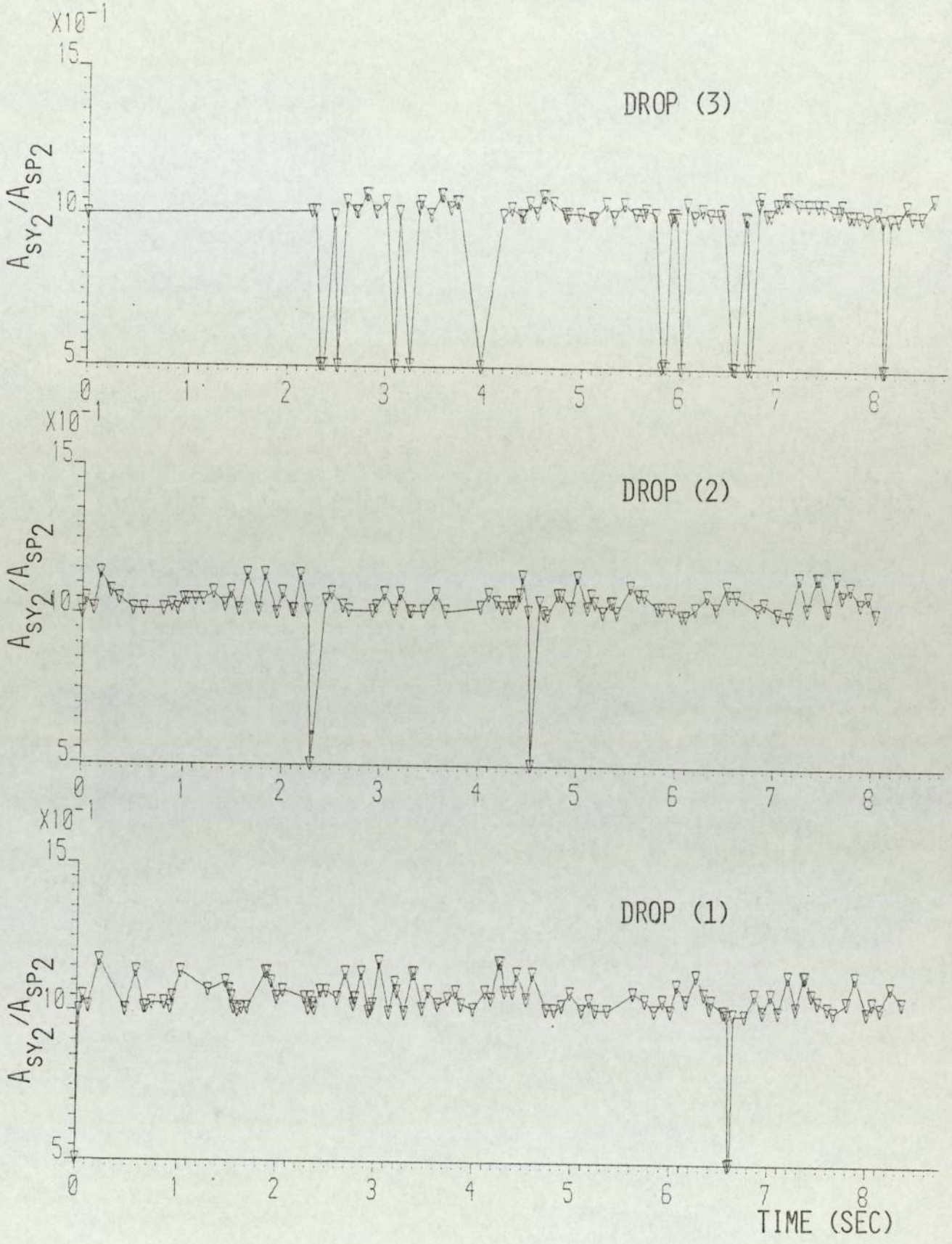

FIG. H.12 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-7, BASSED ON MEAN VOLUME.

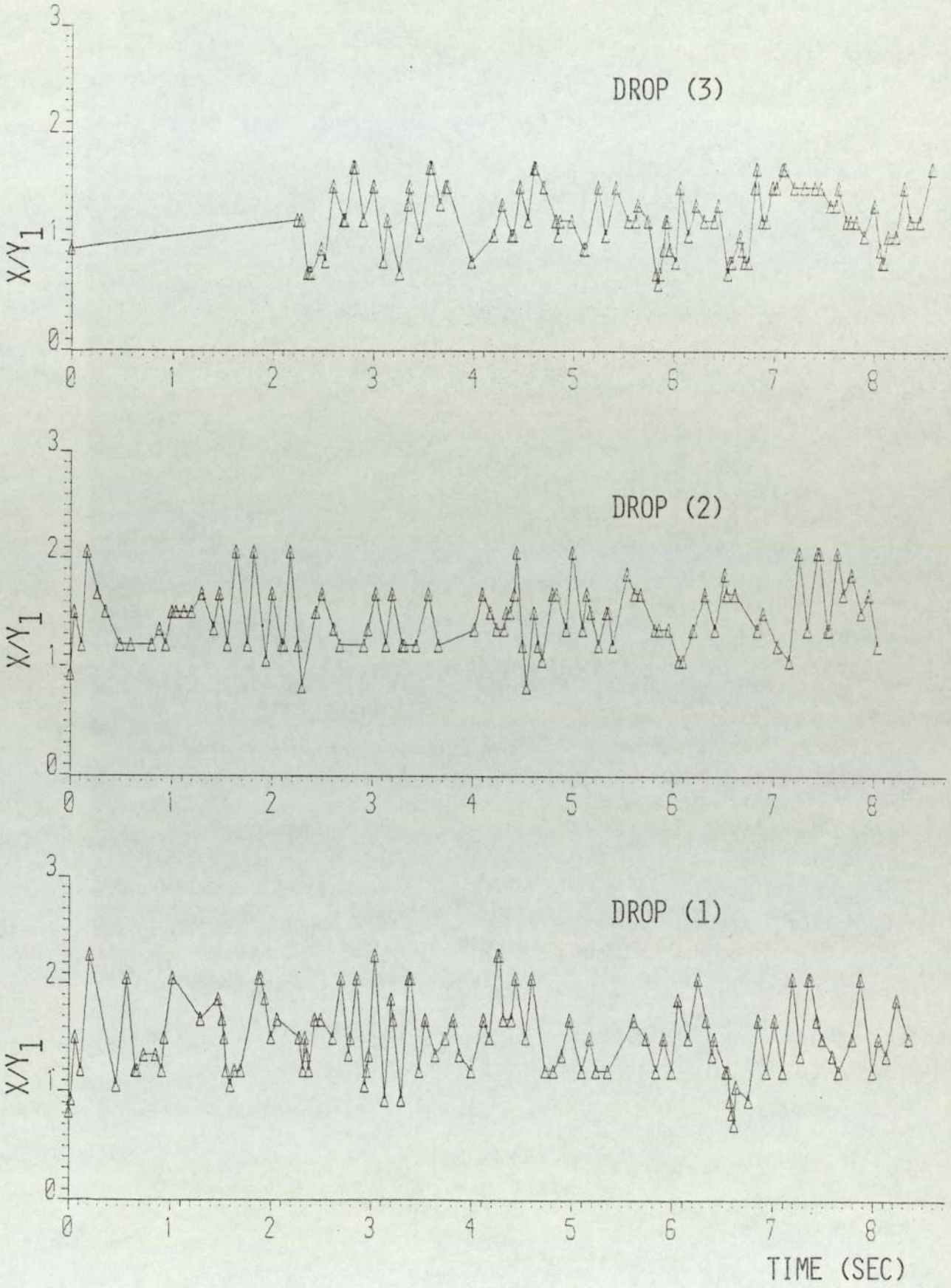

FIG. H.13 AXES RATIO VS. TIME, RUN-7.

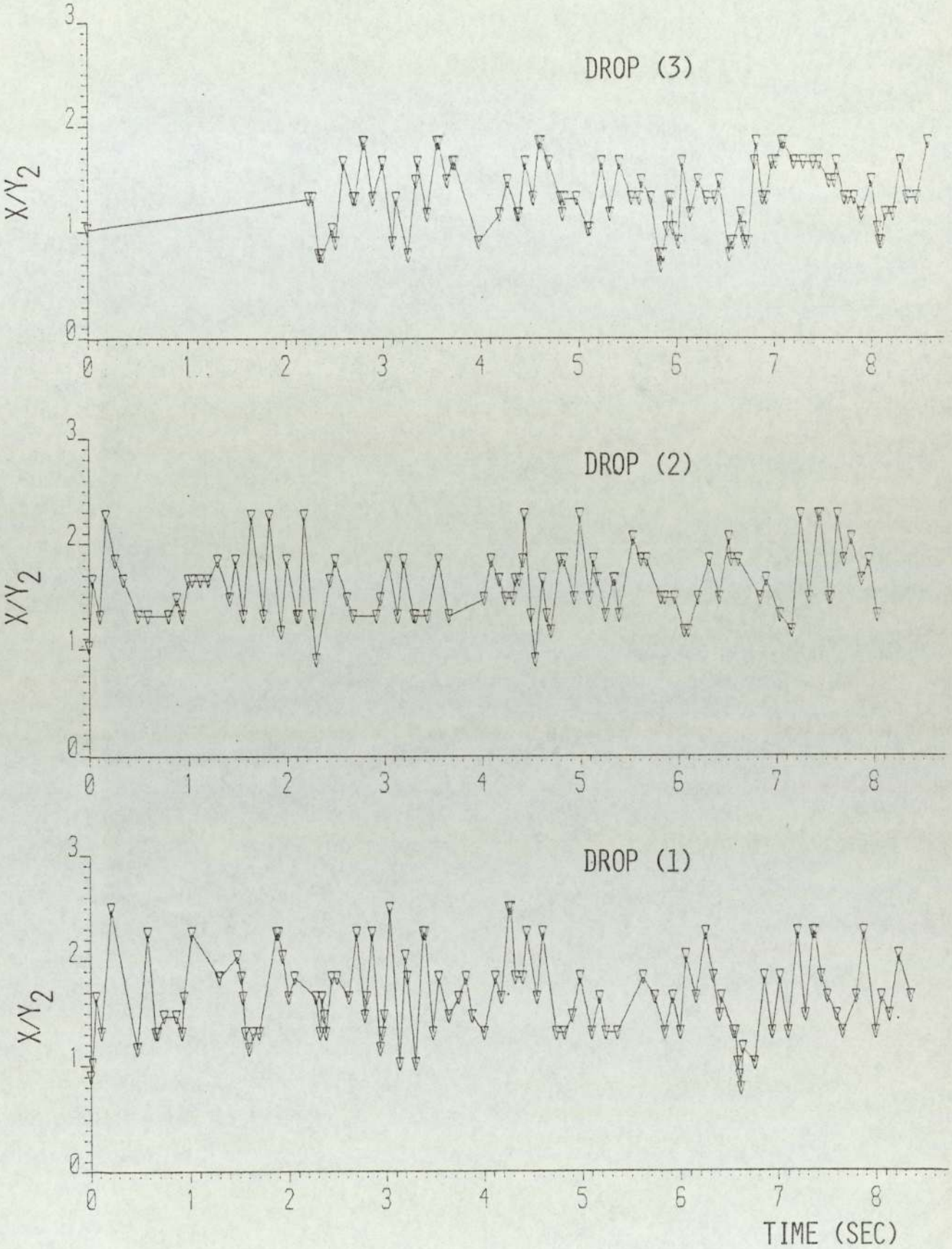

FIG.H.14 AXES RATIO VS. TIME, RUN-7.

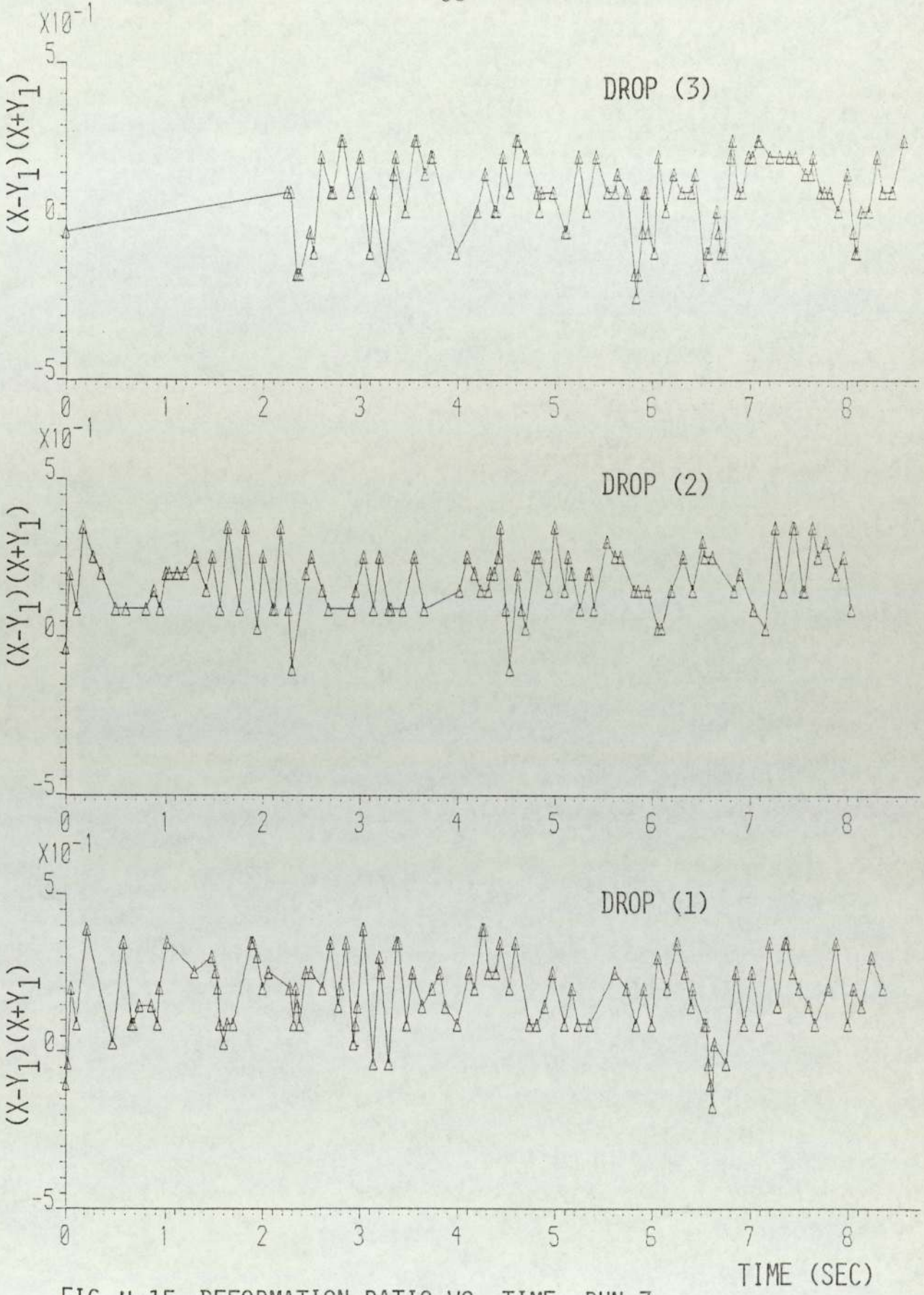

FIG. H.15 DEFORMATION RATIO VS. TIME, RUN-7.

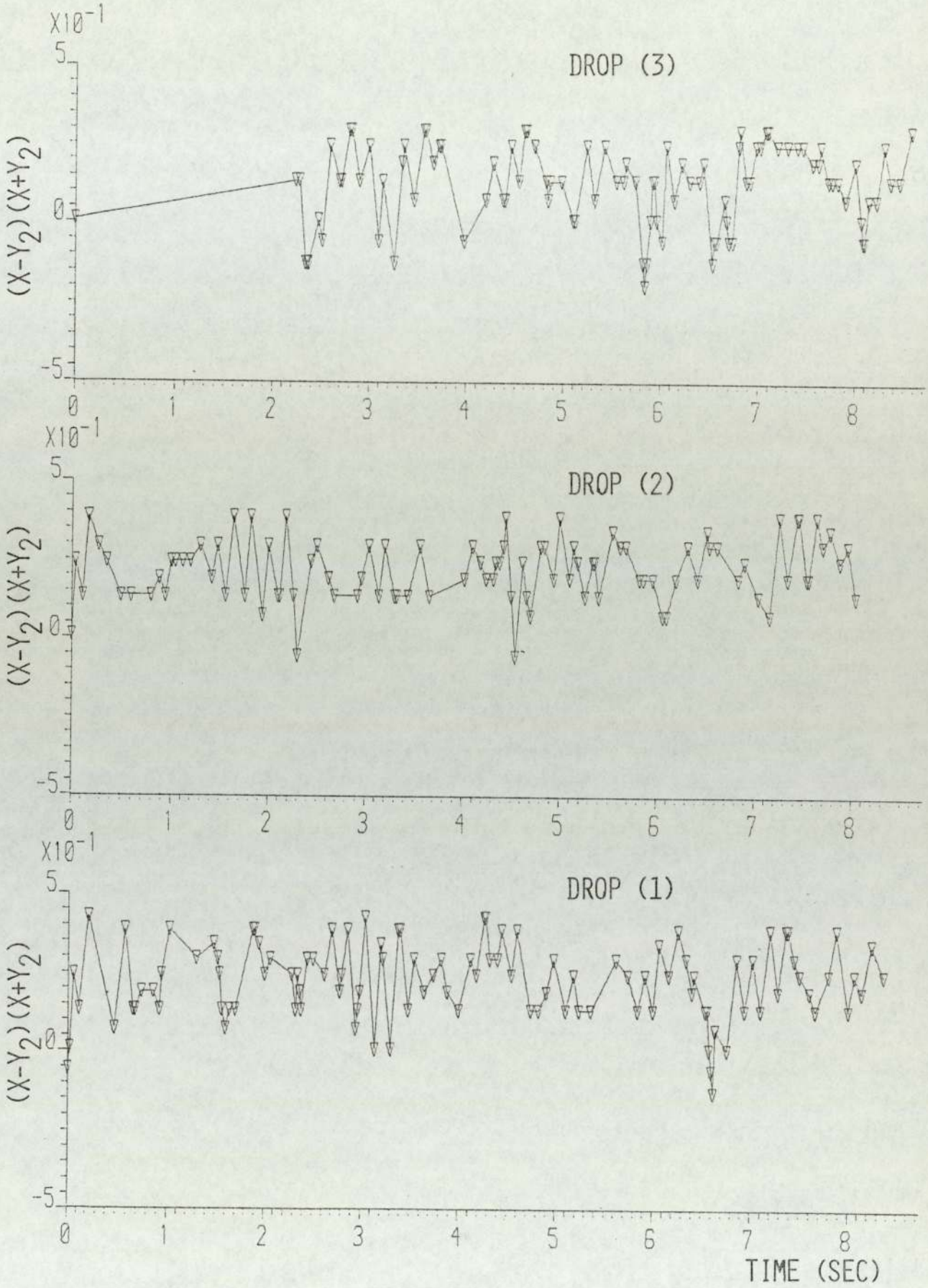

FIG.H.16 DEFORMATION RATIO VS. TIME, RUN-7.

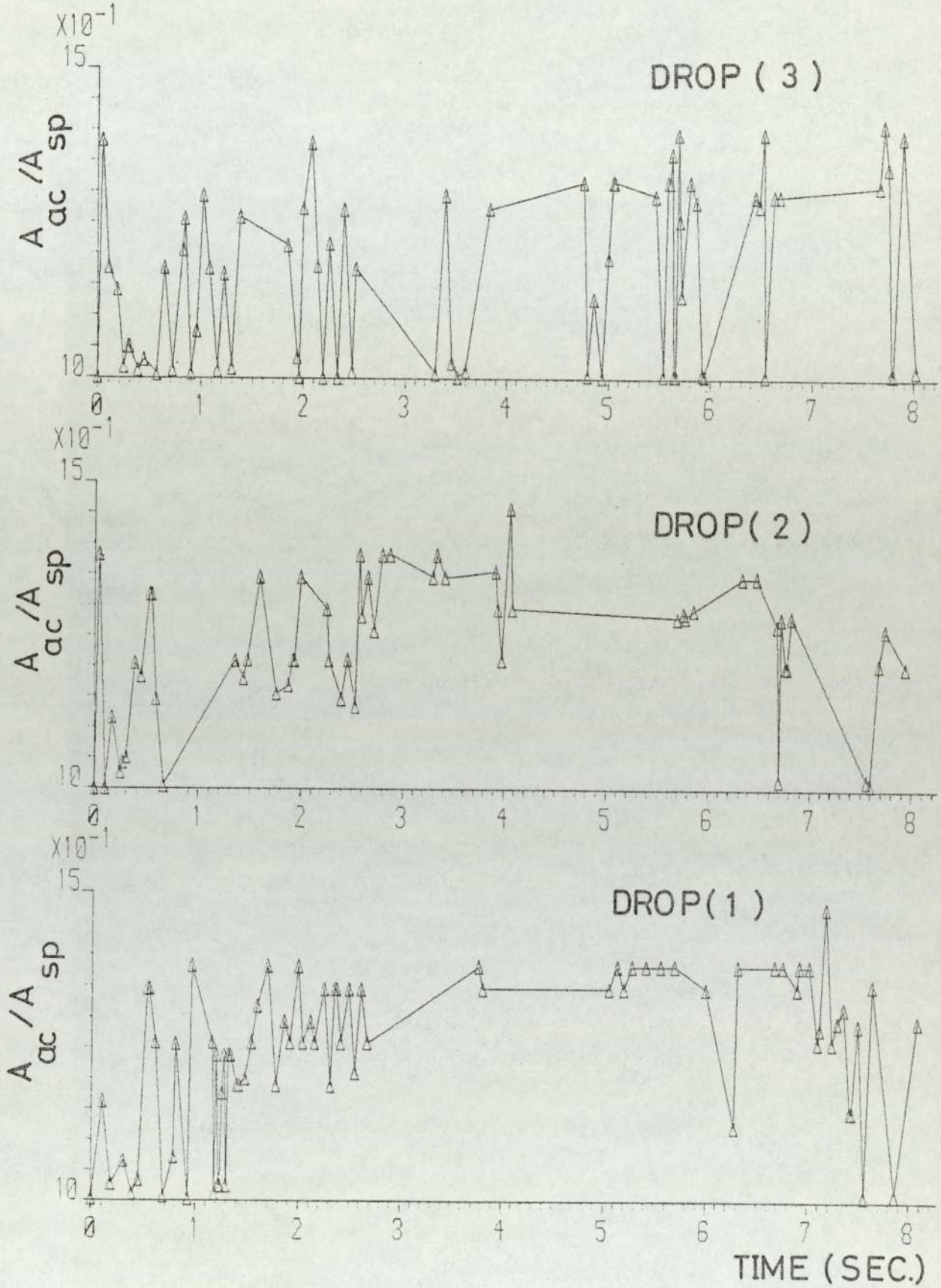

FIG.H.17 AREA RATIO VS. TIME, RUN-8.

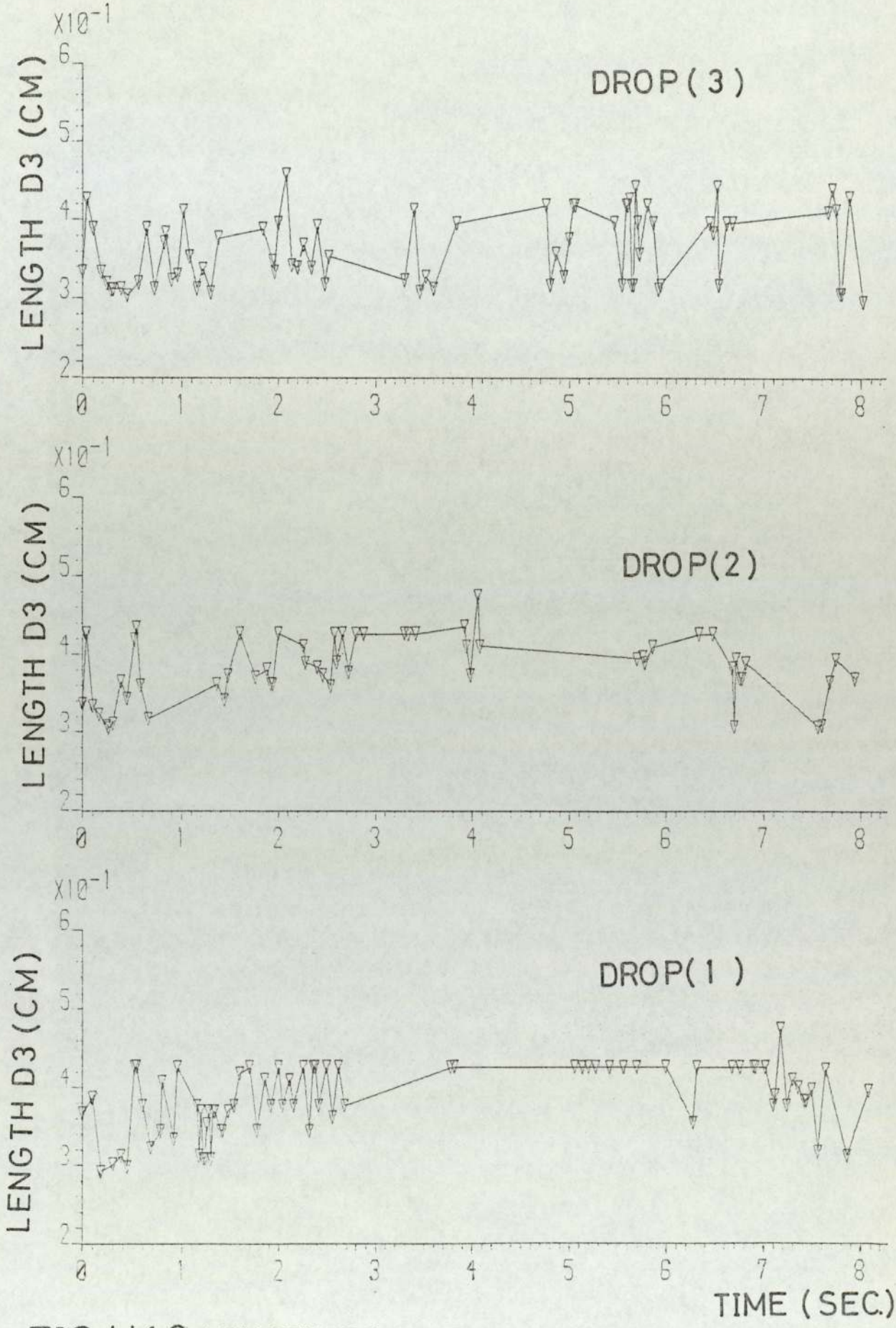

FIG. H.18 LENGTH D3 VS. TIME, RUN-8.

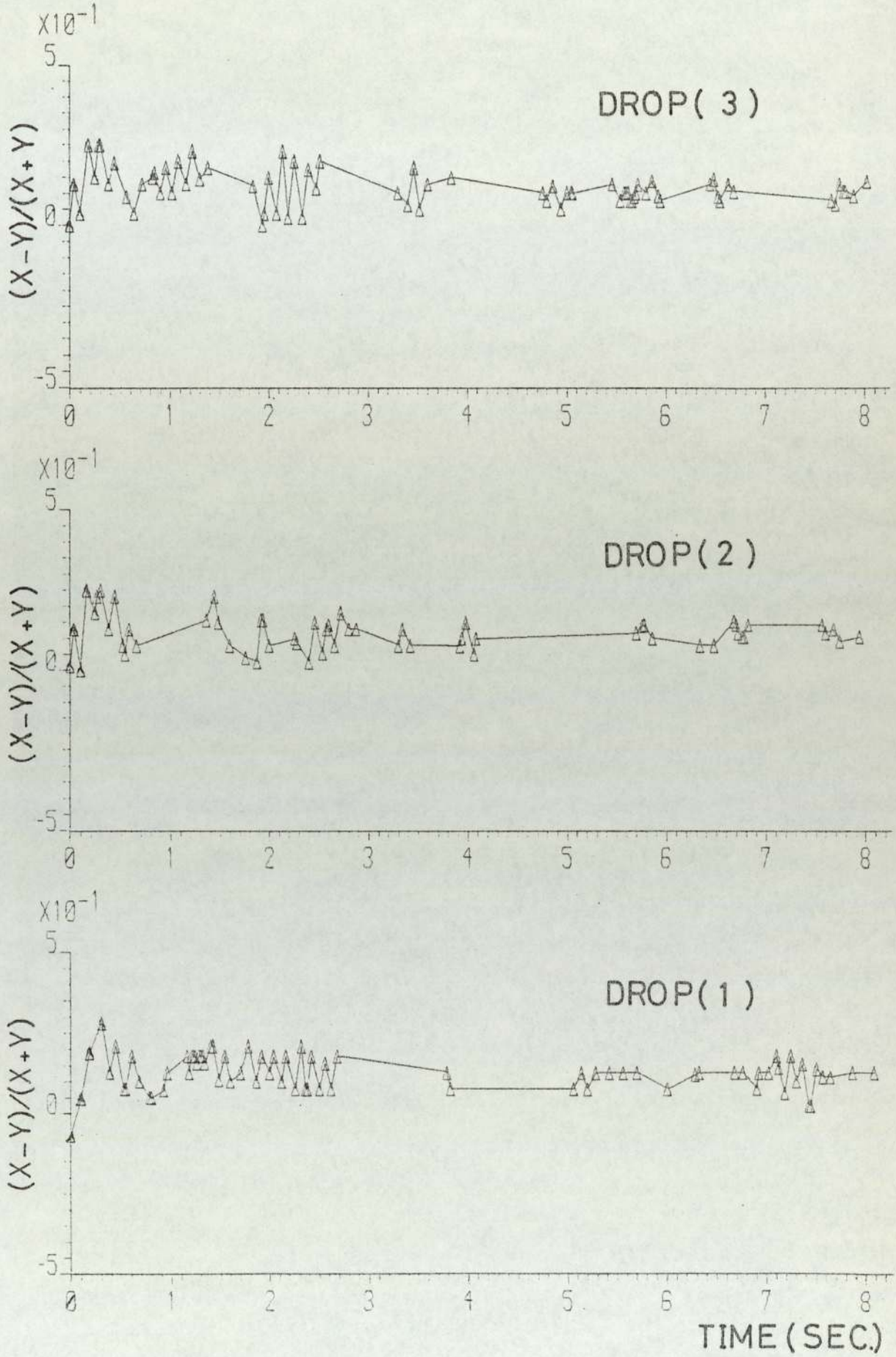

FIG.19 DEFORMATION RATIO VS. TIME, RUN-8.

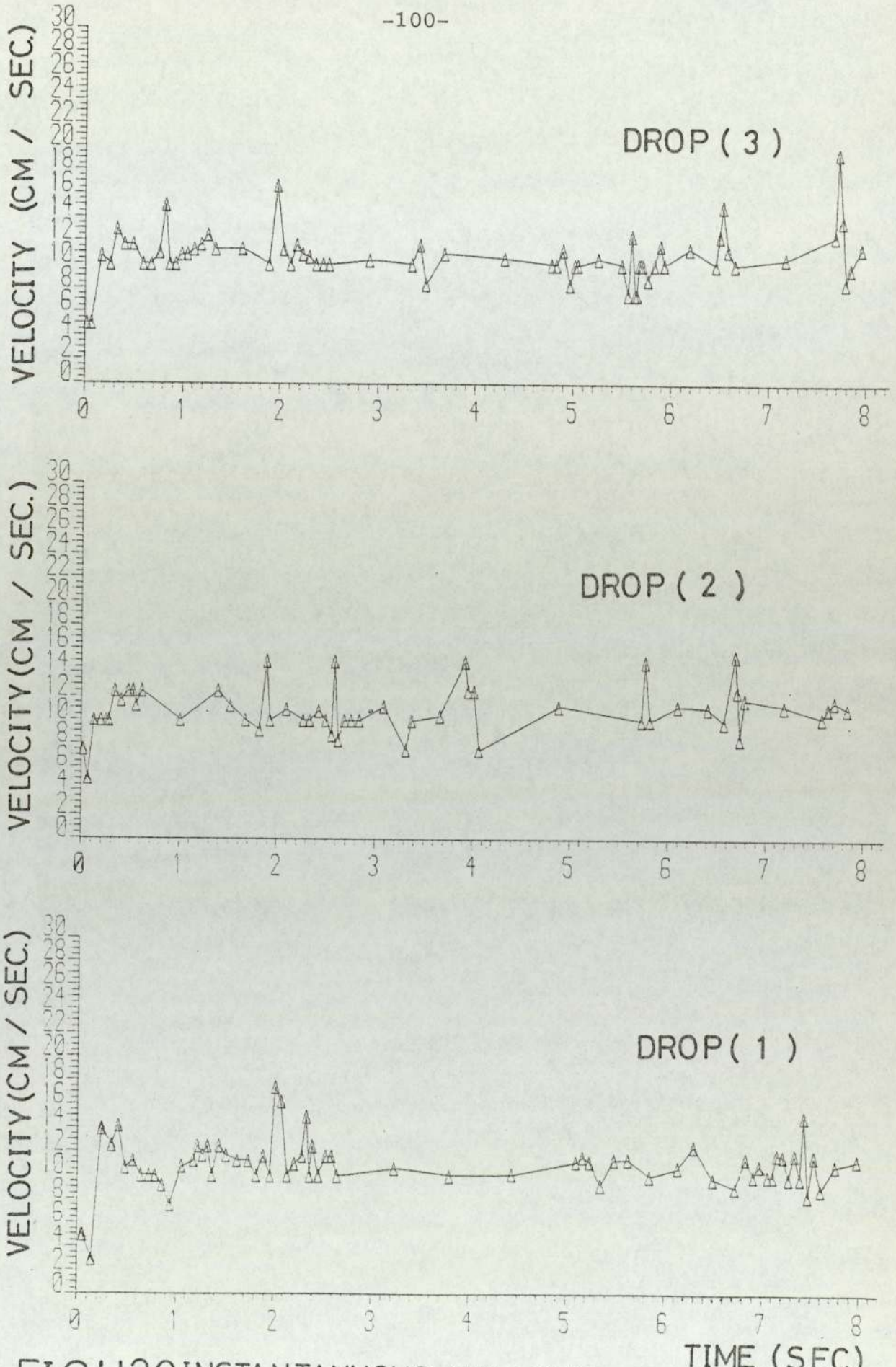

FIG.H.20 INSTANTANUOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-8.

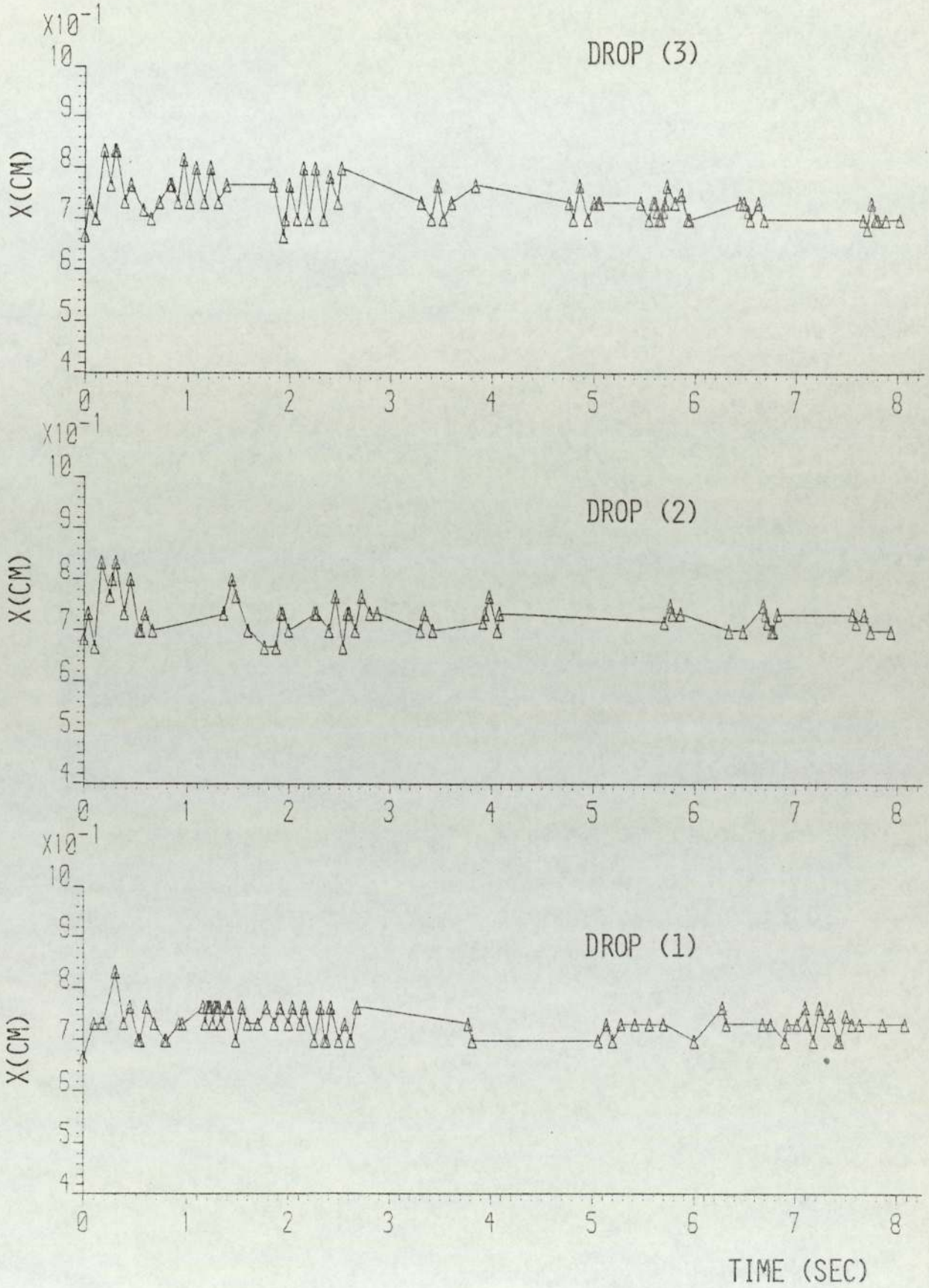

FIG. H.21 X VS. TIME, RUN-8.

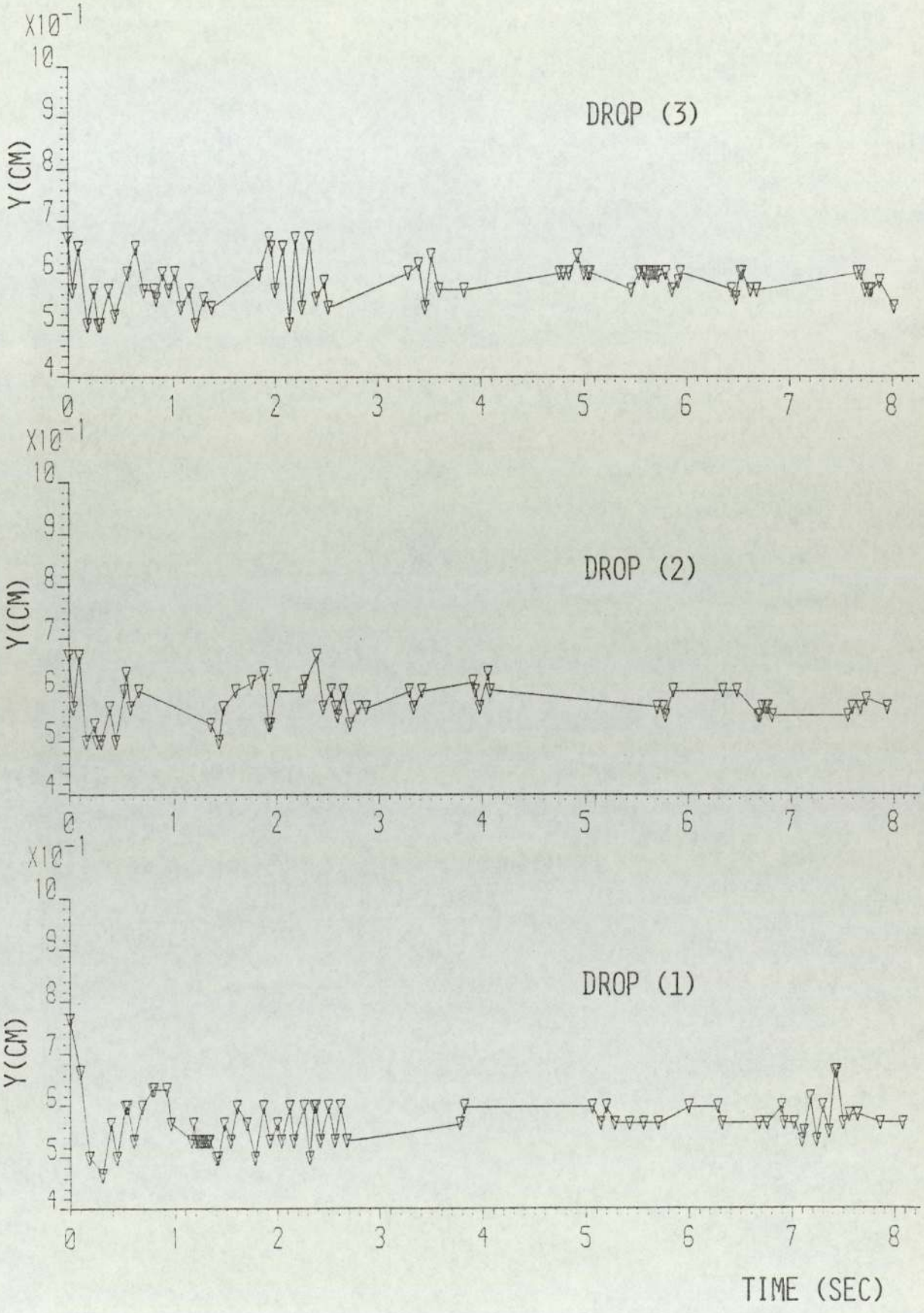

FIG. H.22 Y VS. TIME, RUN-8.

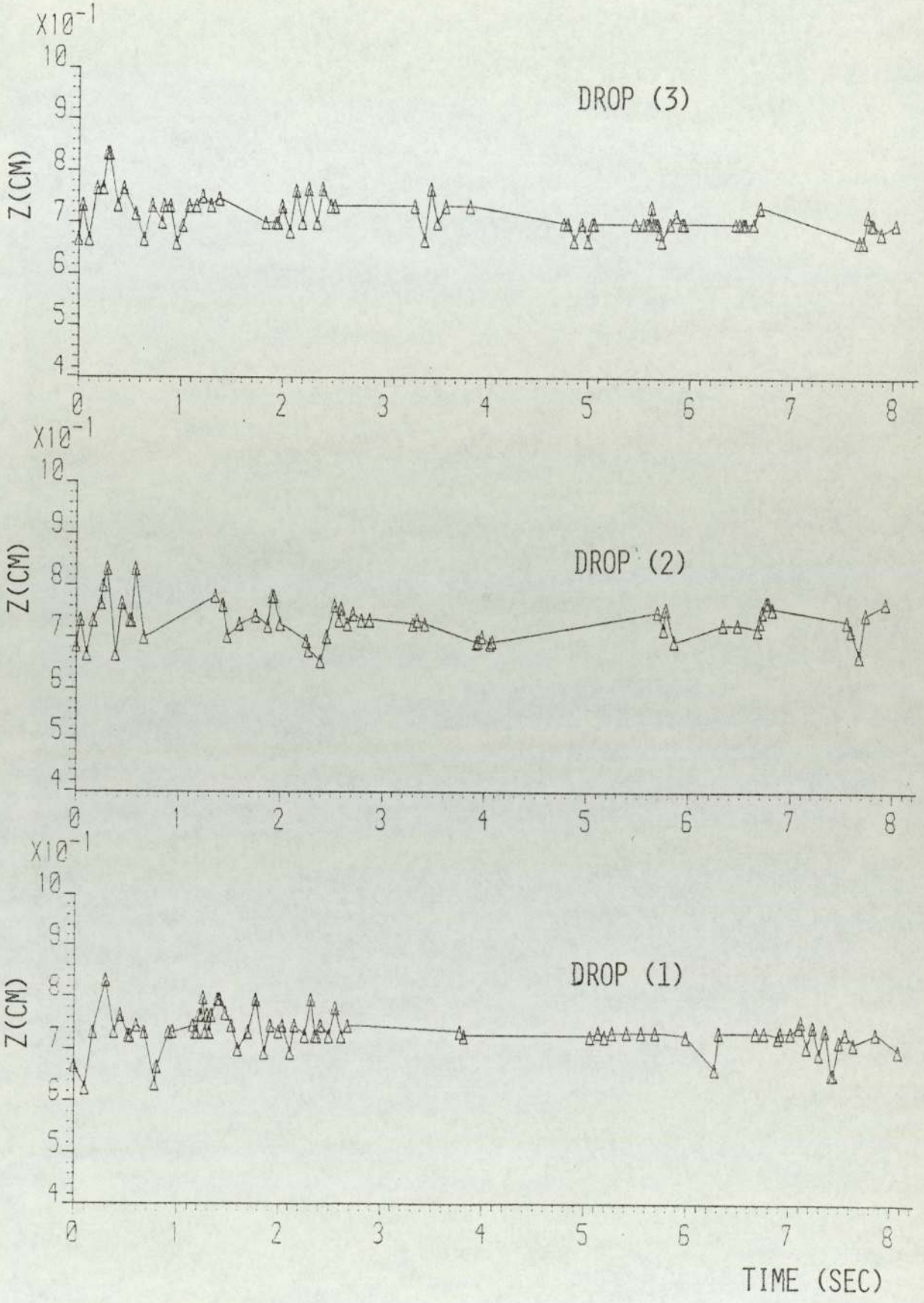

FIG.H.23 Z VS. TIME, RUN-8.

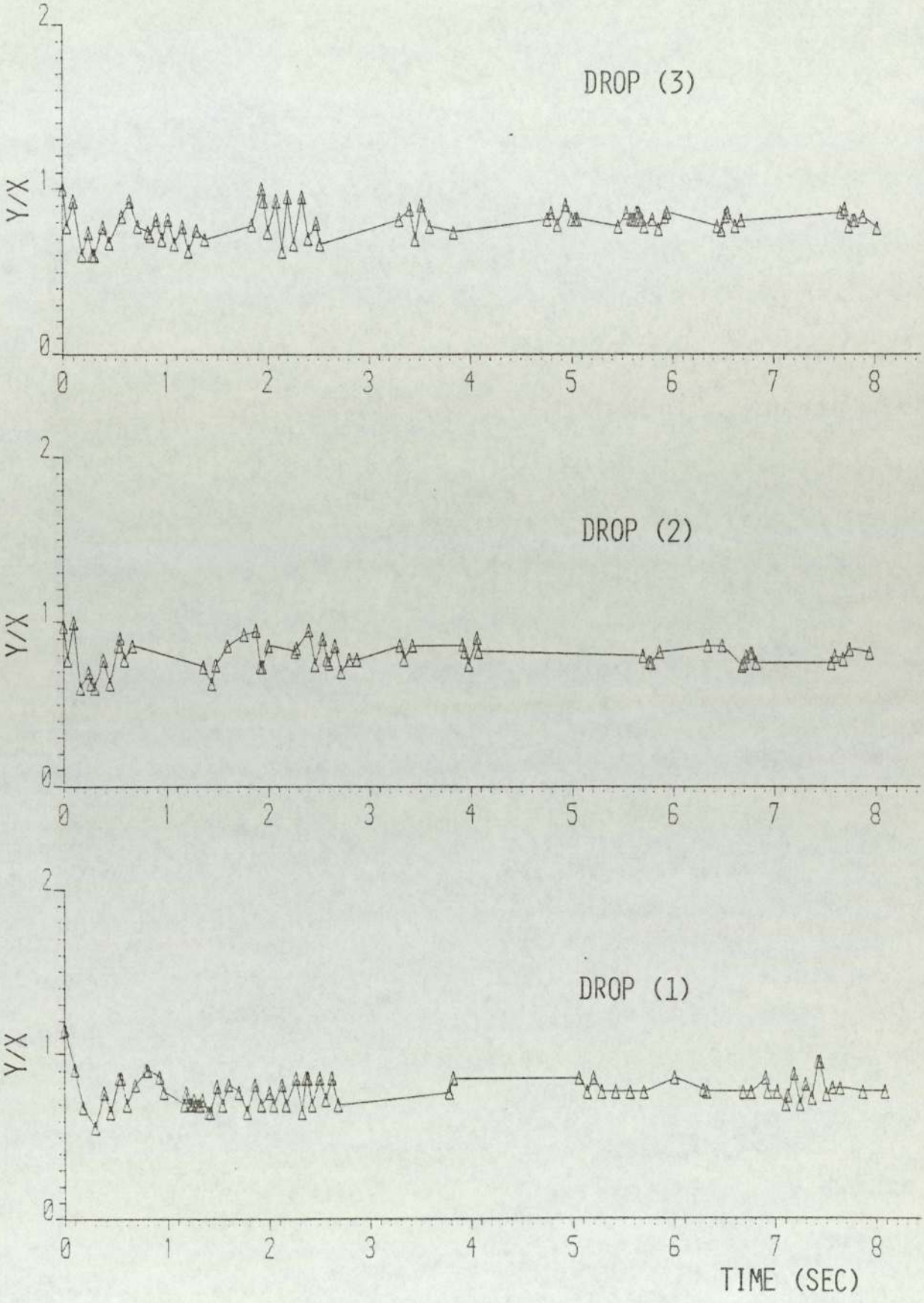

FIG.H.24 AXES RATIO VS. TIME, RUN-8.

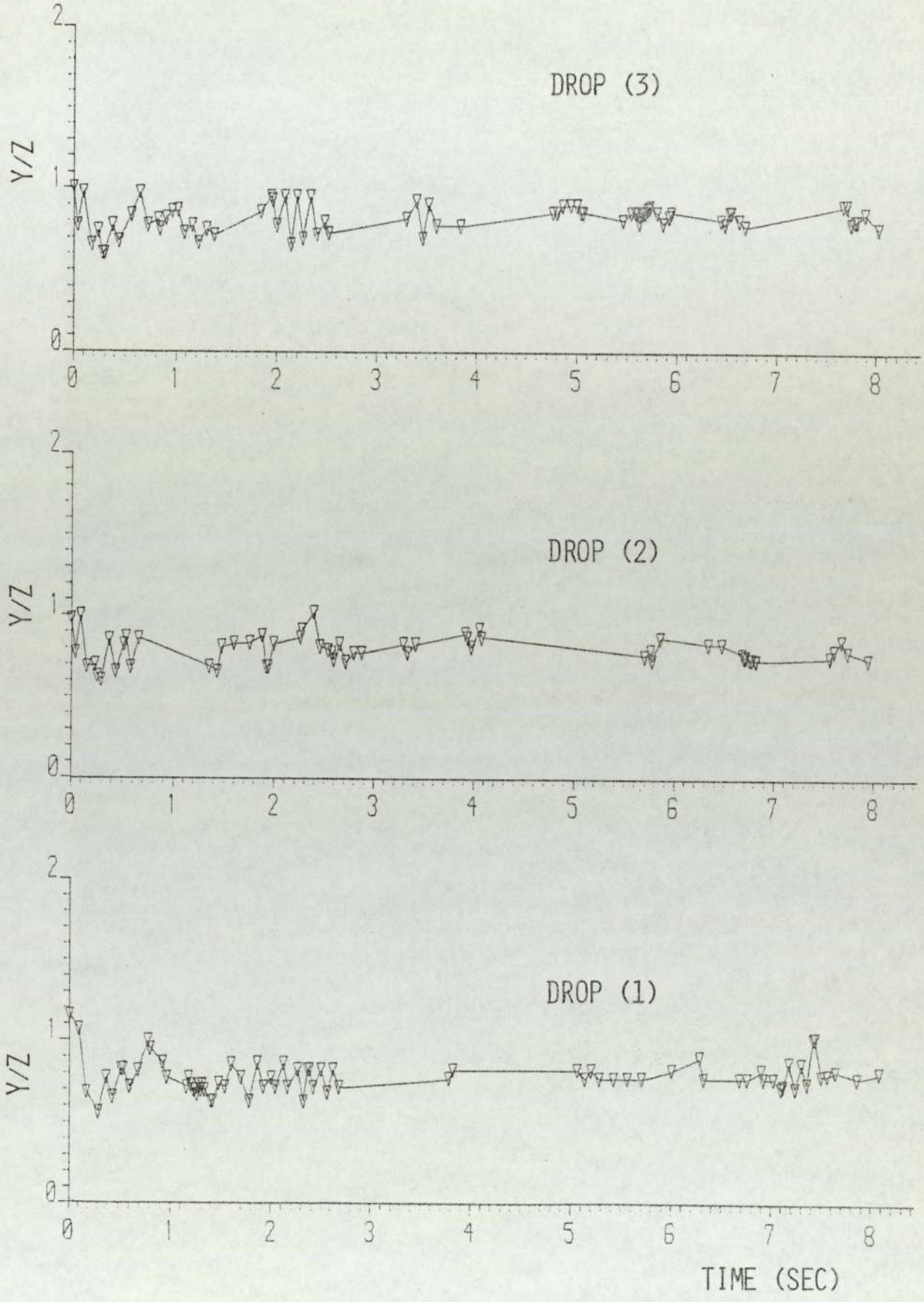

FIG. H.25 AXES RATIO VS. TIME, RUN- 8.

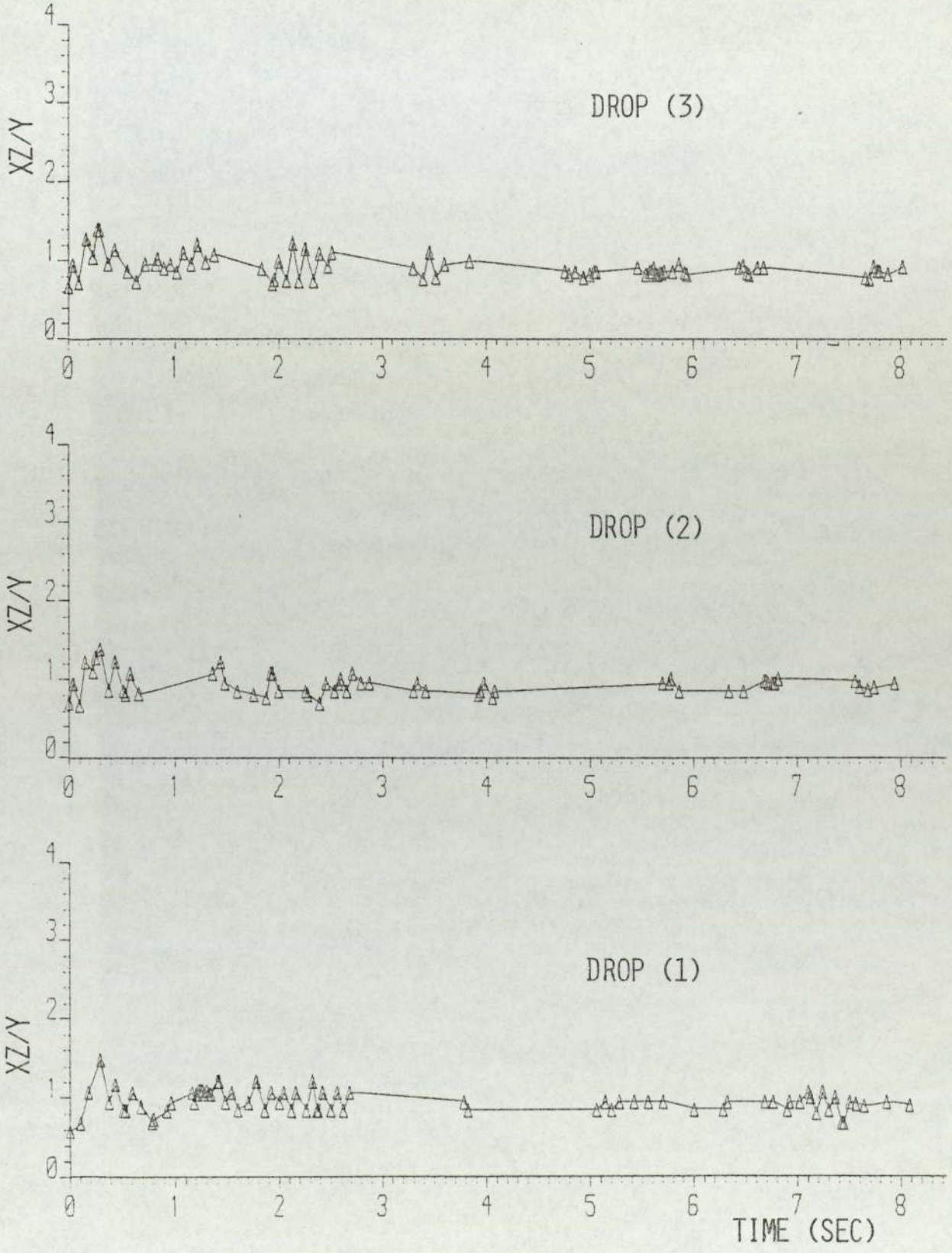

FIG. H.26 AXES RATIO VS. TIME, RUN-8.

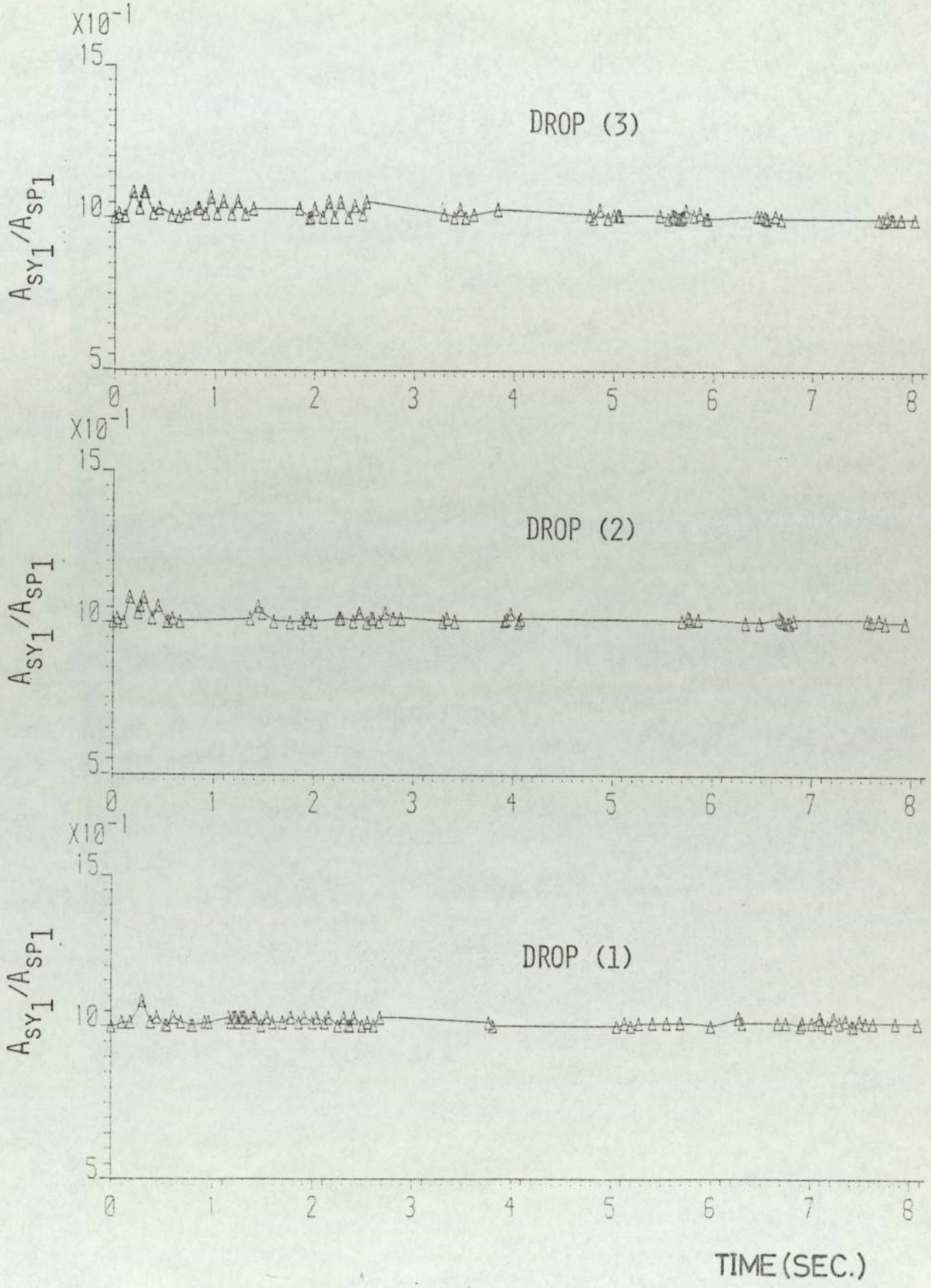

FIG. H.27 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-8, BASED ON DISPLACED VOLUME.

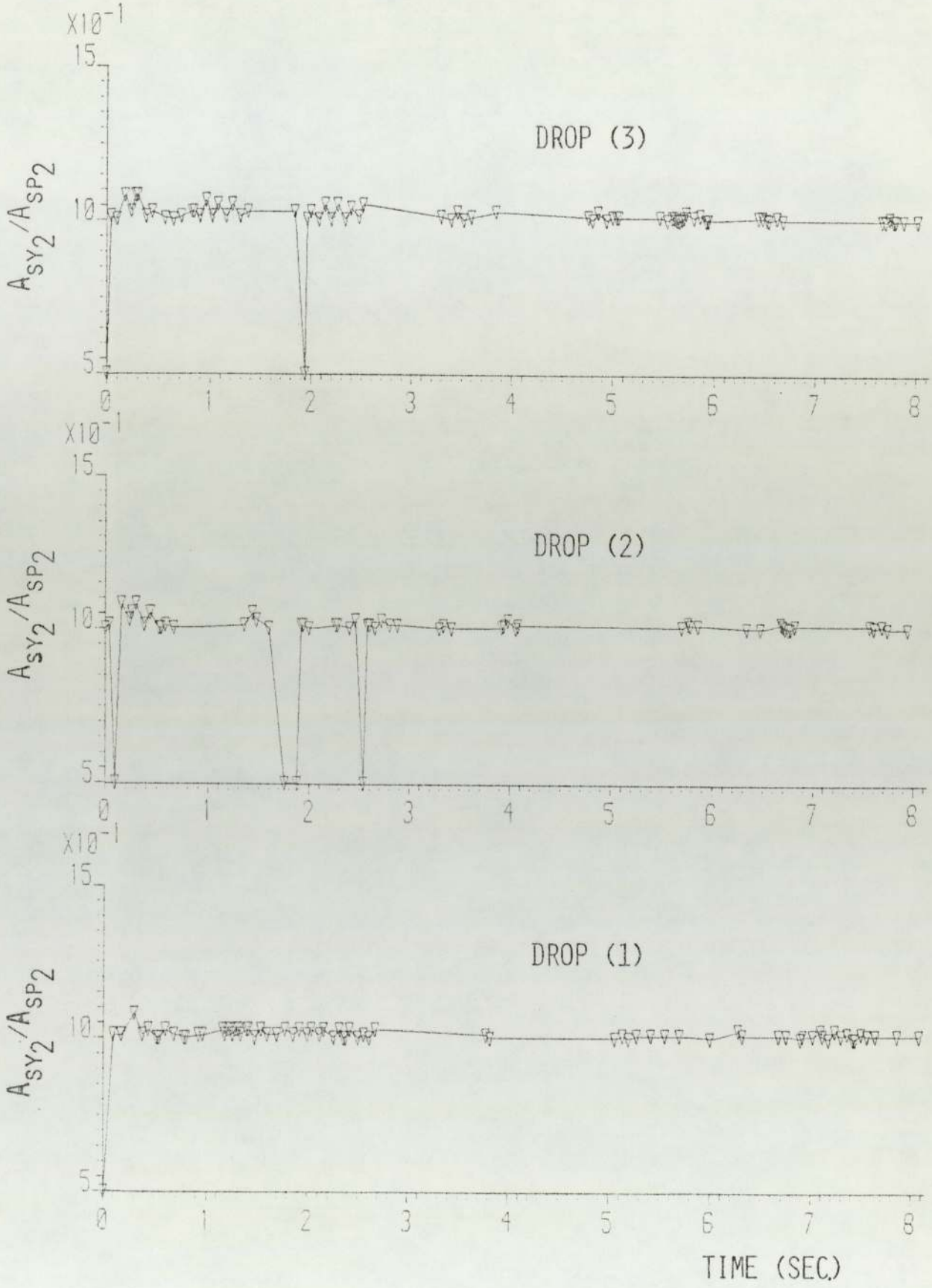

FIG. H.28 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-8, BASED ON MEAN VOLUME.

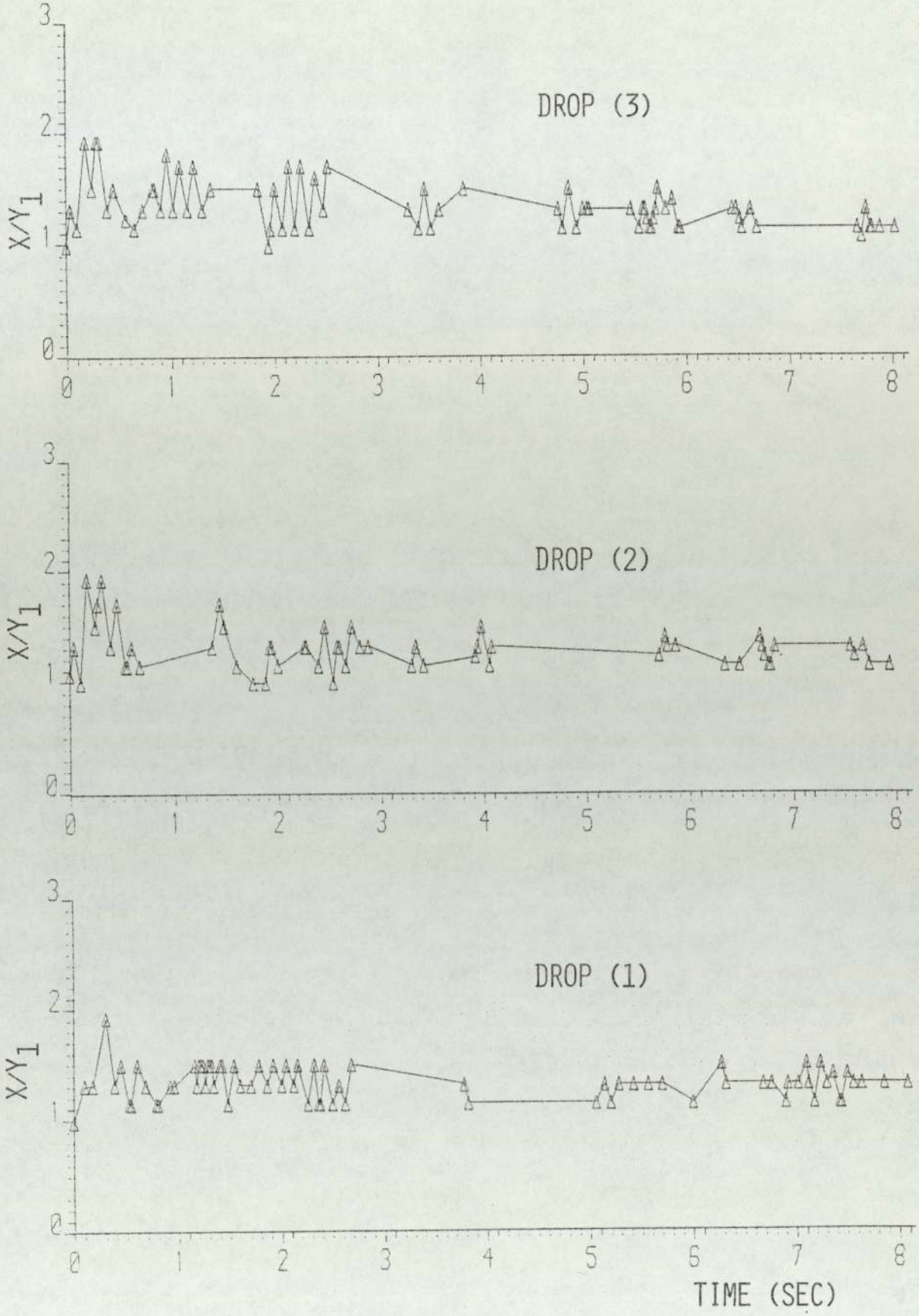

FIG. H.29 AXES RATIO VS. TIME, RUN-8.

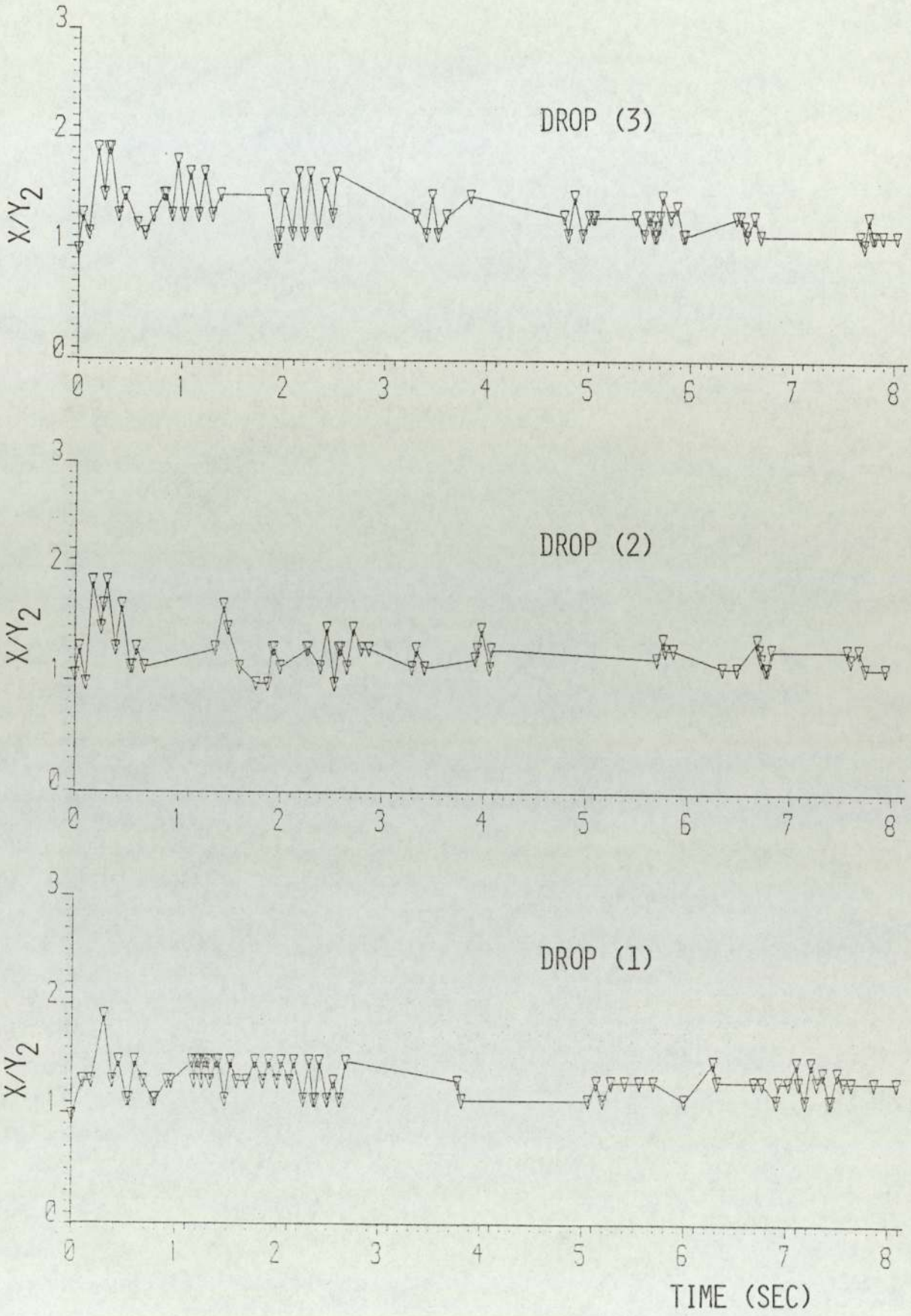

FIG. H.30 AXES RATIO VS. TIME, RUN-8.

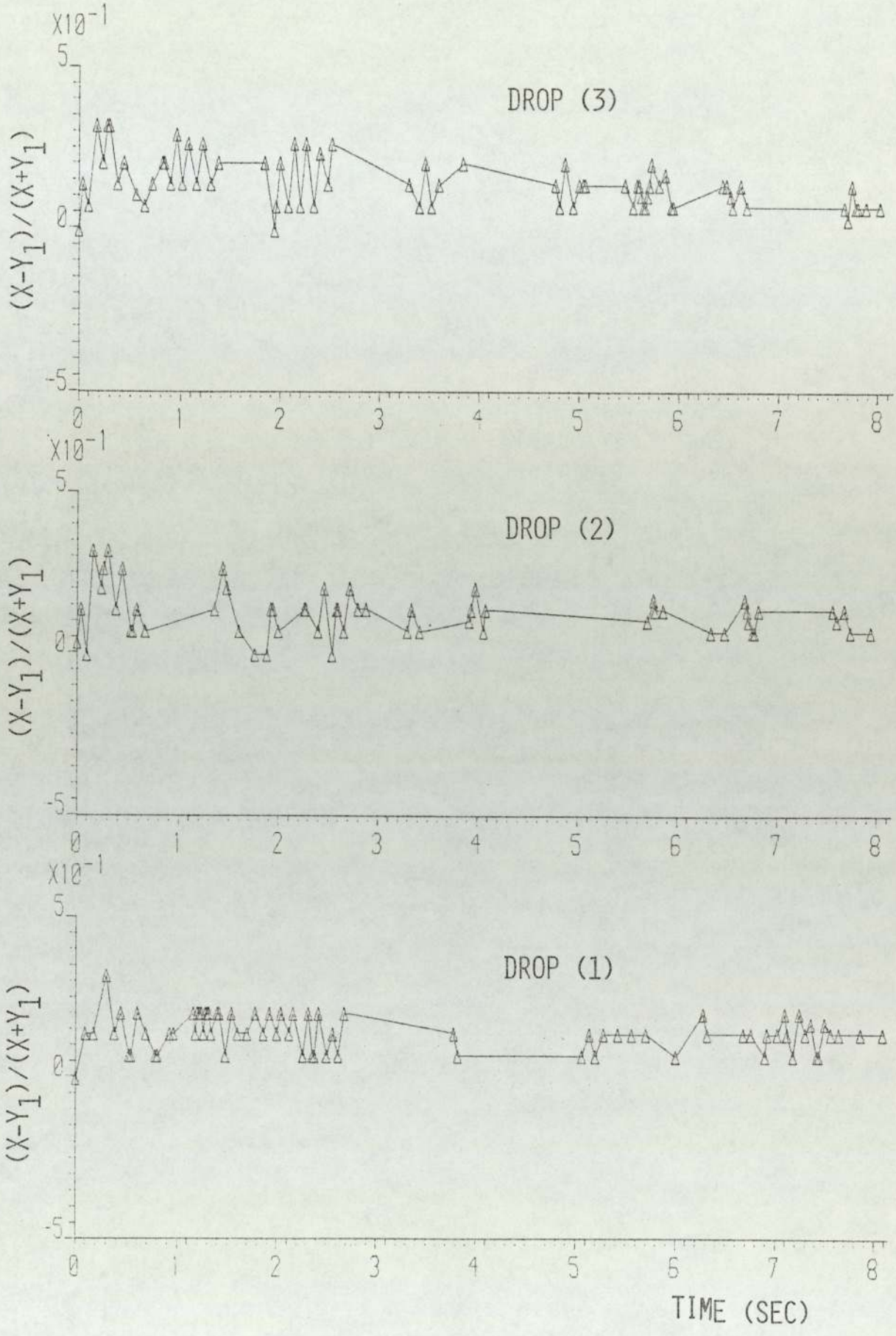

FIG. H.31 DEFORMATION RATIO VS. TIME, RUN-8.

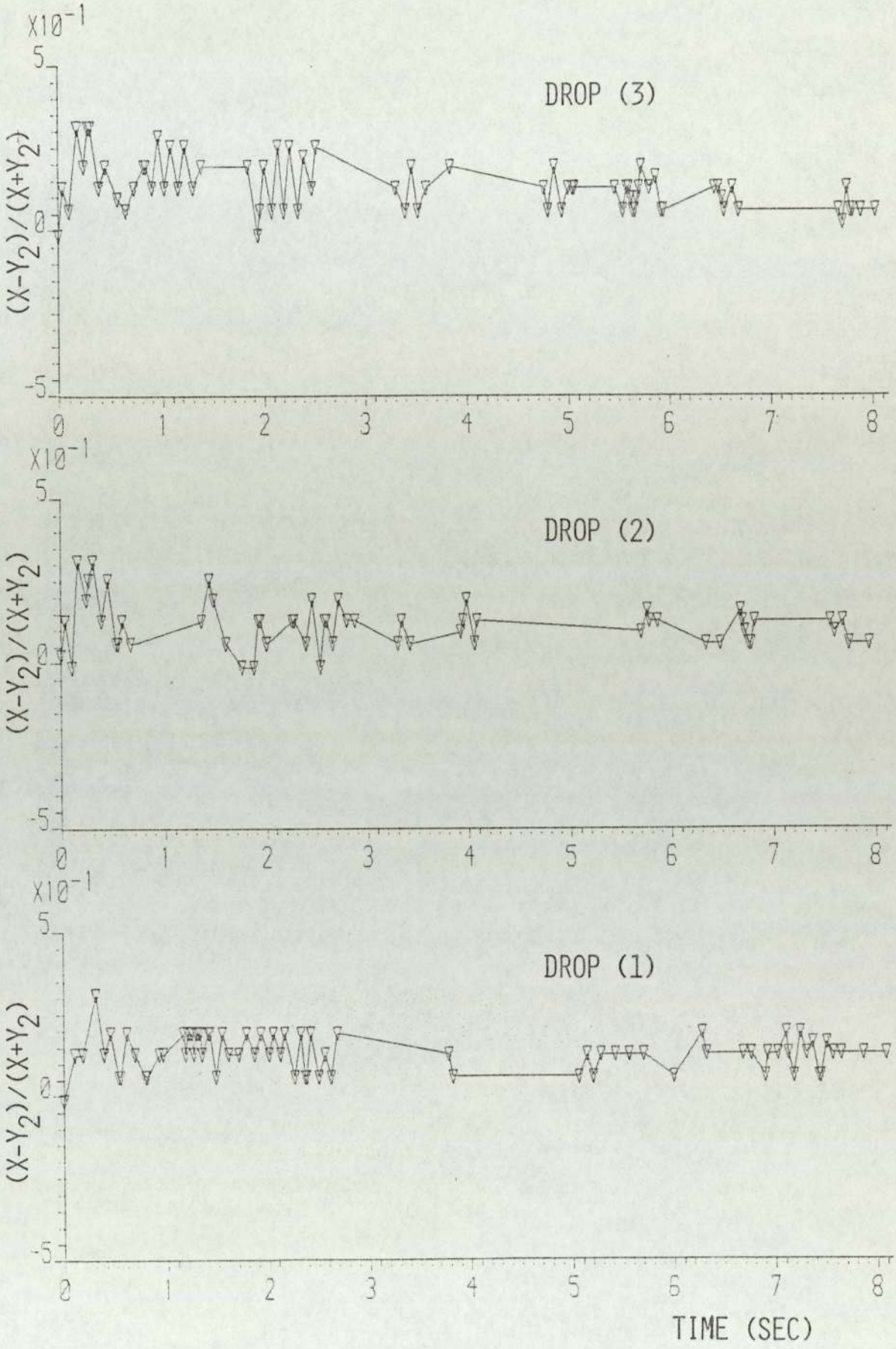

FIG. H.32 DEFORMATION RATIO VS. TIME, RUN-8.

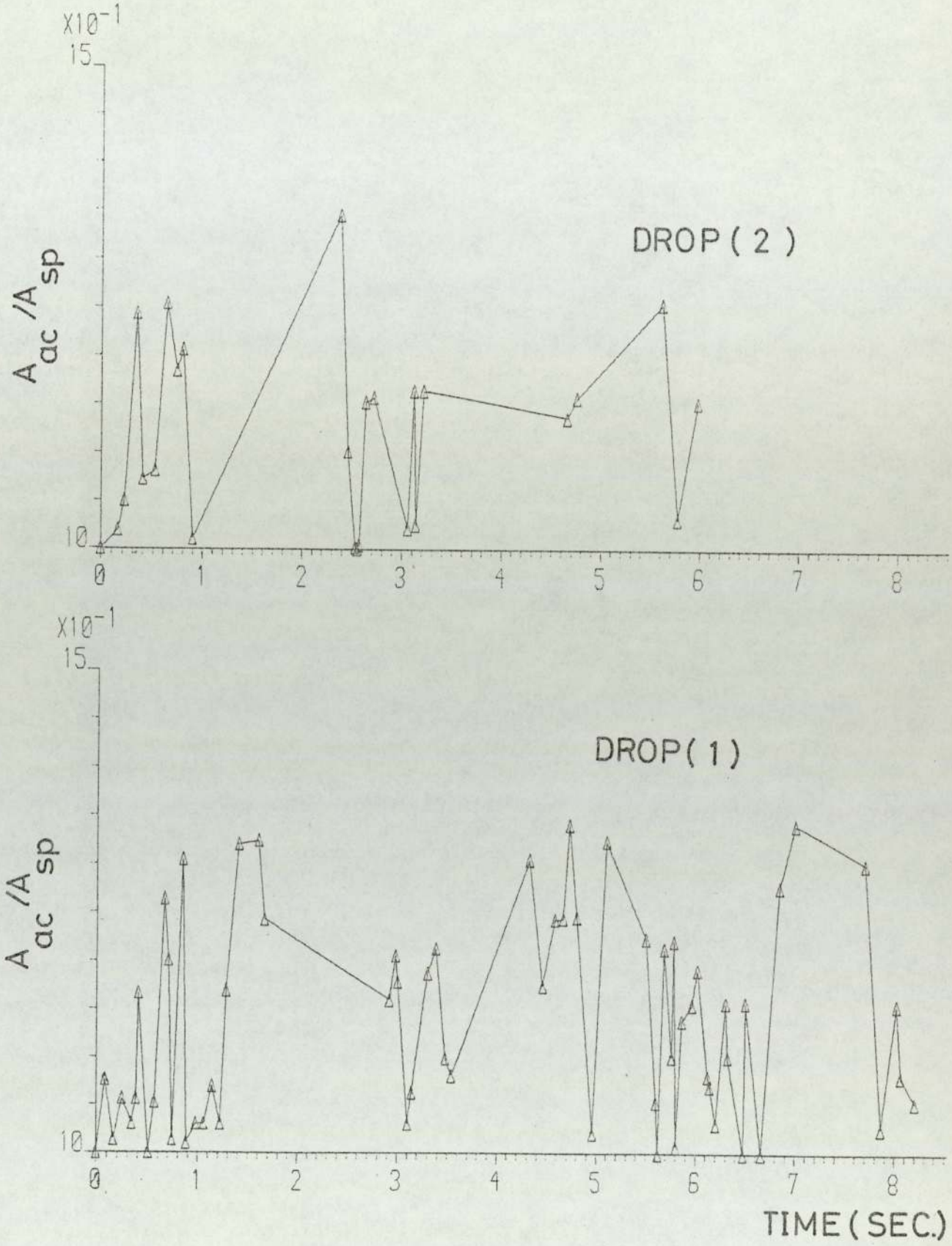

FIG.H.33 AREA RATIO VS. TIME, RUN-9.

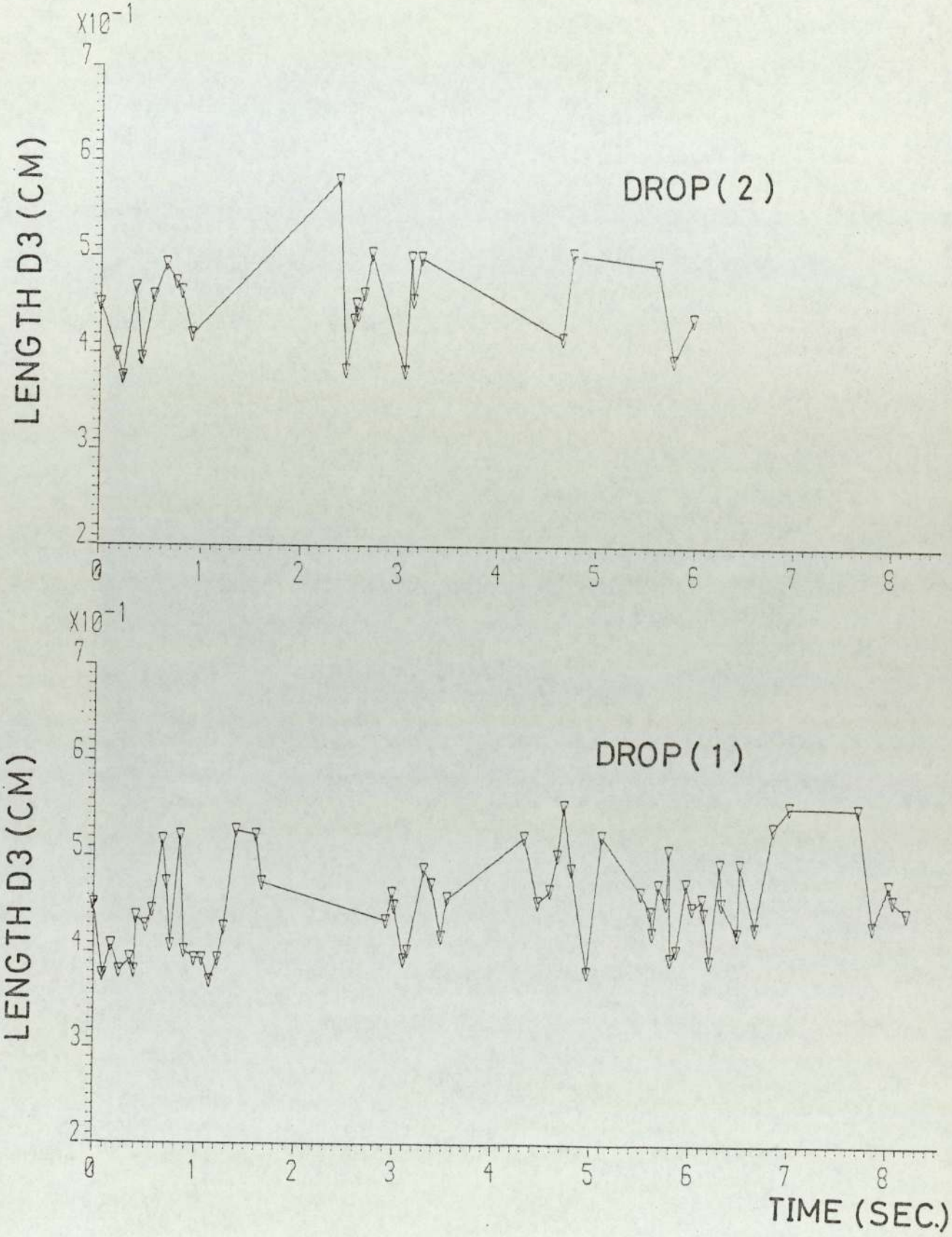

FIG.H.34 : LENGTH D3 VS. TIME, RUN-9.

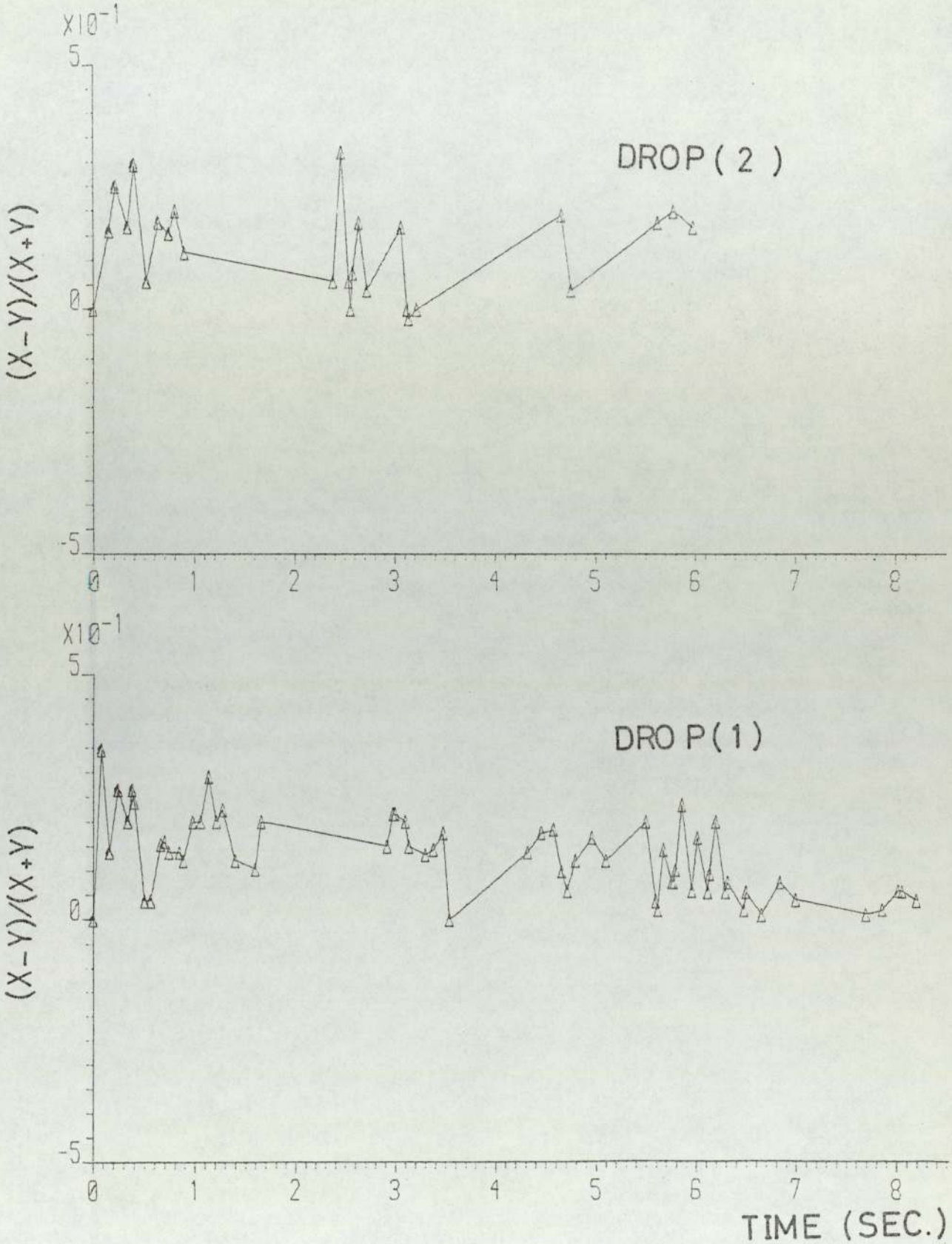

FIG. H.35 DEFORMATION RATIO VS. TIME, RUN-9.

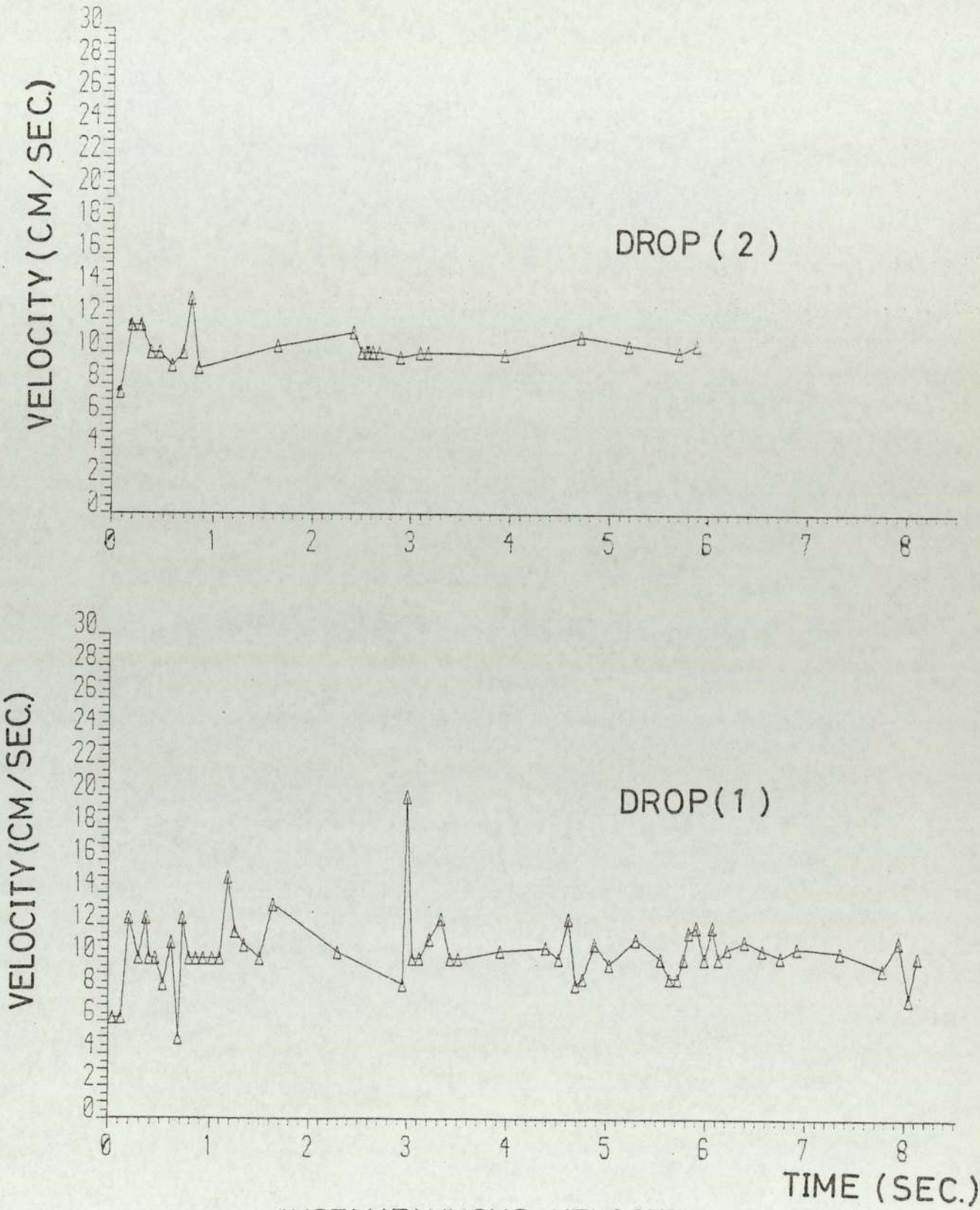

FIG.H.36 INSTANTANUOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-9.

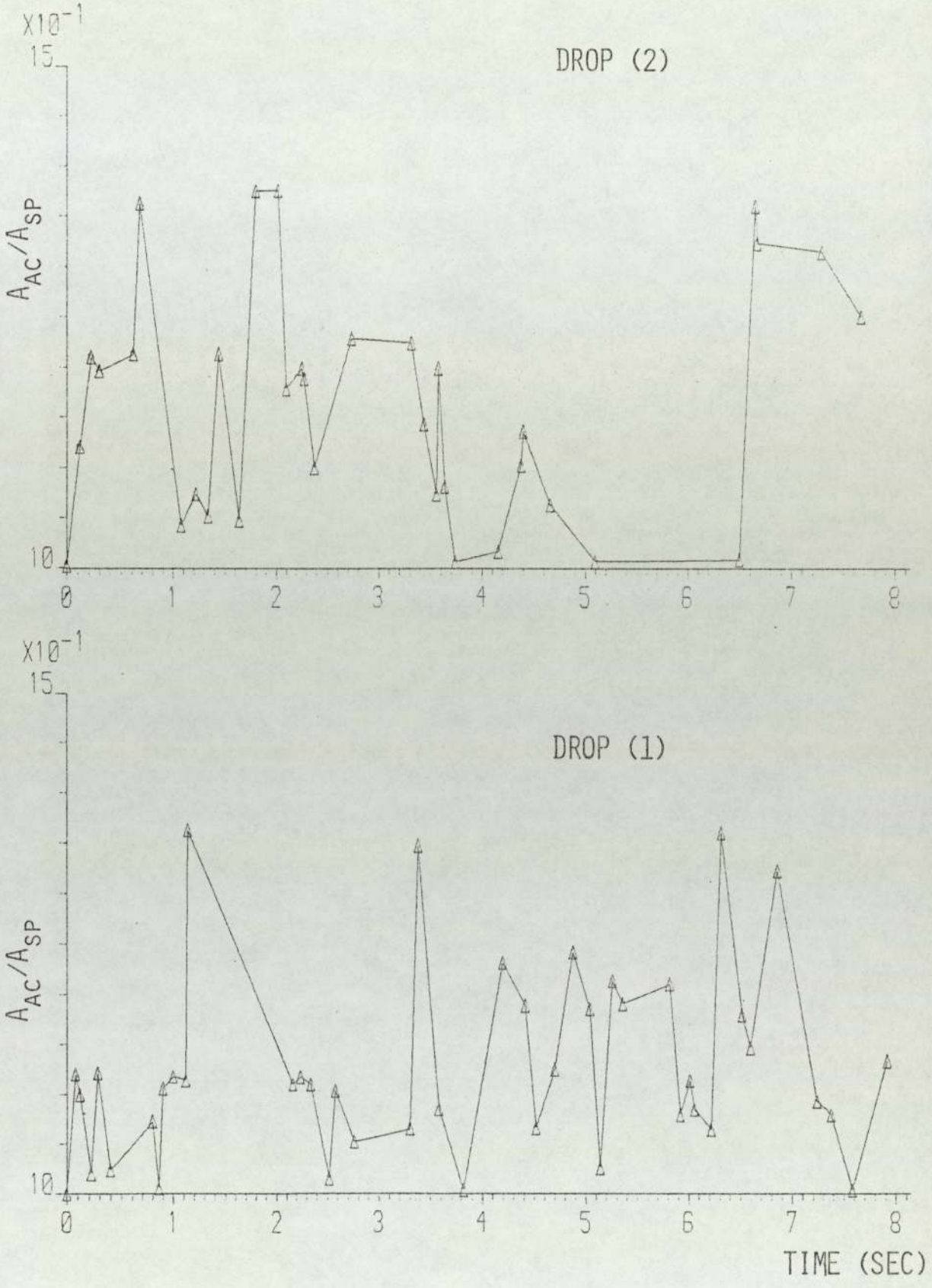

FIG. H.37 AREA RATIO VS. TIME, RUN-12.

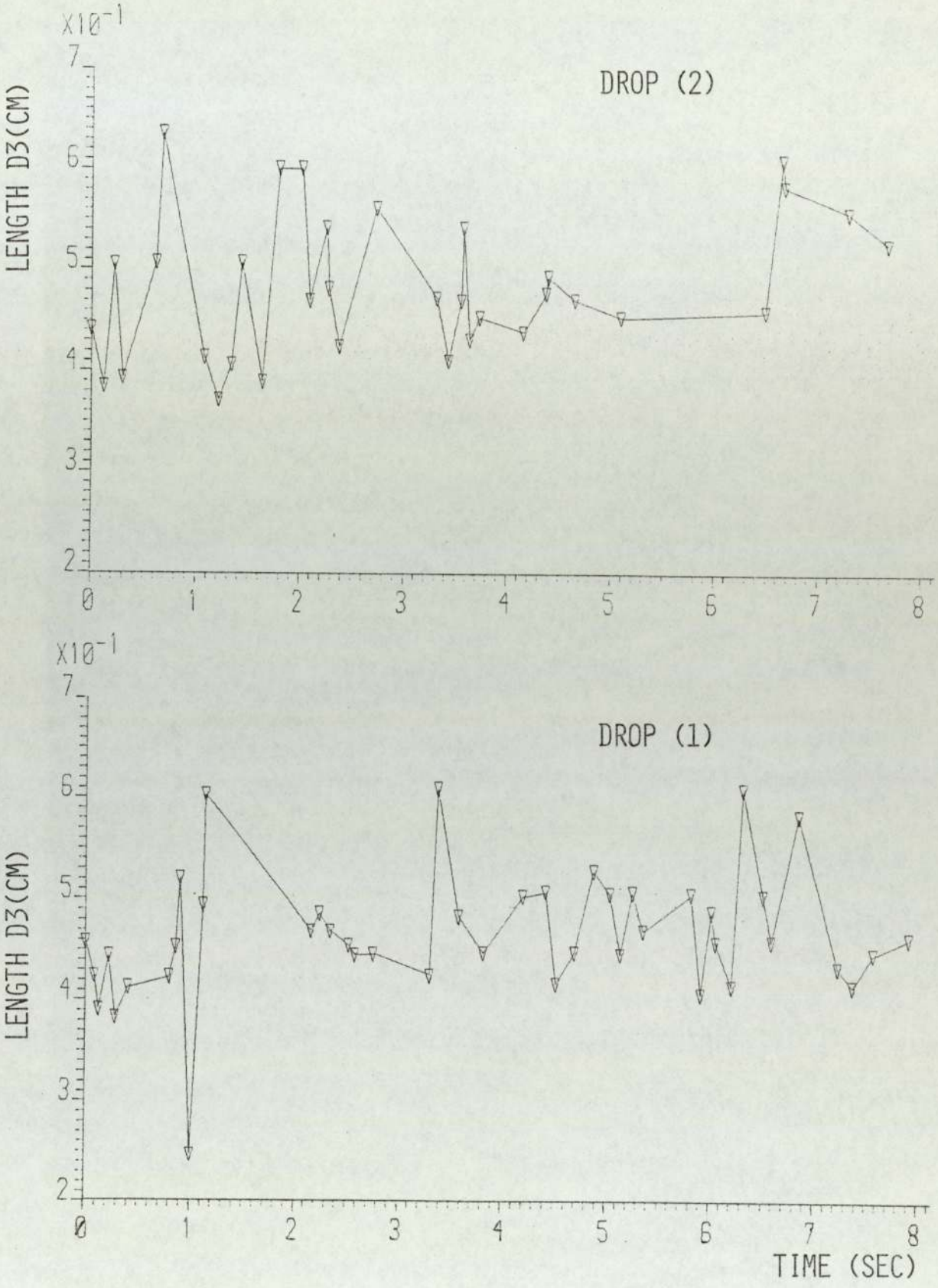

FIG.H.38 LENGTH D3 VS. TIME, RUN-12 .

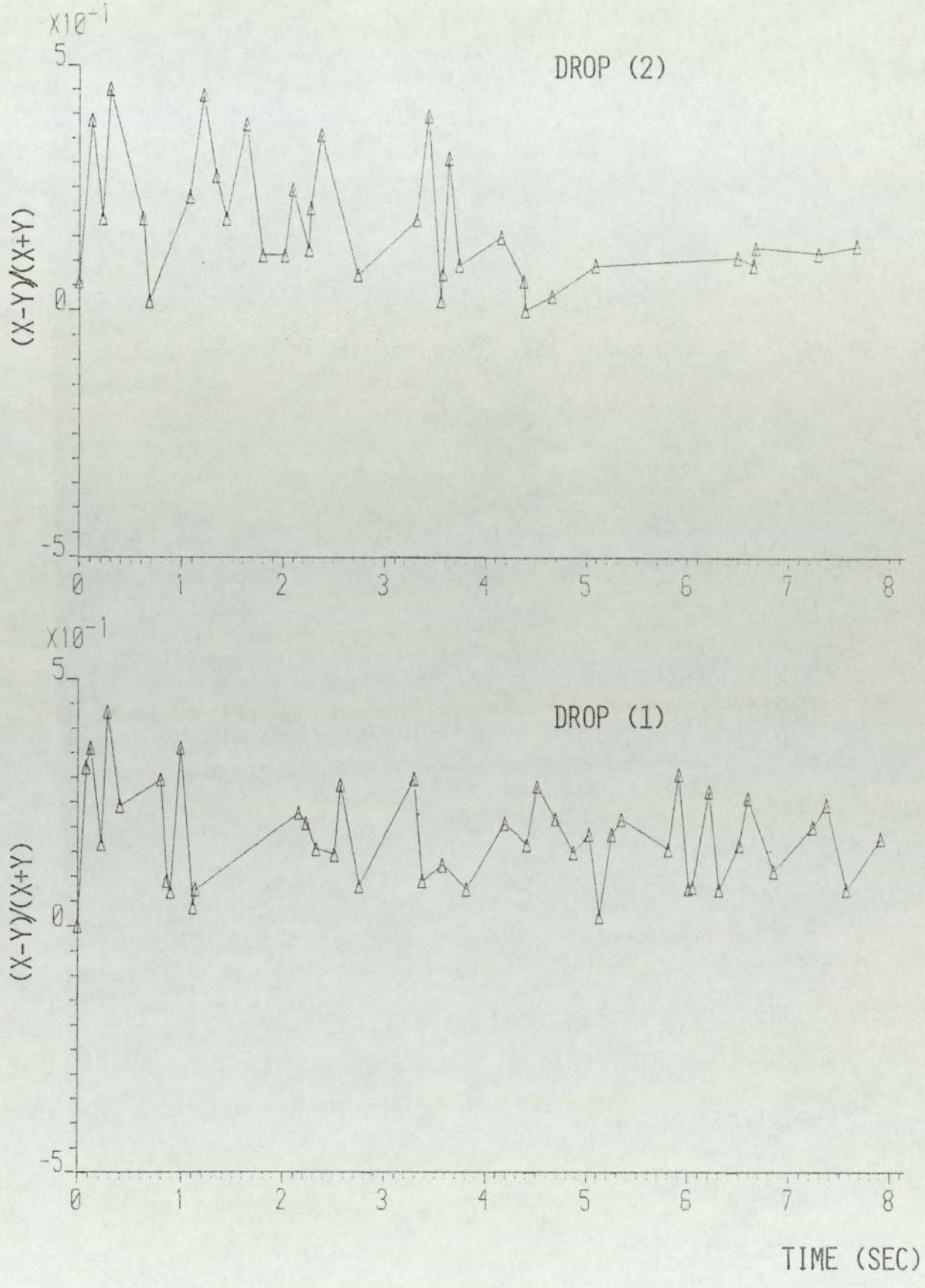

FIG.H.39 DEFORMATION RATIO VS. TIME, RUN-12.

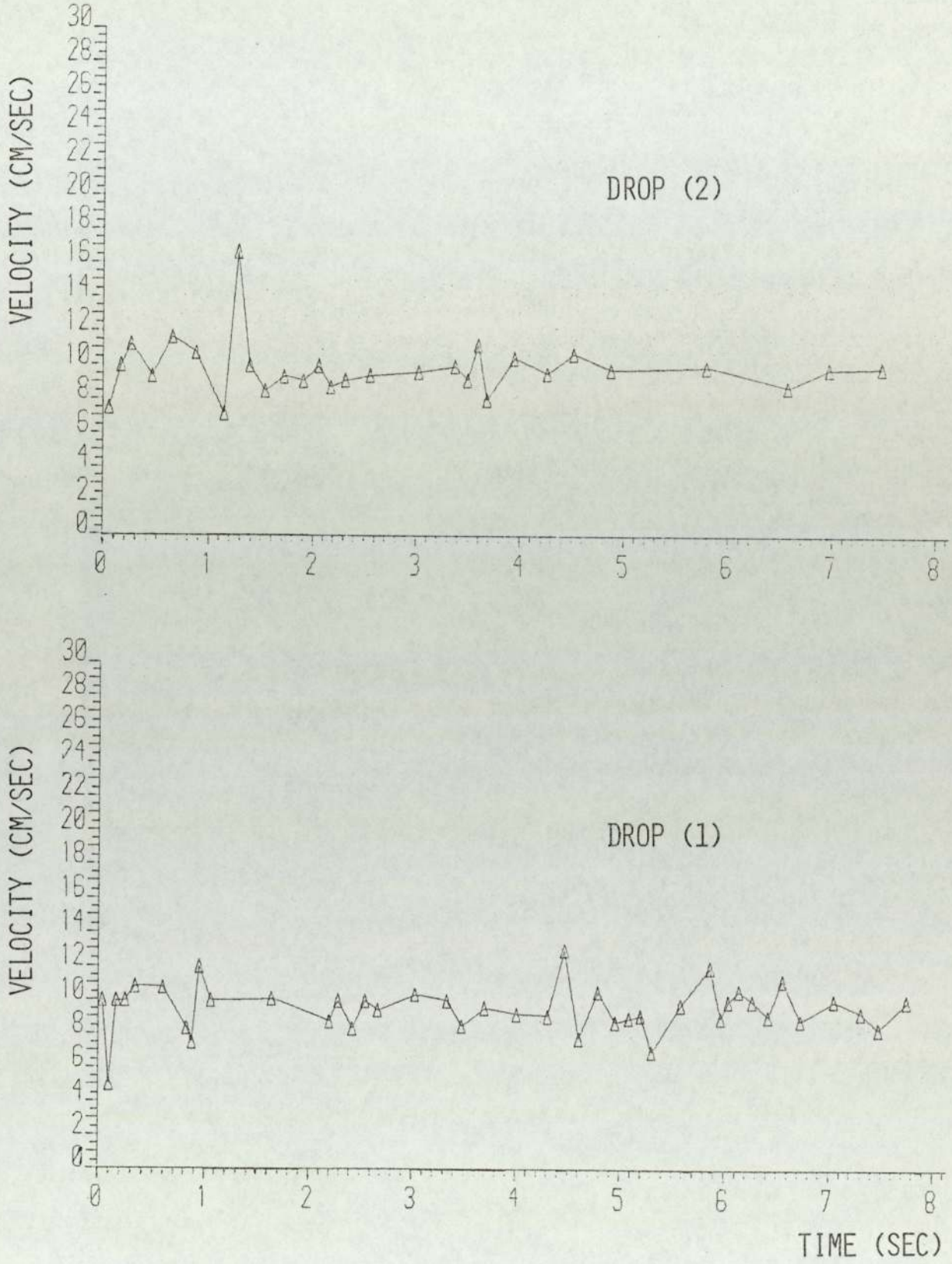

FIG. H.40 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-12.

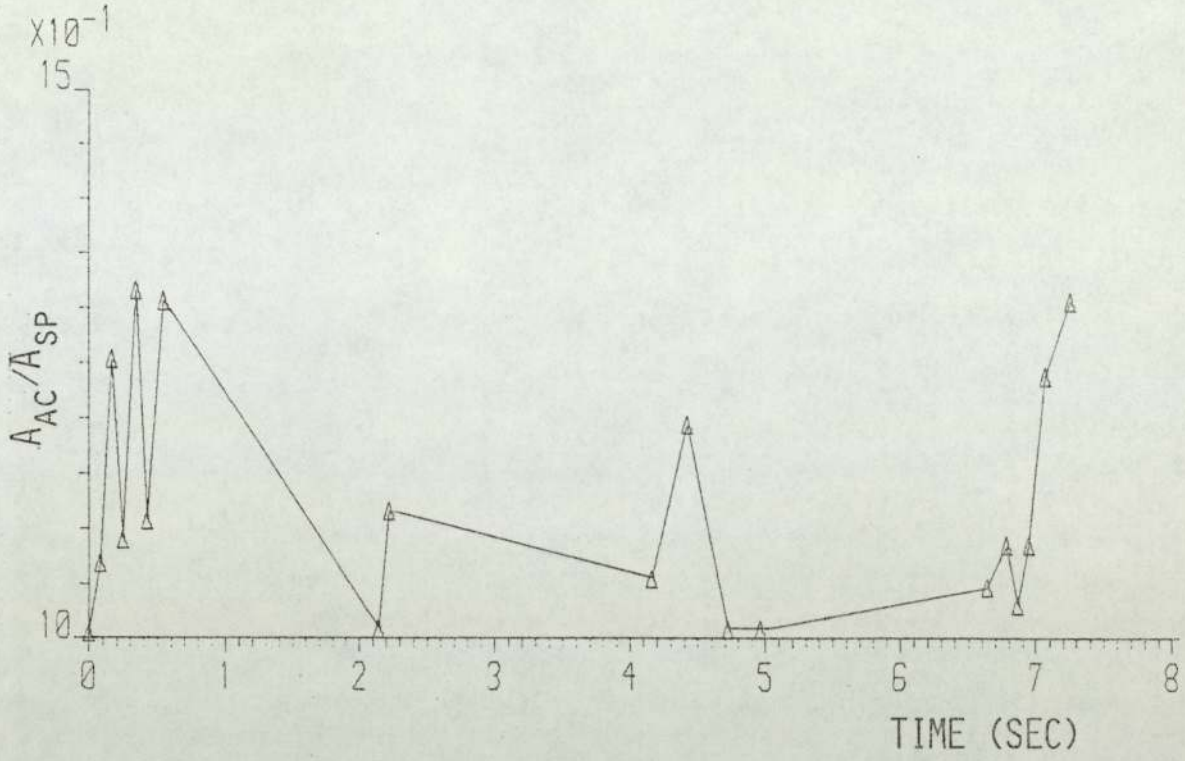

FIG. H.41 AREA RATIO VS. TIME, RUN-13.

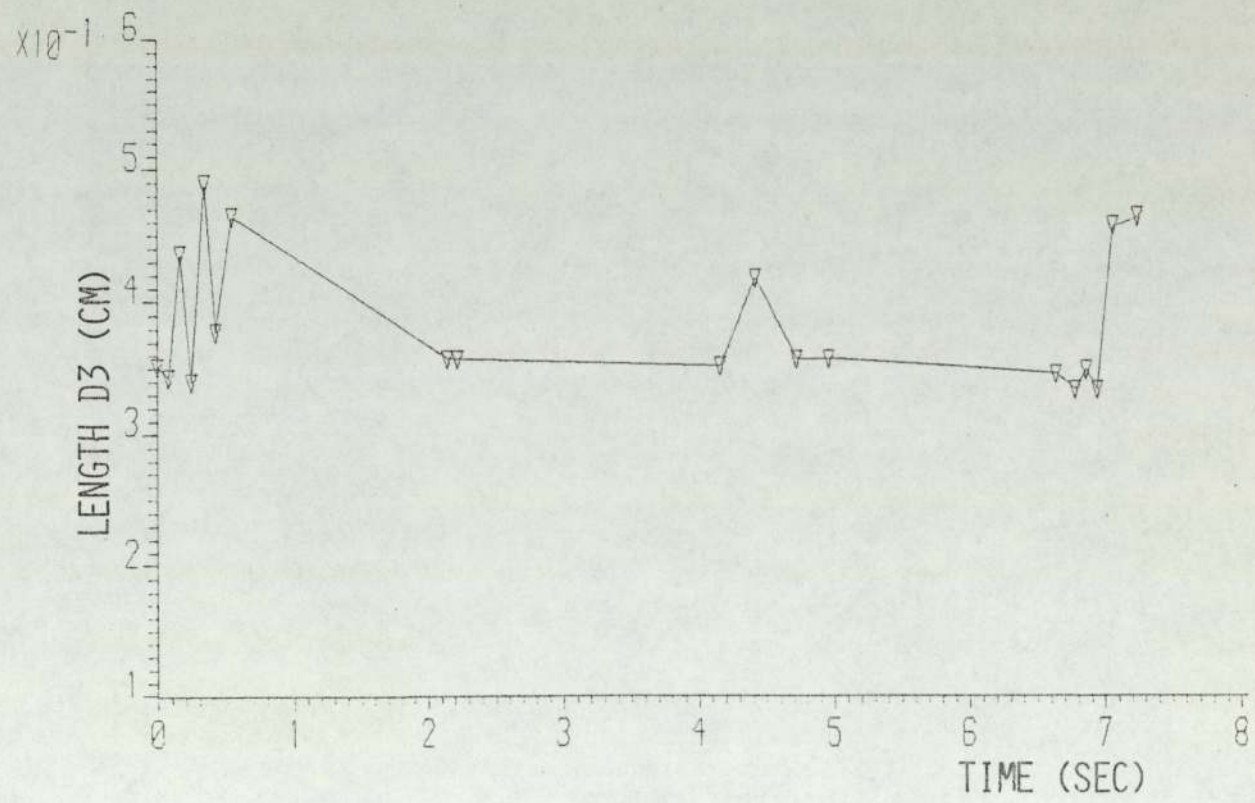

FIG. H.42 LENGTH D3 VS. TIME, RUN-13.

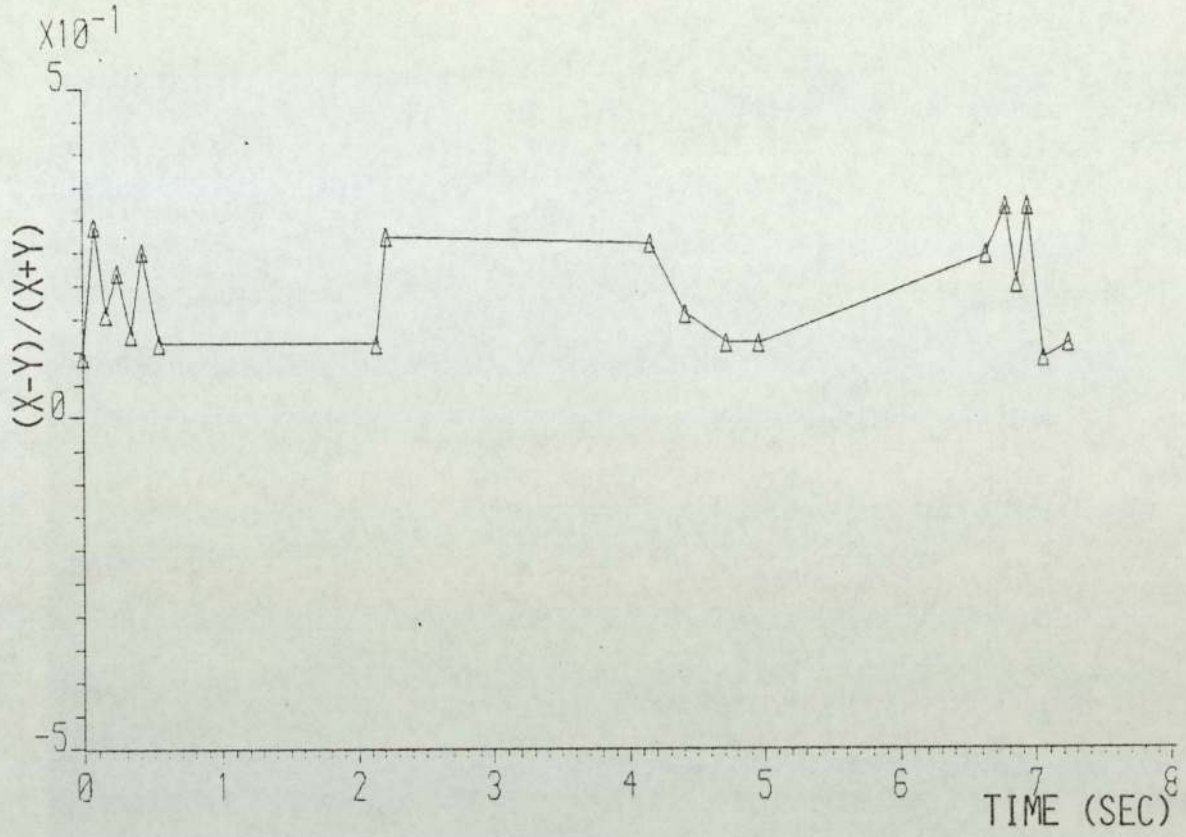

FIG. H.43 DEFORMATION RATIO VS. TIME, RUN-13.

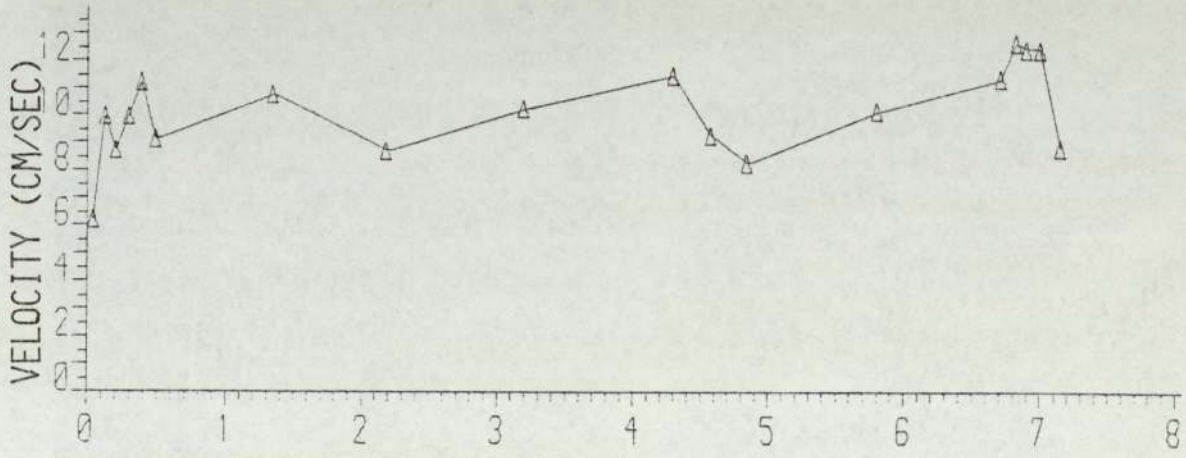

FIG. H.44 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-13 .

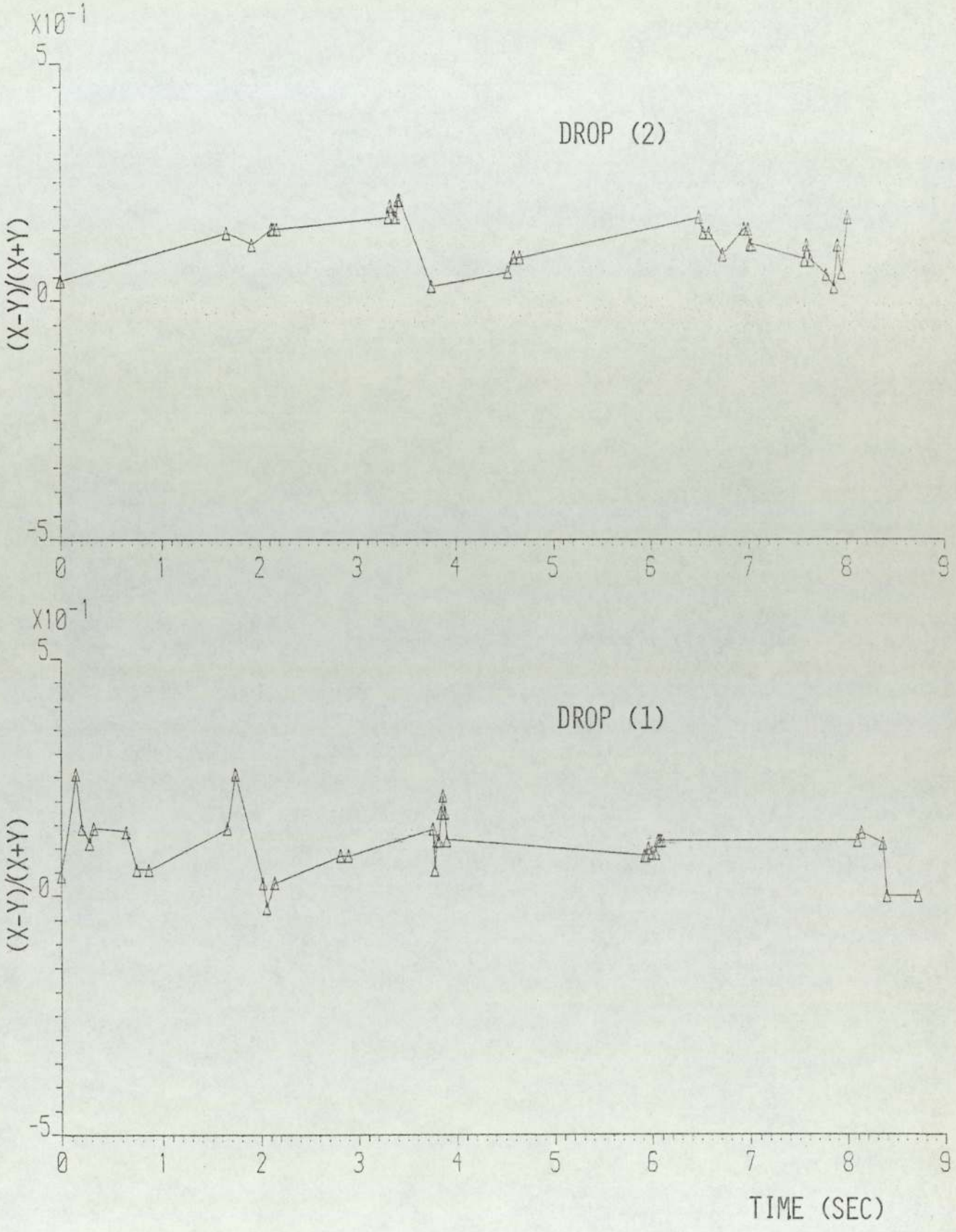

FIG.H.47 DEFORMATION RATIO VS. TIME, RUN-14.

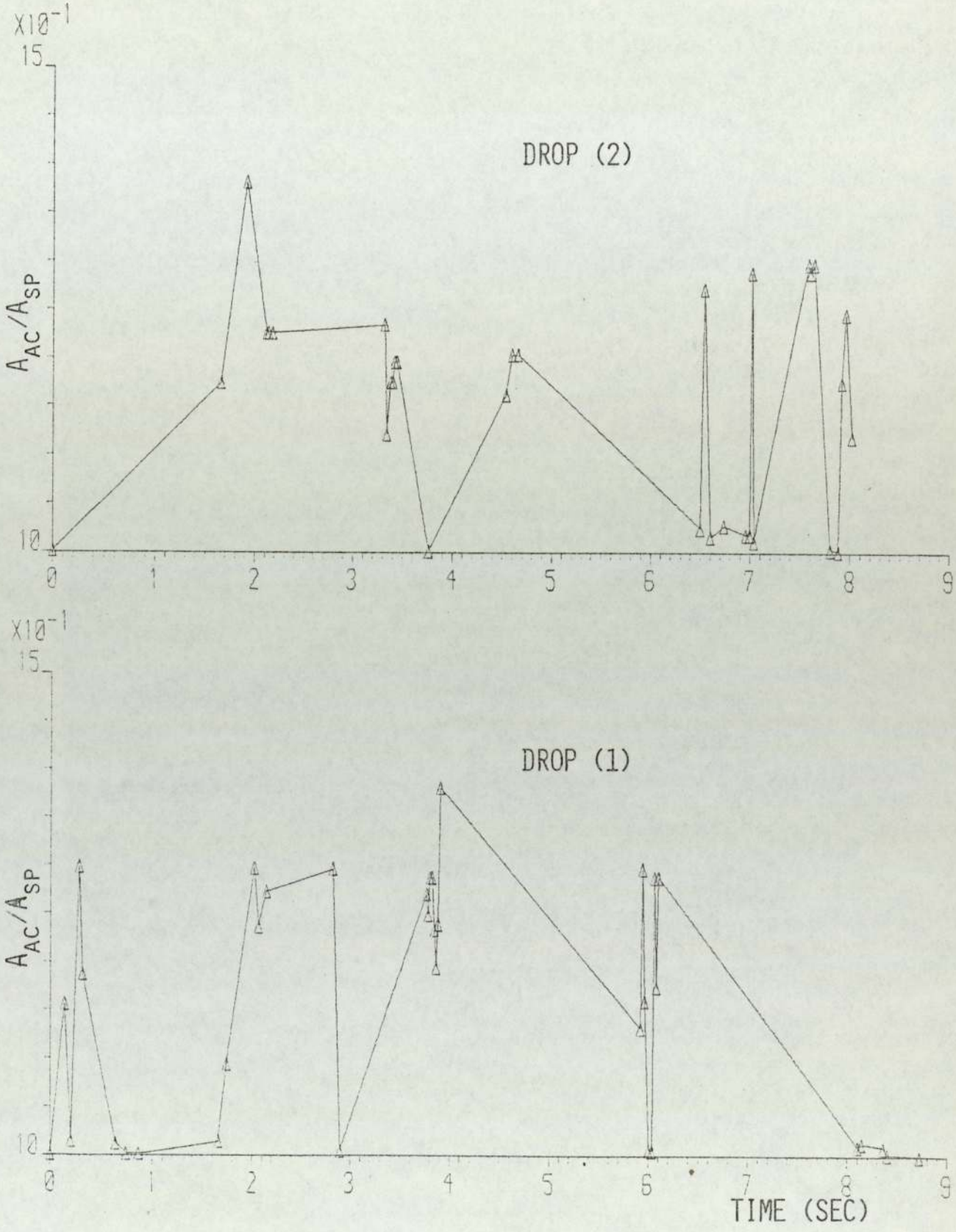

FIG. H.45 AREA RATIO VS. TIME, RUN-14.

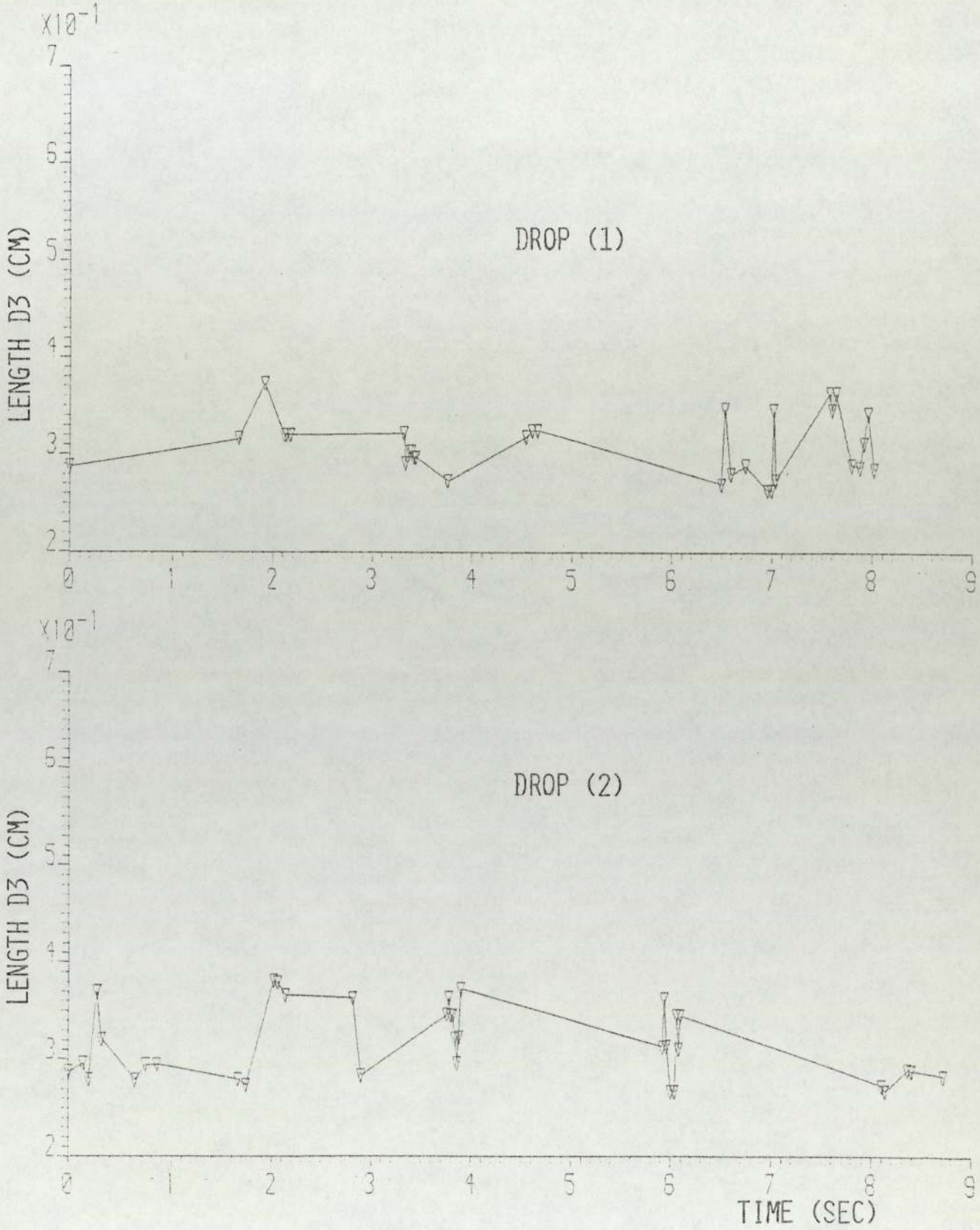

FIG. H.46 LENGTH D3 VS. TIME, RUN-14.

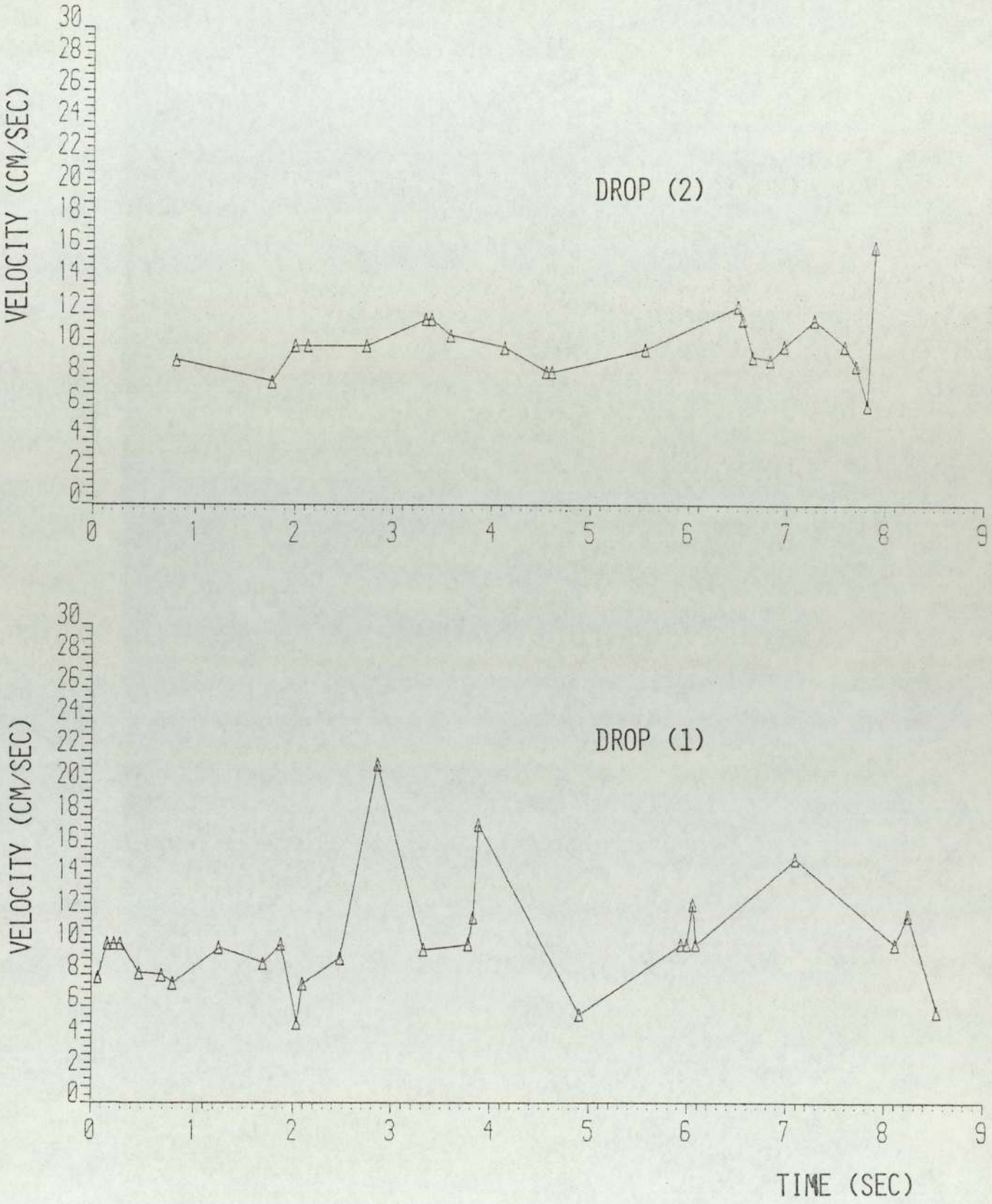

FIG. H.48 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-14.

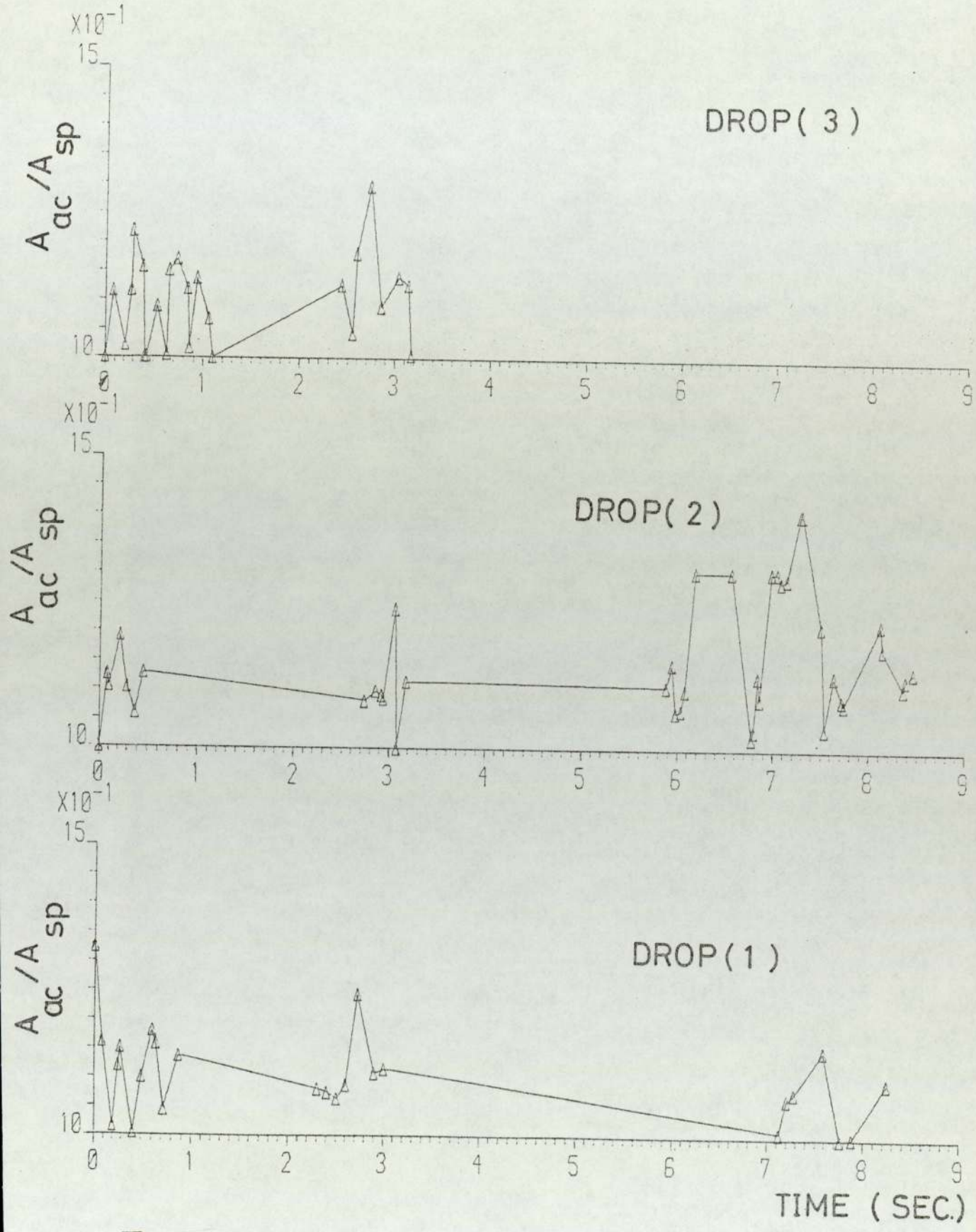

FIG. H.49 AREA RATIO VS. TIME, RUN-16.

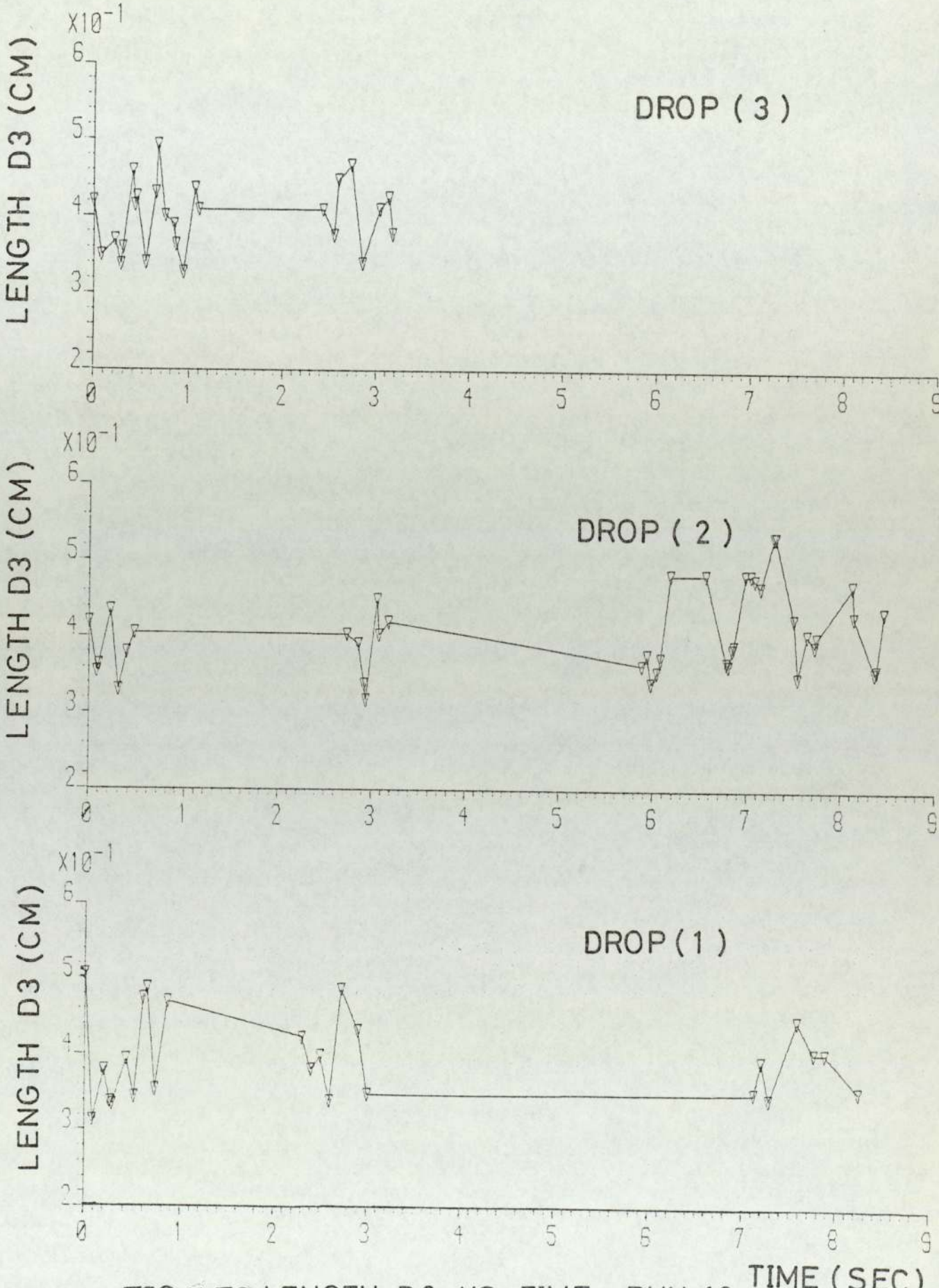

FIG.H.50 LENGTH D3 VS. TIME, RUN-16.

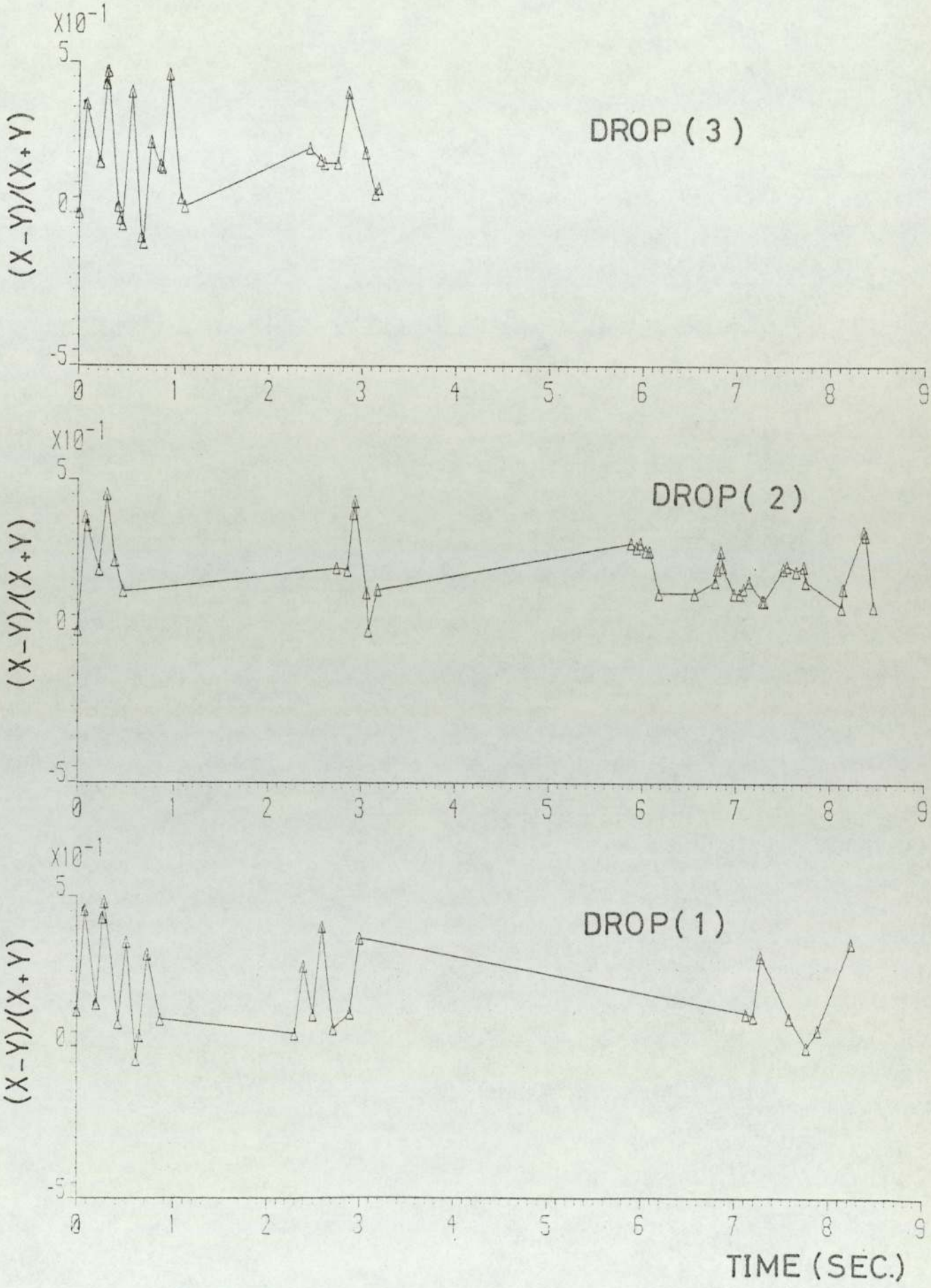

FIG. H-51 DEFORMATION RATIO VS. TIME , RUN-16.

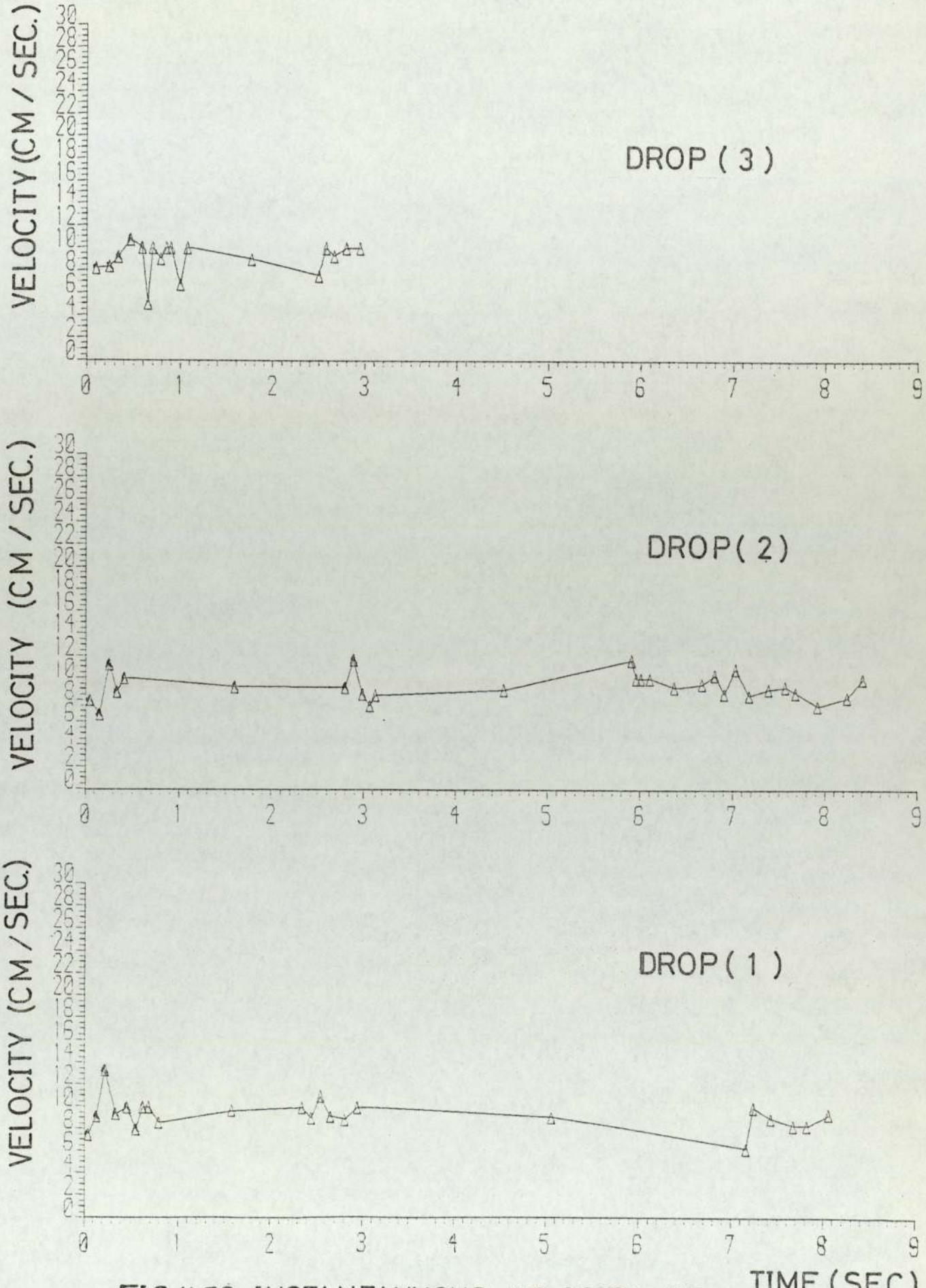

FIG. H-52 INSTANTANUOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-16.

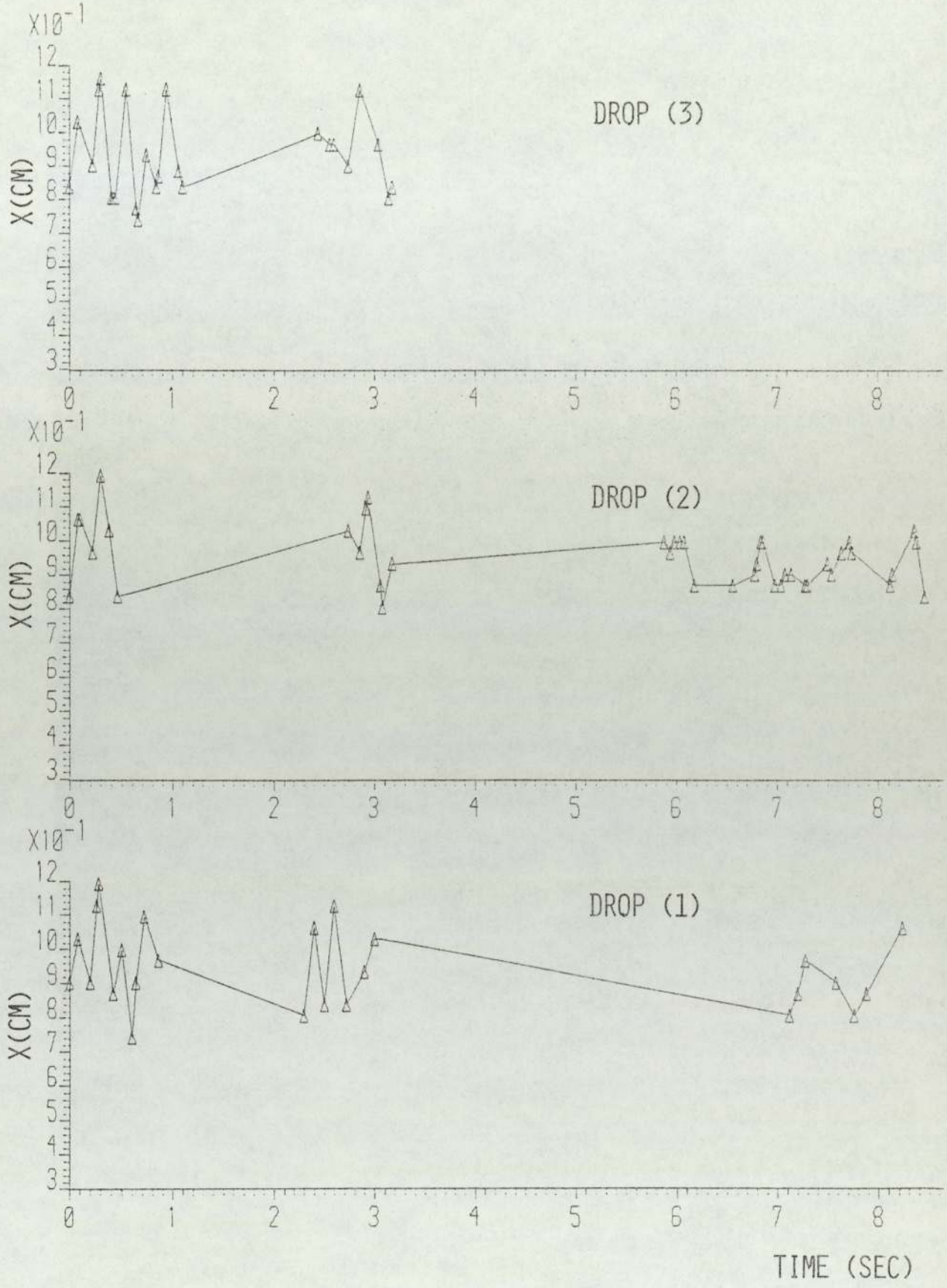

FIG.H.53 X VS. TIME, RUN-16.

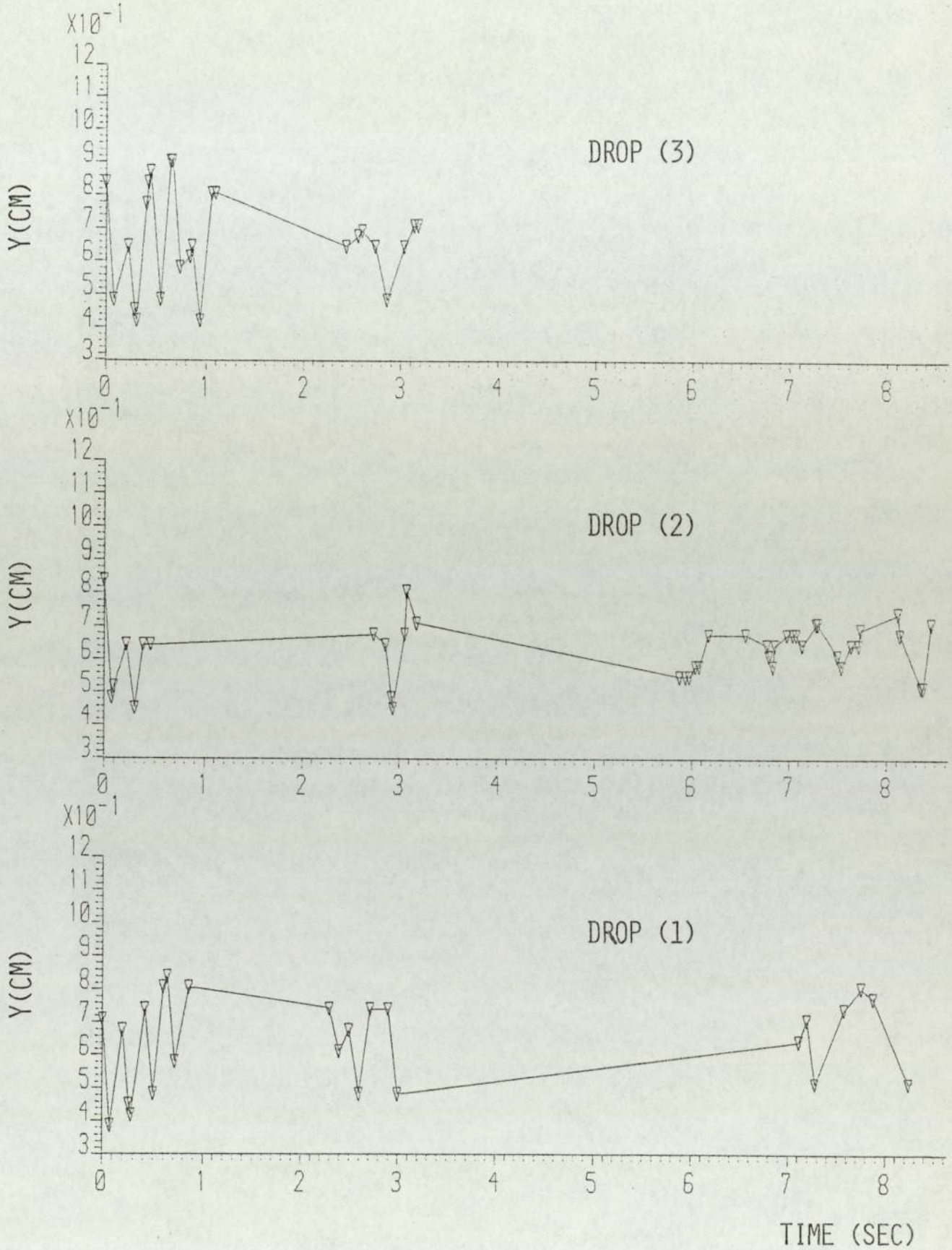

FIG. H.54 Y VS. TIME, RUN-16.

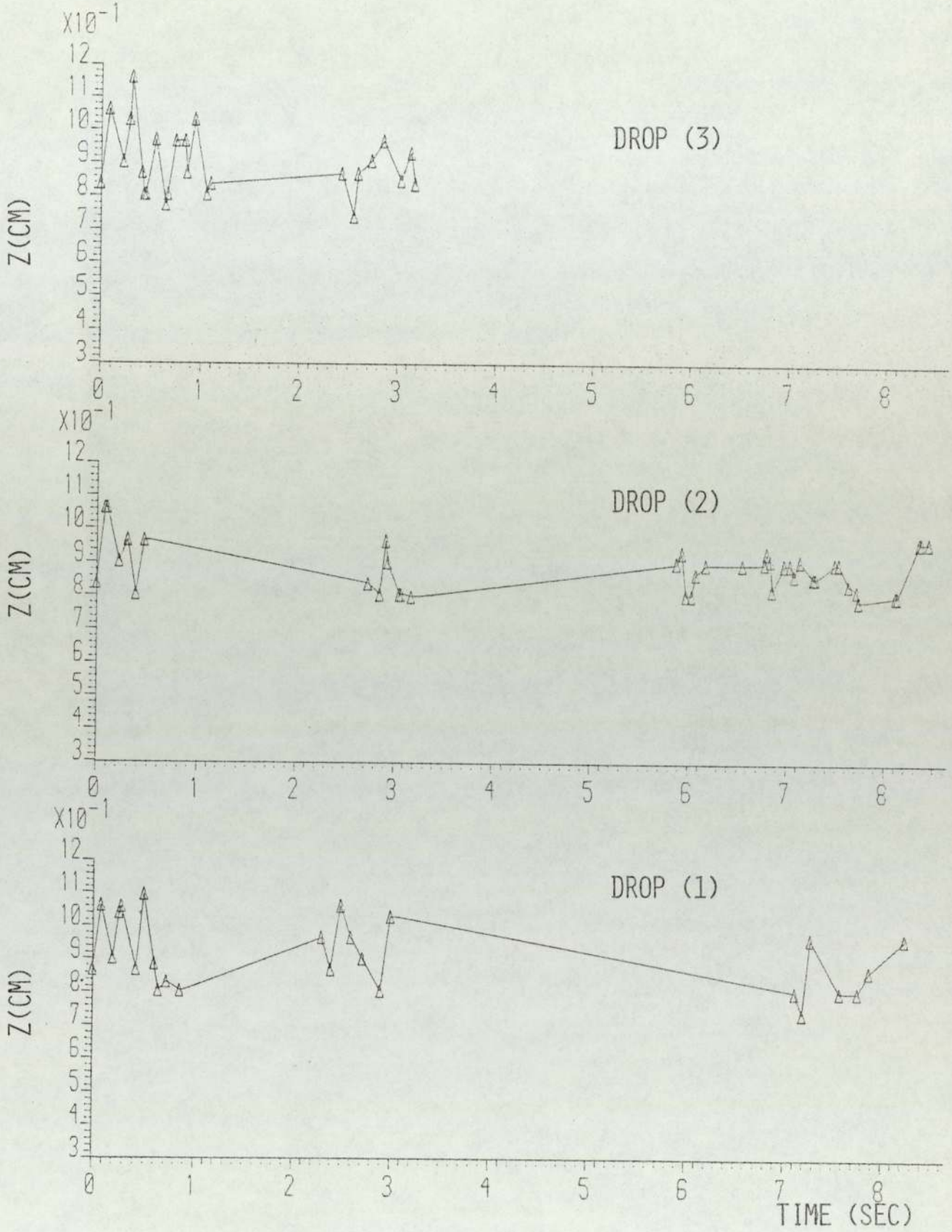

FIG. H.55 Z VS. TIME, RUN-16.

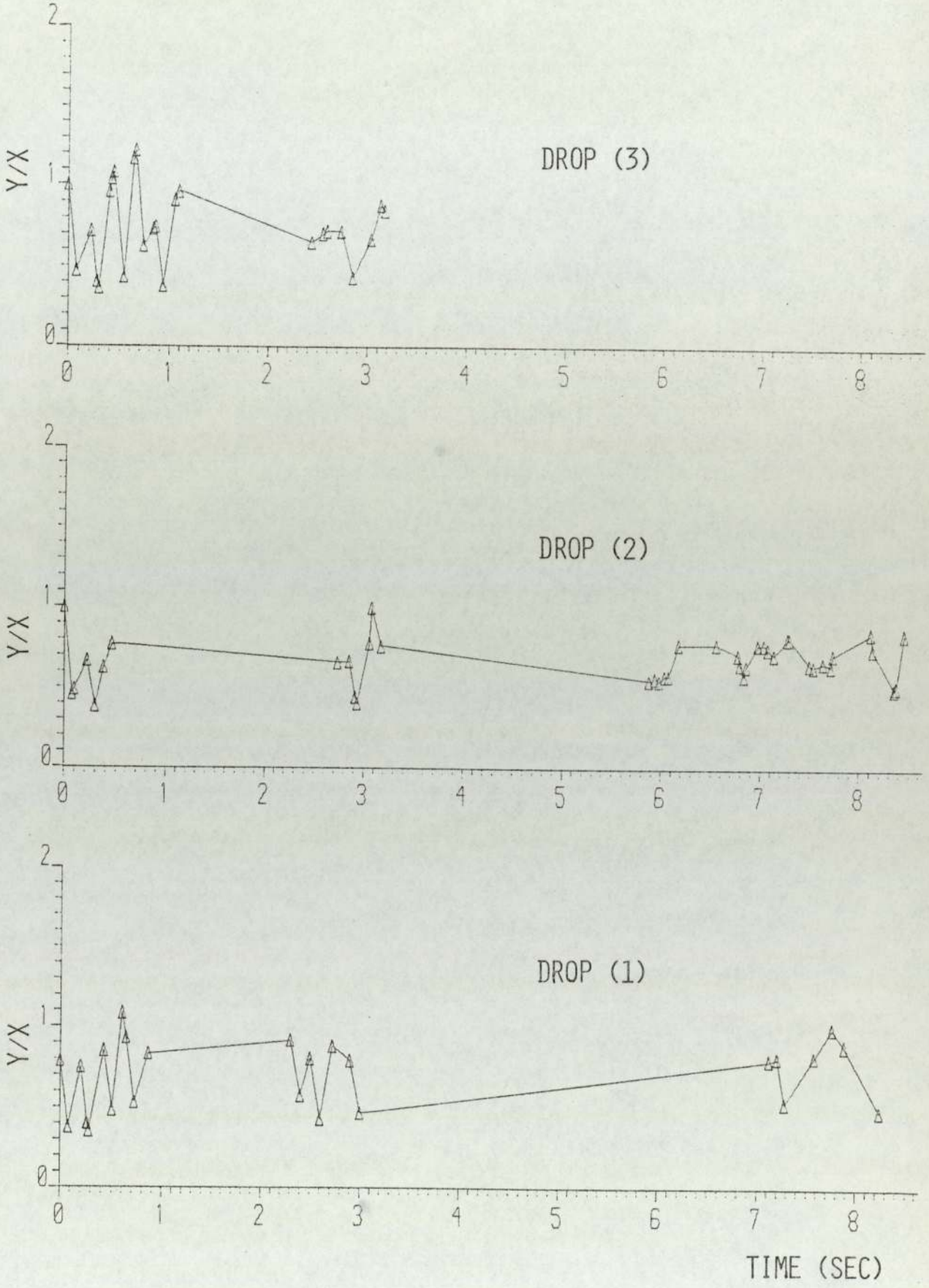

FIG. H.56 AXES RATIO VS. TIME, RUN-16.

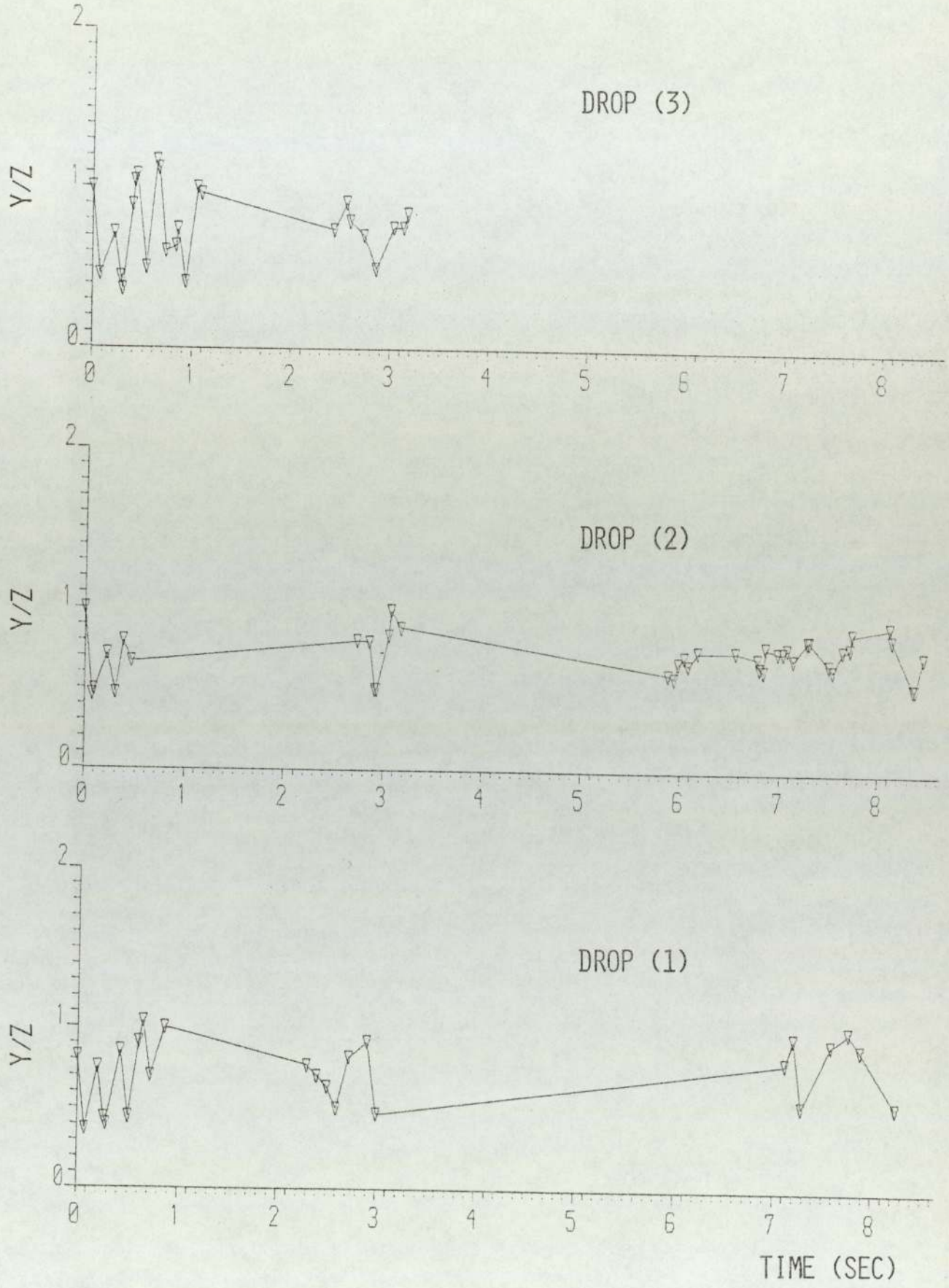

FIG.H.57 AXES RATIO VS. TIME, RUN-16.

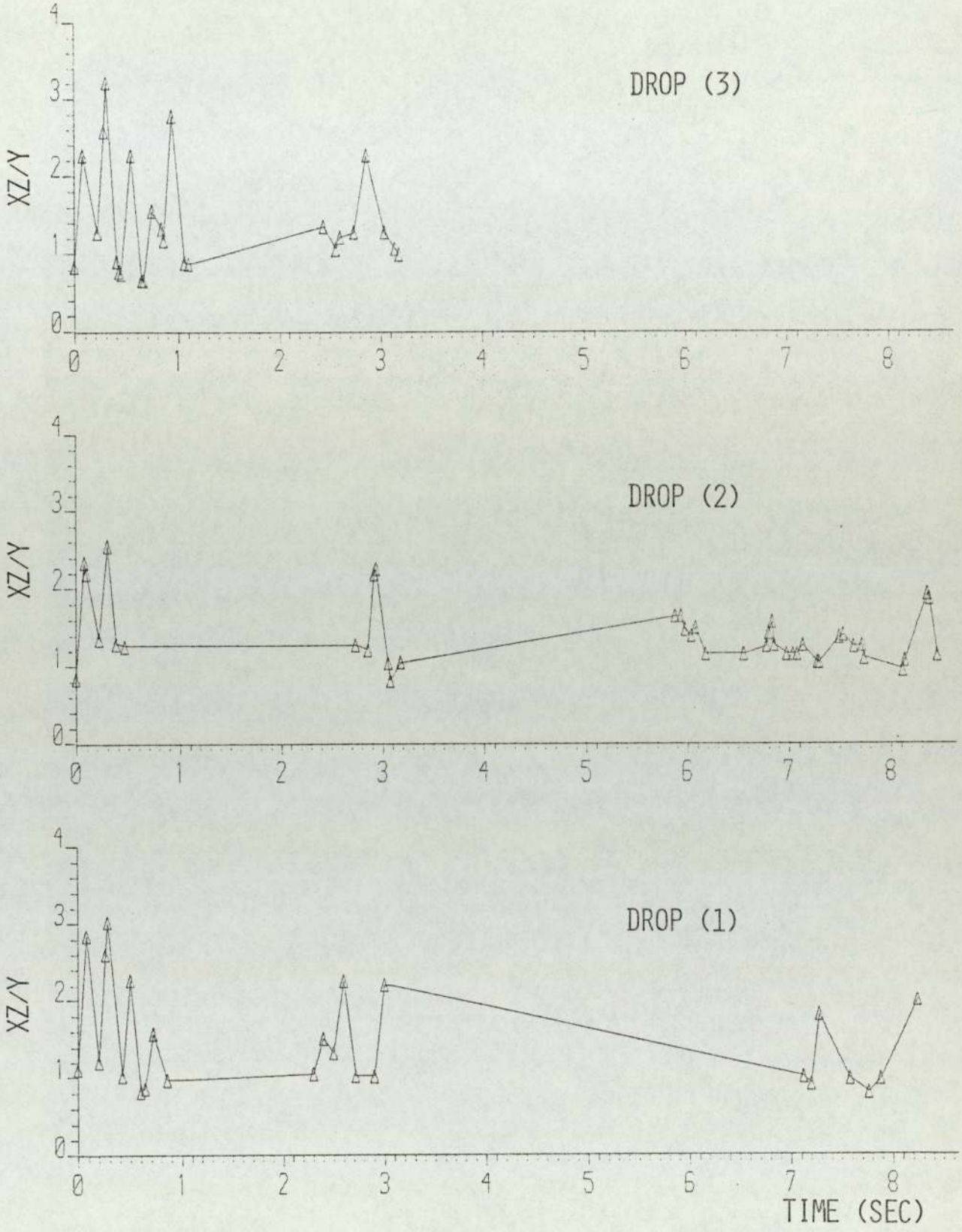

FIG.H.58 AXES RATIO VS. TIME, RUN-16.

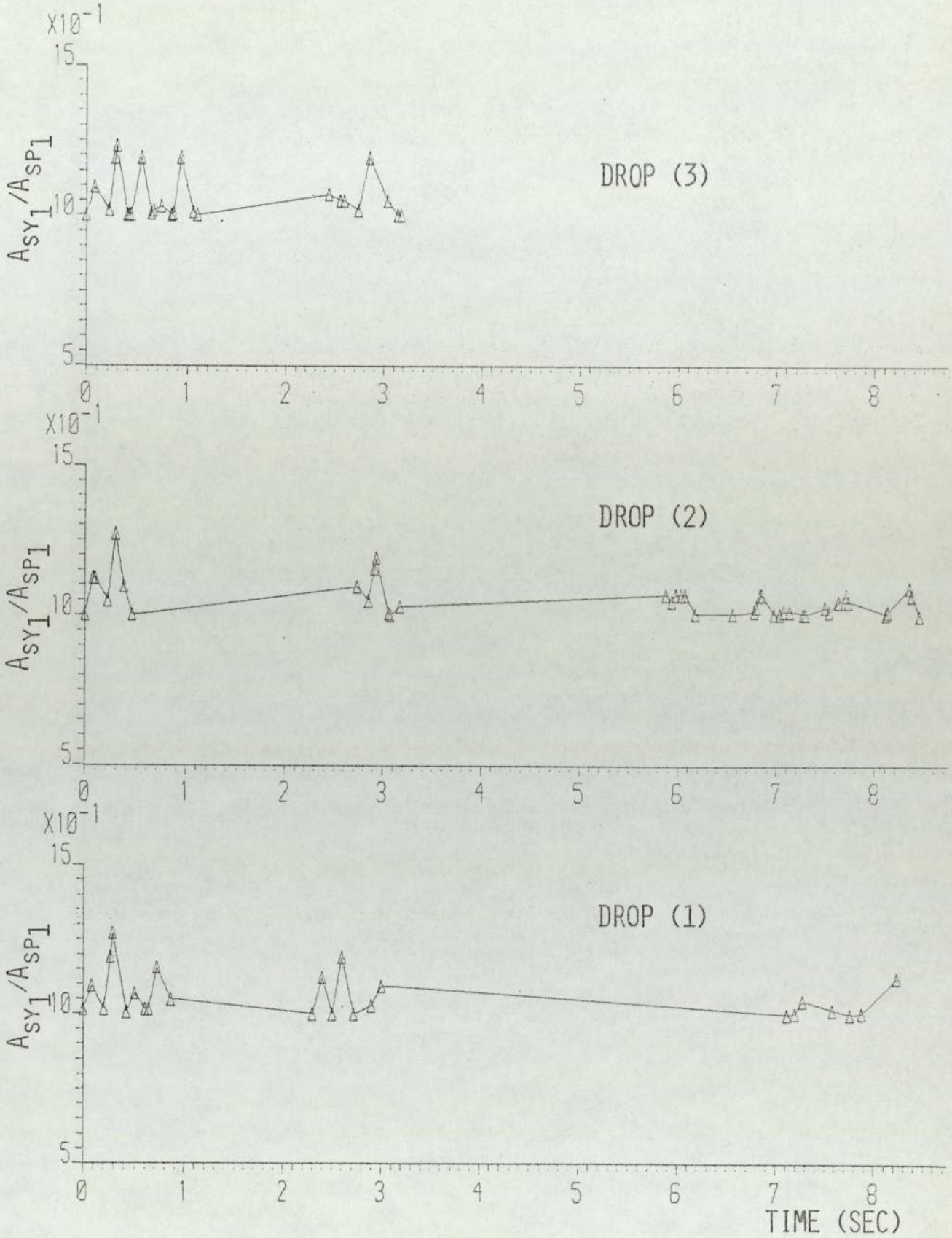

FIG. H.59 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-16, BASED ON DISPLACED VOLUME.

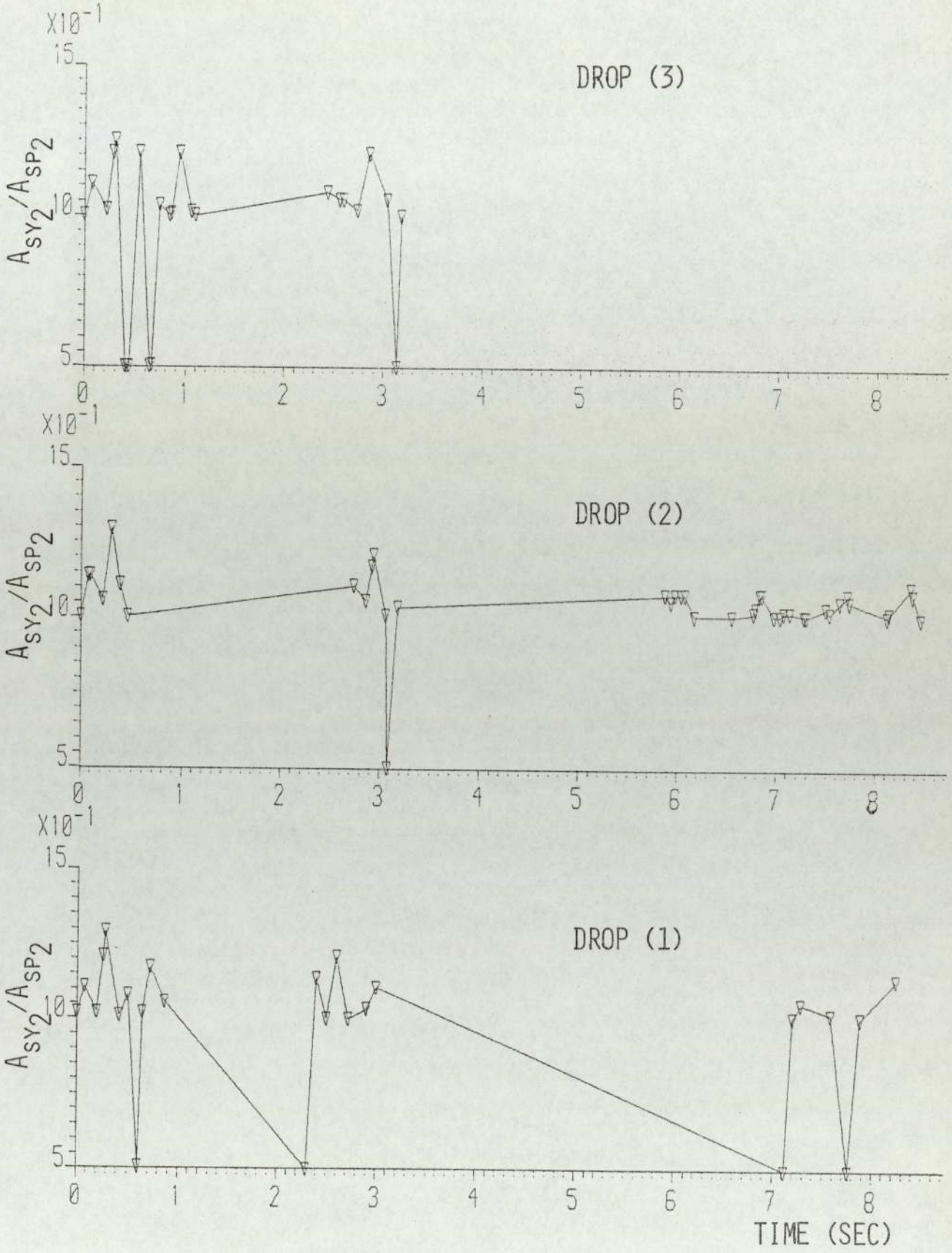

FIG. H.60 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-16, BASED ON MEAN VOLUME.

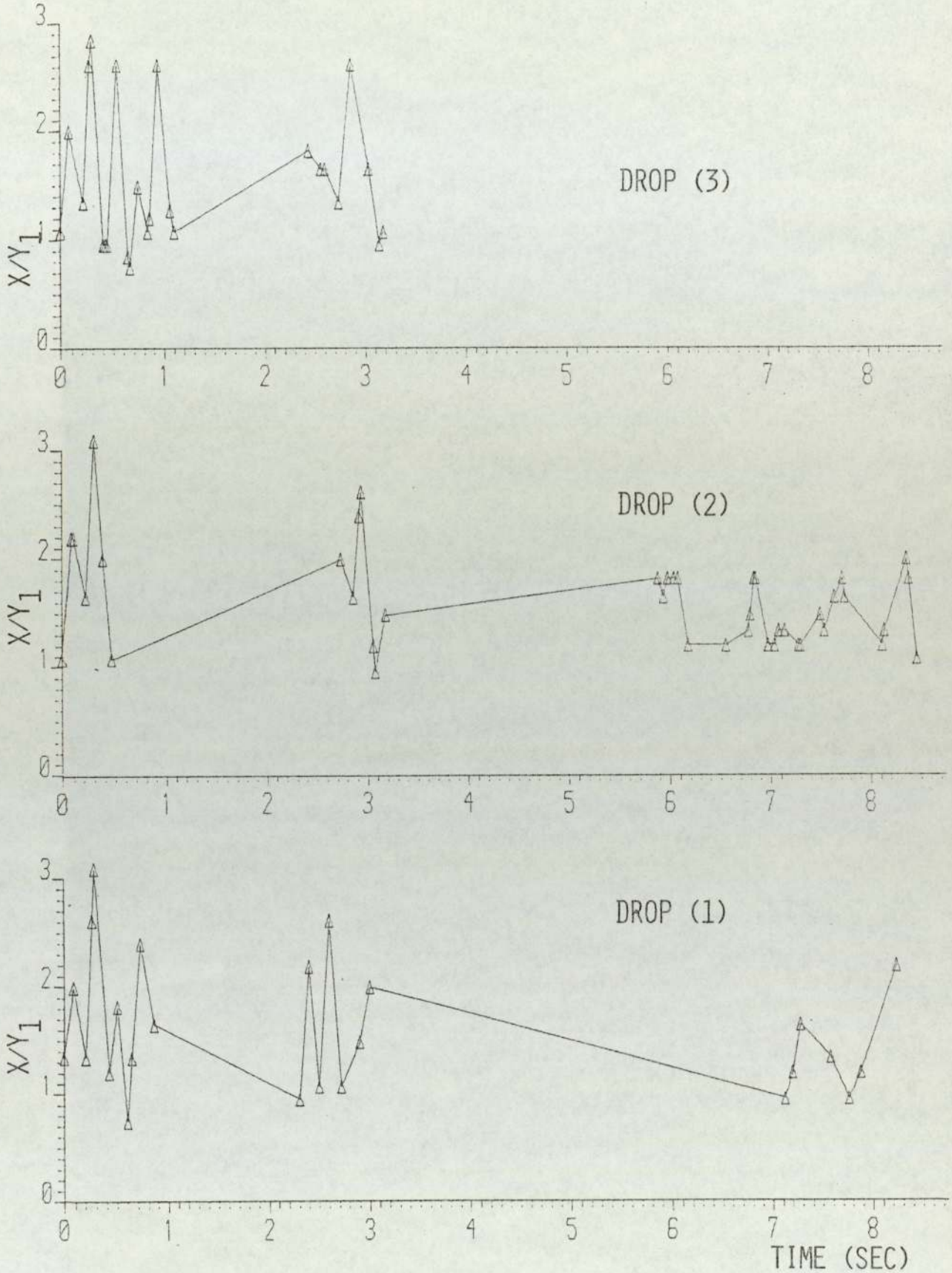

FIG. H.61 AXES RATIO VS. TIME, RUN-16.

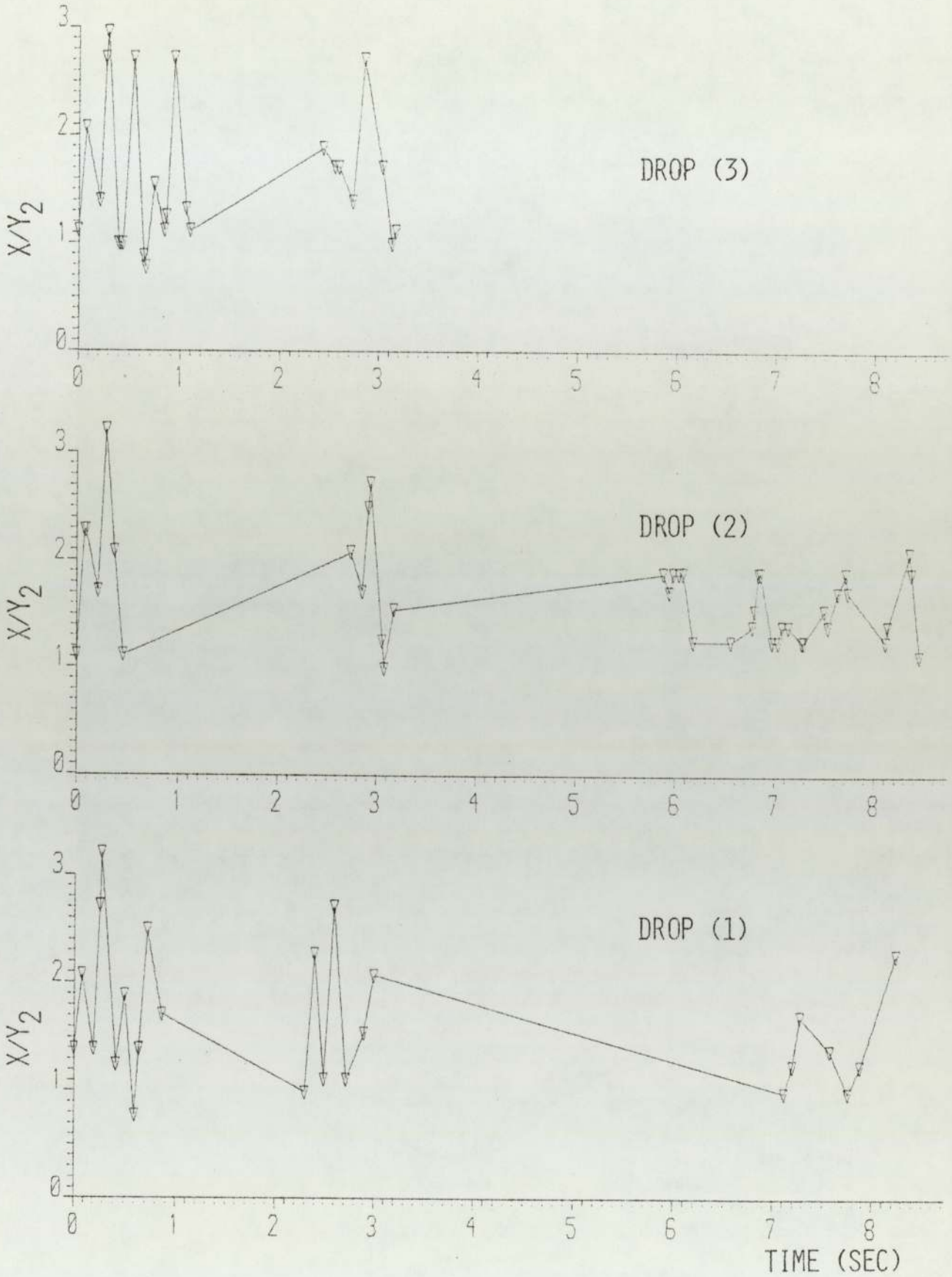

FIG.H.62 AXES RATIO VS. TIME, RUN-16.

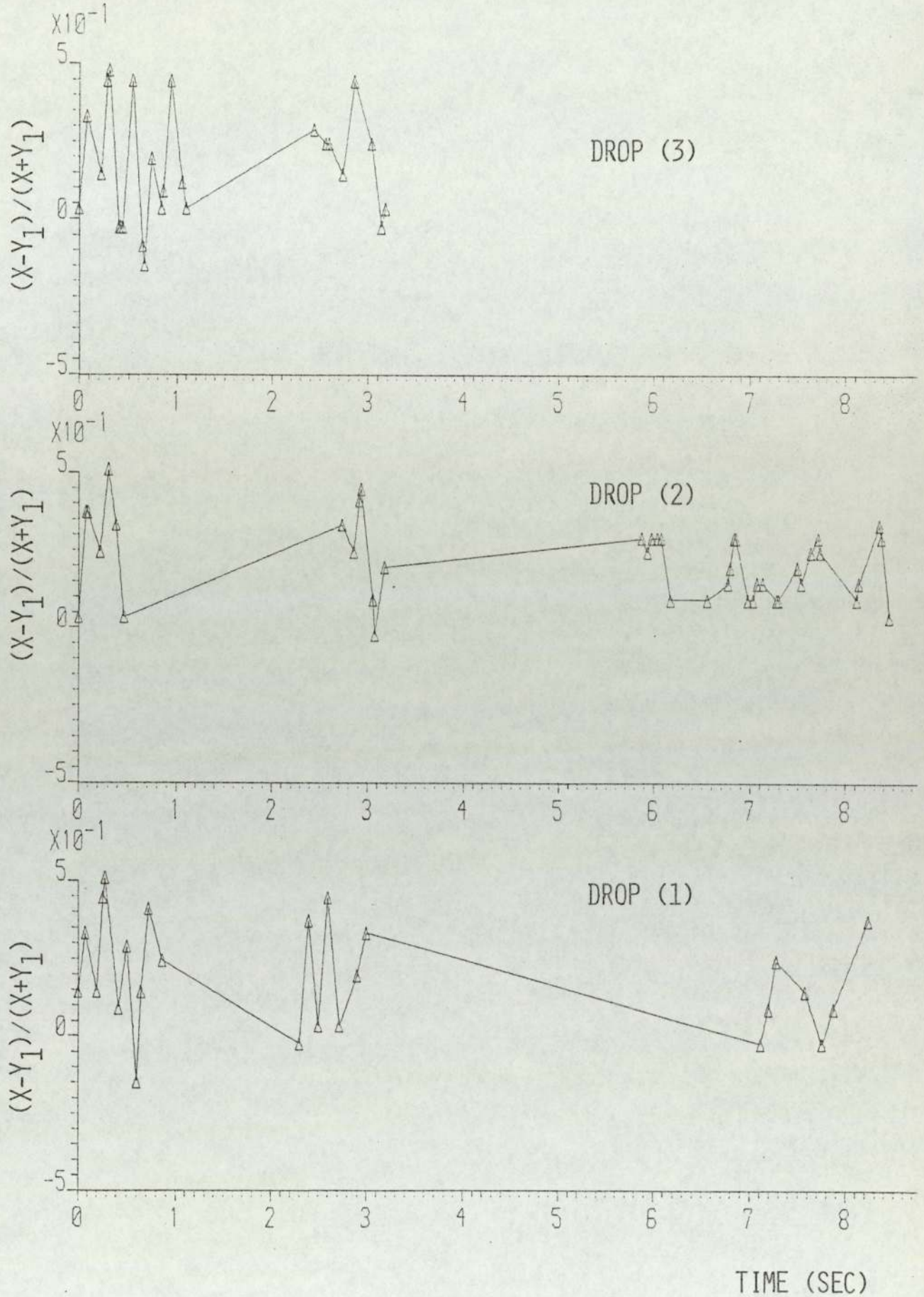

FIG.H.63 DEFORMATION RATIO VS. TIME, RUN-16.

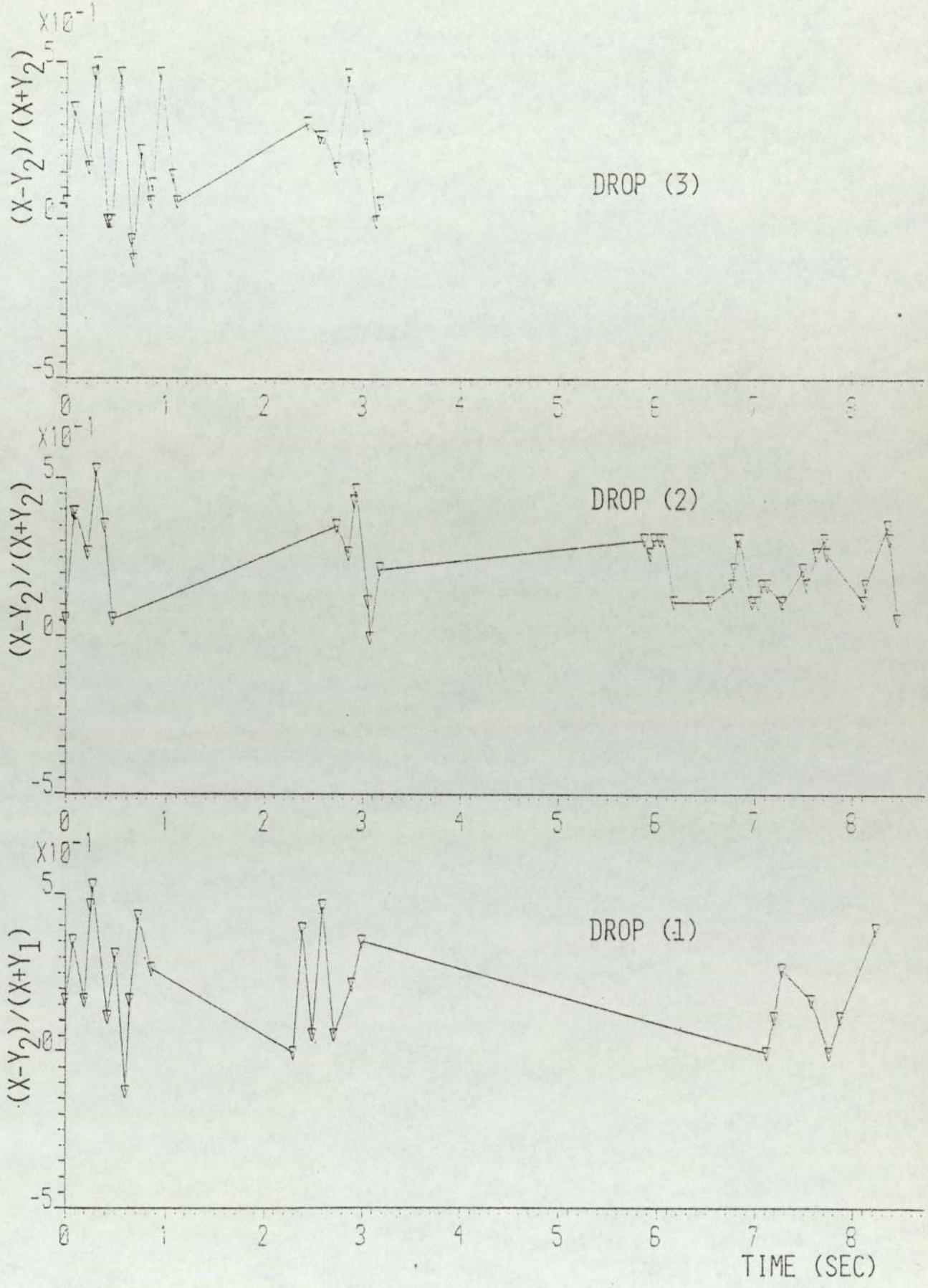

FIG.H.64 DEFORMATION RATIO VS. TIME, RUN-16.

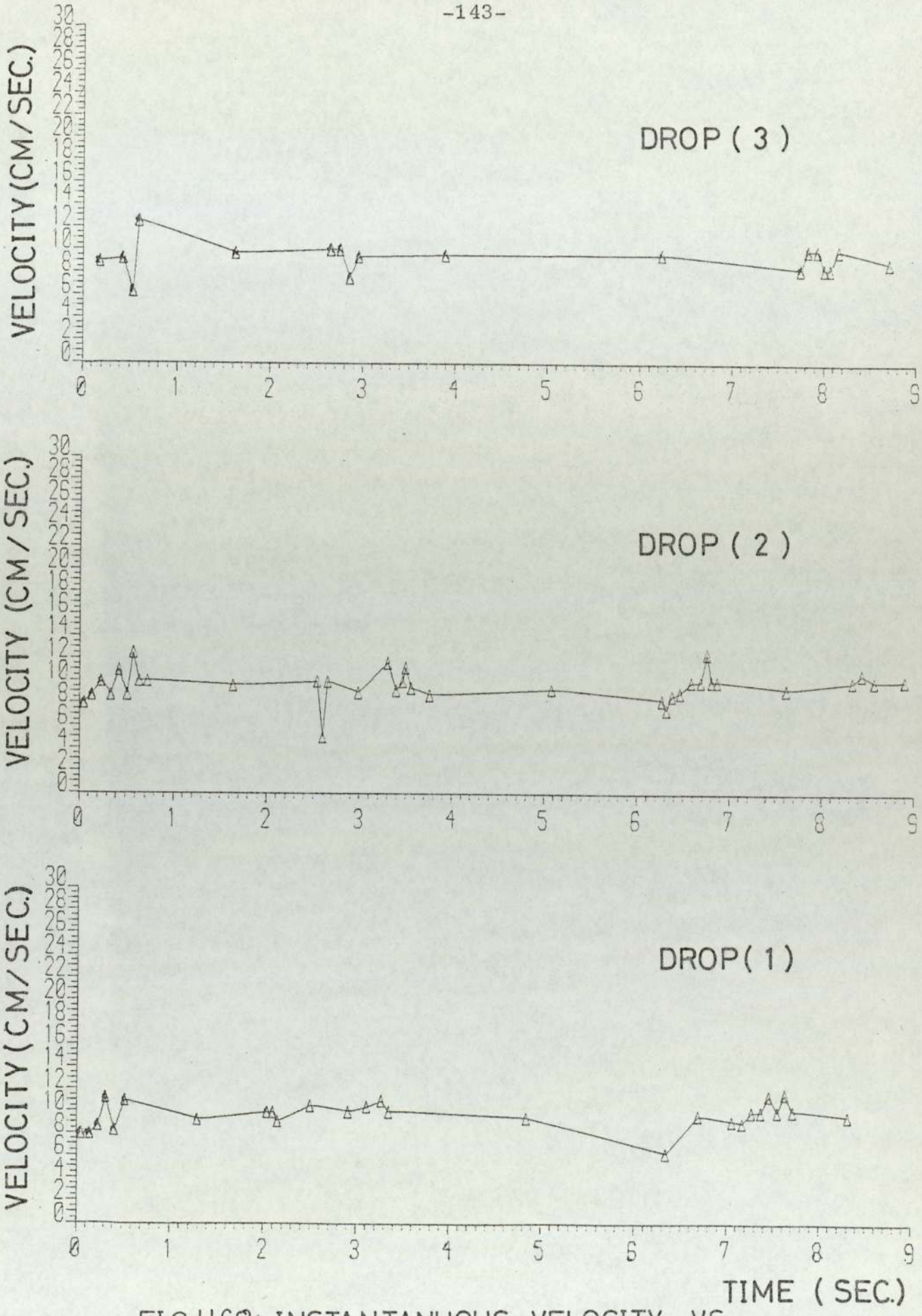

FIG. H.68 INSTANTANUOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-17.

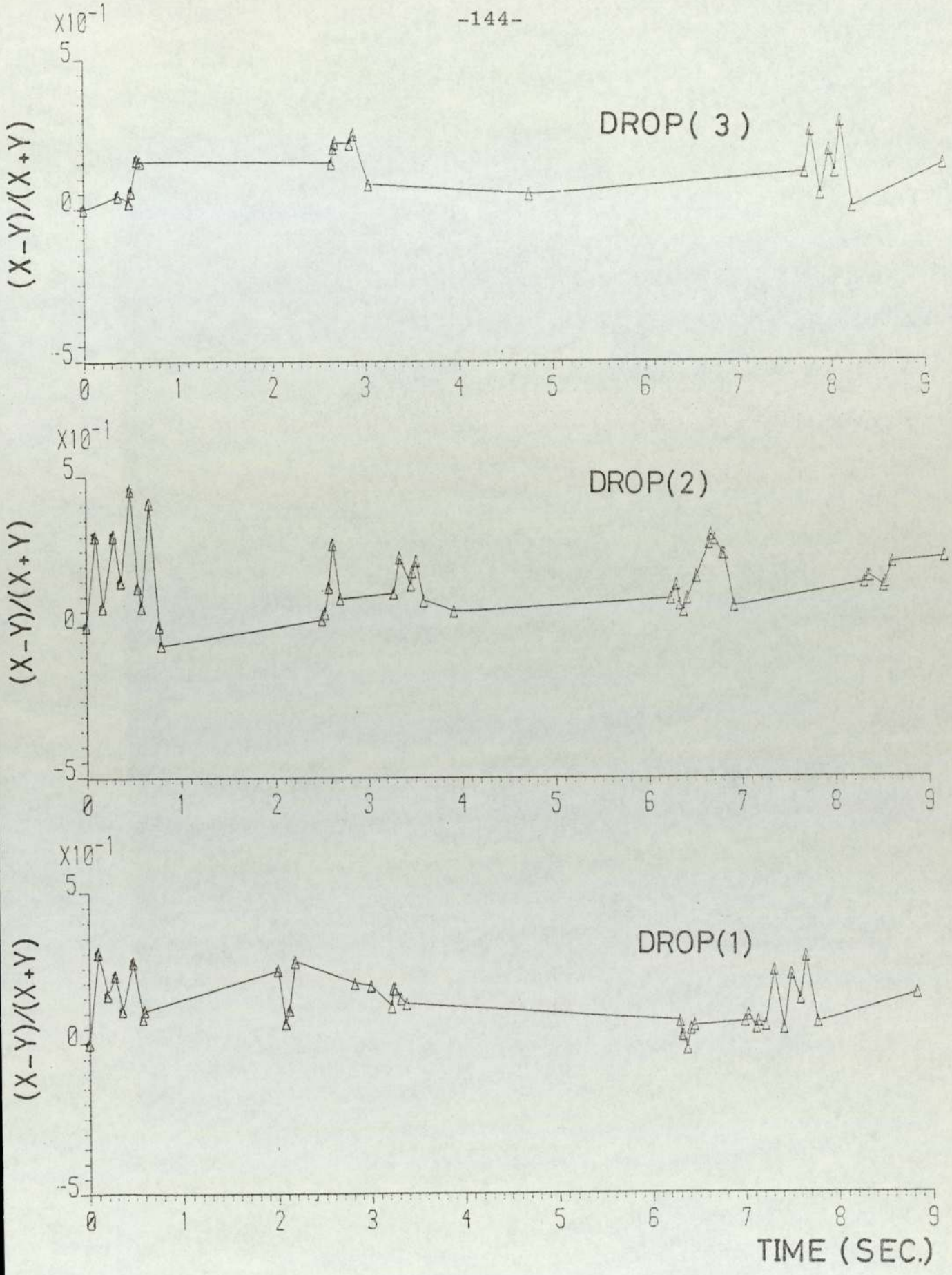

FIG.H.67 DEFORMATION RATIO VS. TIME, RUN-17.

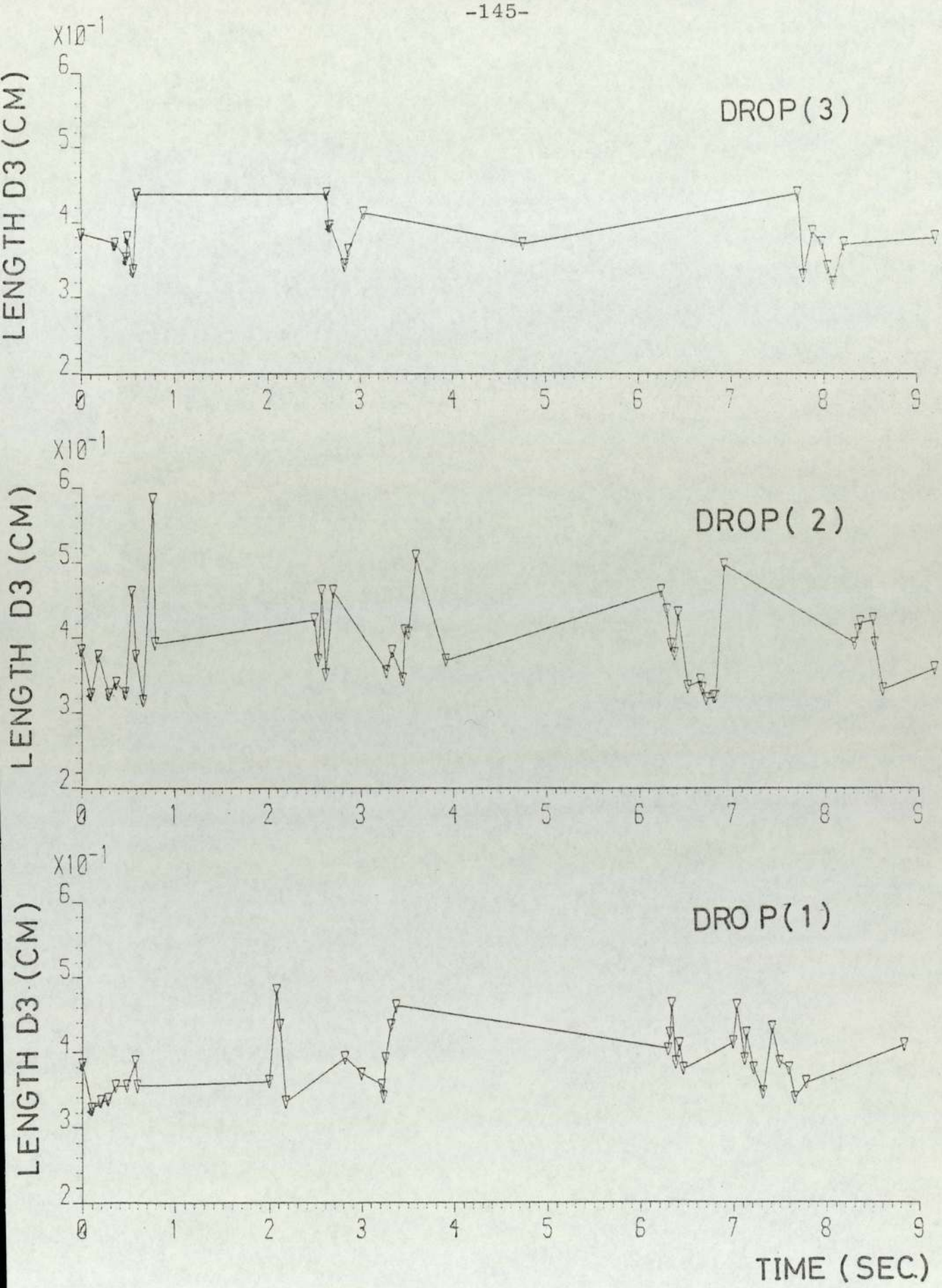

FIG.H.66 LENGTH D3 VS. TIME, RUN-17.

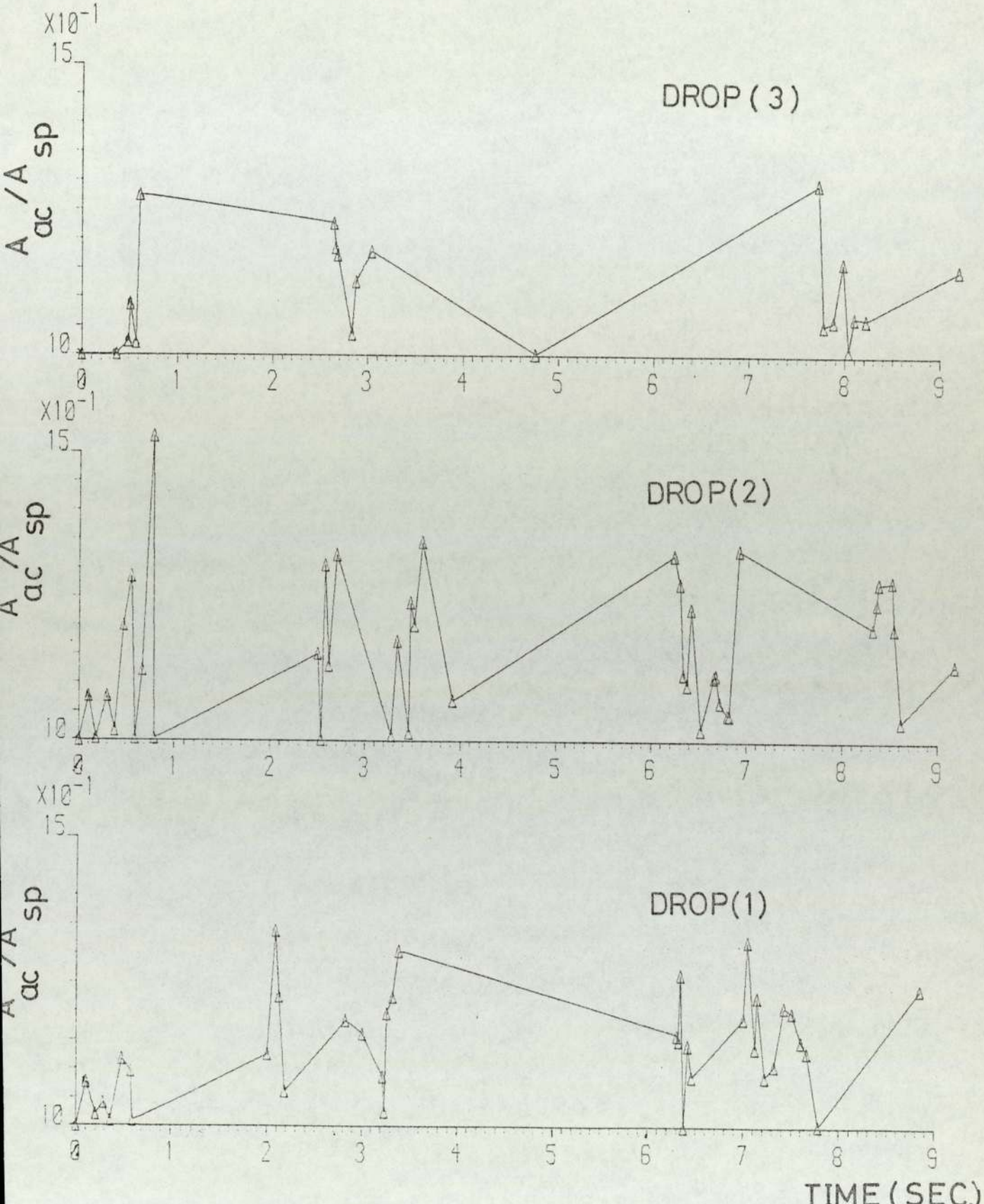

FIG. H.65 AREA RATIO VS. TIME, RUN-17.

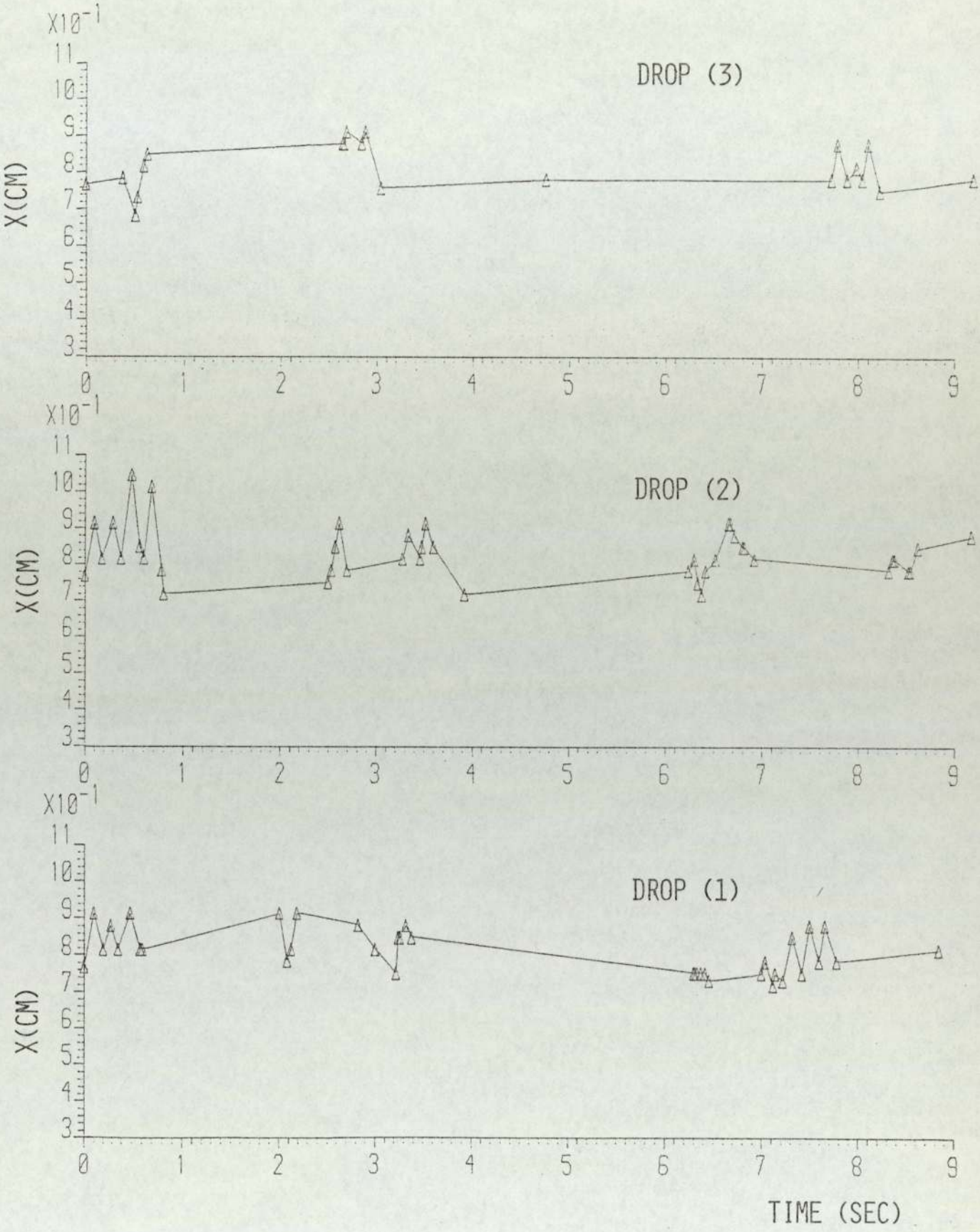

FIG. H.70 X VS. TIME, RUN-17.

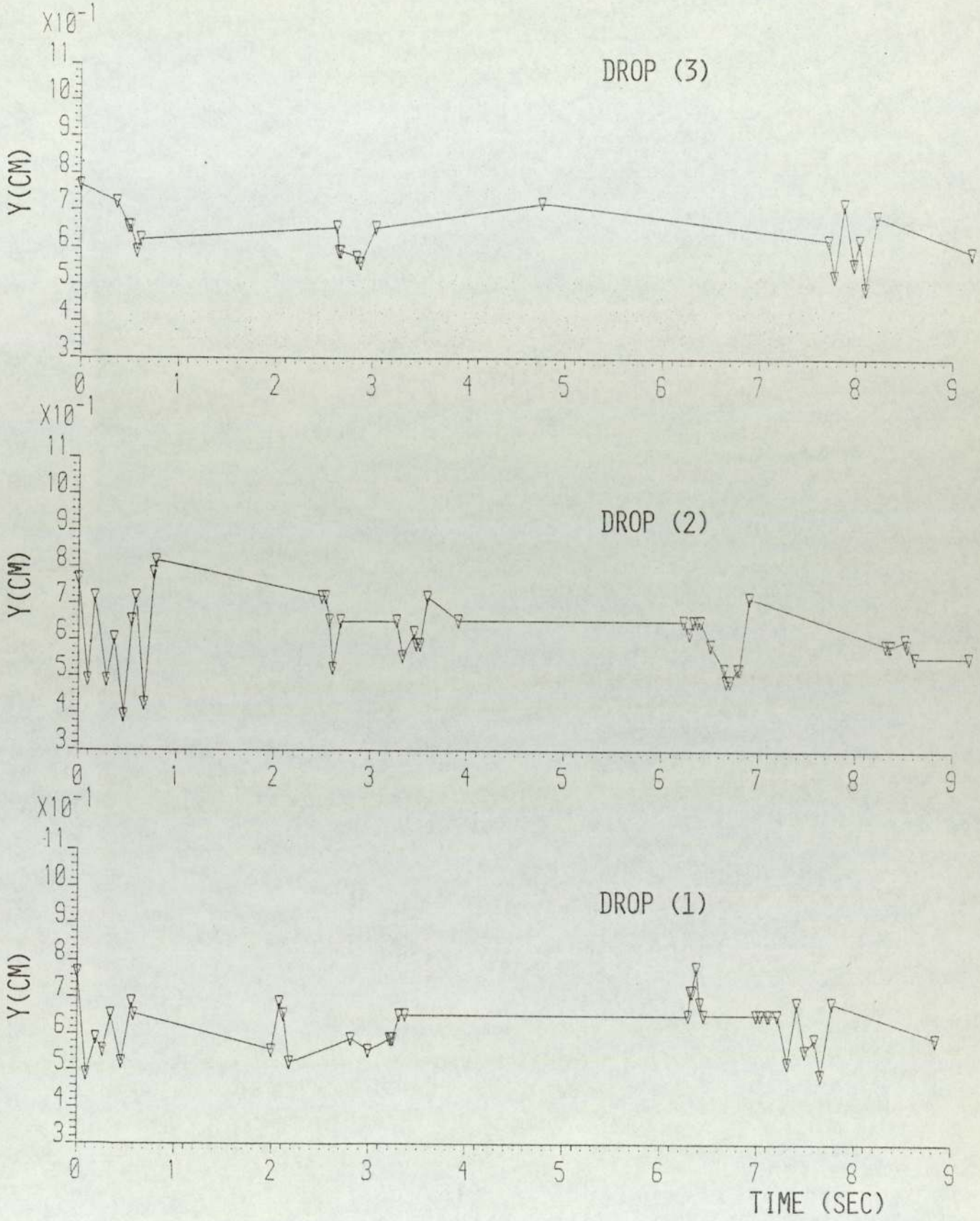

FIG.H.71 Y VS. TIME, RUN-17.

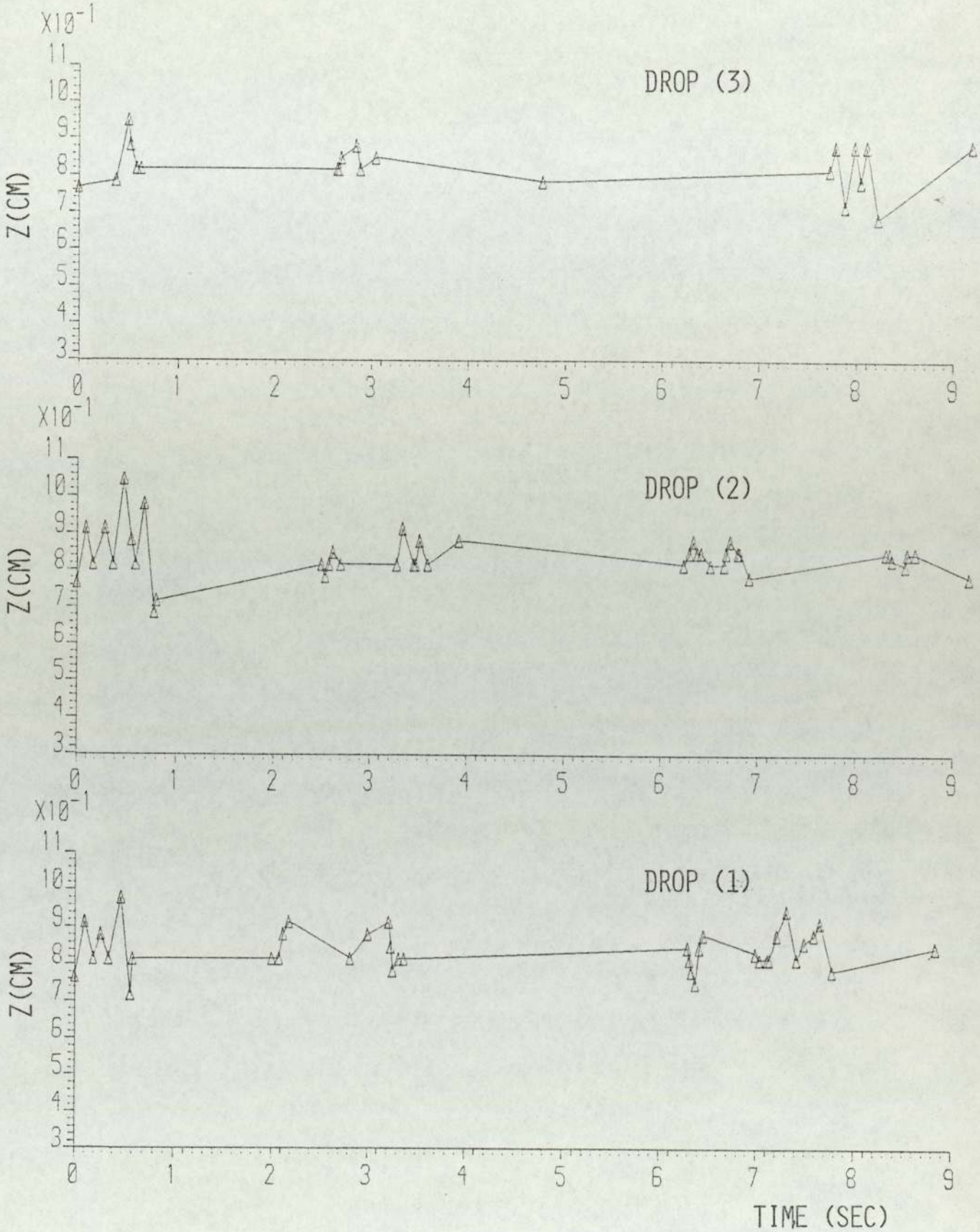

FIG.H.72 Z VS. TIME, RUN-17.

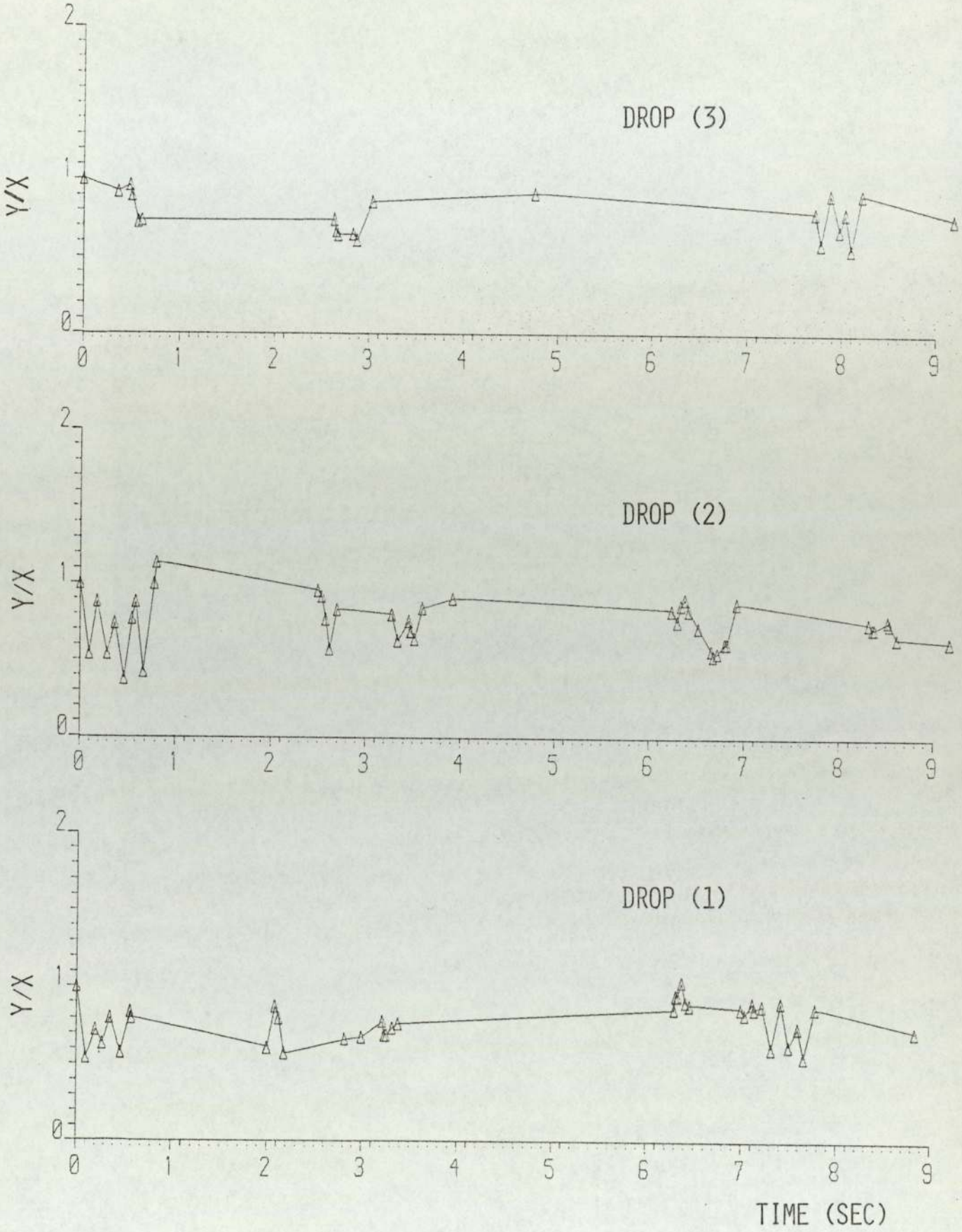

FIG. H.73 AXES RATIO VS. TIME, RUN-17.

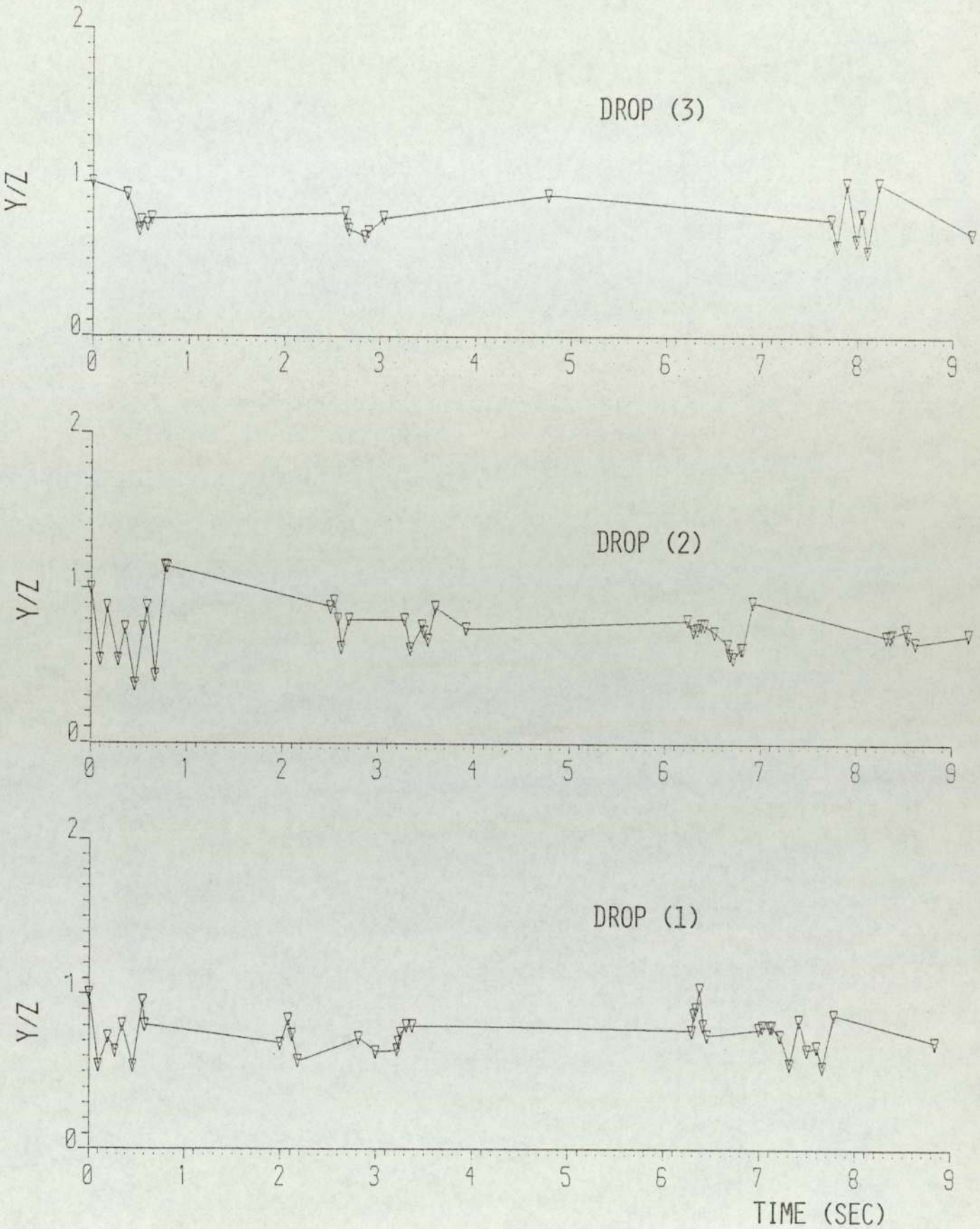

FIG. H.74 AXES RATIO VS. TIME, RUN-17.

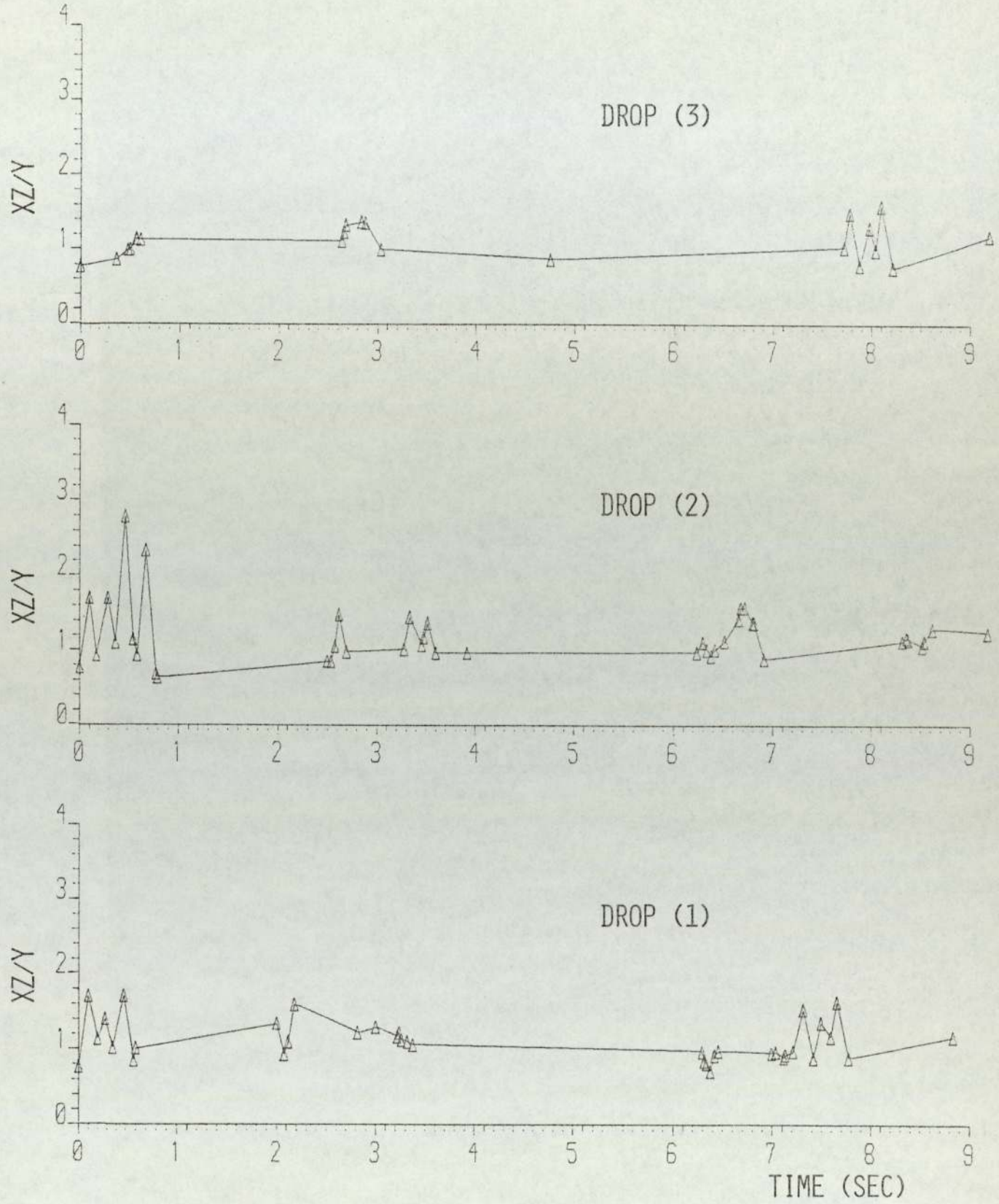

FIG.H.75 AXES RATIO VS. TIME, RUN-17.

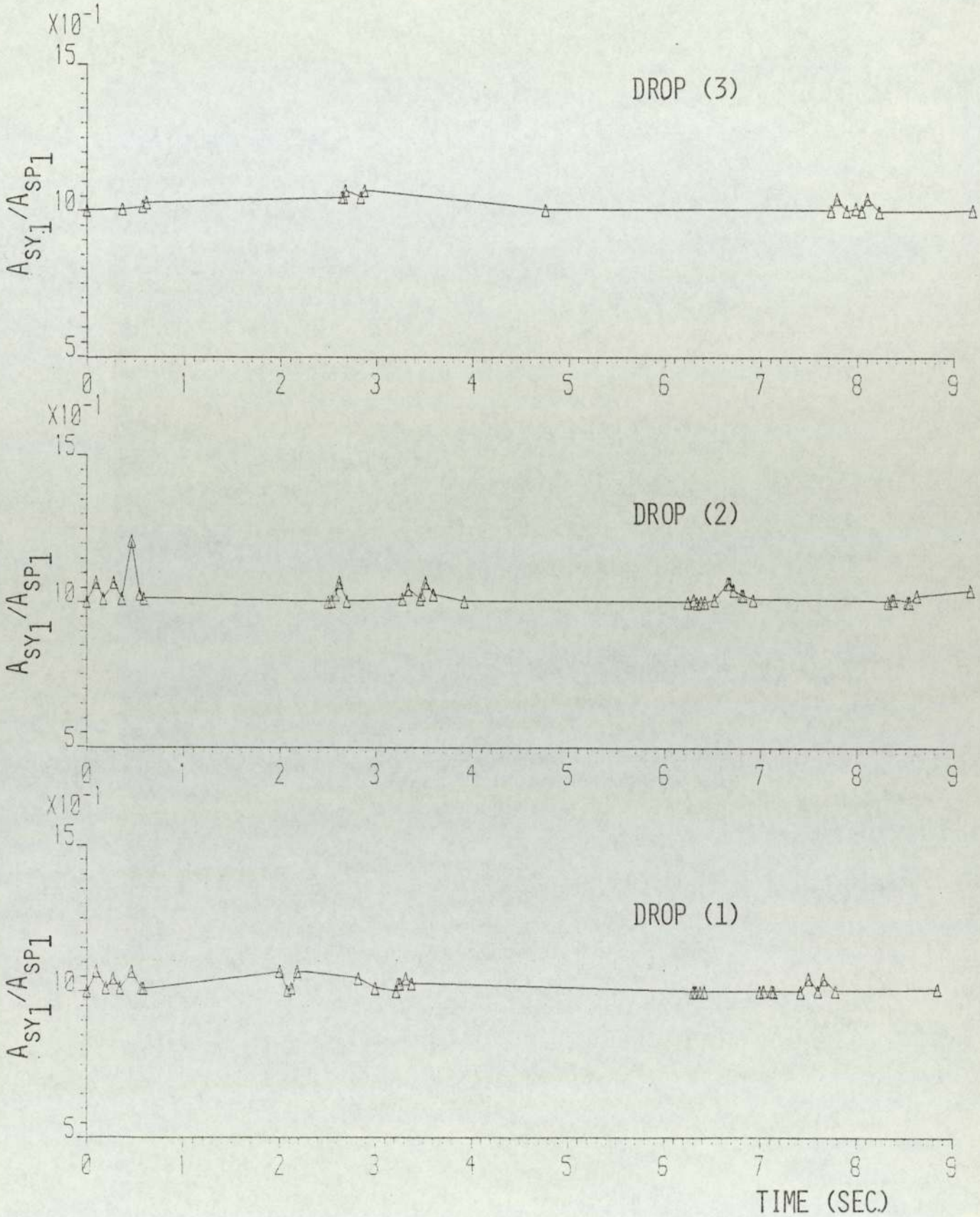

FIG.H.76 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-17, BASED ON DISPLACED VOLUME.

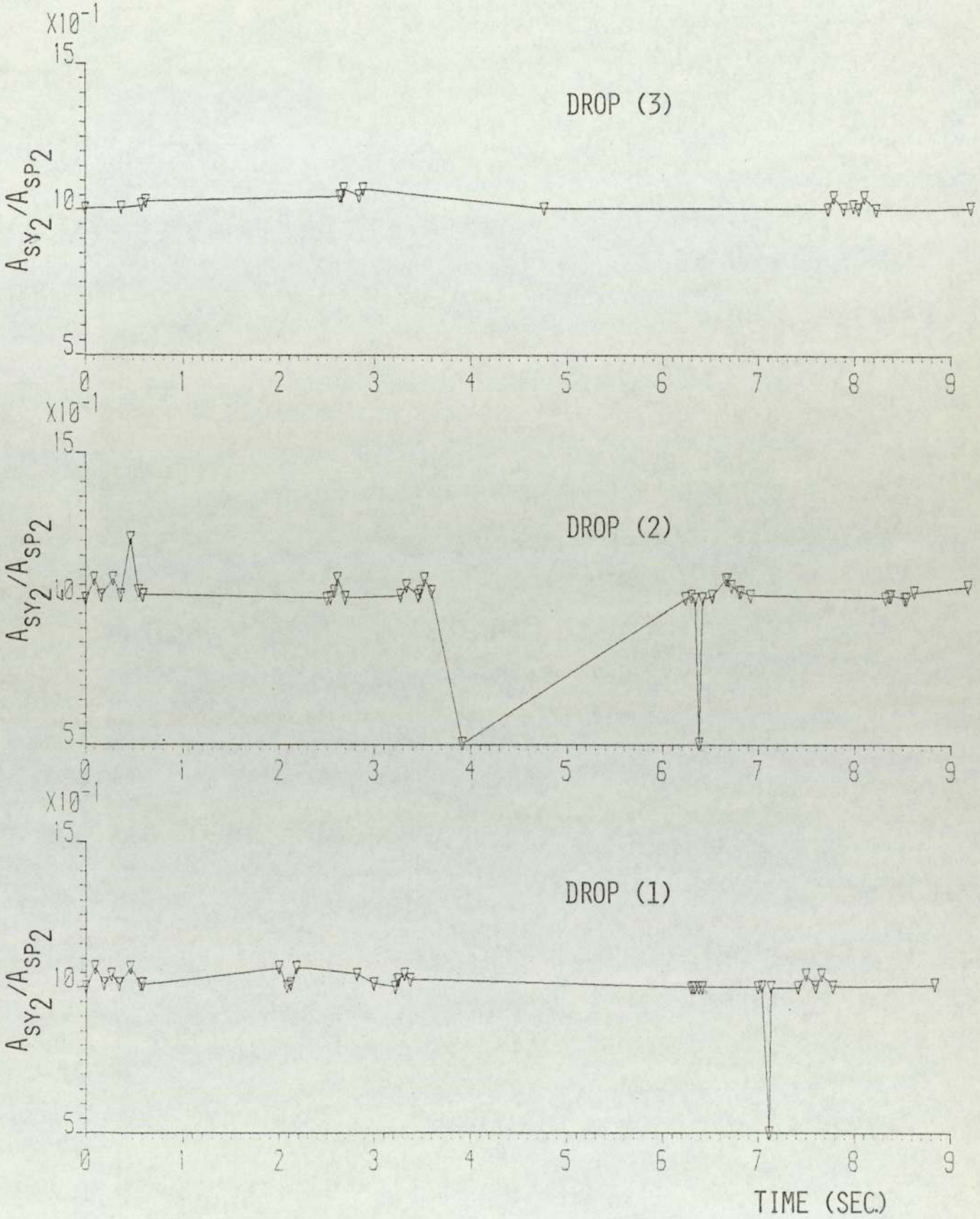

FIG.H.77 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-17, BASED ON MEAN VOLUME.

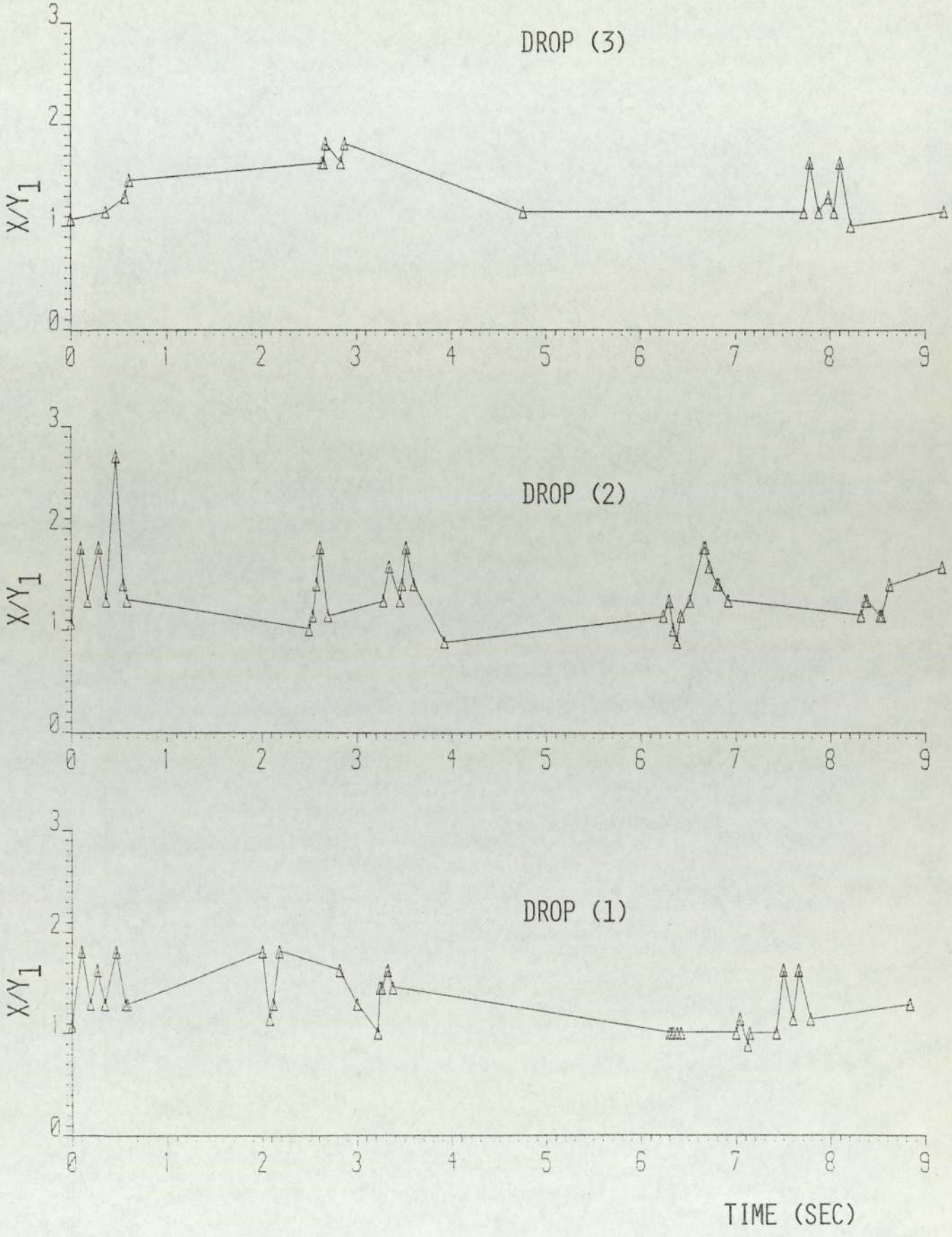

FIG. H.78 AXES RATIO VS. TIME, RUN-17.

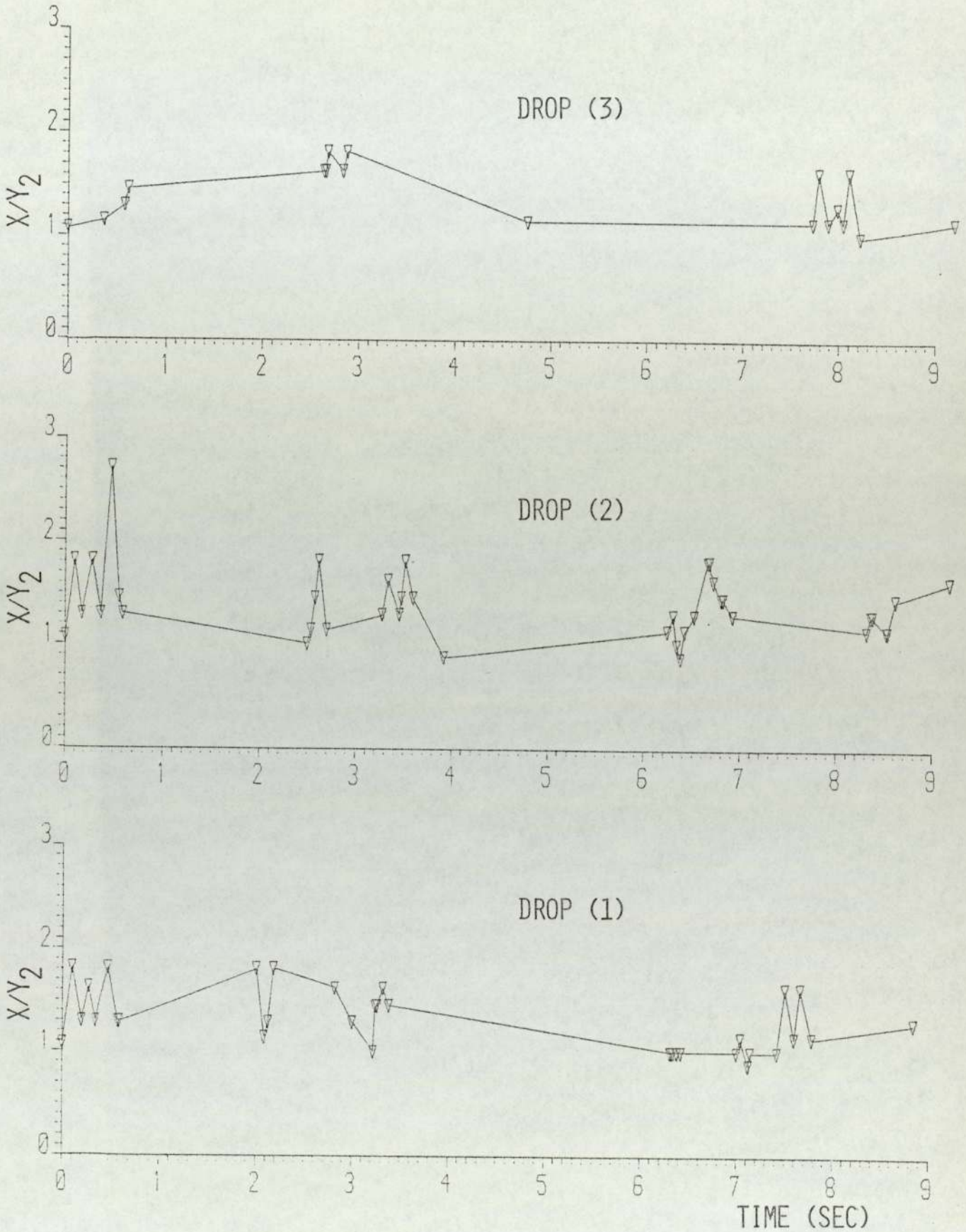

FIG.H.79 AXES RATIO VS. TIME, RUN-17.

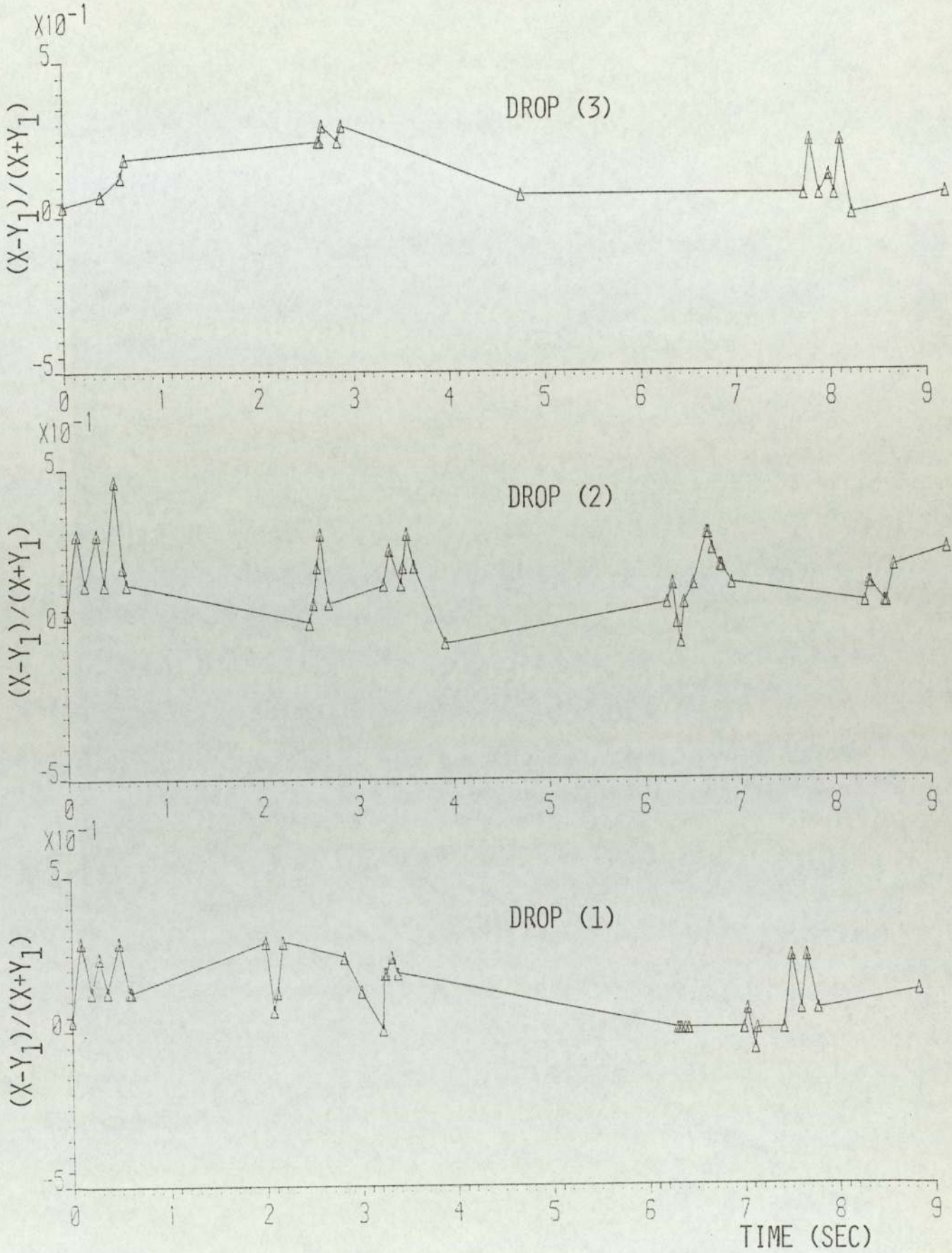

FIG. H.80 DEFORMATION RATIO VS. TIME, RUN-17.

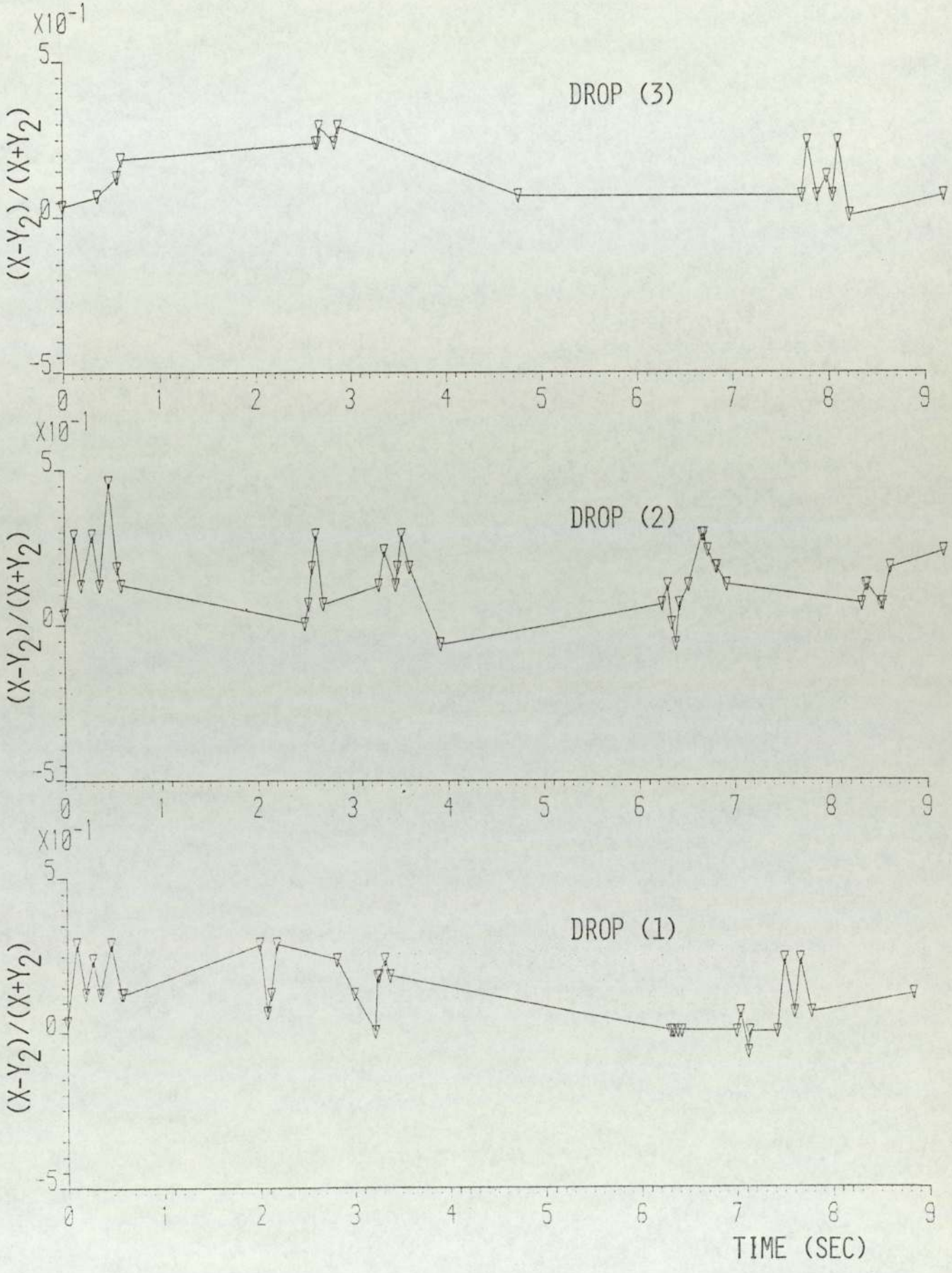

FIG. H.81 DEFORMATION RATIO VS. TIME, RUN-17.

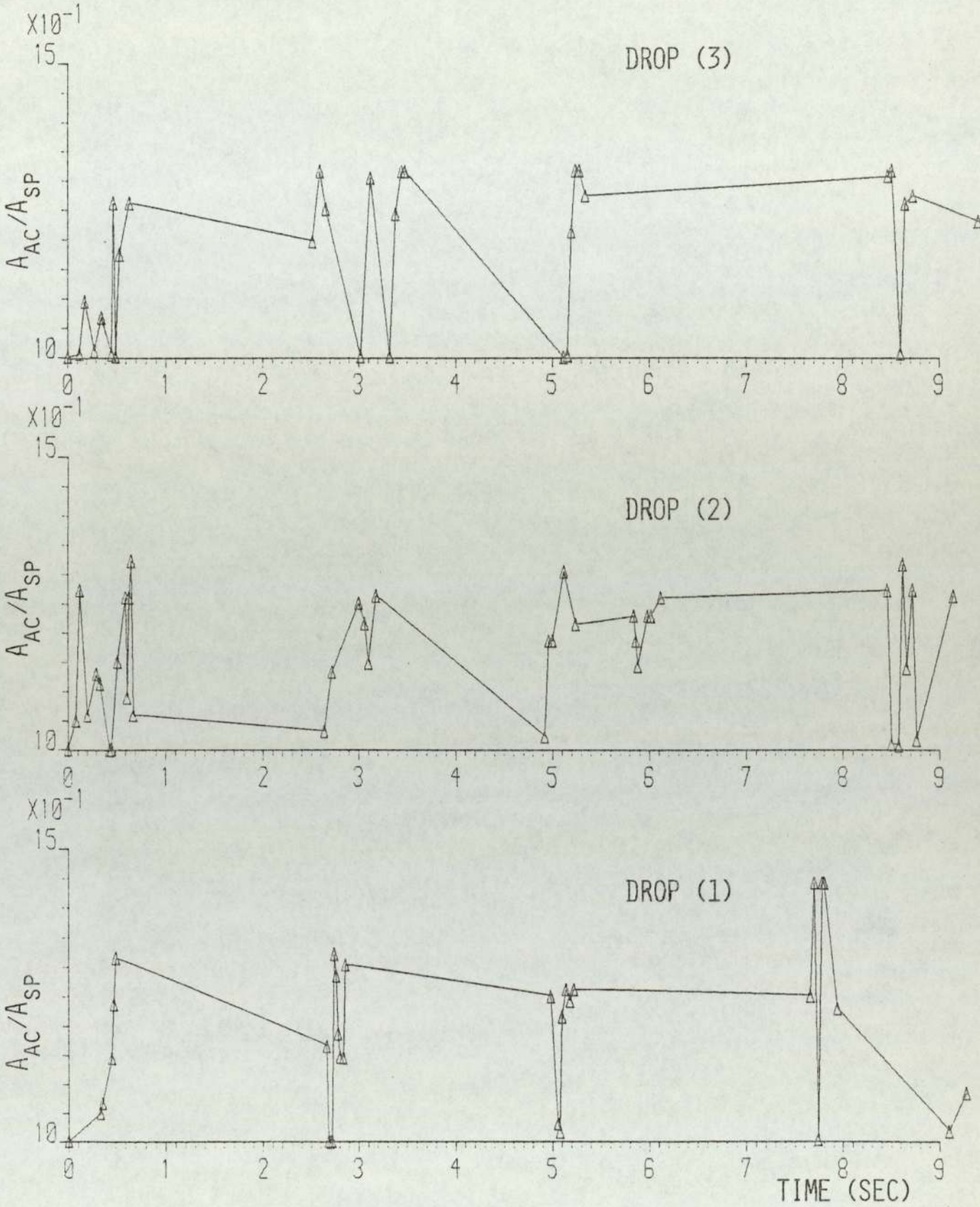

FIG.H.82 AREA RATIO VS. TIME, RUN-18.

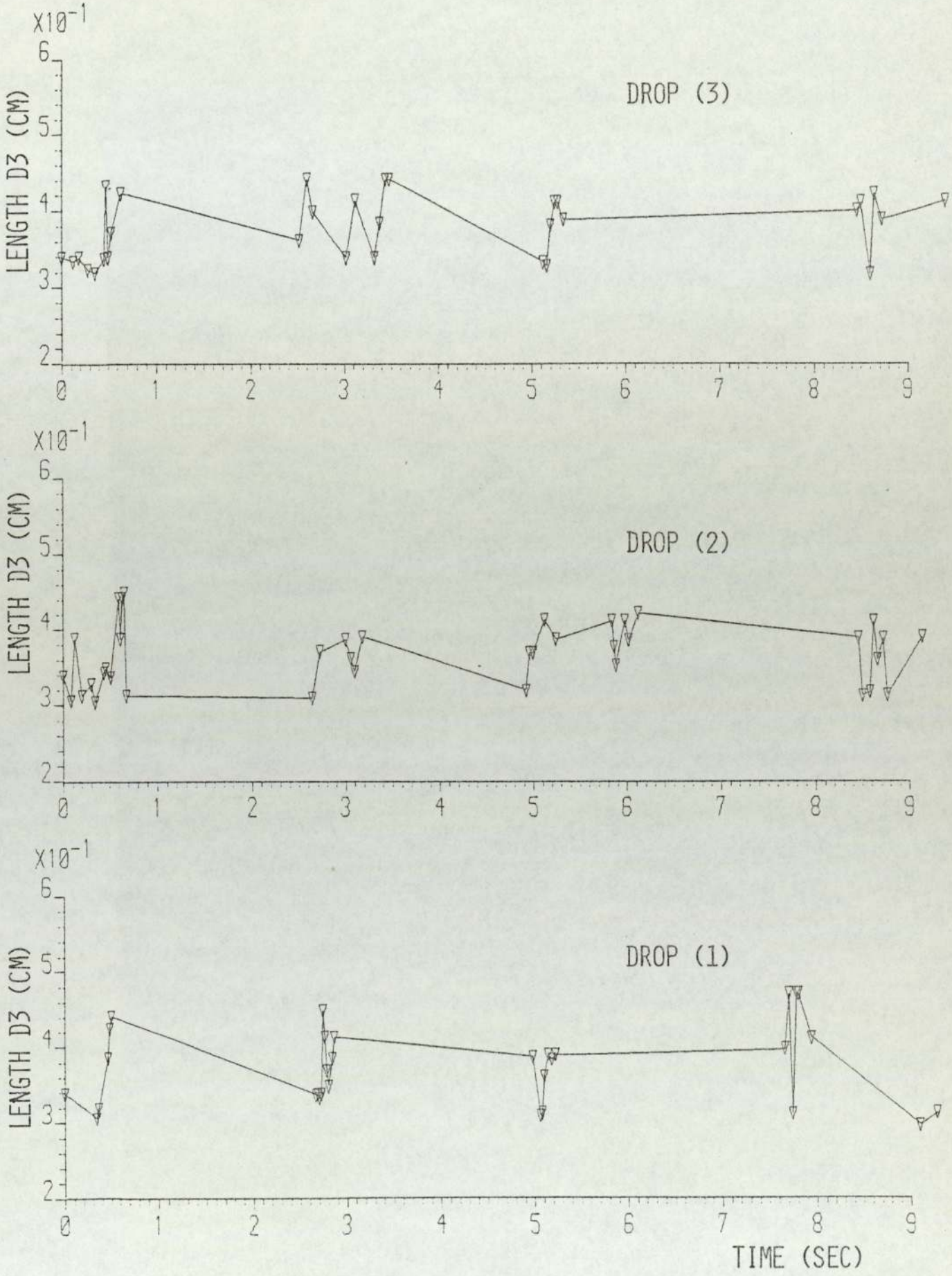

FIG. H.83 LENGTH D3 VS. TIME, RUN-18.

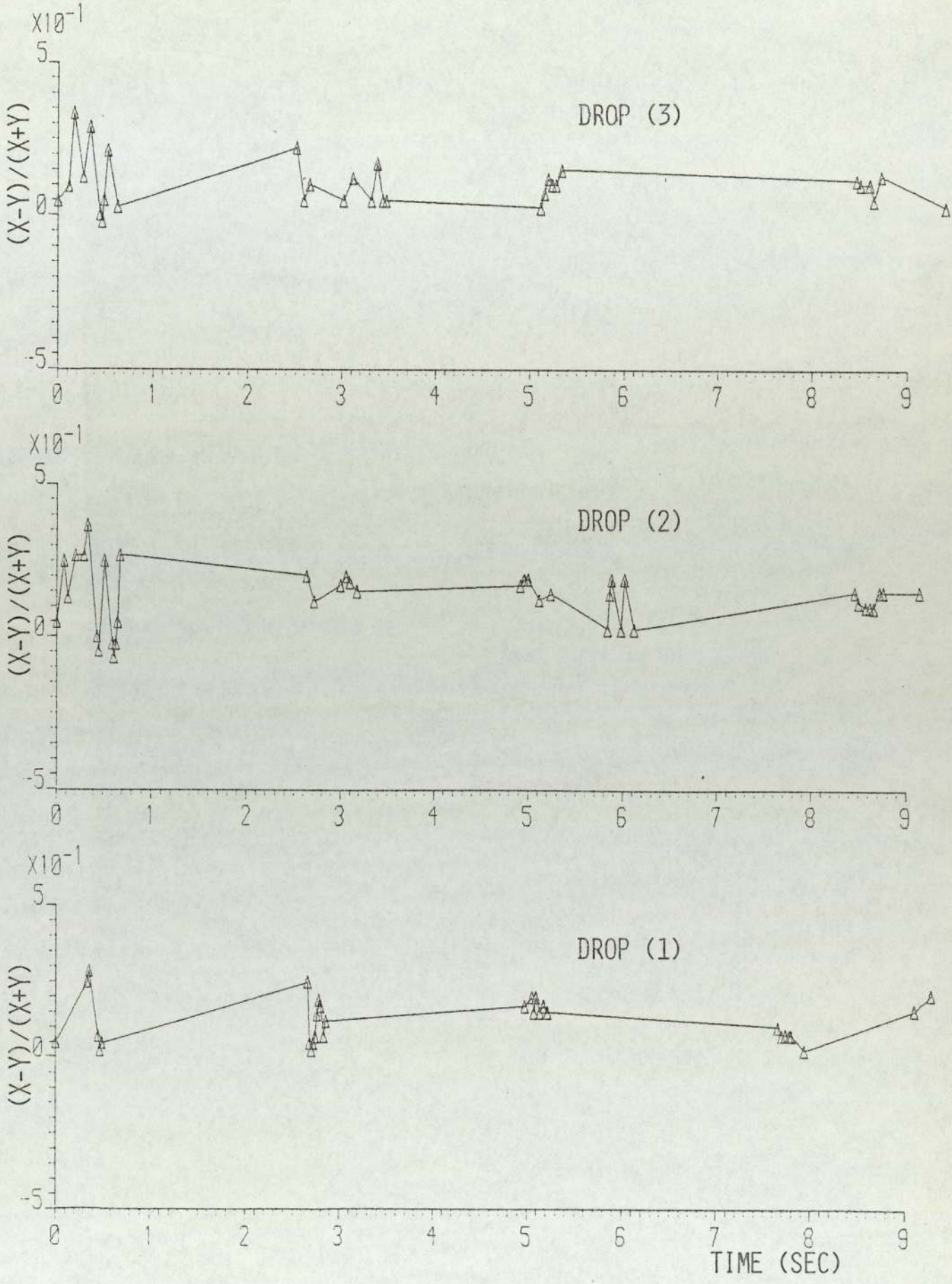

FIG. H.84 DEFORMATION RATIO VS. TIME, RUN-18.

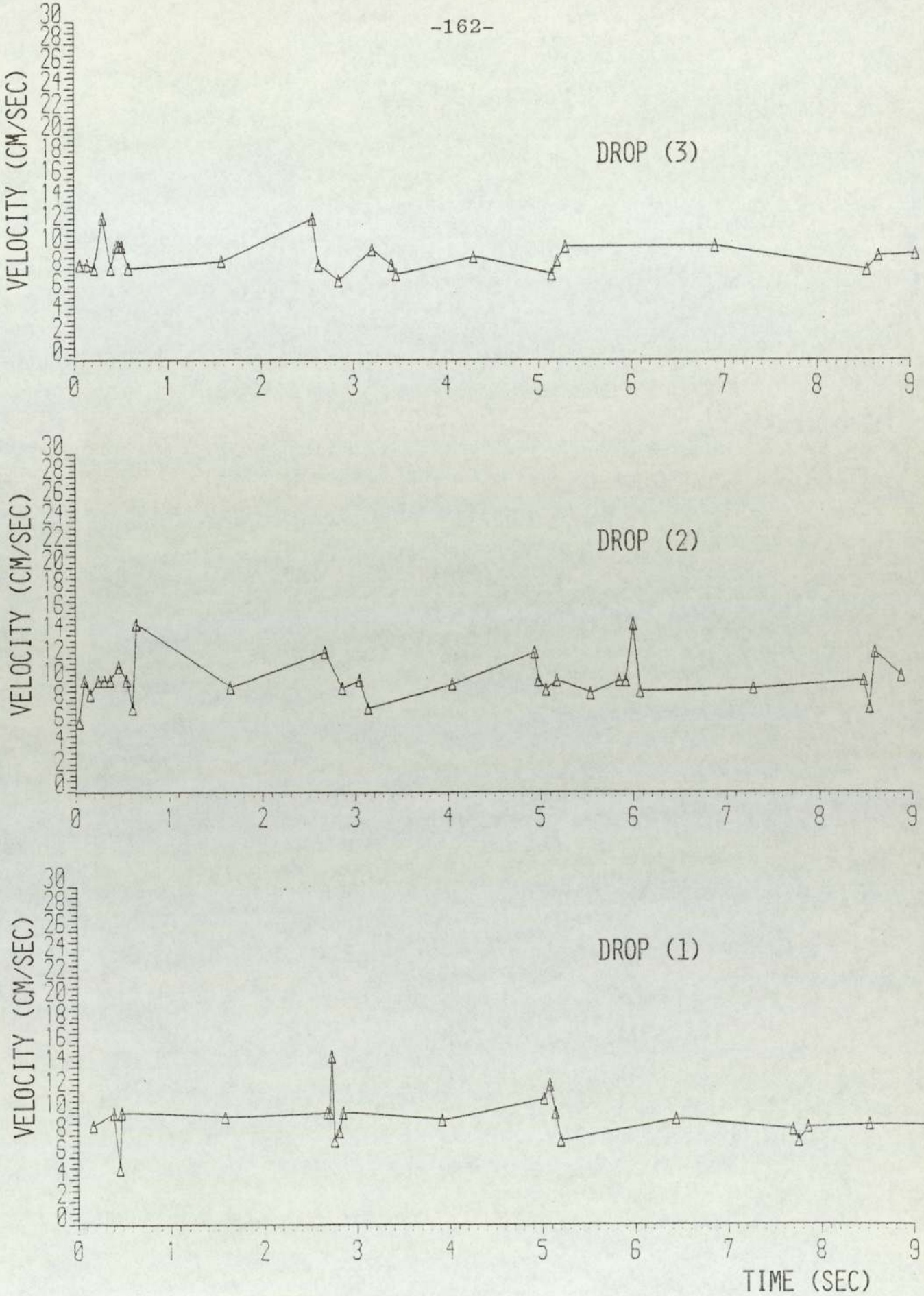

FIG.H.85 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-18.

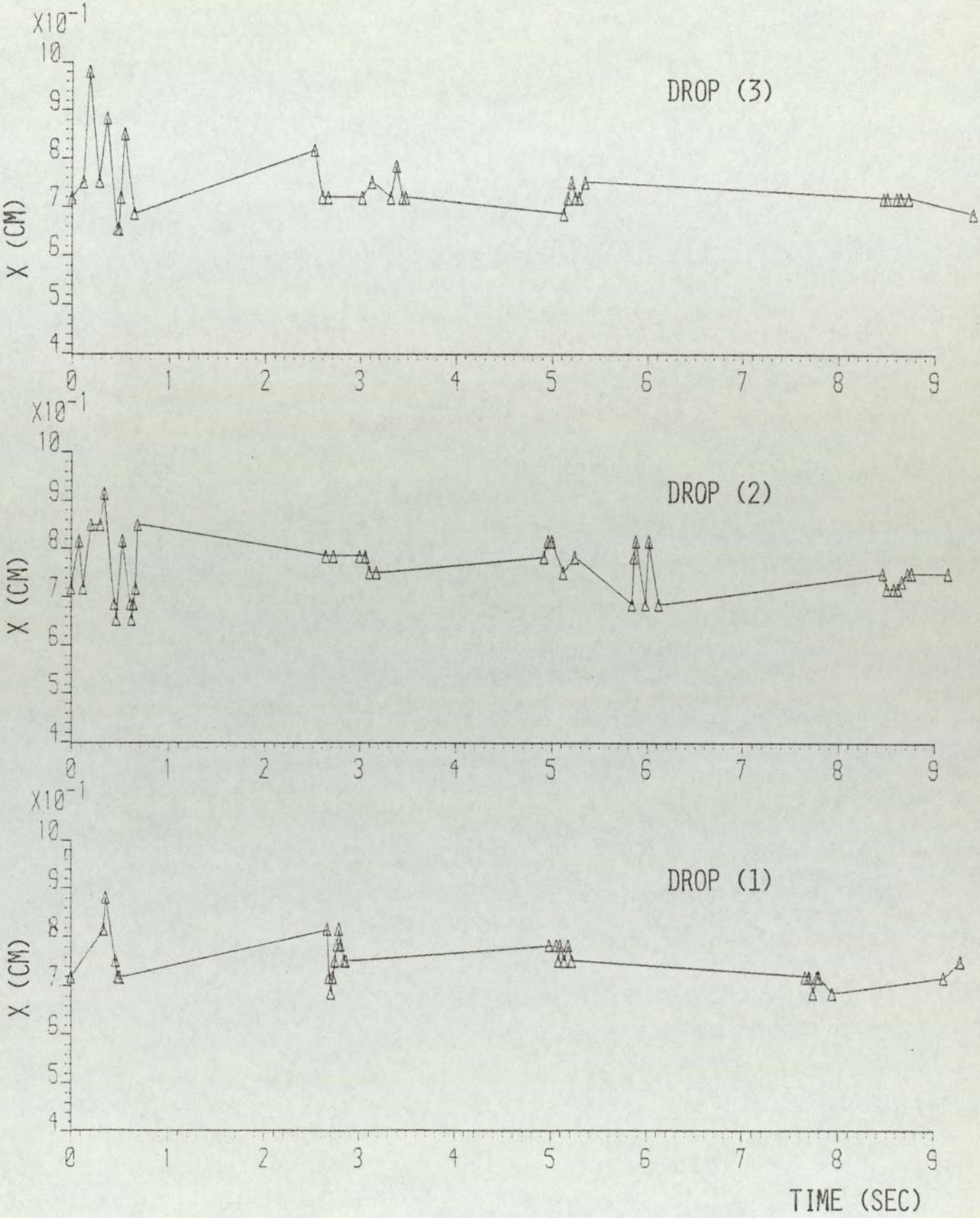

FIG. H.86 X VS. TIME, RUN-18.

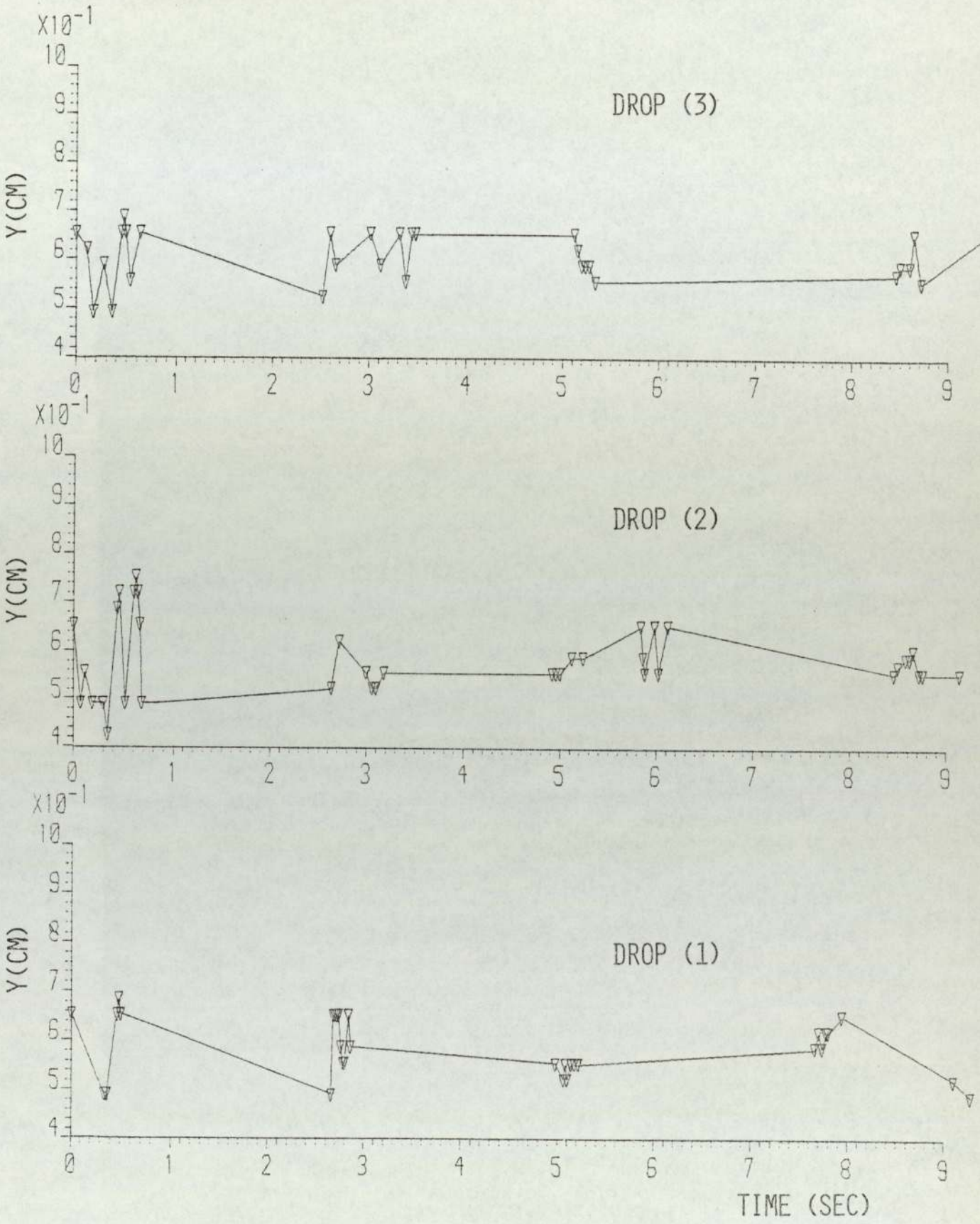

FIG.H.87 Y VS. TIME, RUN-18.

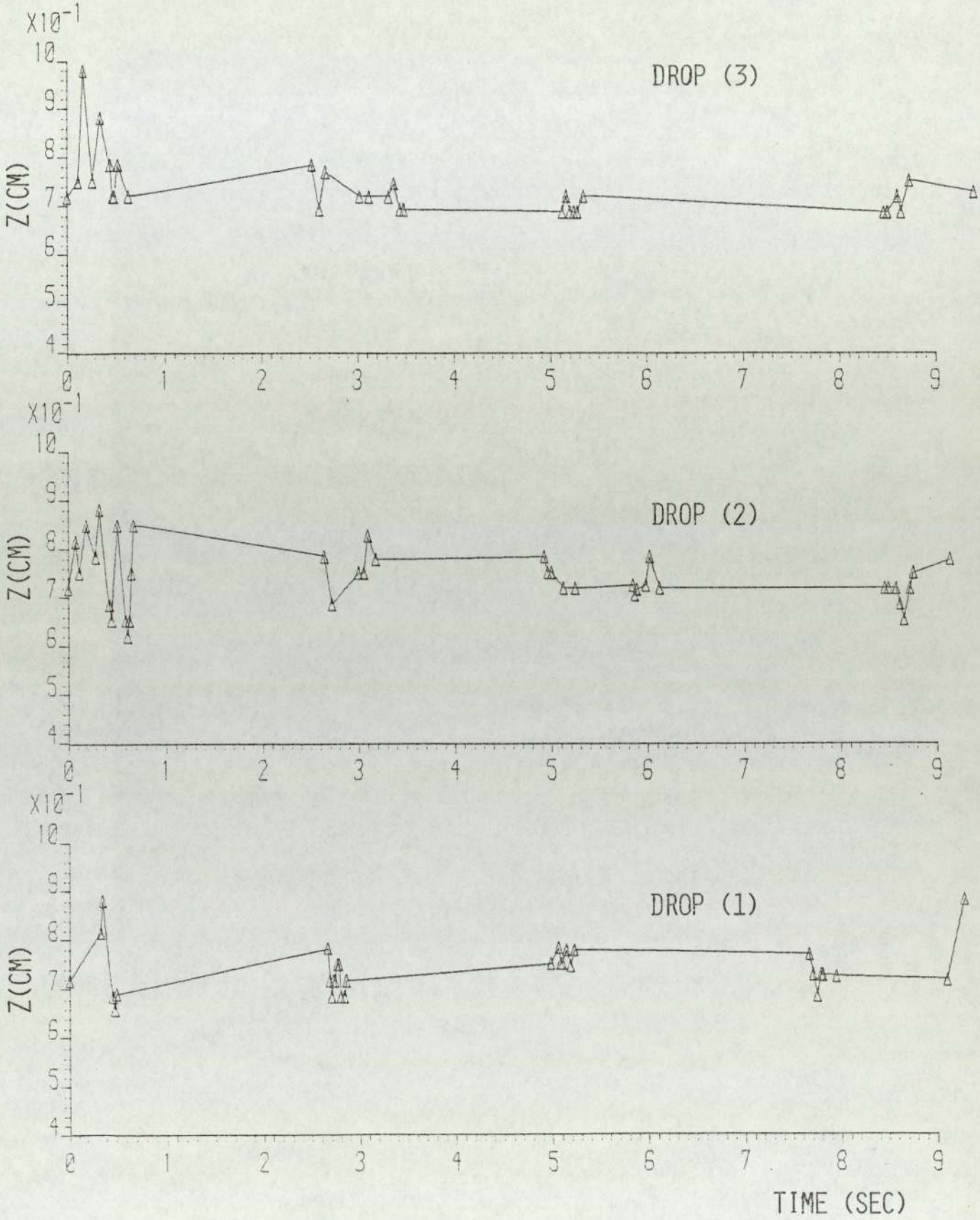

FIG. H.88 Z VS. TIME, RUN-18.

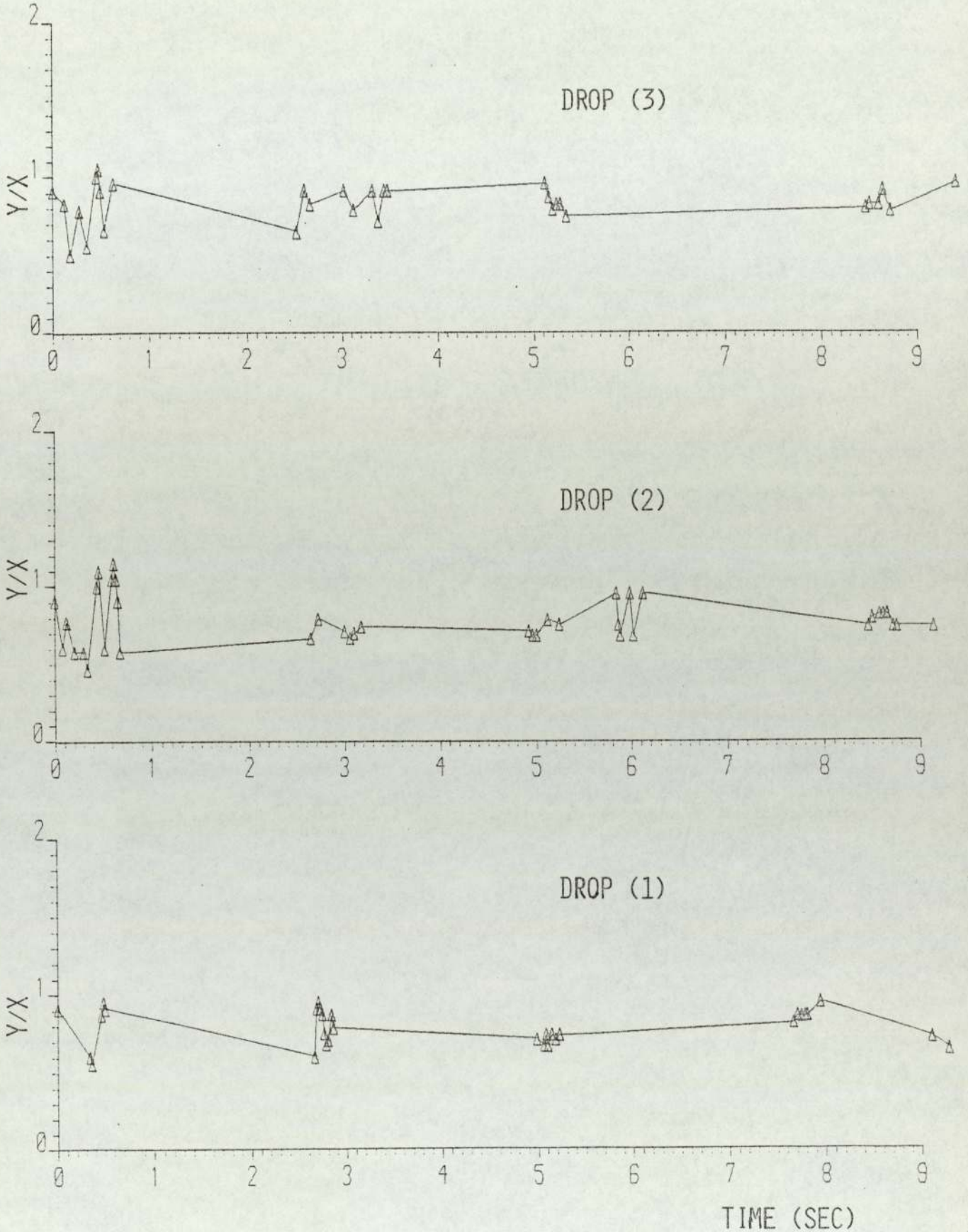

FIG. H.89 AXES RATIO VS. TIME, RUN-18.

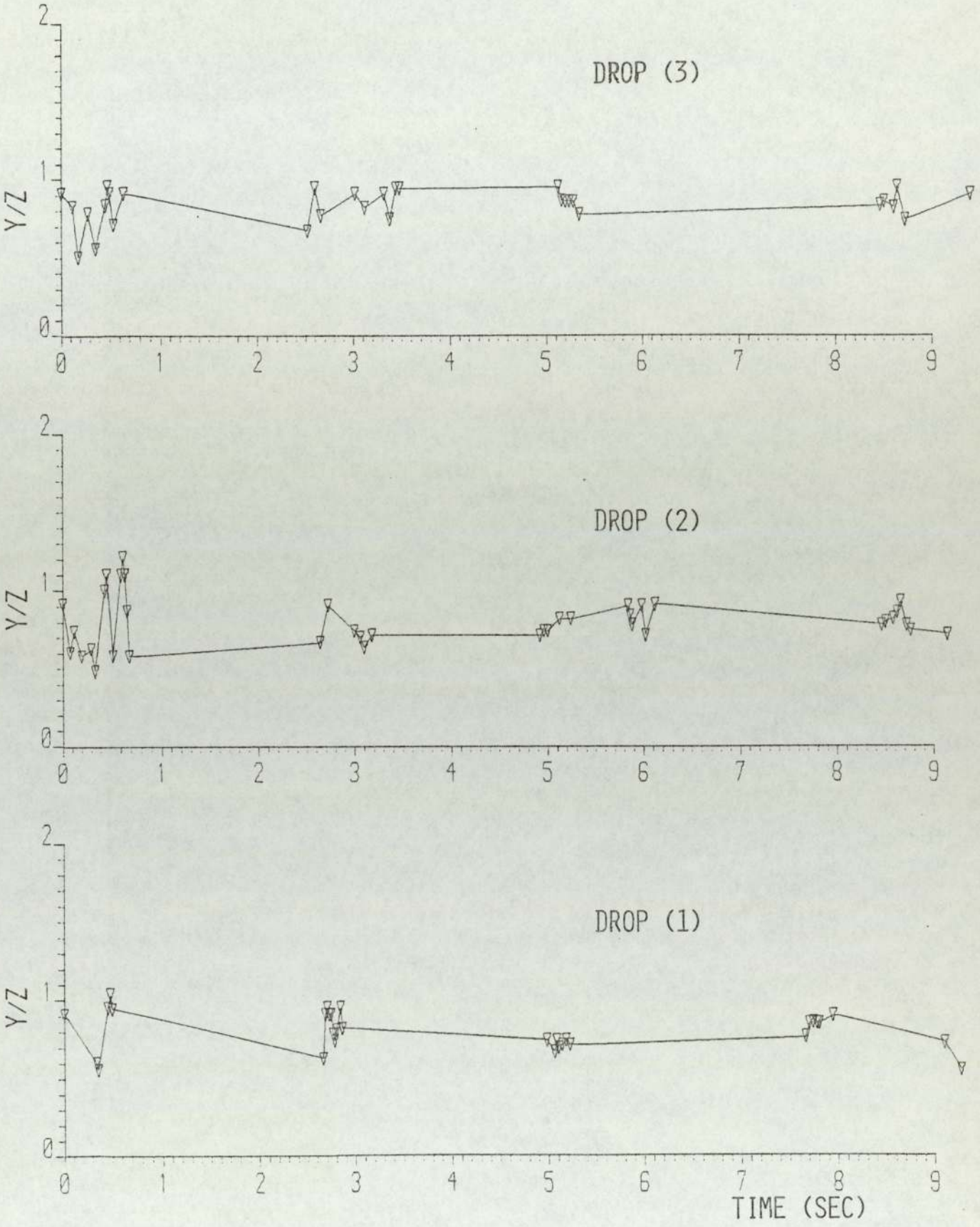

FIG. H.90 AXES RATIO VS. TIME, RUN-18.

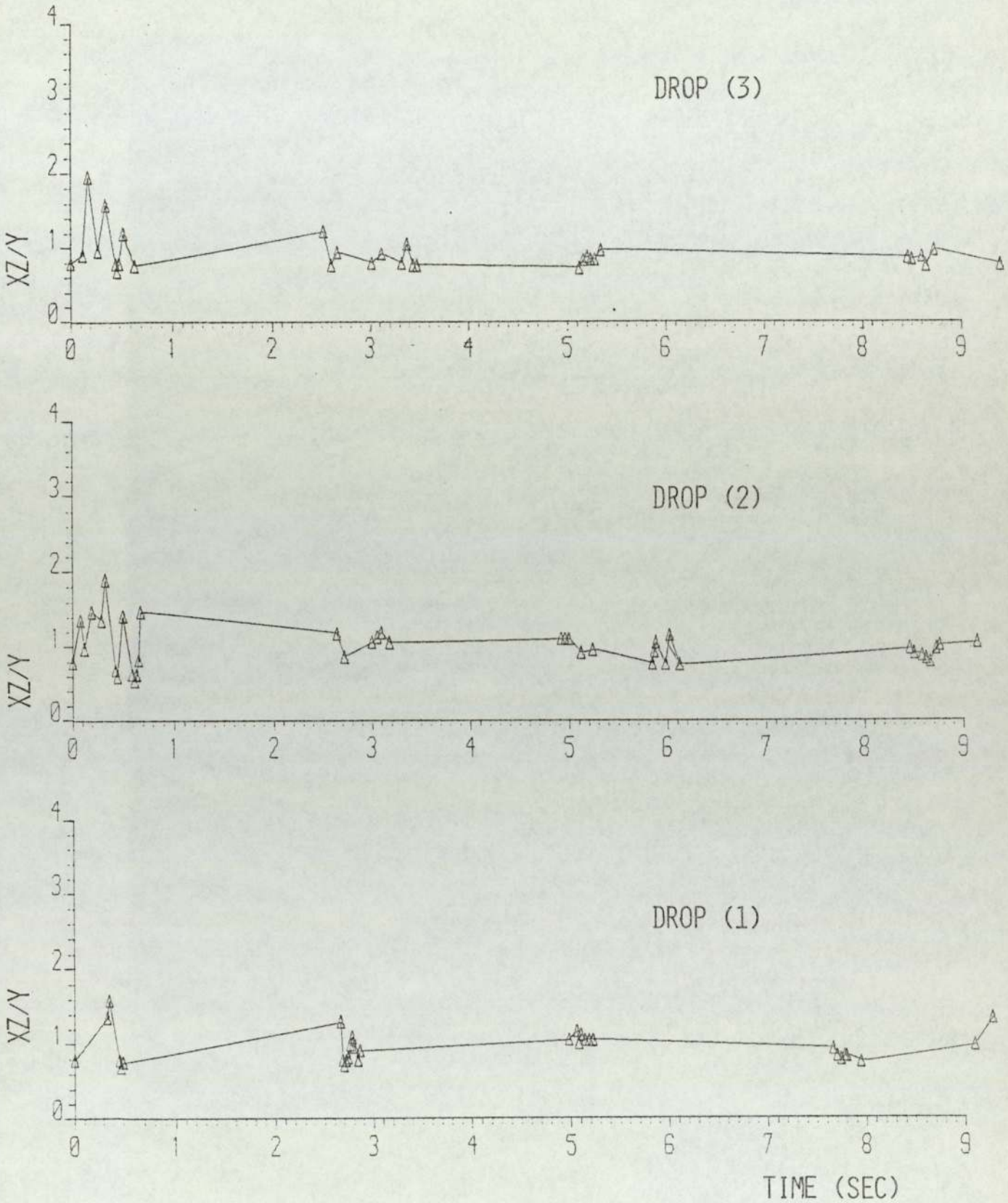

FIG. H.91 AXES RATIO VS. TIME, RUN-18.

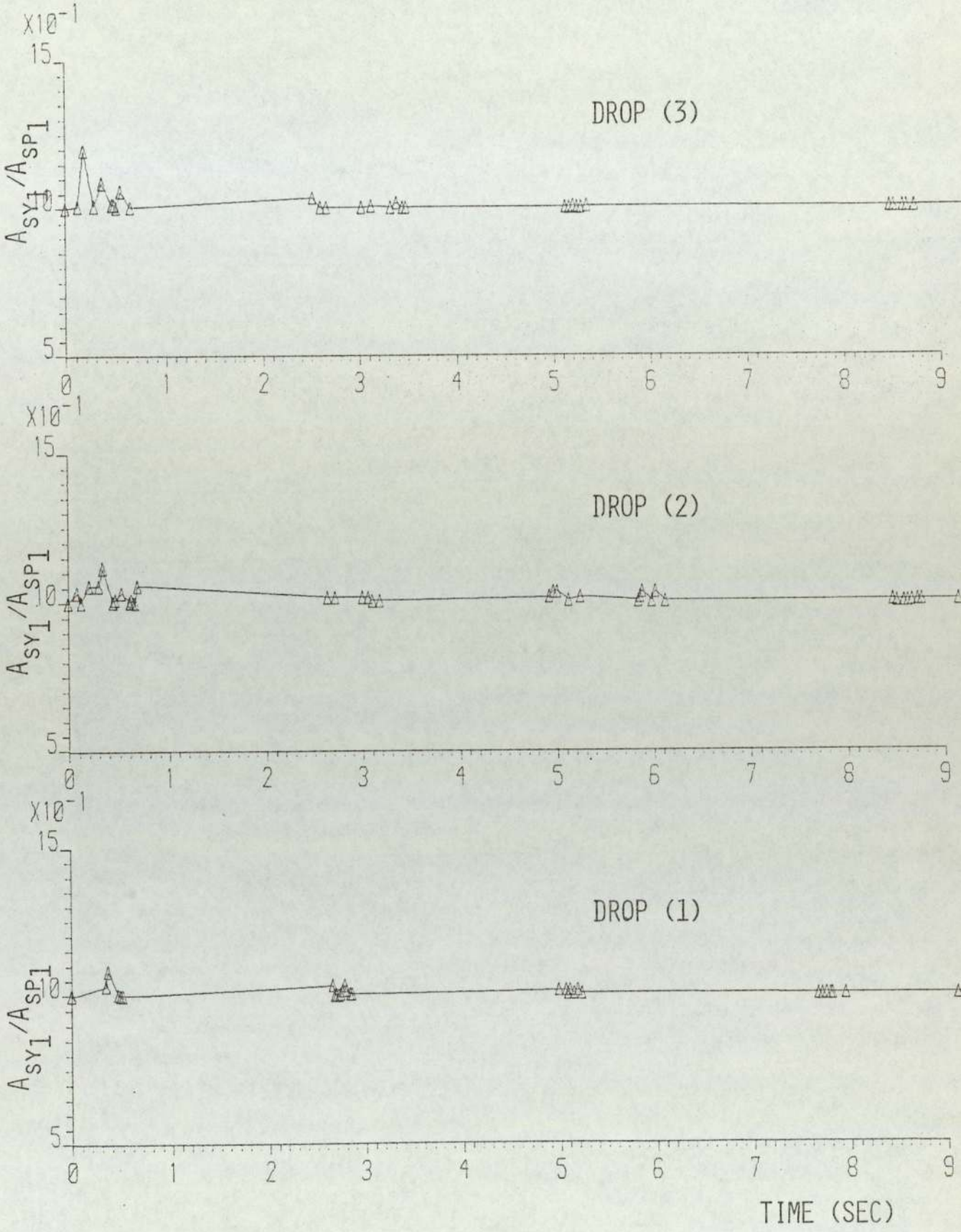

FIG. H.92 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-18, BASED ON DISPLACED VOLUME.

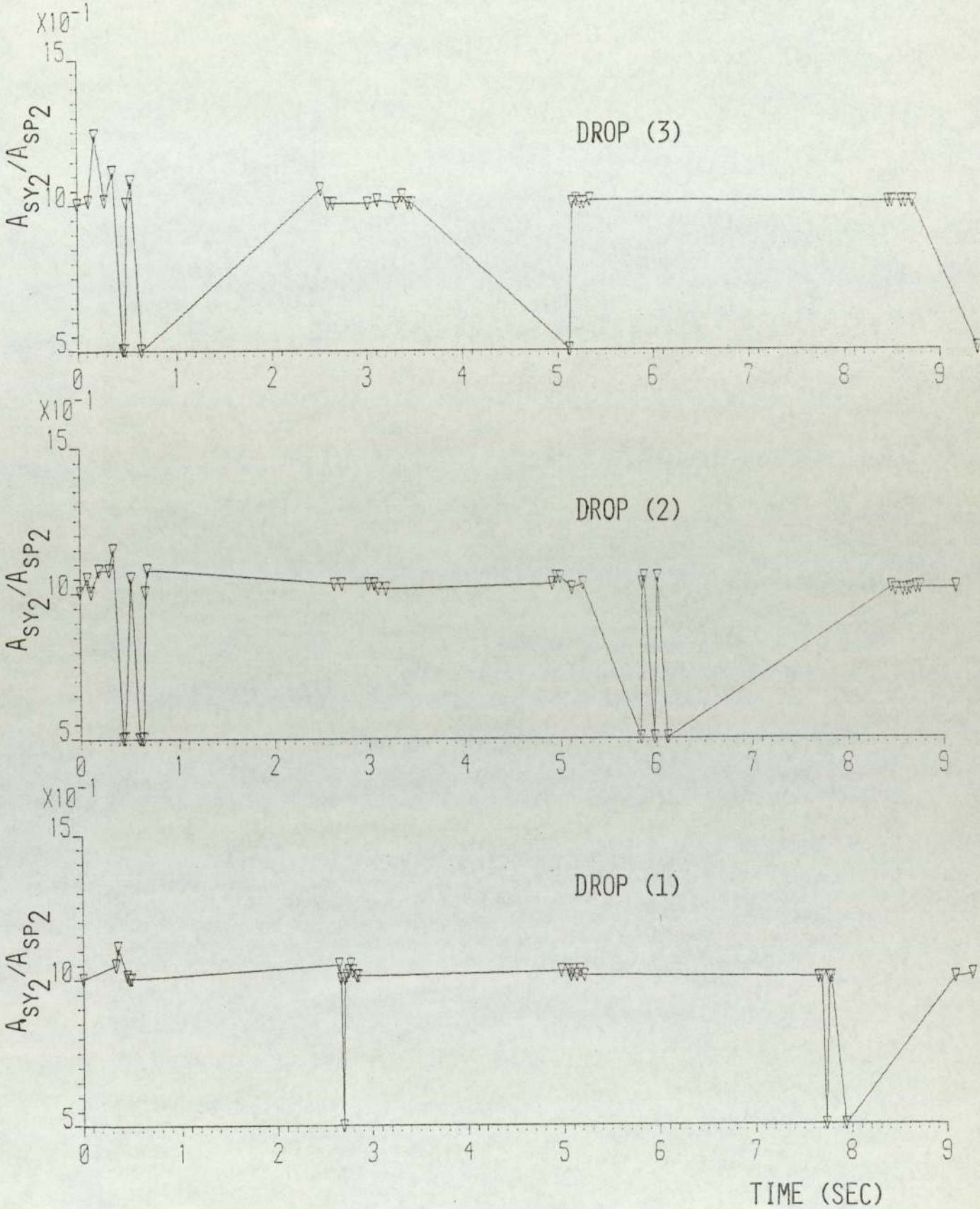

FIG. H.93 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-18, BASED ON MEAN VOLUME.

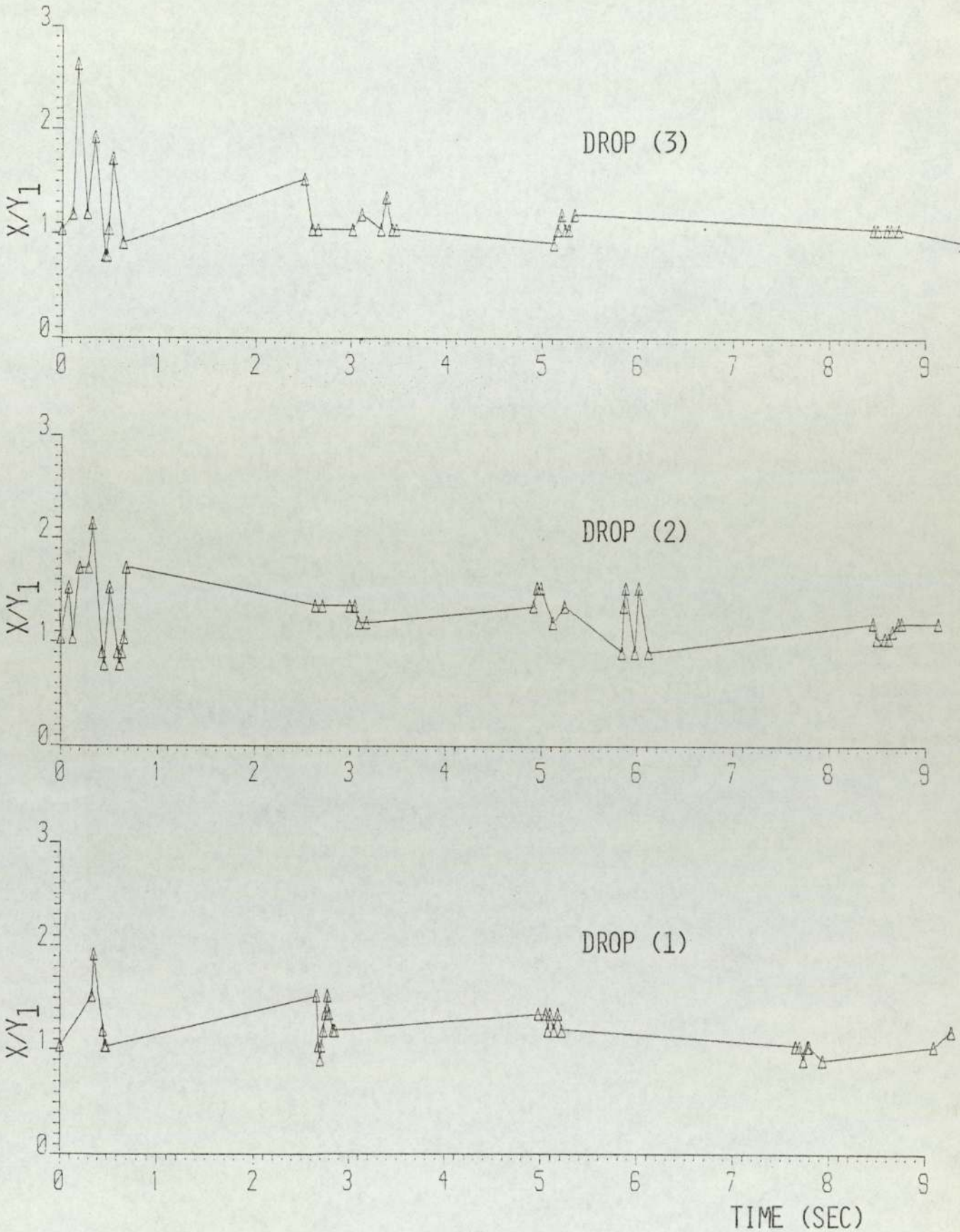

FIG. H.94 AXES RATIO VS. TIME, RUN-18.

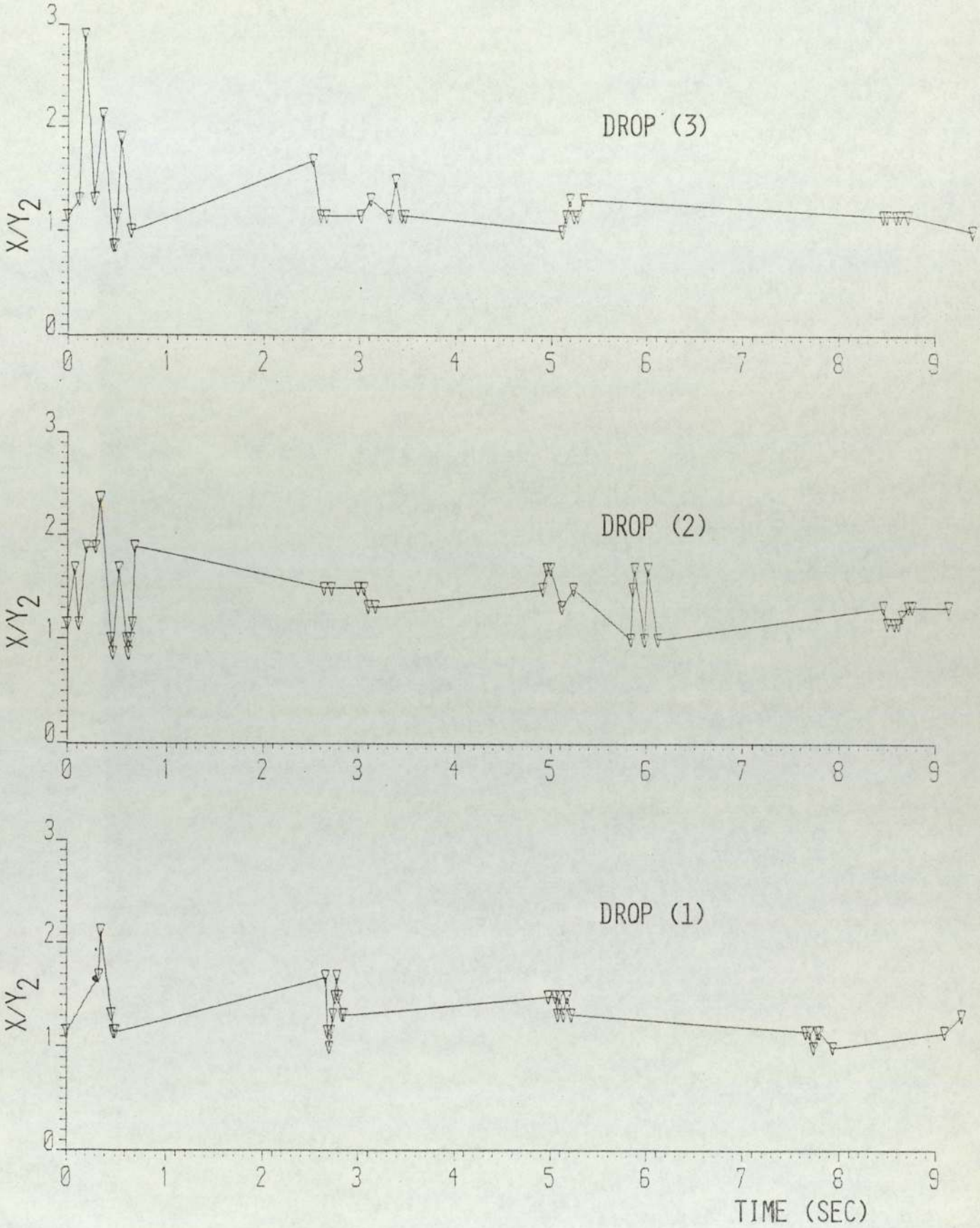

FIG. H.95 AXES RATIO VS. TIME, RUN-18.

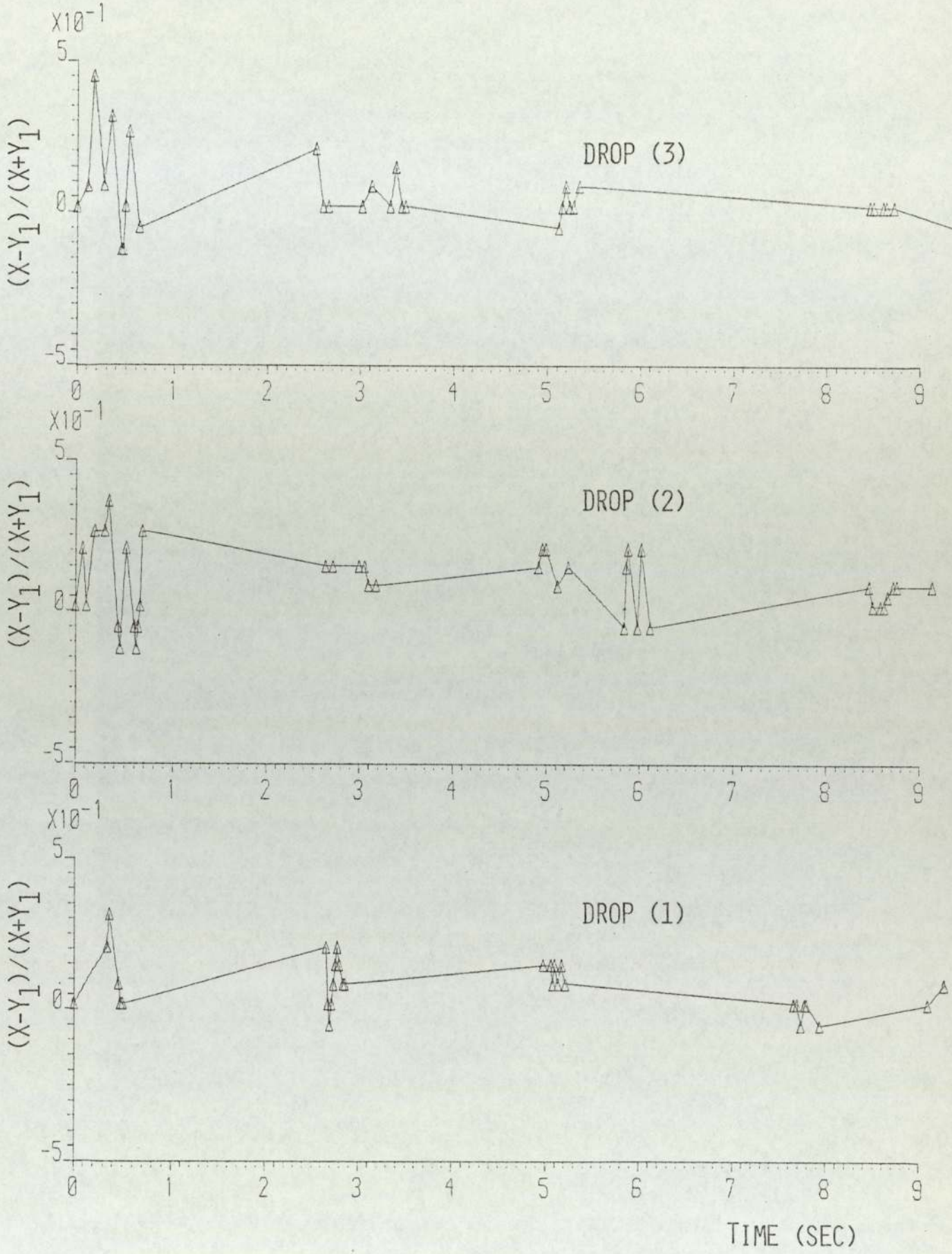

FIG. H.96 DEFORMATION RATIO VS. TIME, RUN-18.

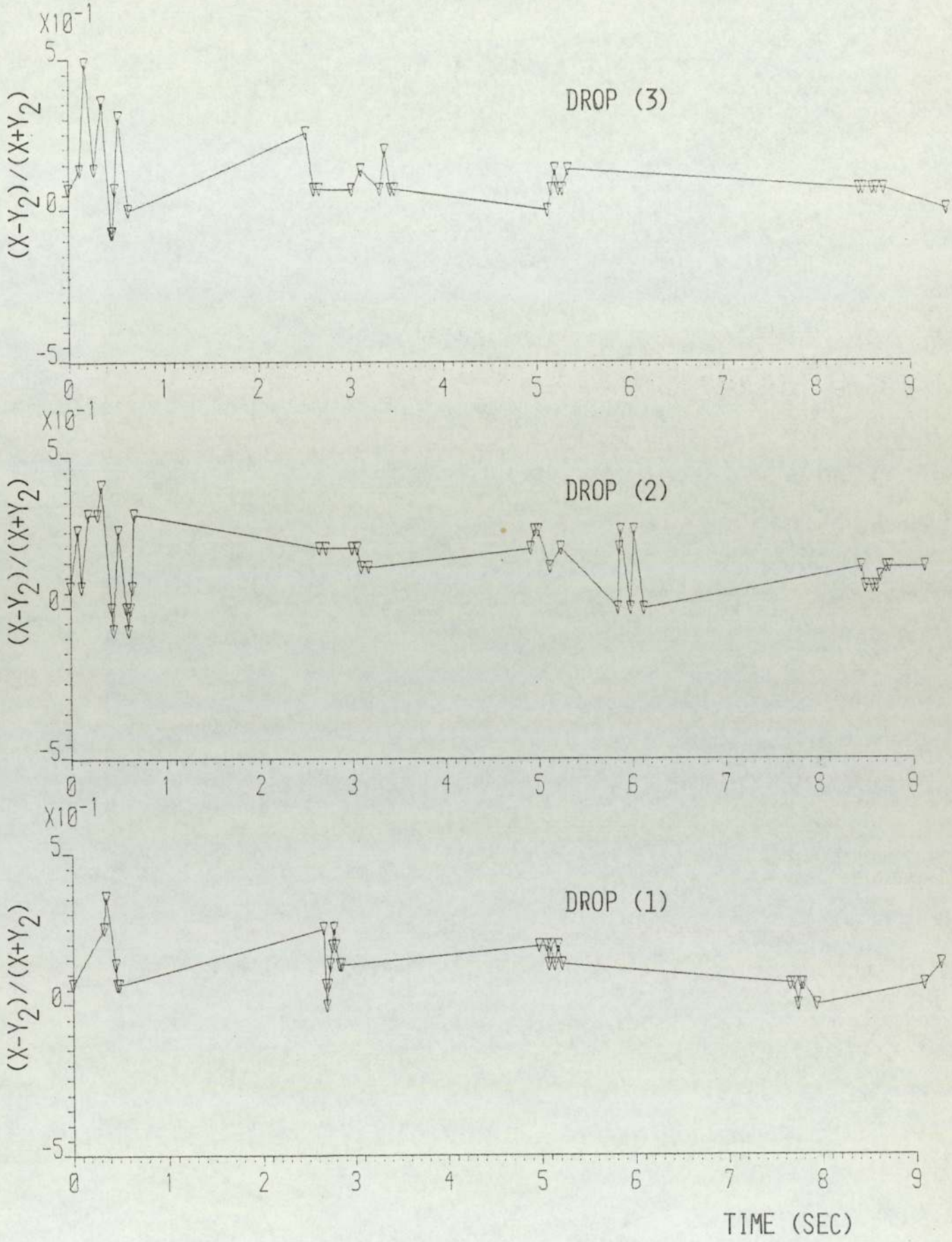

FIG. H.97 DEFORMATION RATIO VS. TIME, RUN-18.

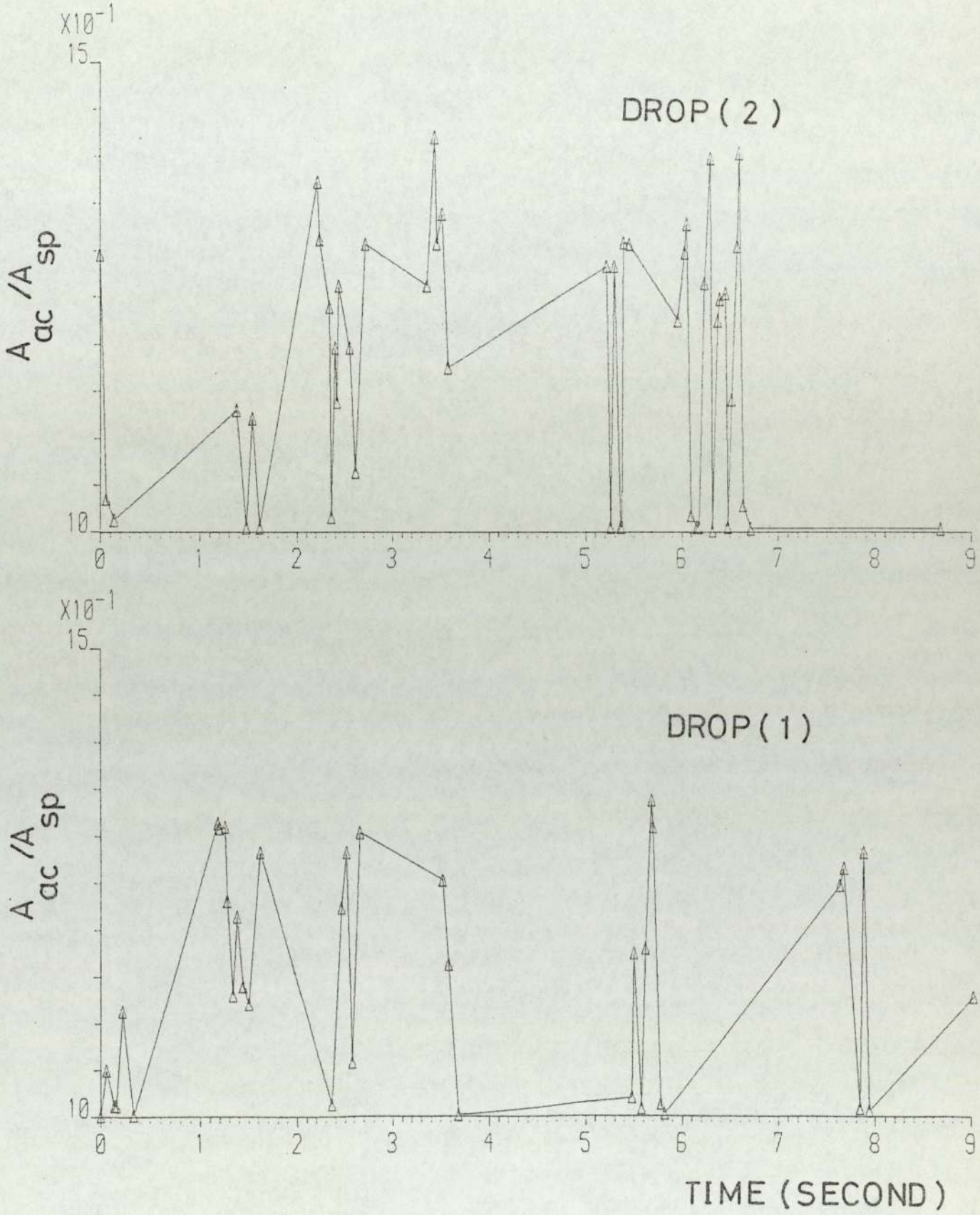

FIG. H.98 AREA RATIO VS. TIME, RUN-20.

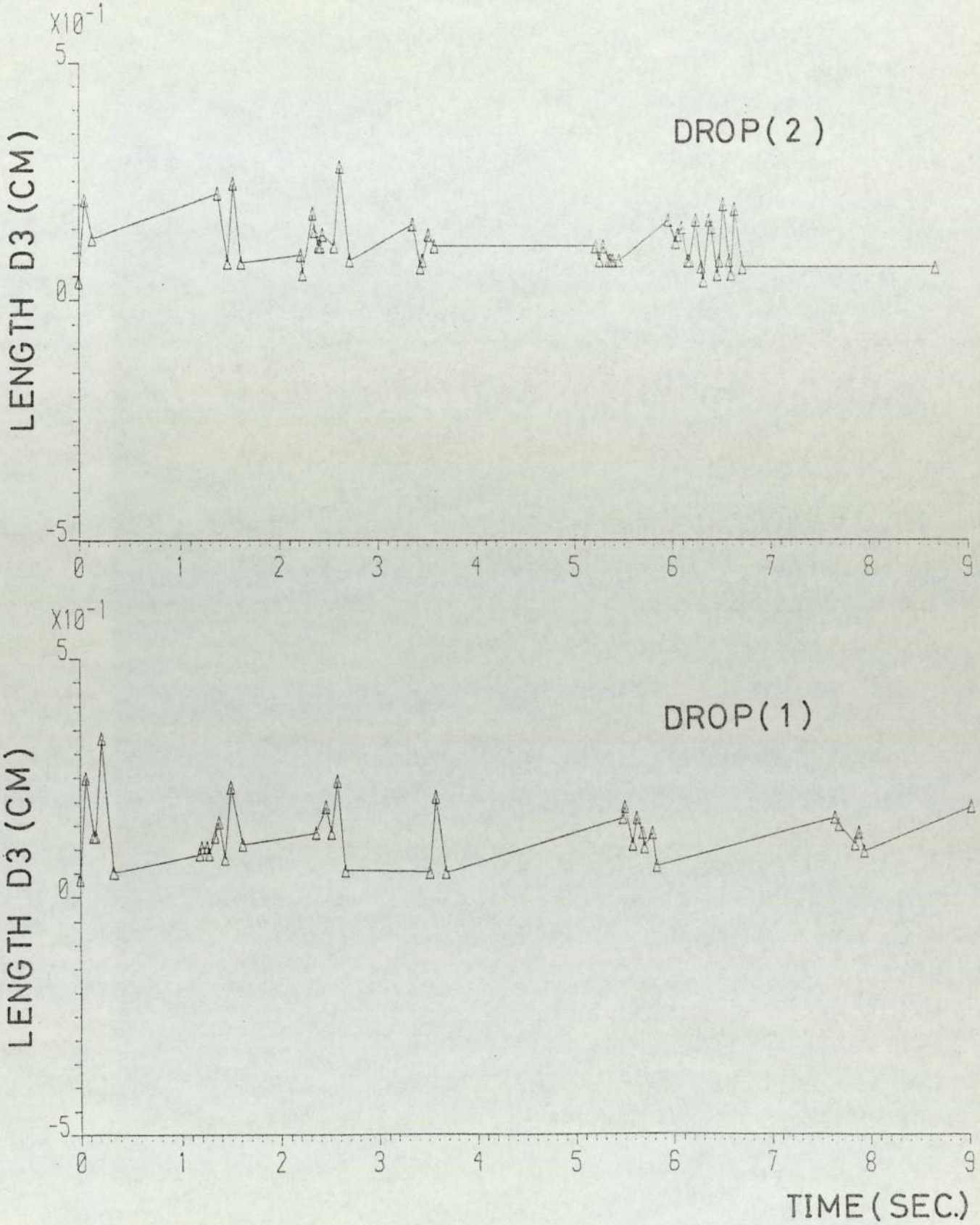

FIG. H.99 DEFORMATION RATIO VS. TIME, RUN-20.

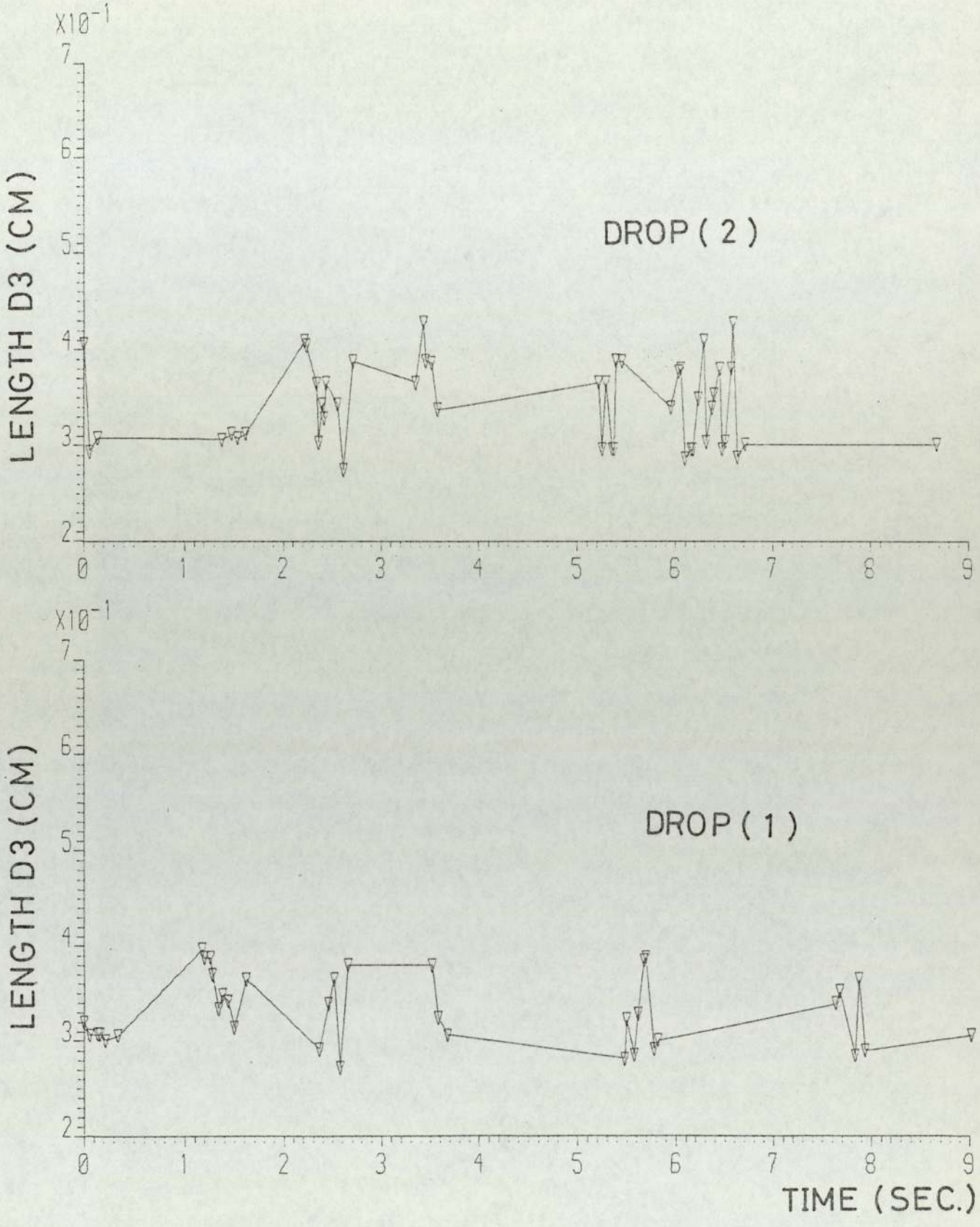

FIG. H.100 LENGTH D3 VS. TIME, RUN-20.

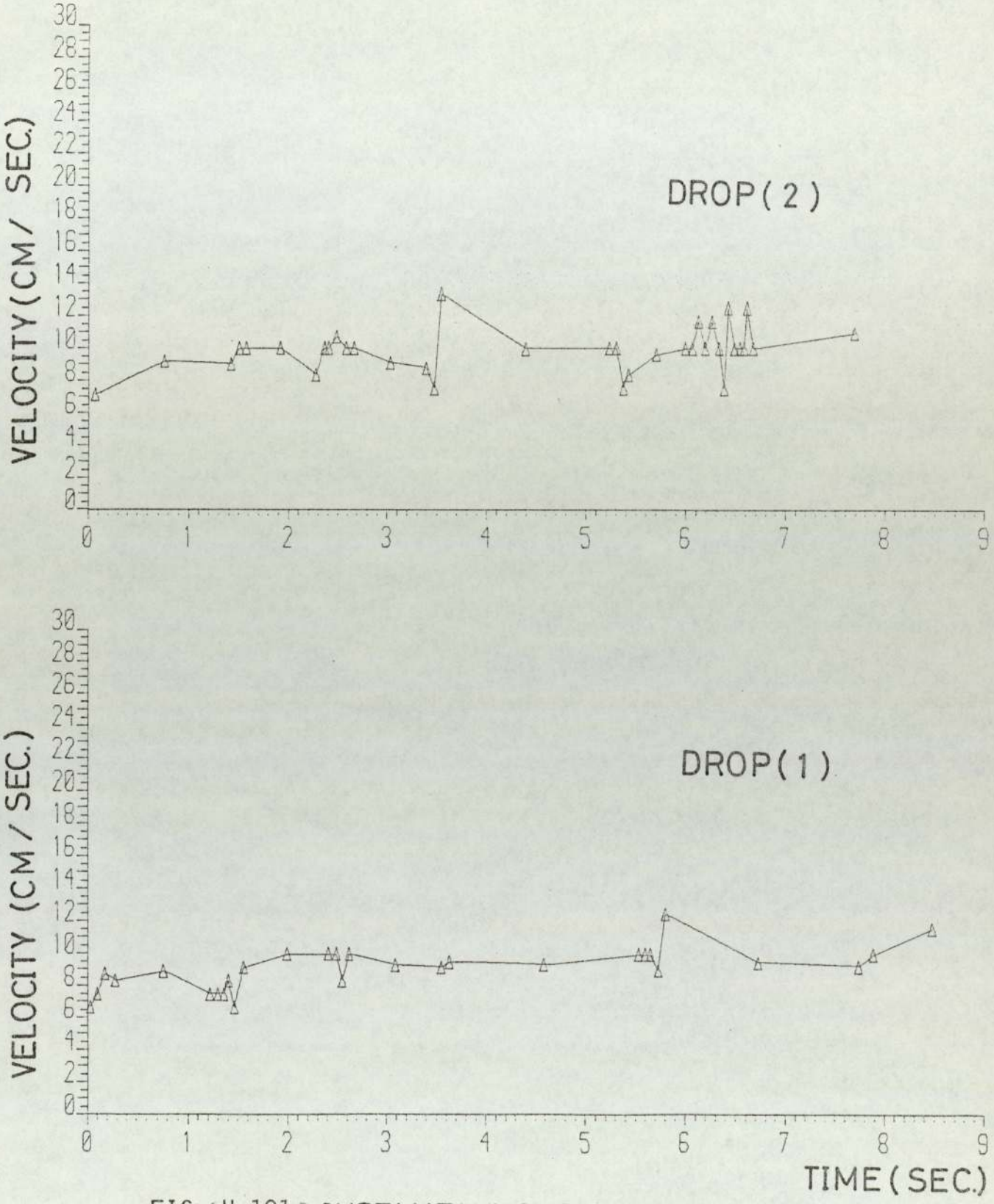

FIG. H.101 INSTANTANUOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-20.

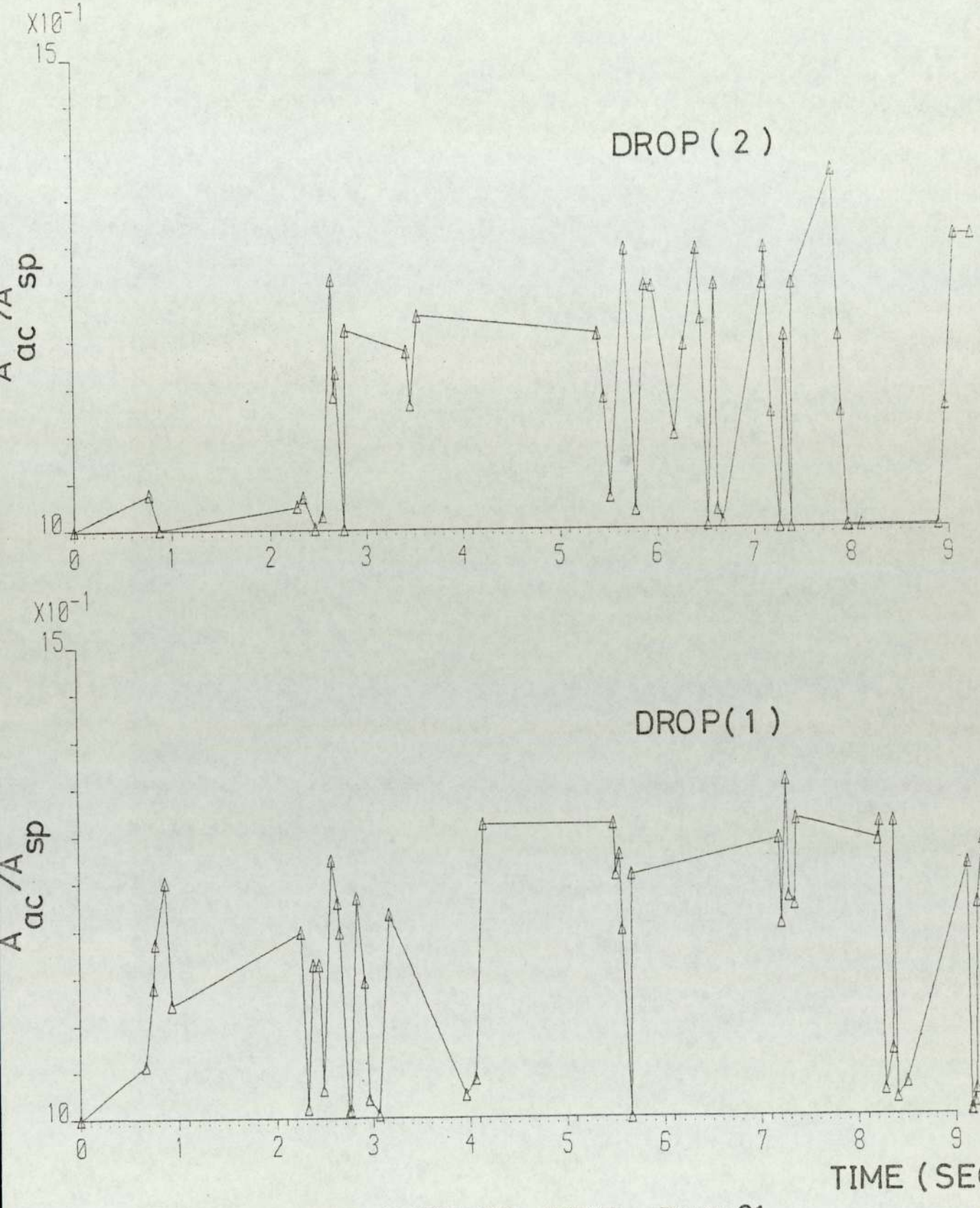

FIG. H.102 AREA RATIO VS. TIME, RUN-21.

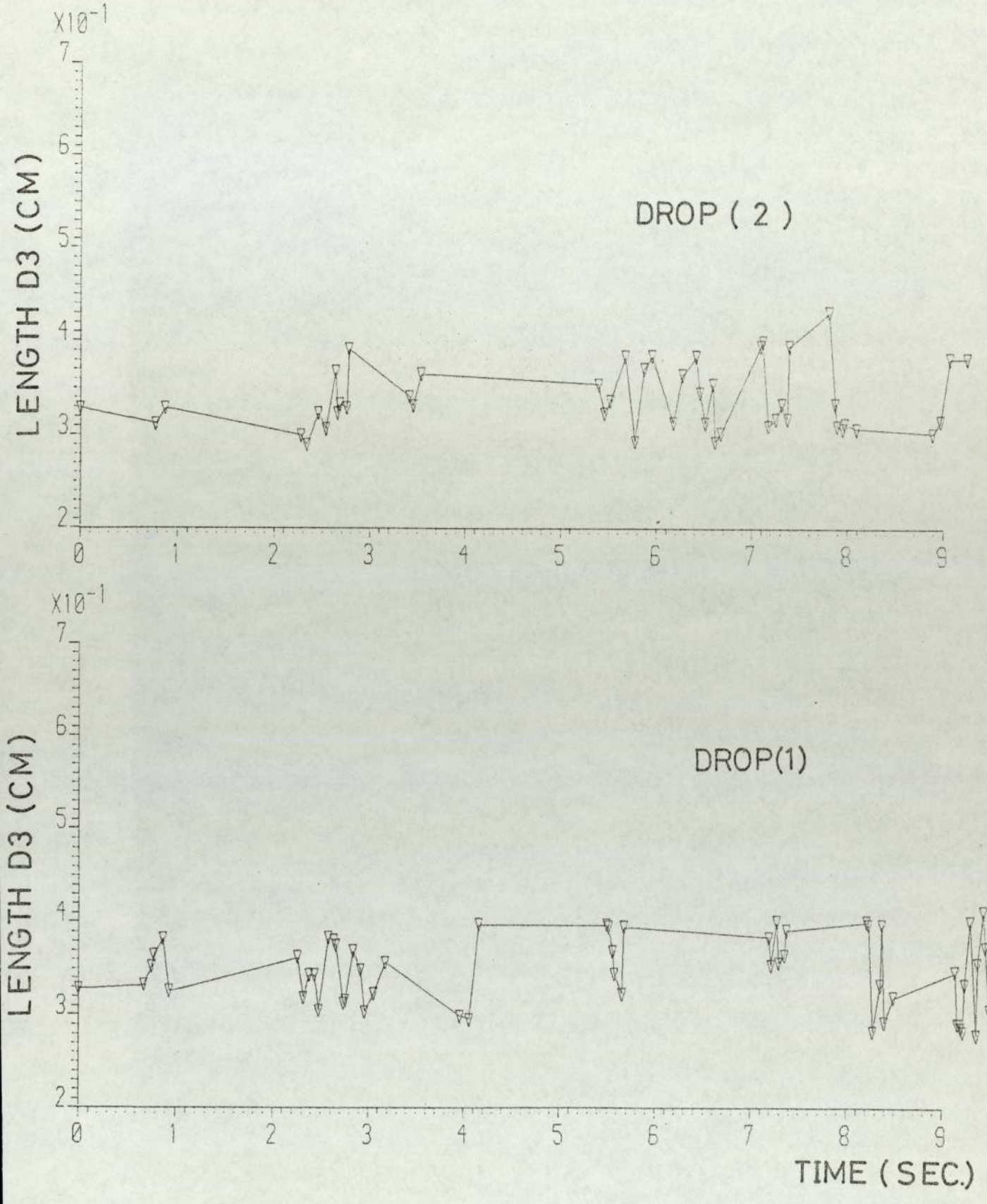

FIG. H.103 LENGTH D3 VS. TIME, RUN-21.

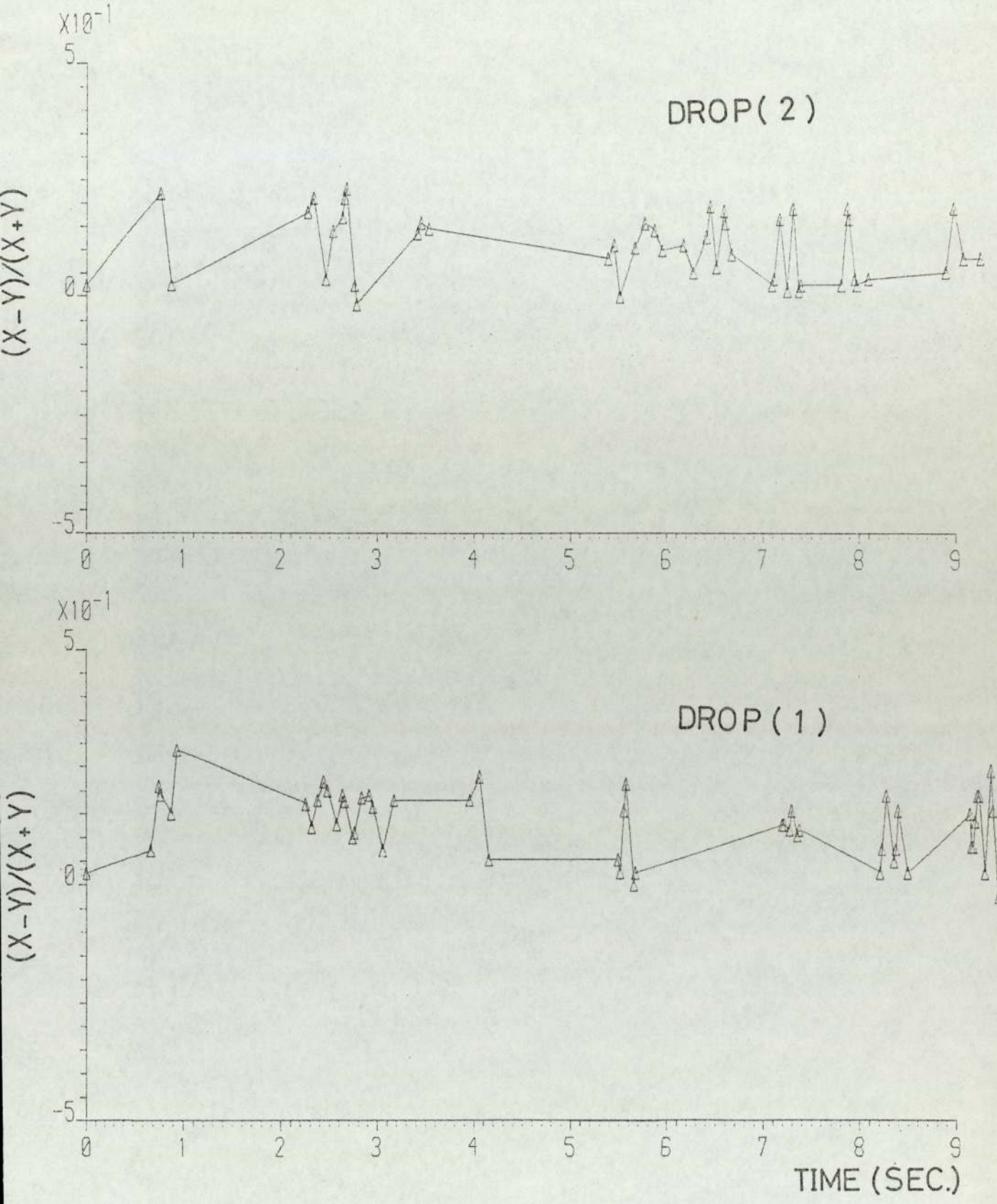

FIG. H.104 DEFORMATION RATIO VS. TIME, RUN-21.

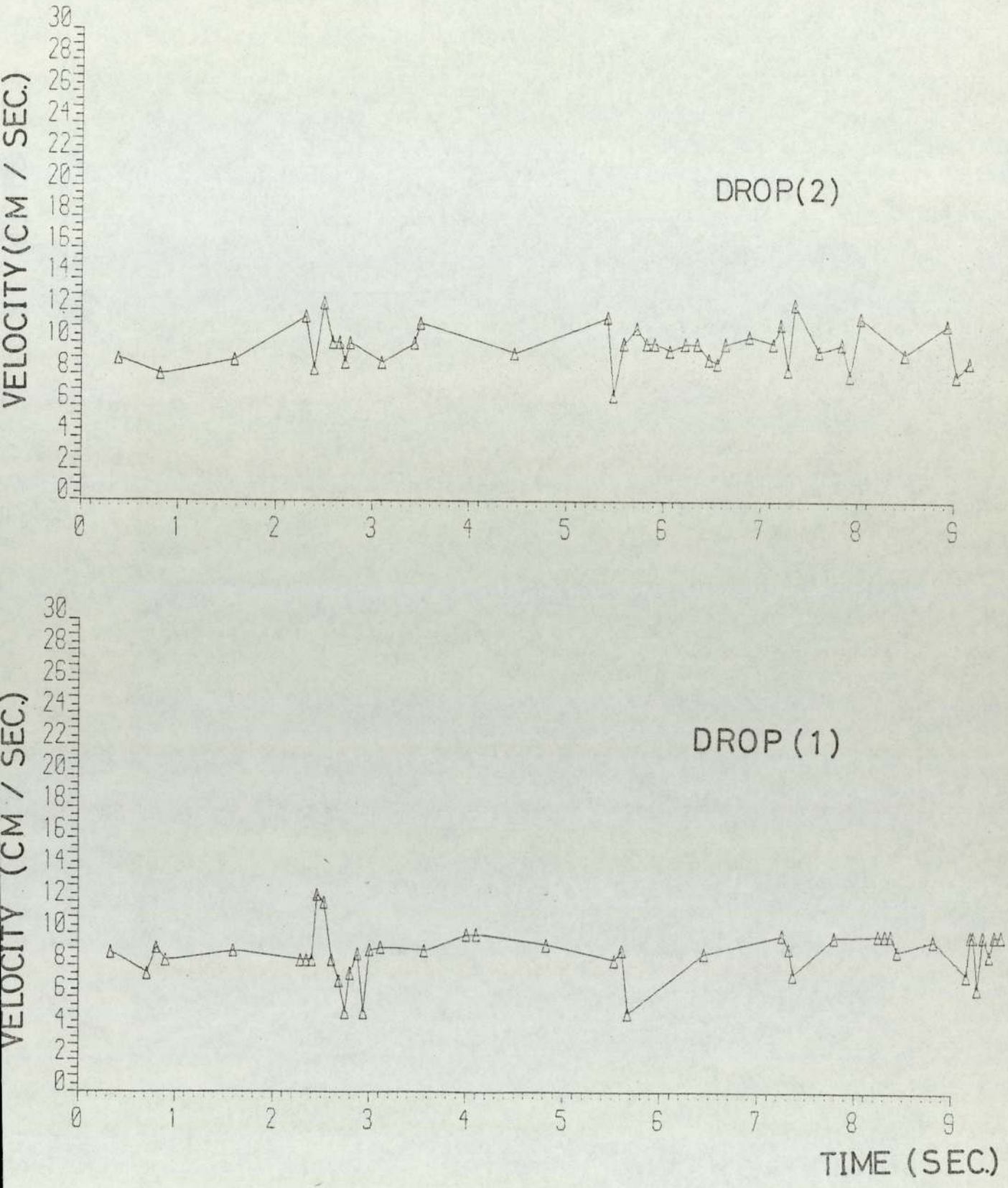

FIG. H.105 INSTANTANUOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-21 .

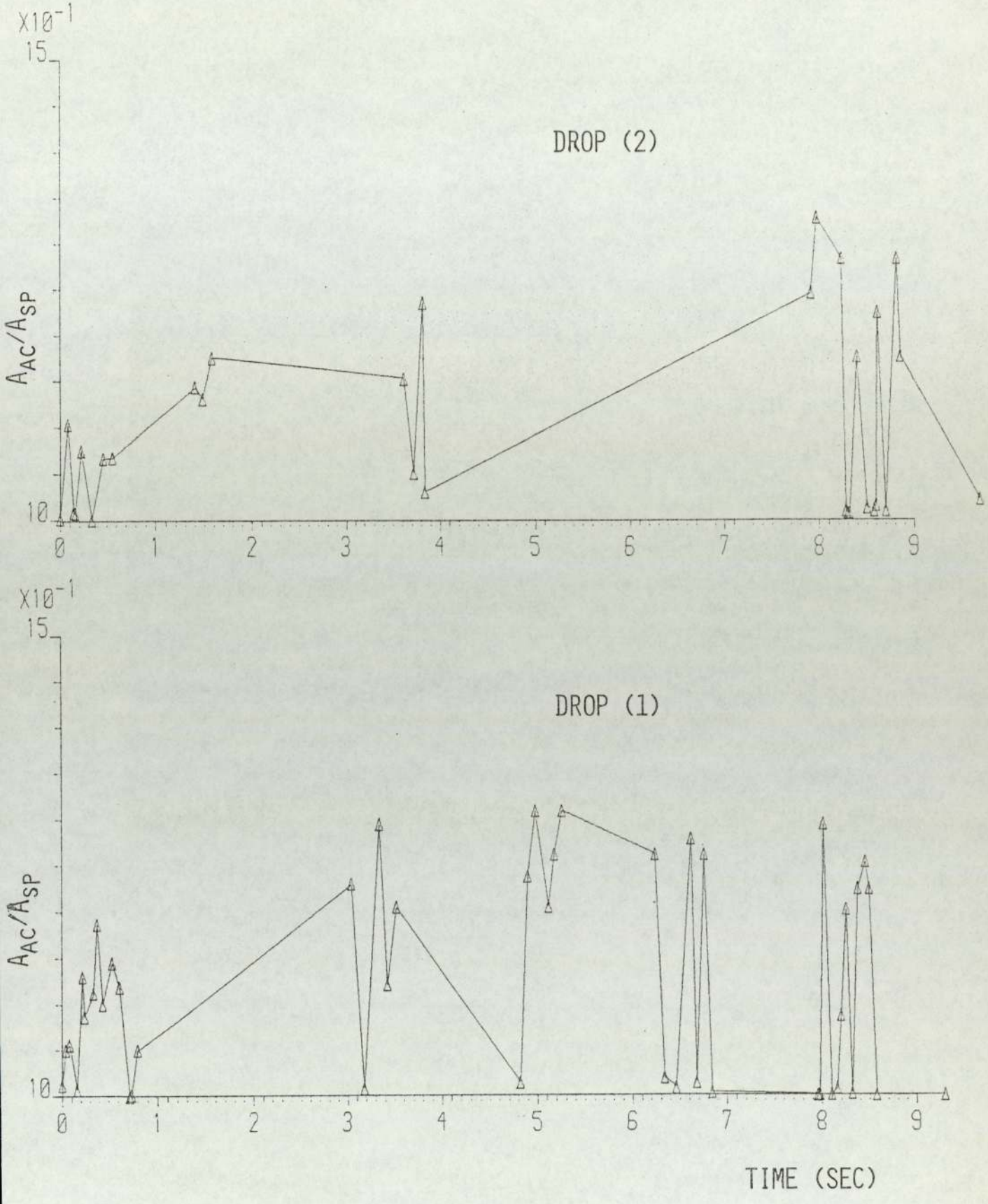

FIG.H.106 AREA RATIO VS. TIME, RUN-25.

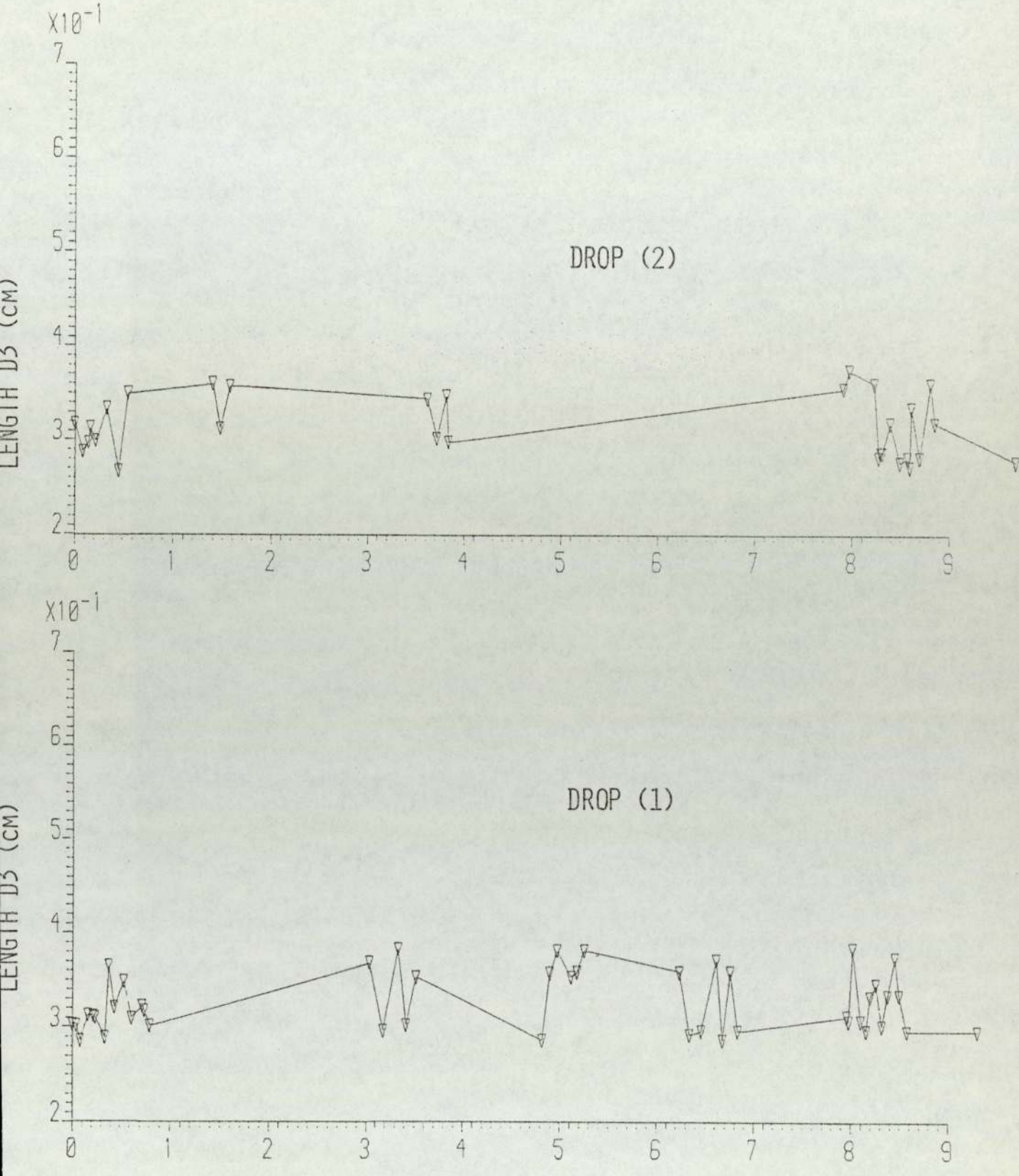

FIG. H.107 LENGTH D3 VS TIME, RUN-25.

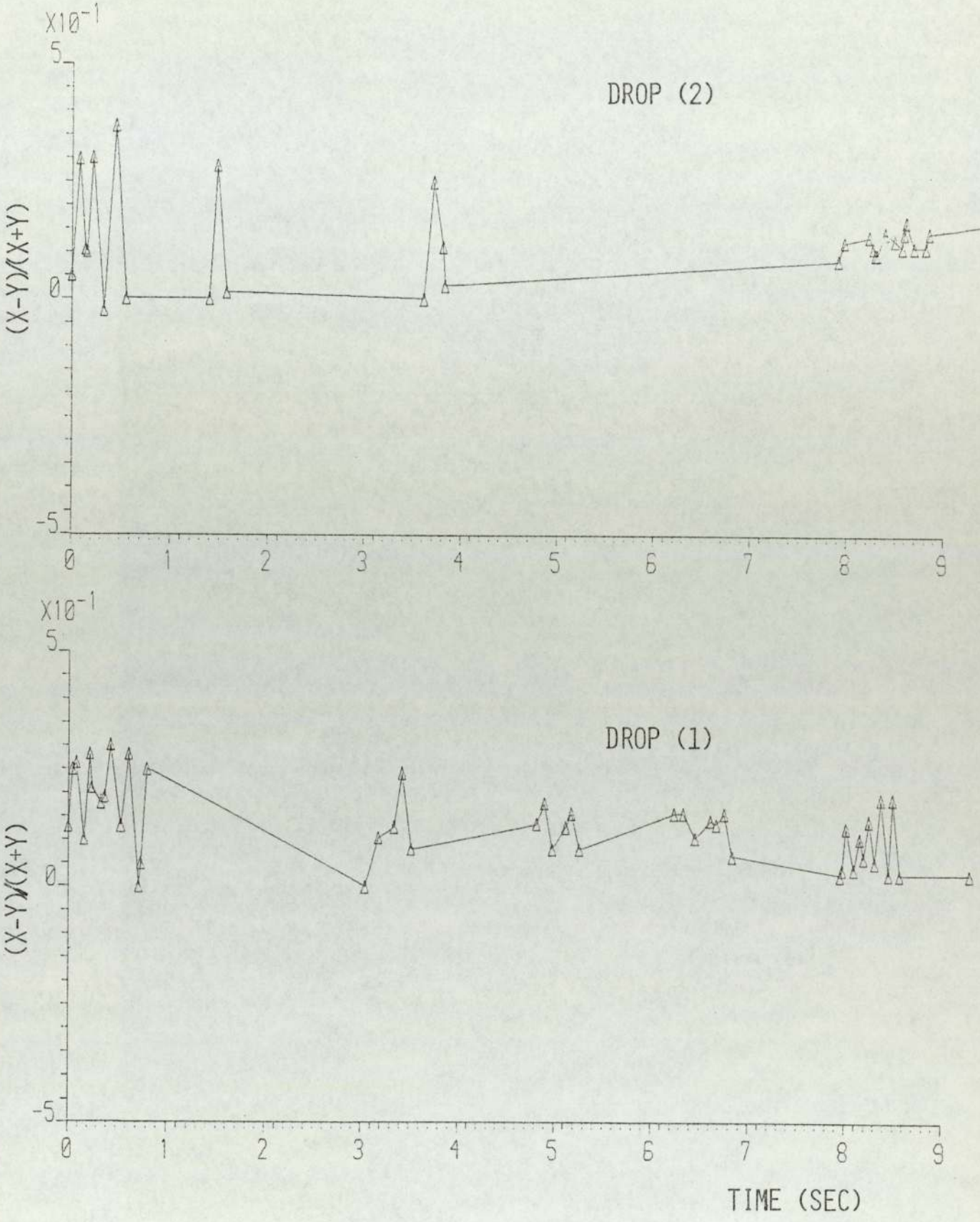

FIG.H.108 DEFORMATION RATIO VS. TIME, RUN-25.

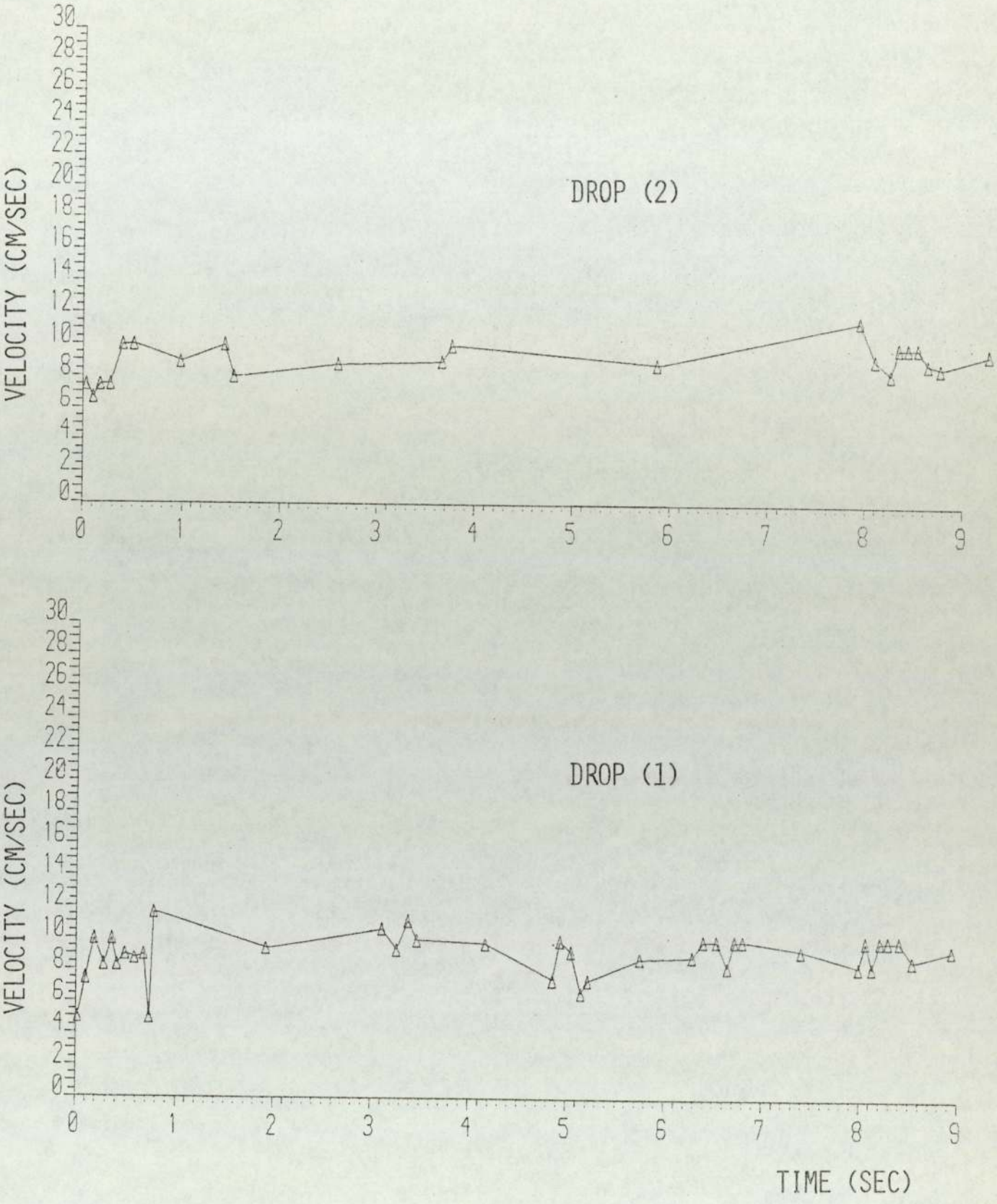

FIG.H.109 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-25.

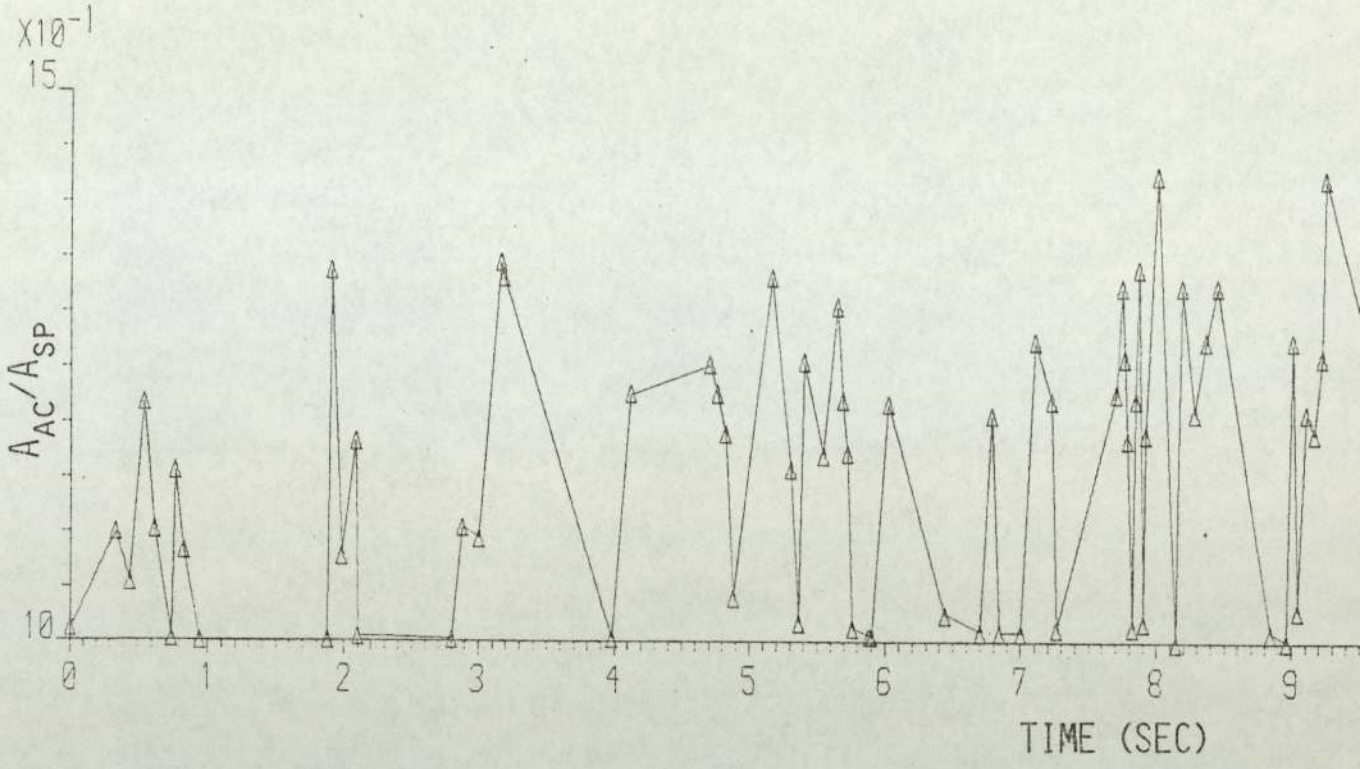

FIG. H.110 AREA RATIO VS. TIME, RUN-26.

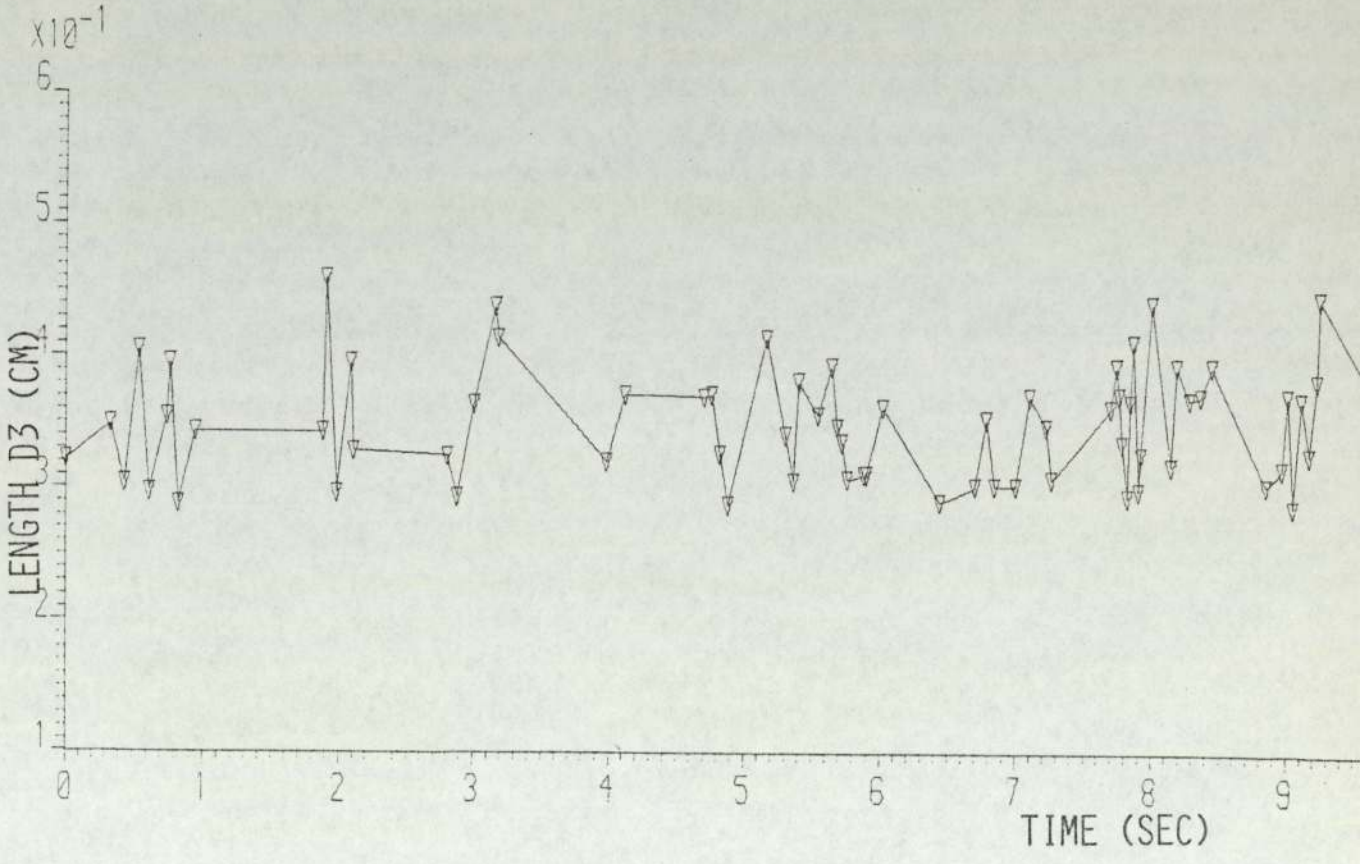

FIG. H.111 LENGTH D3 VS. TIME, RUN-26.

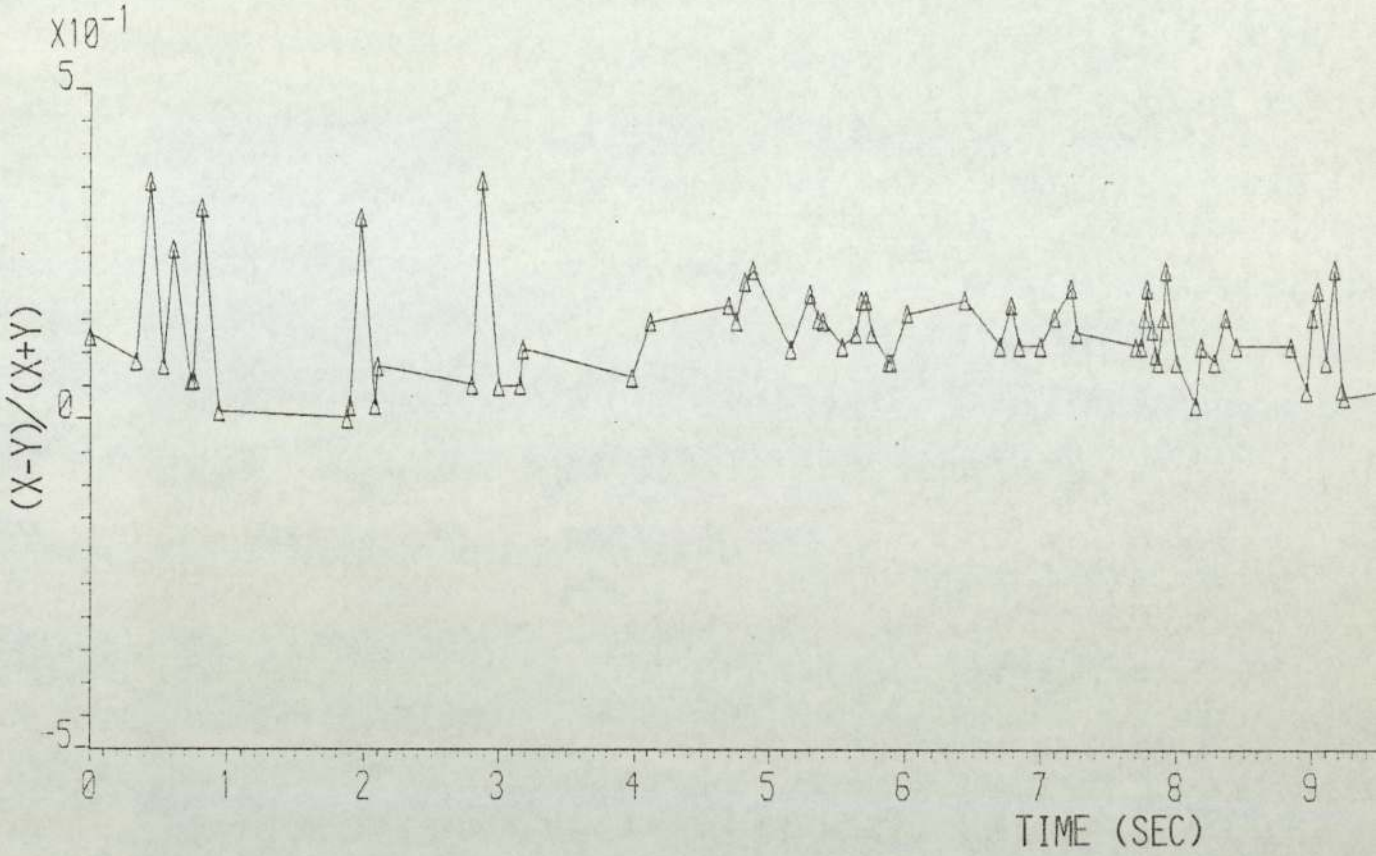

FIG. H.112 DEFORMATION RATIO VS. TIME, RUN-26.

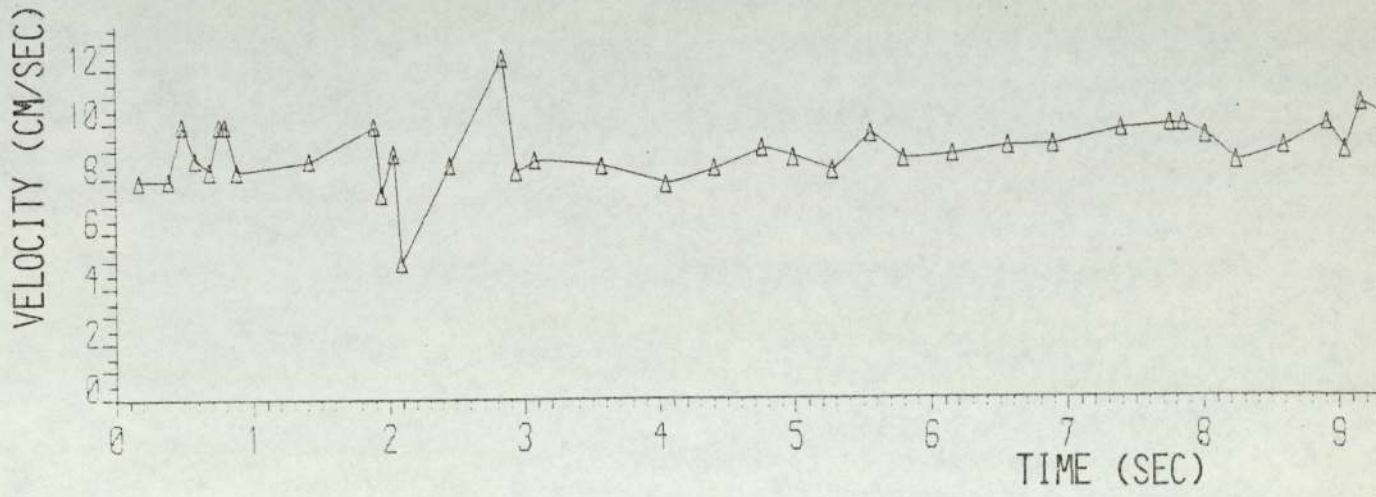

FIG. H.113 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-26.

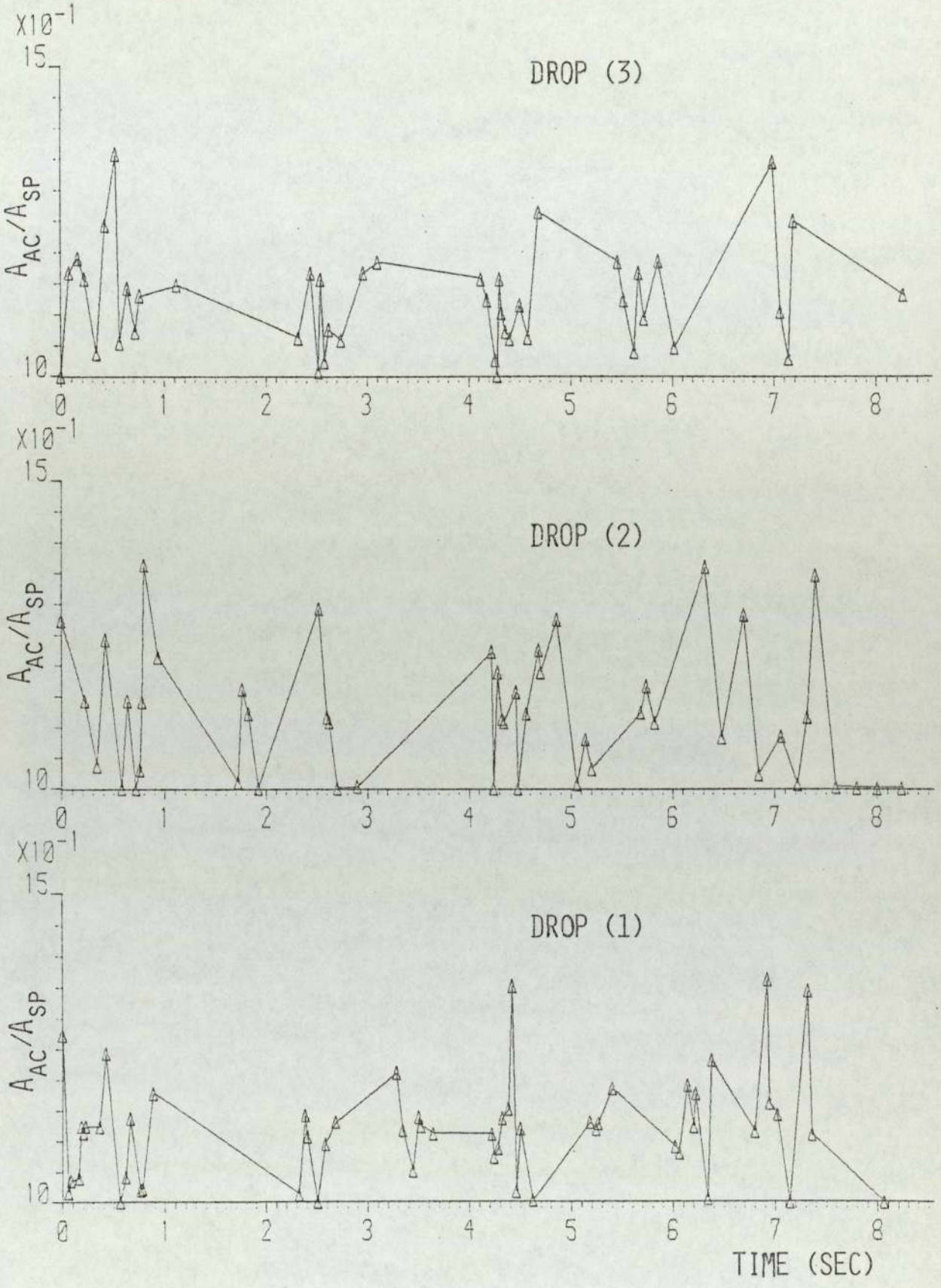

FIG.H.114 AREA RATIO VS. TIME, RUN-27.

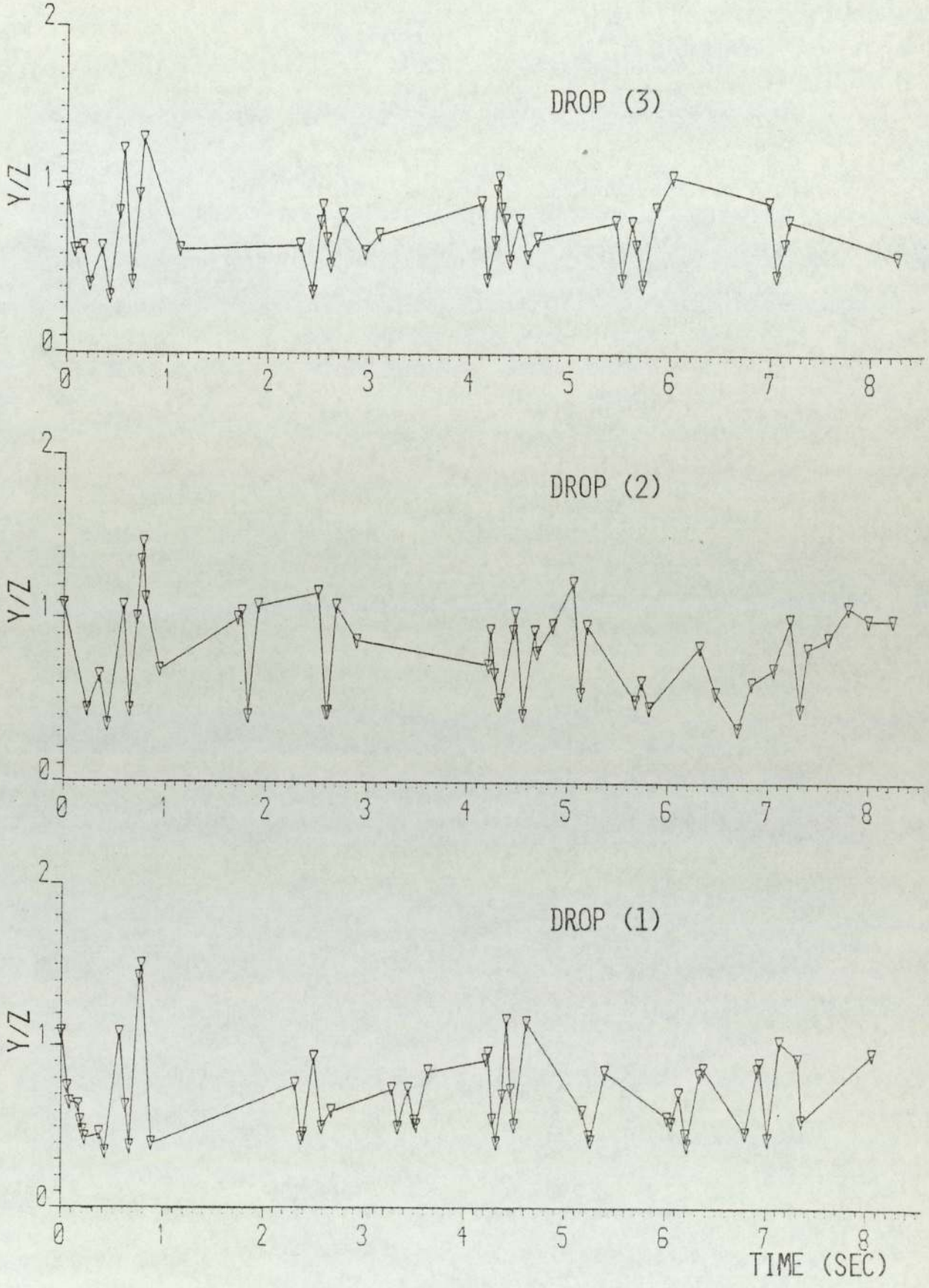

FIG. H.122 AXES RATIO VS. TIME, RUN-27.

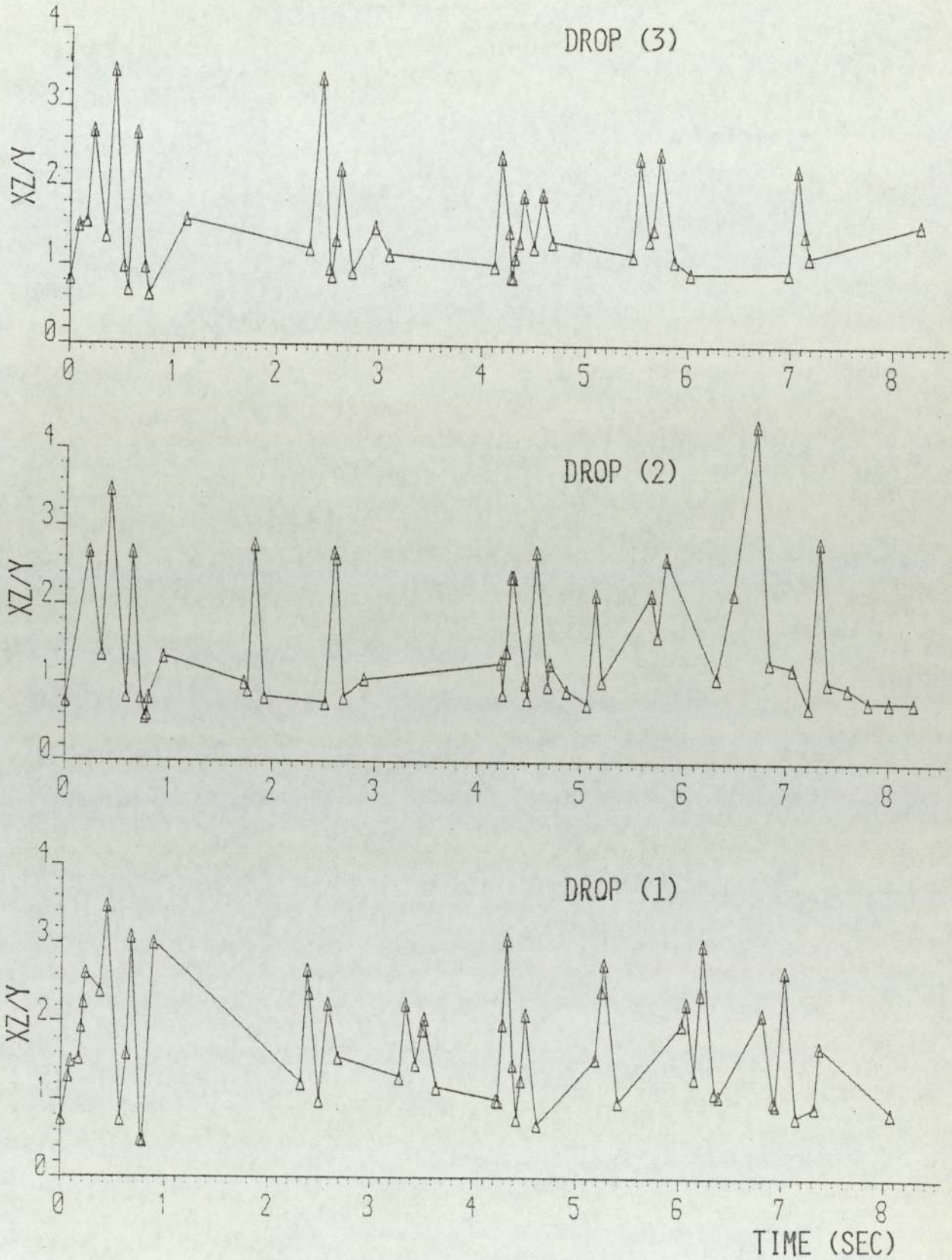

FIG.H.123 AXES RATIO VS. TIME, RUN-27.

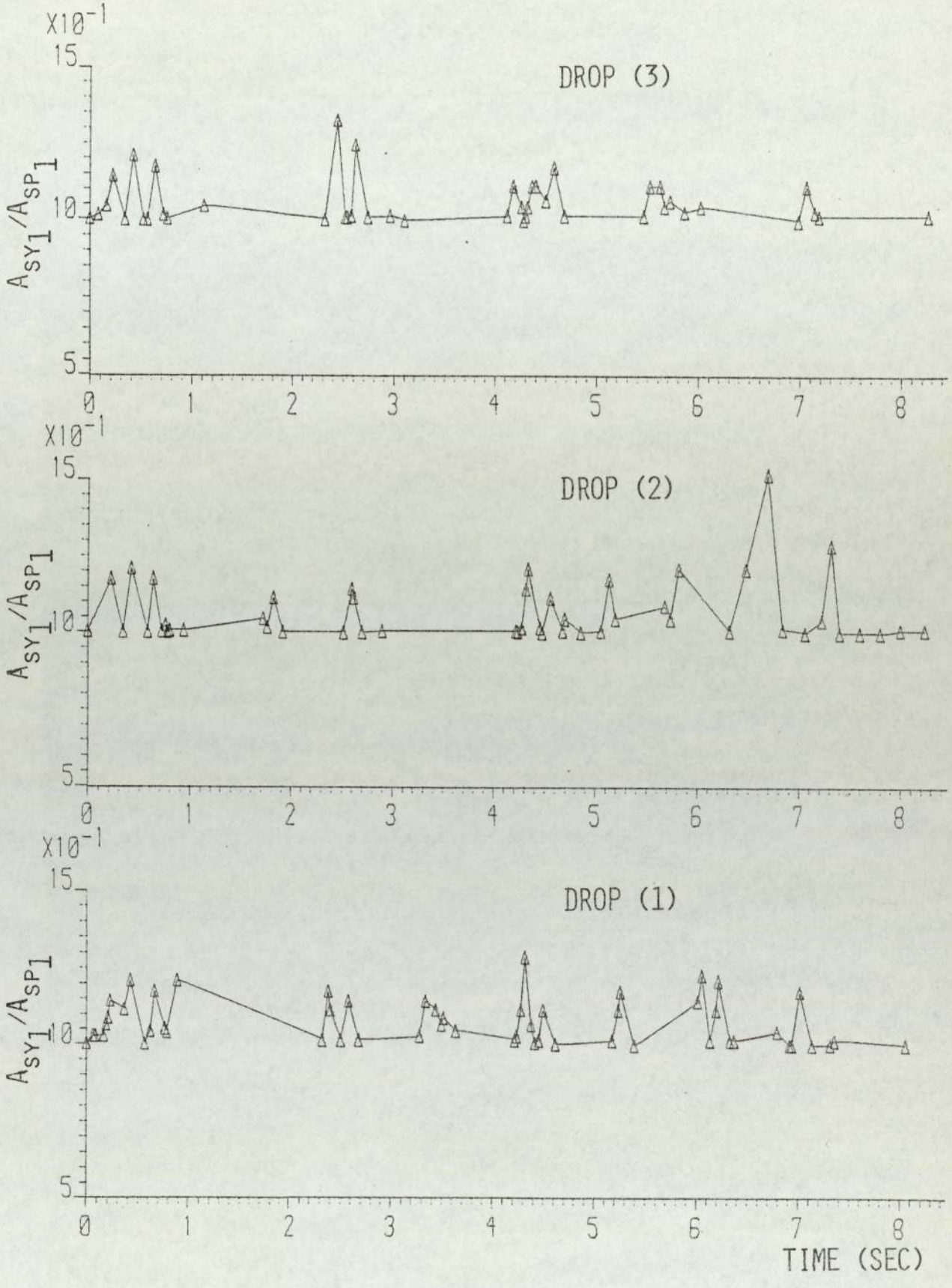

FIG. H.124 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-27.

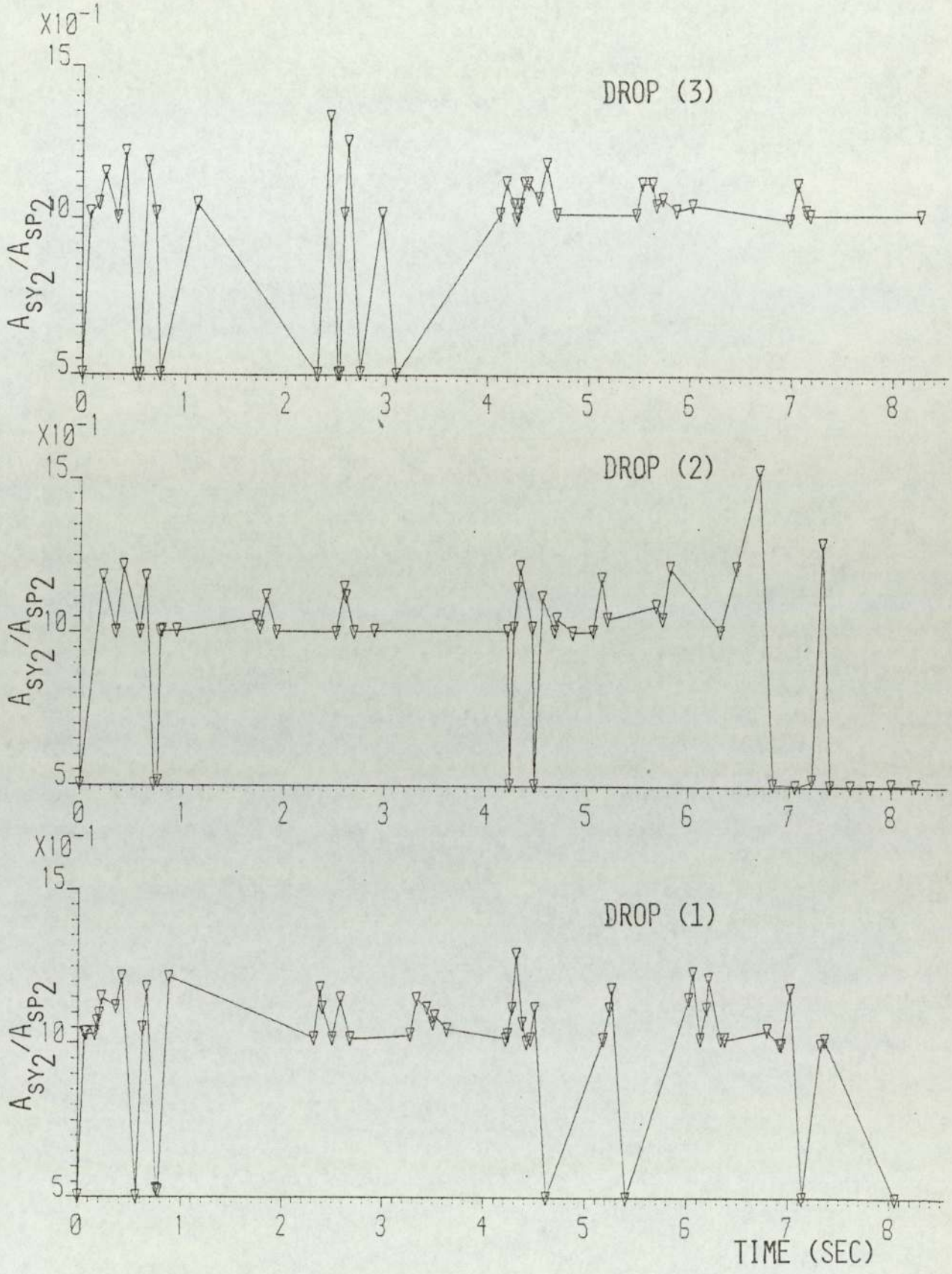

FIG. H.125 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-27, BASED ON MEAN VOLUME.

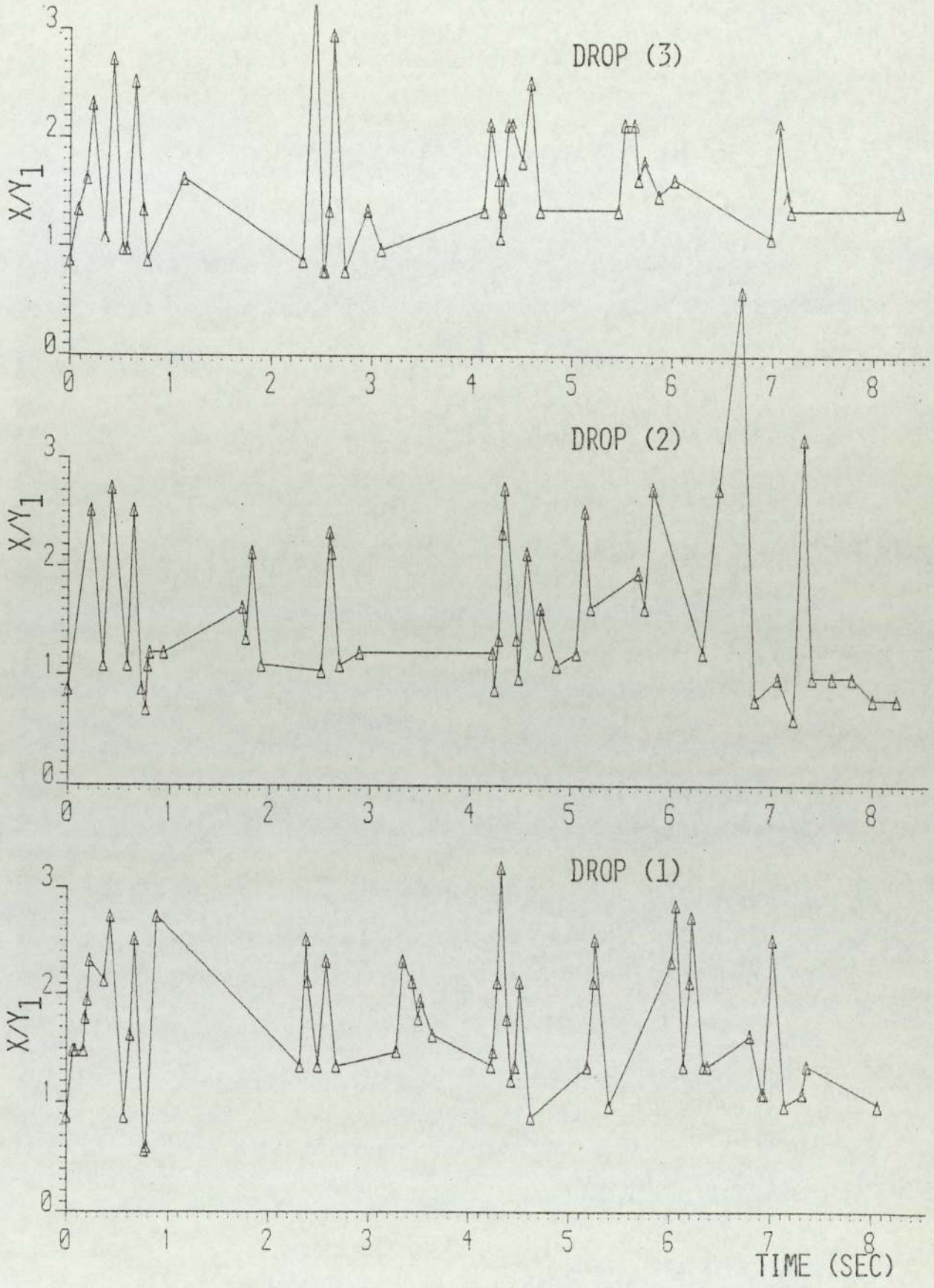

FIG.H.126 AXES RATIO VS. TIME, RUN-27.

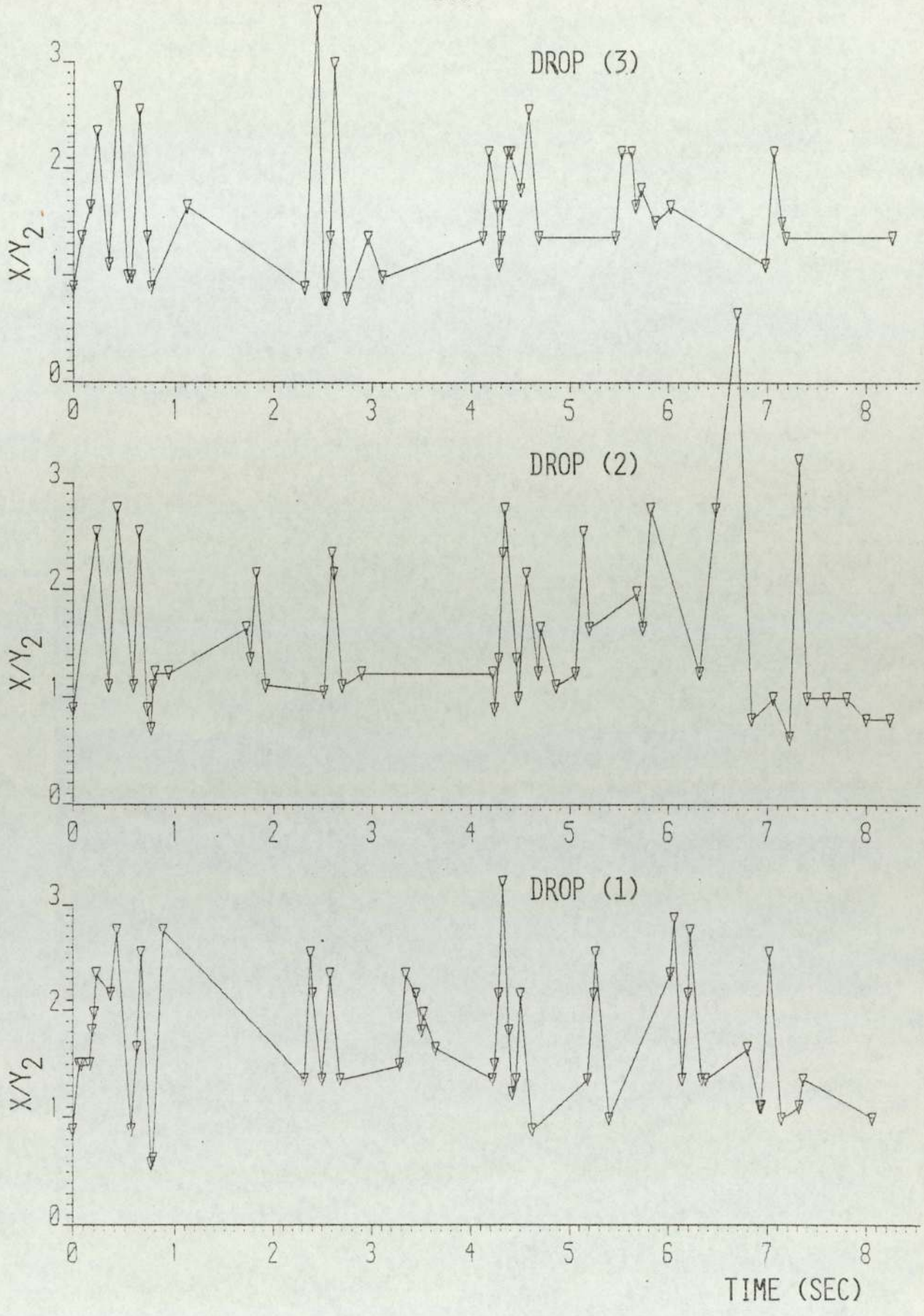

FIG.H.127 AXES RATIO VS. TIME, RUN-27.

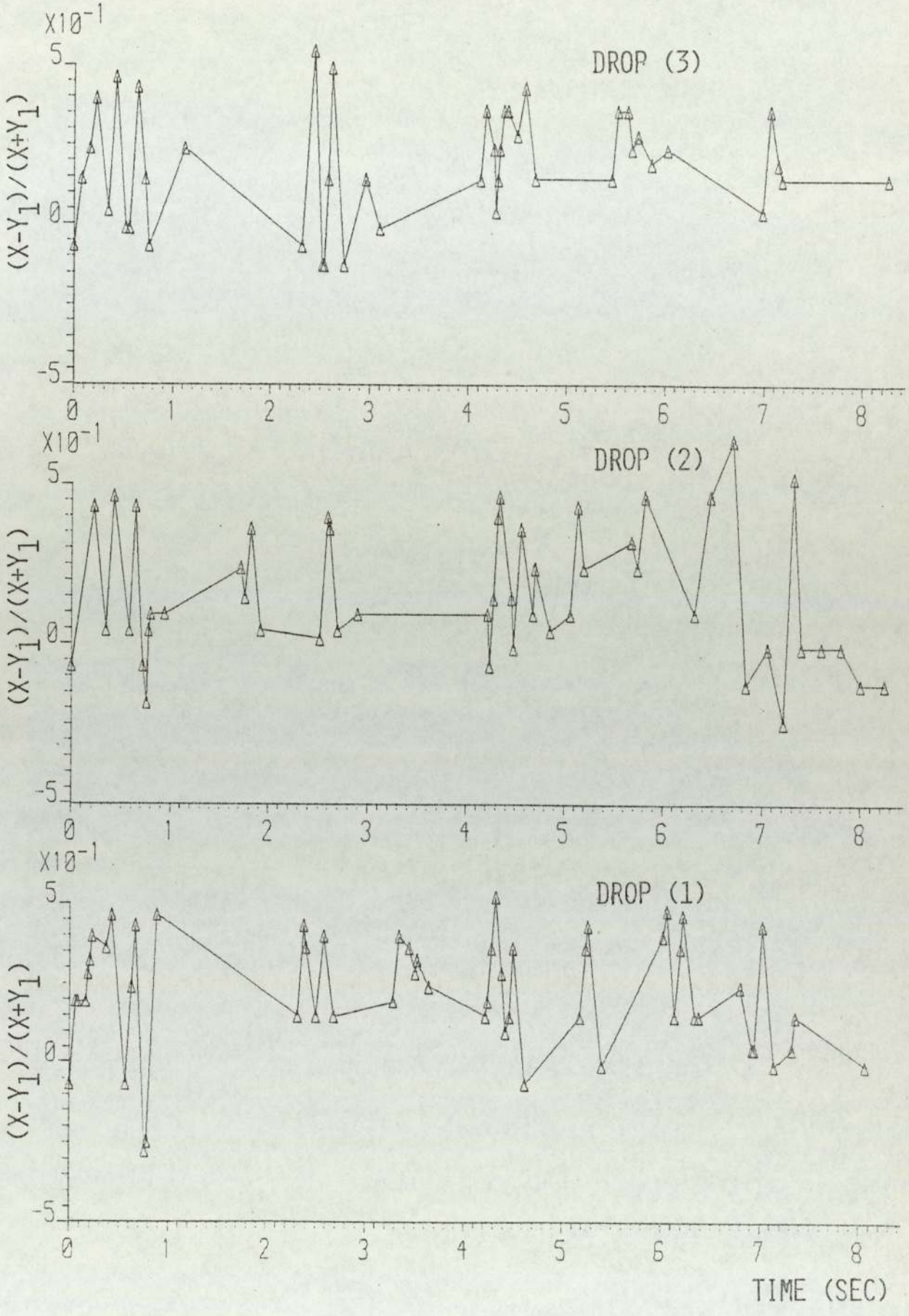

FIG.H.128 DEFORMATION RATIO VS. TIME, RUN-27.

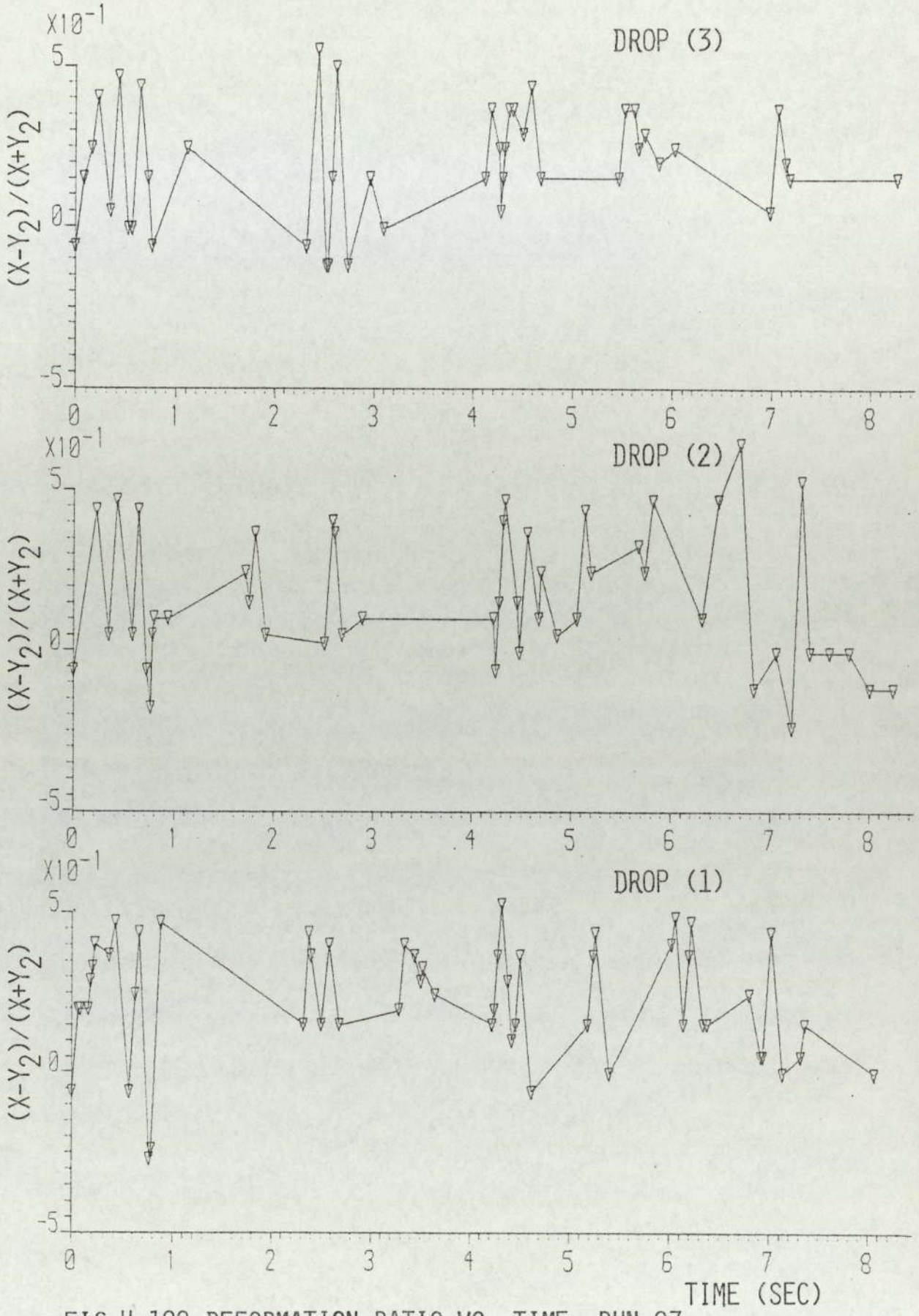

FIG.H.129 DEFORMATION RATIO VS. TIME, RUN-27.

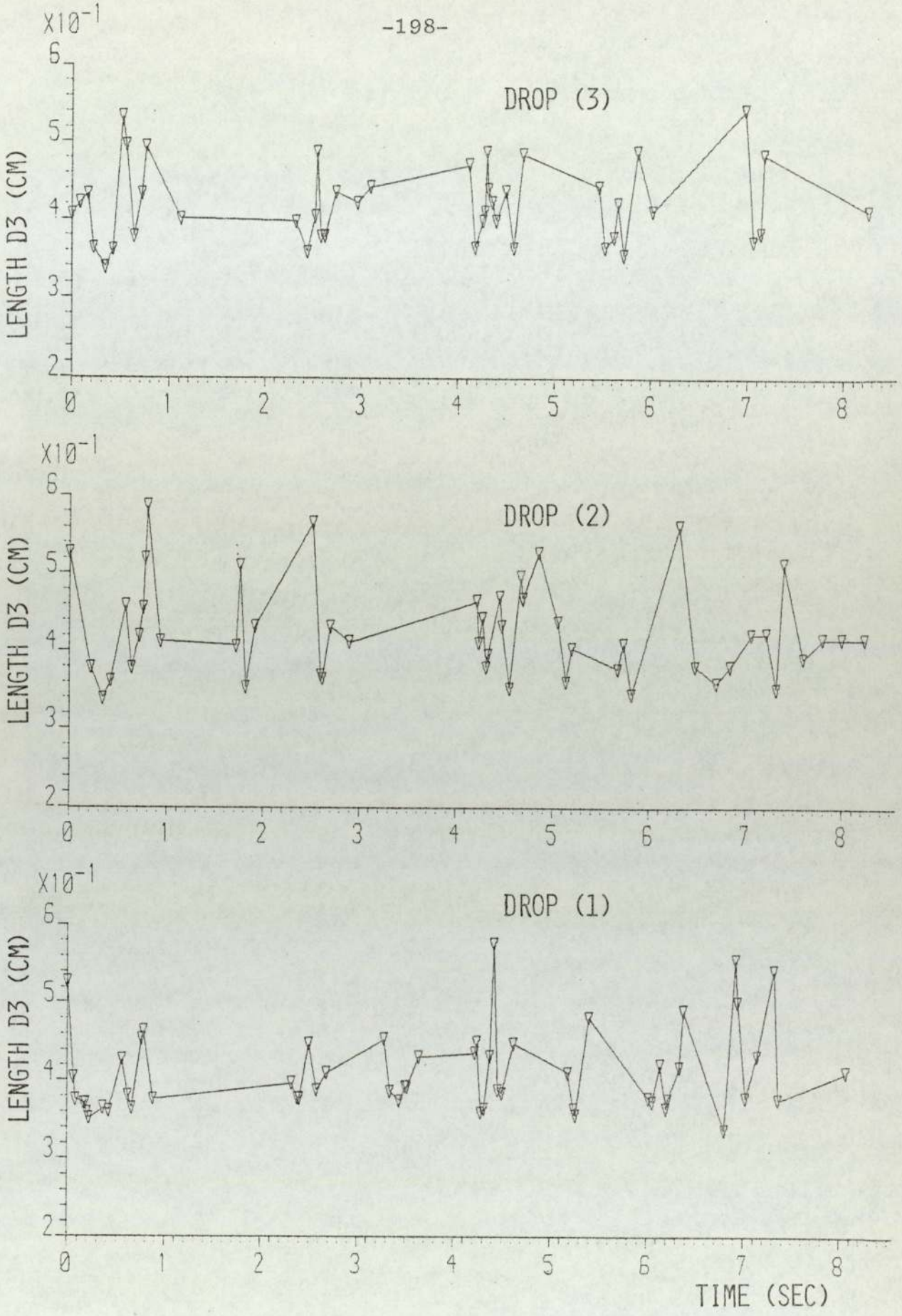

FIG. H.115 LENGTH D3 VS. TIME, RUN-27.

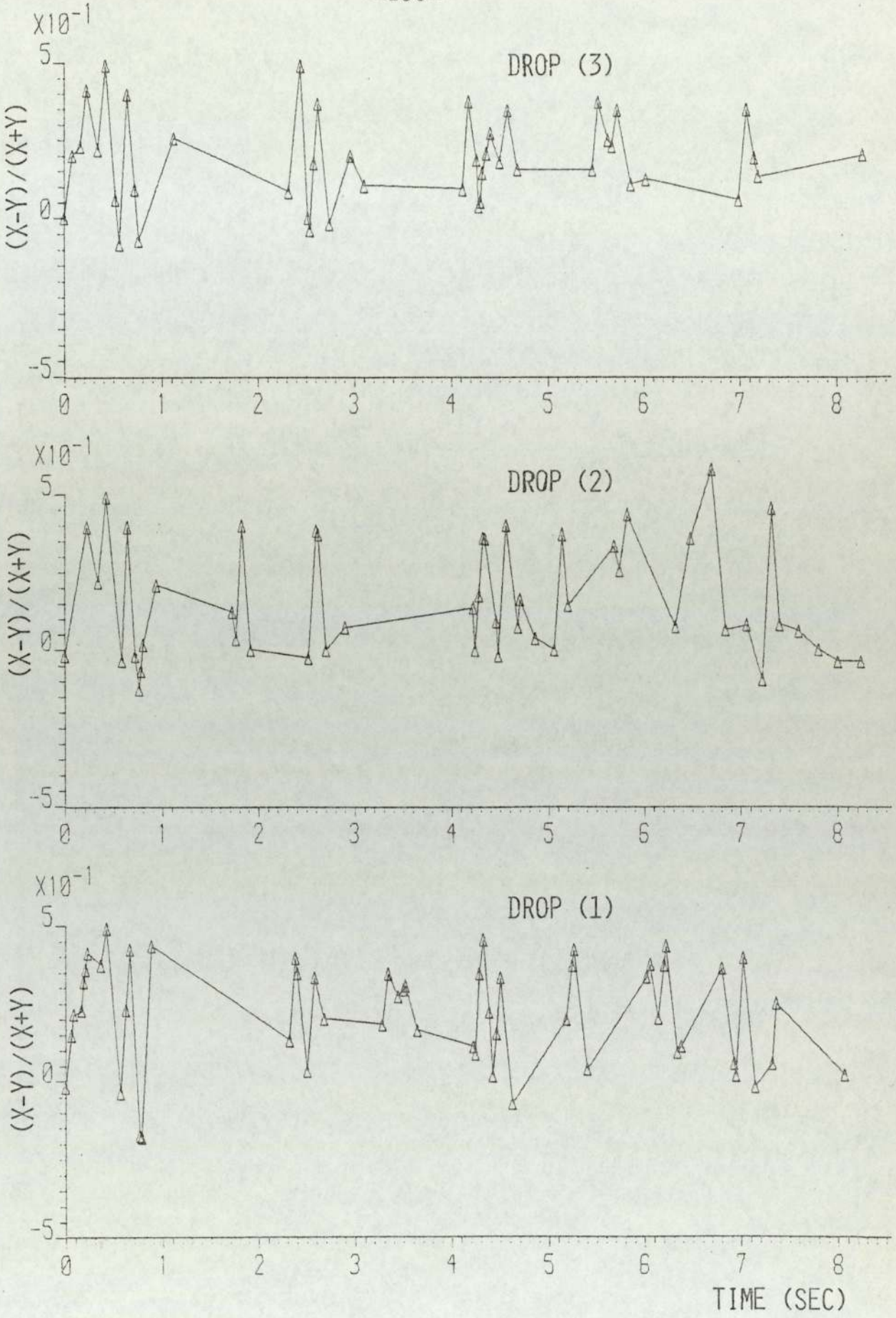

FIG.H.116 DEFORMATION RATIO VS. TIME, RUN-27.

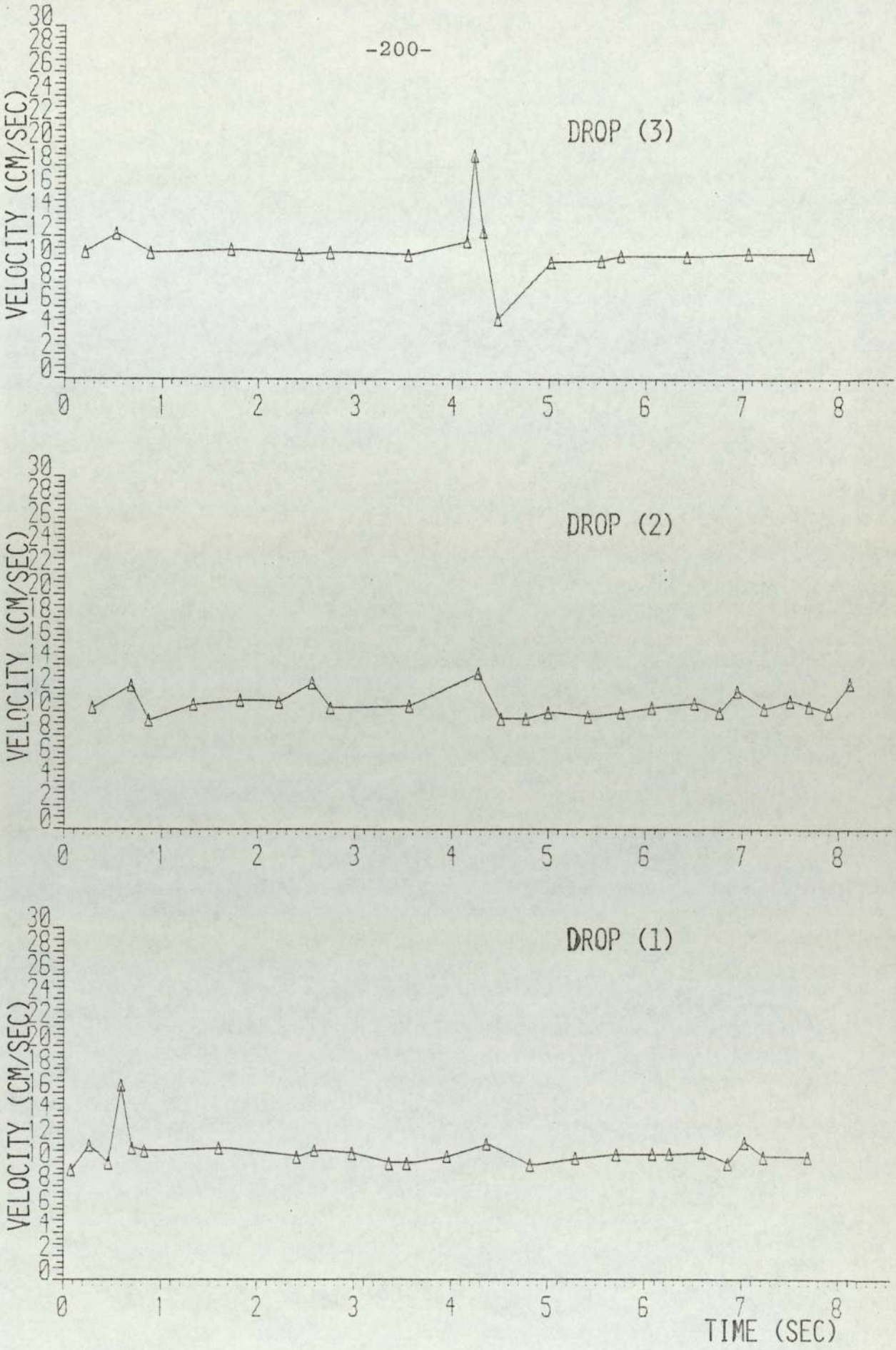

FIG. H.117 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-27.

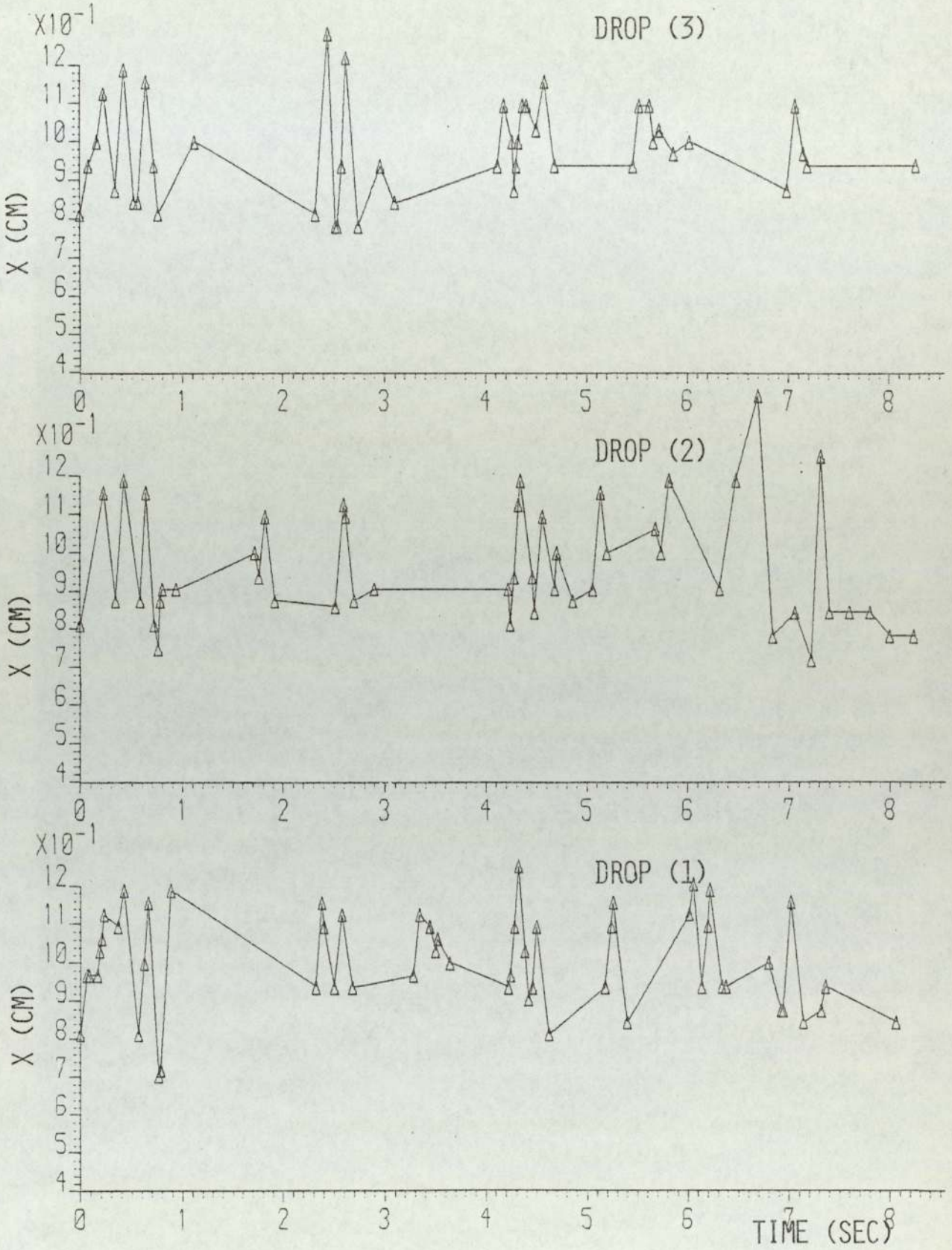

FIG.H.118 X VS. TIME, RUN-27.

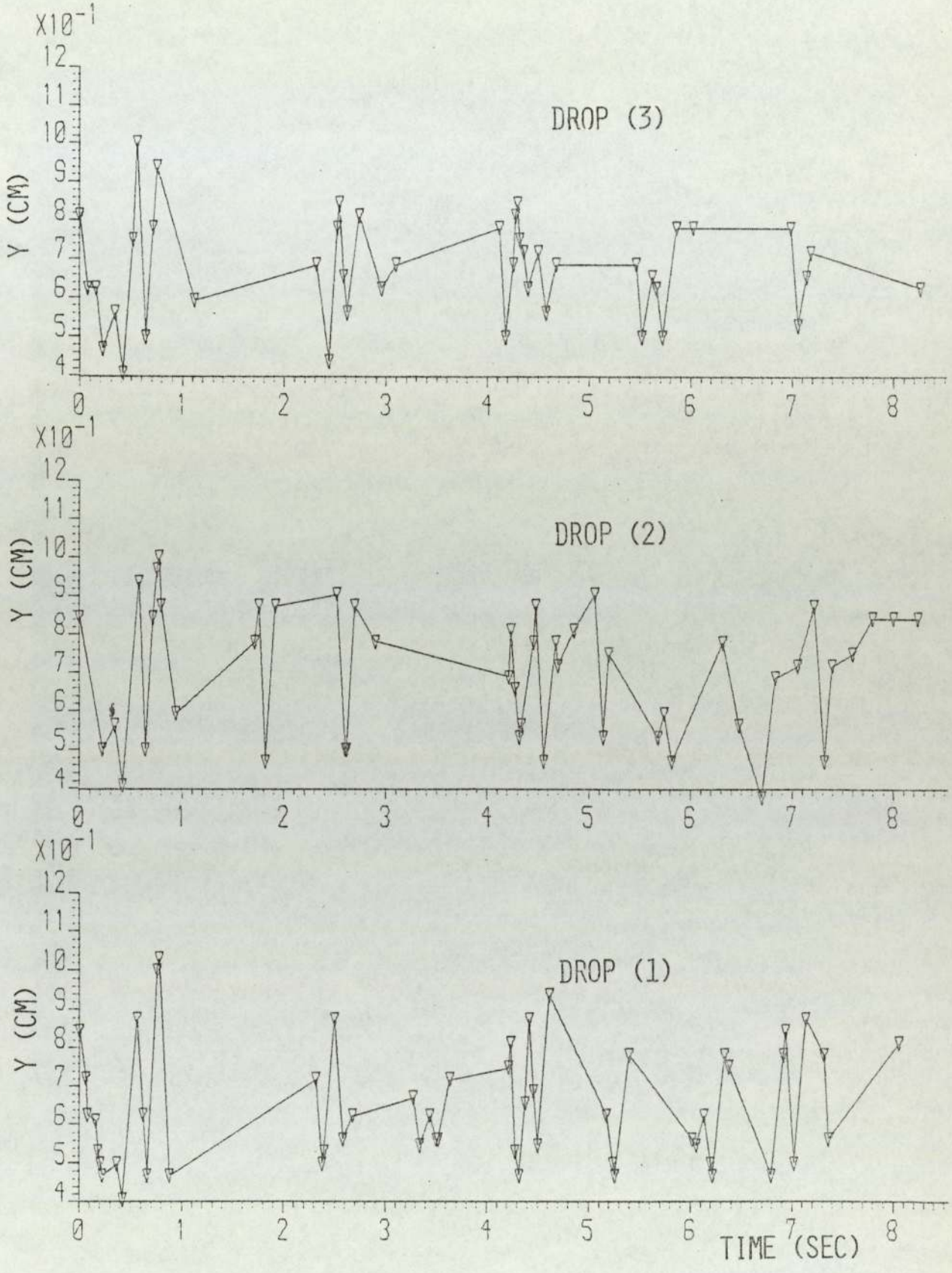

FIG.H.119 Y VS. TIME, RUN-27.

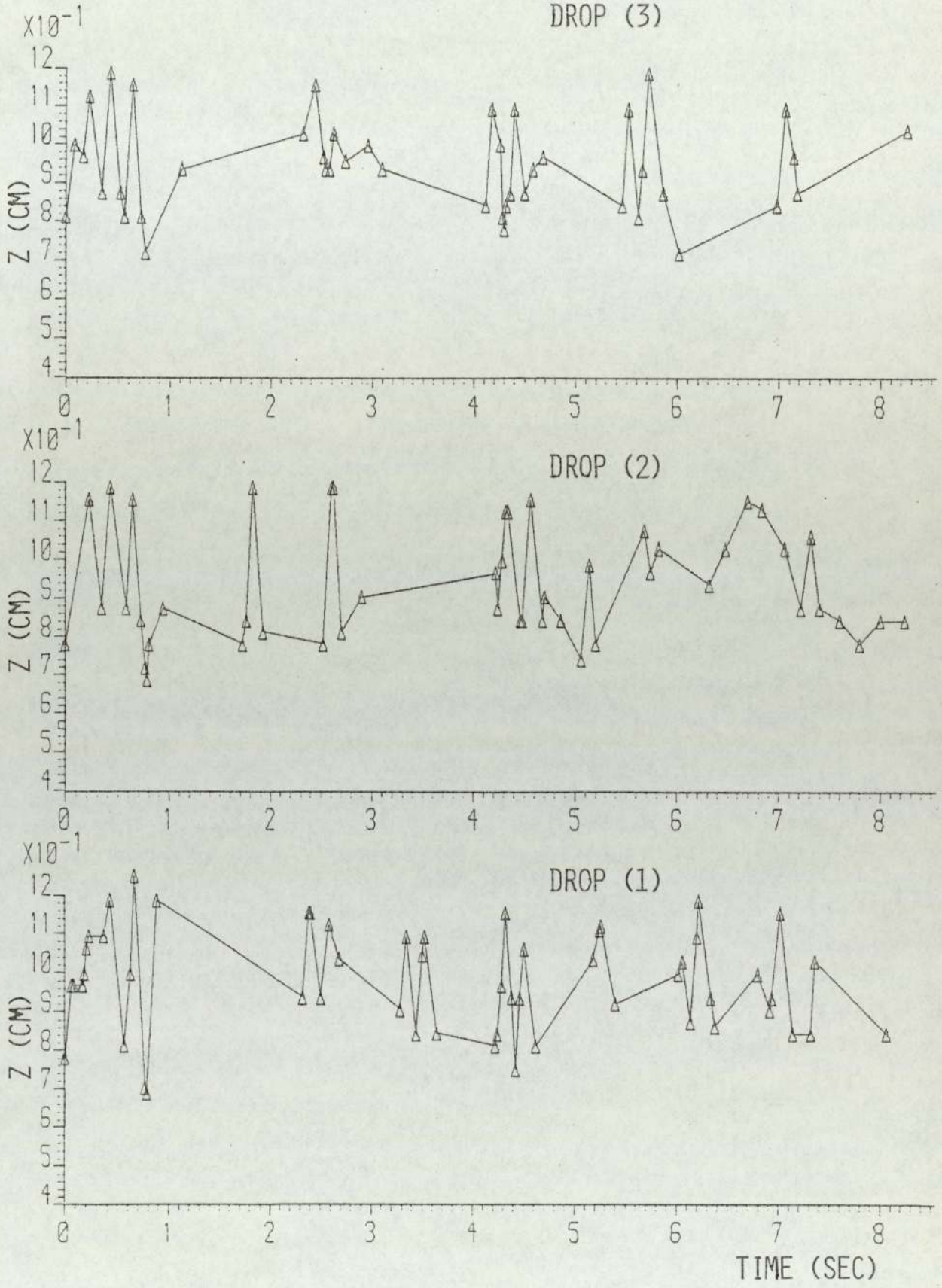

FIG.H.120 Z VS. TIME, RUN-27.

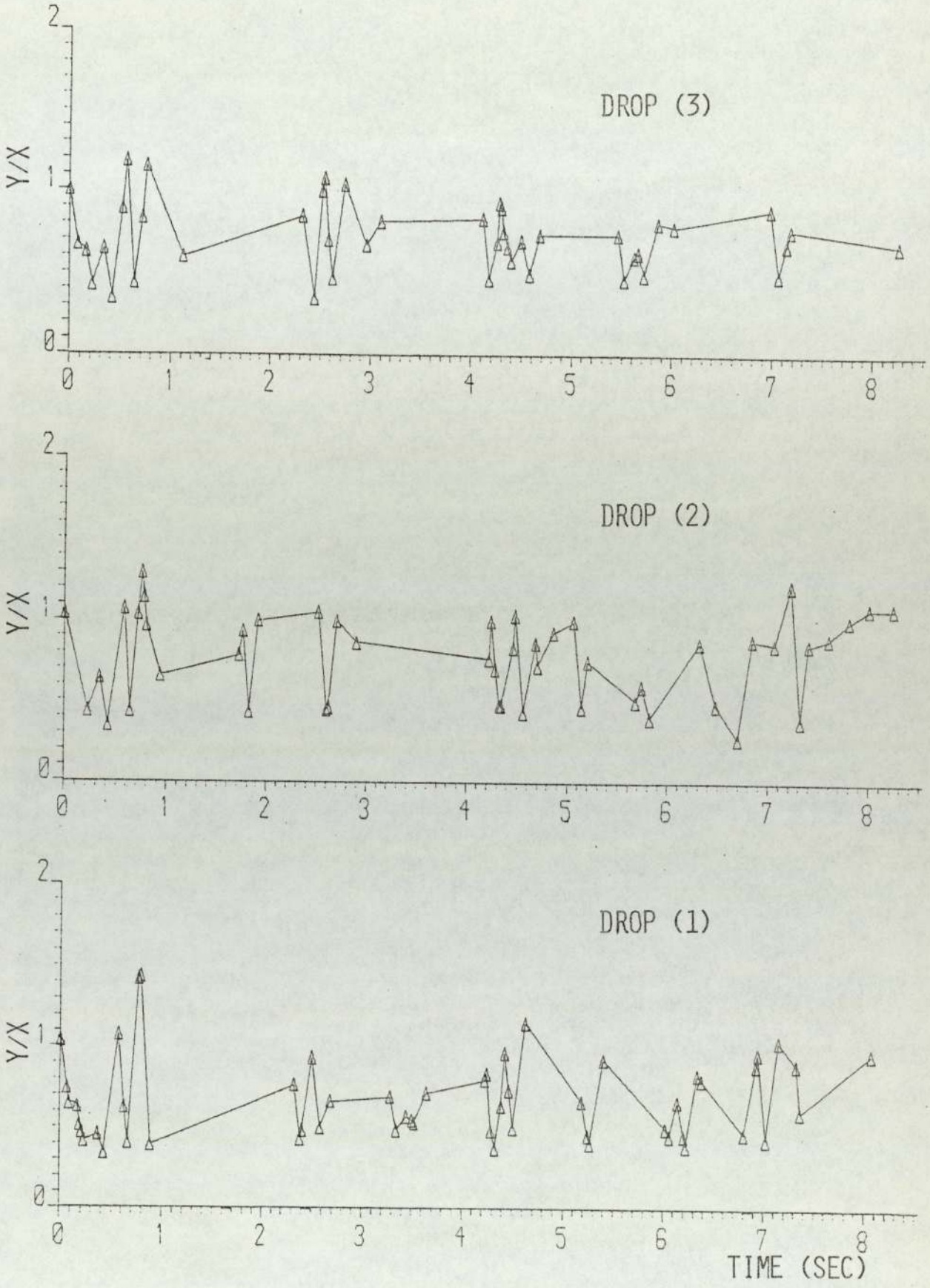

FIG.H.121 AXES RATIO VS. TIME, RUN-27.

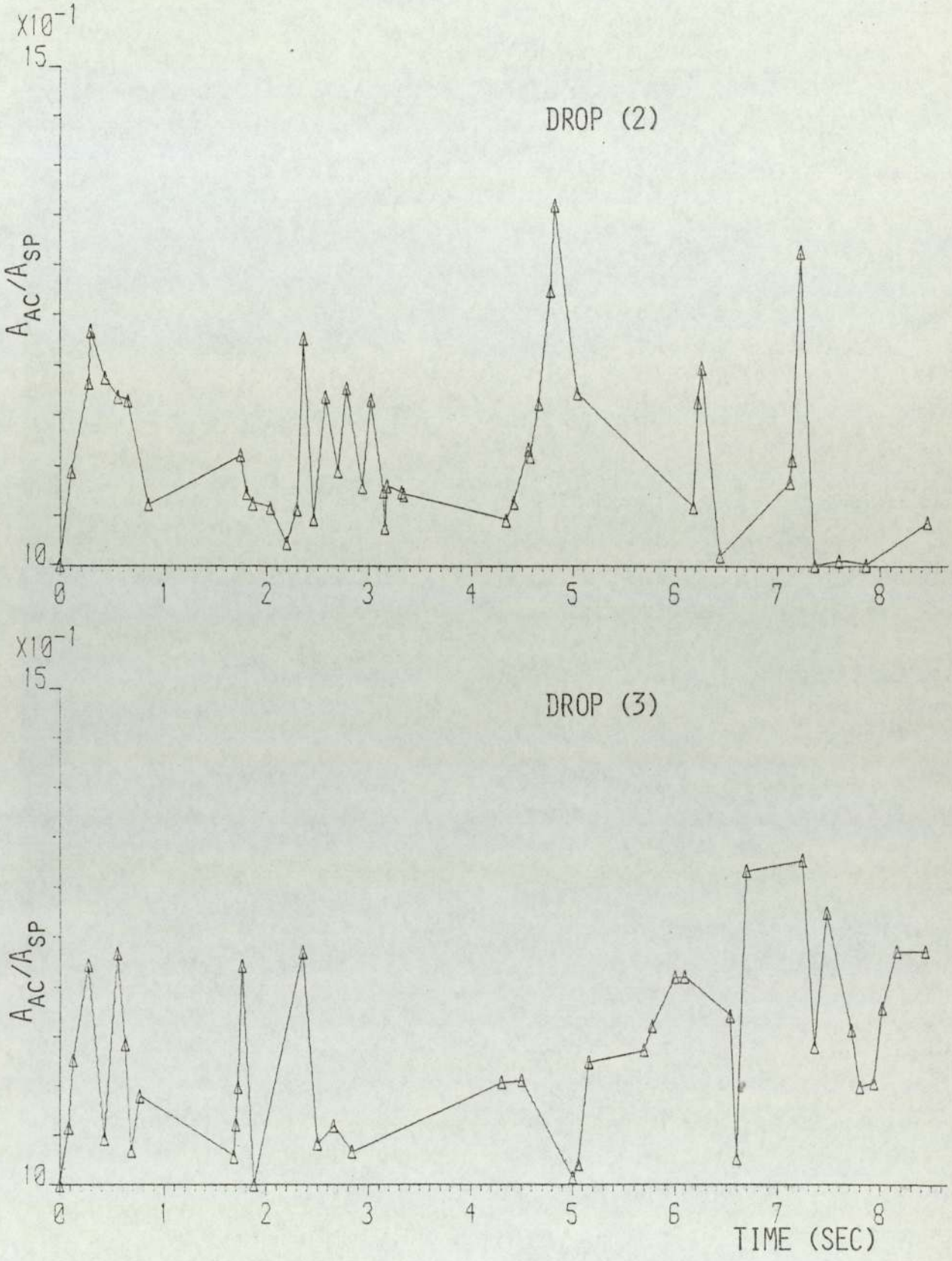

FIG.H.130 AREA RATIO VS. TIME, RUN-28.

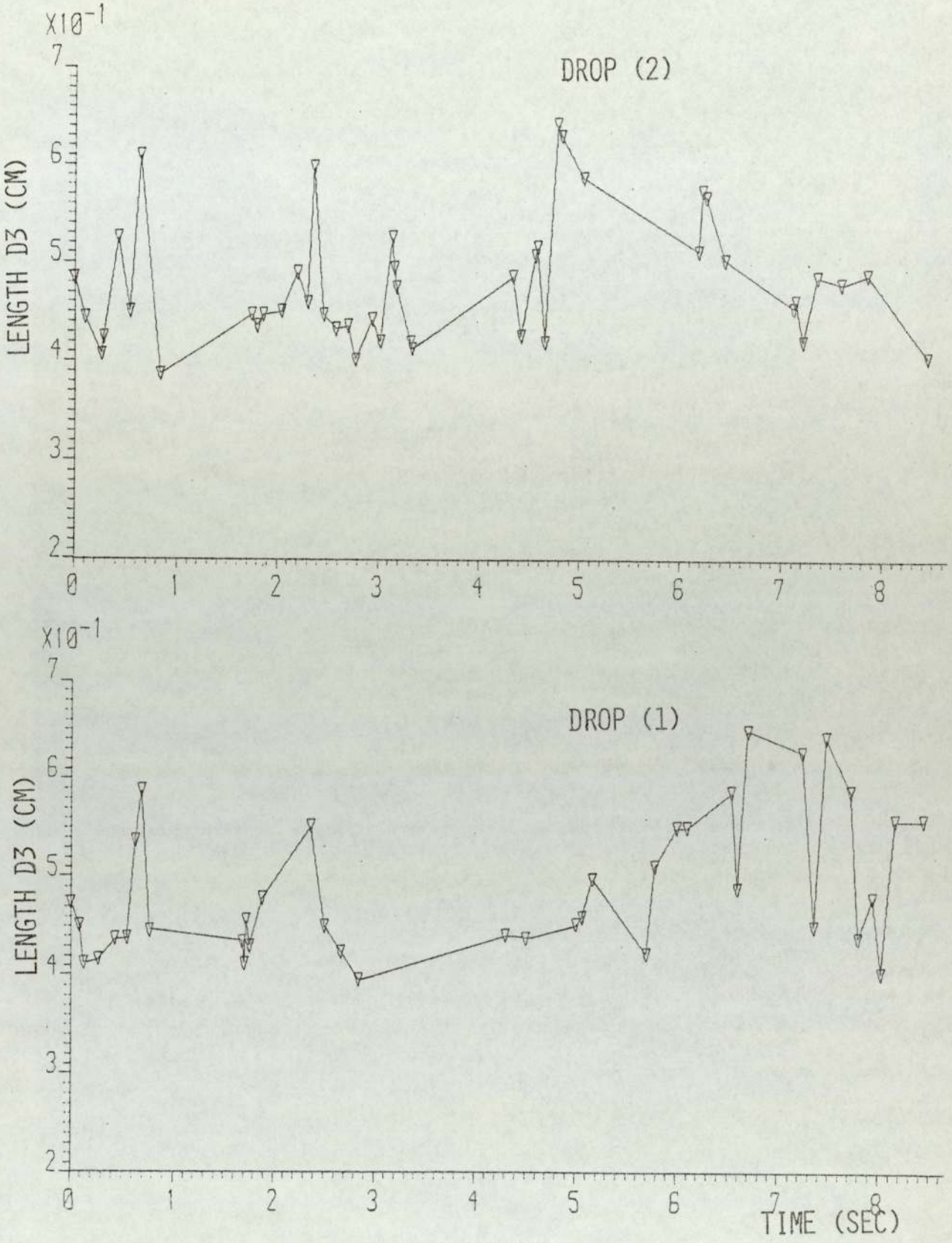

FIG.H.131 LENGTH D3 VS. TIME, RUN-28.

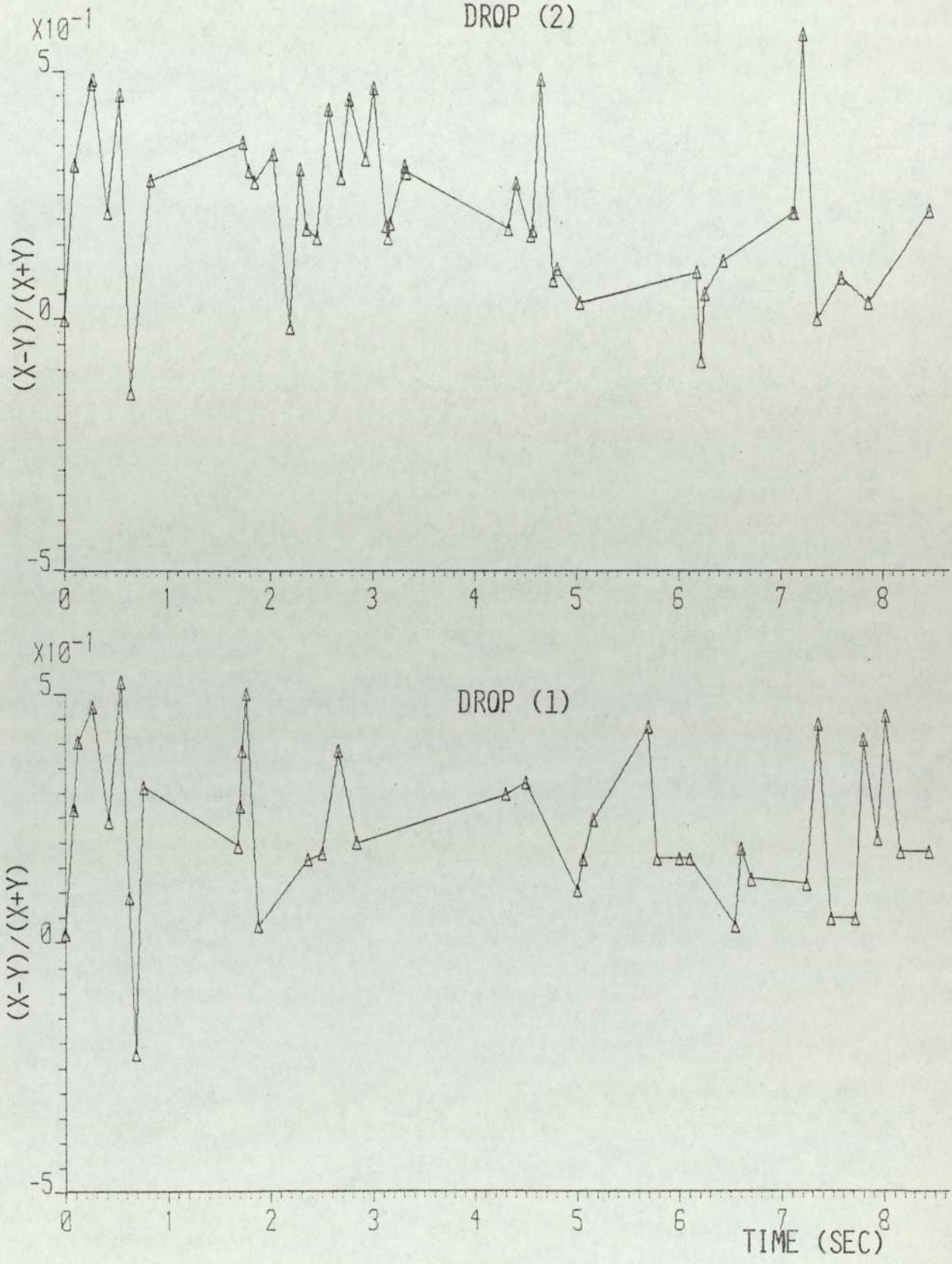

FIG. H.132 DEFORMATION RATIO VS. TIME, RUN-28.

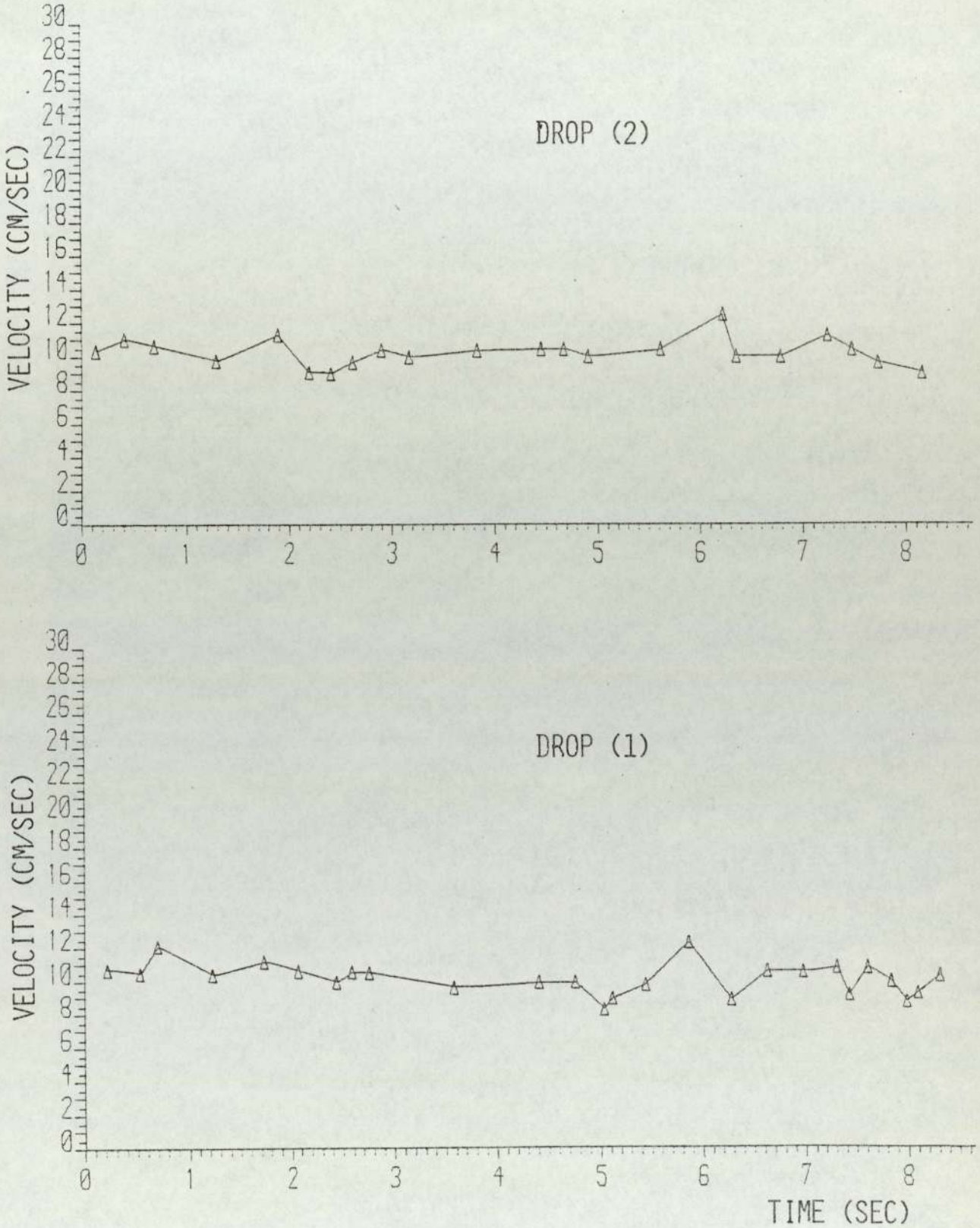

FIG.H.133 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-28.

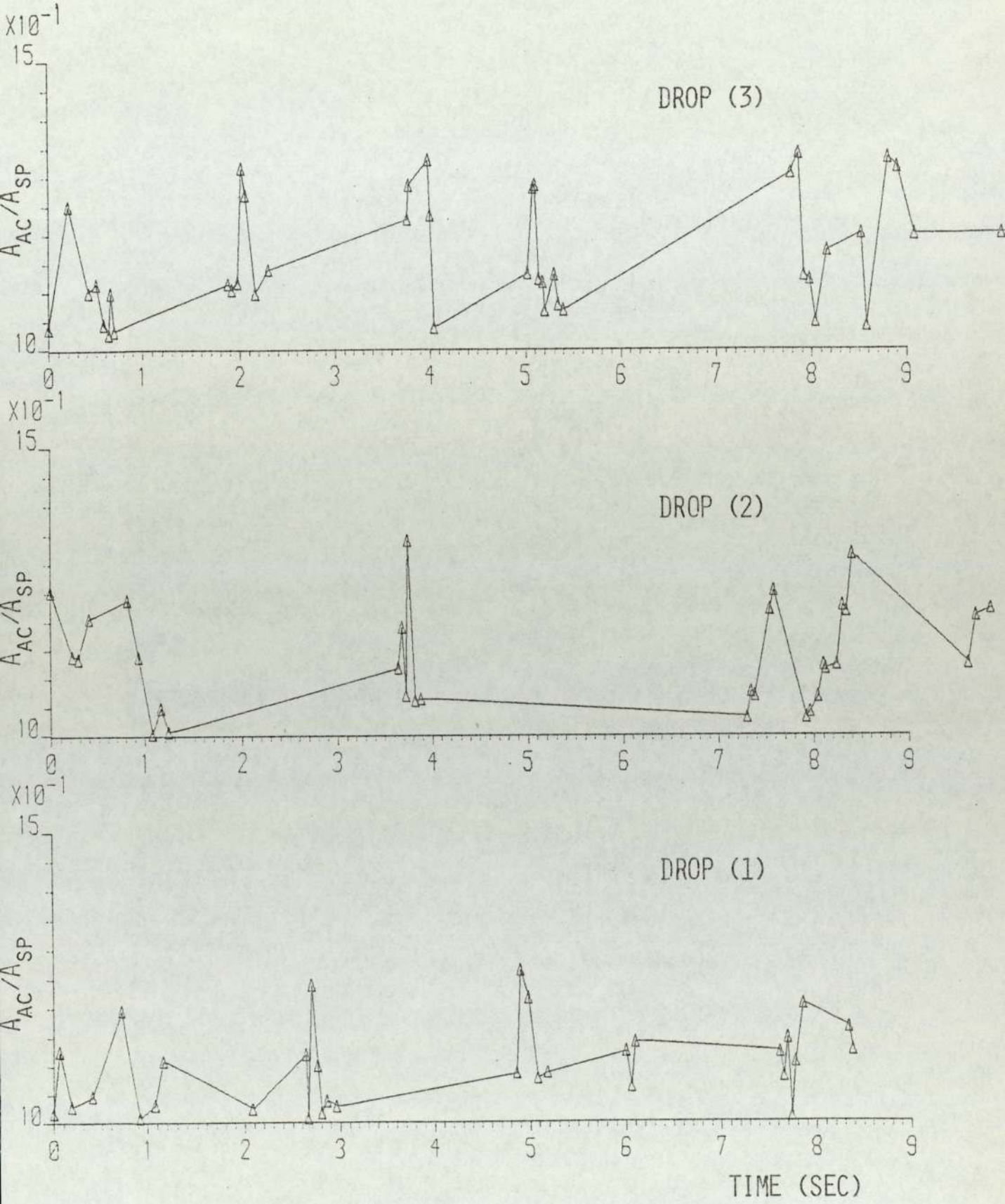

FIG.H.134 AREA RATIO VS. TIME, RUN-57.

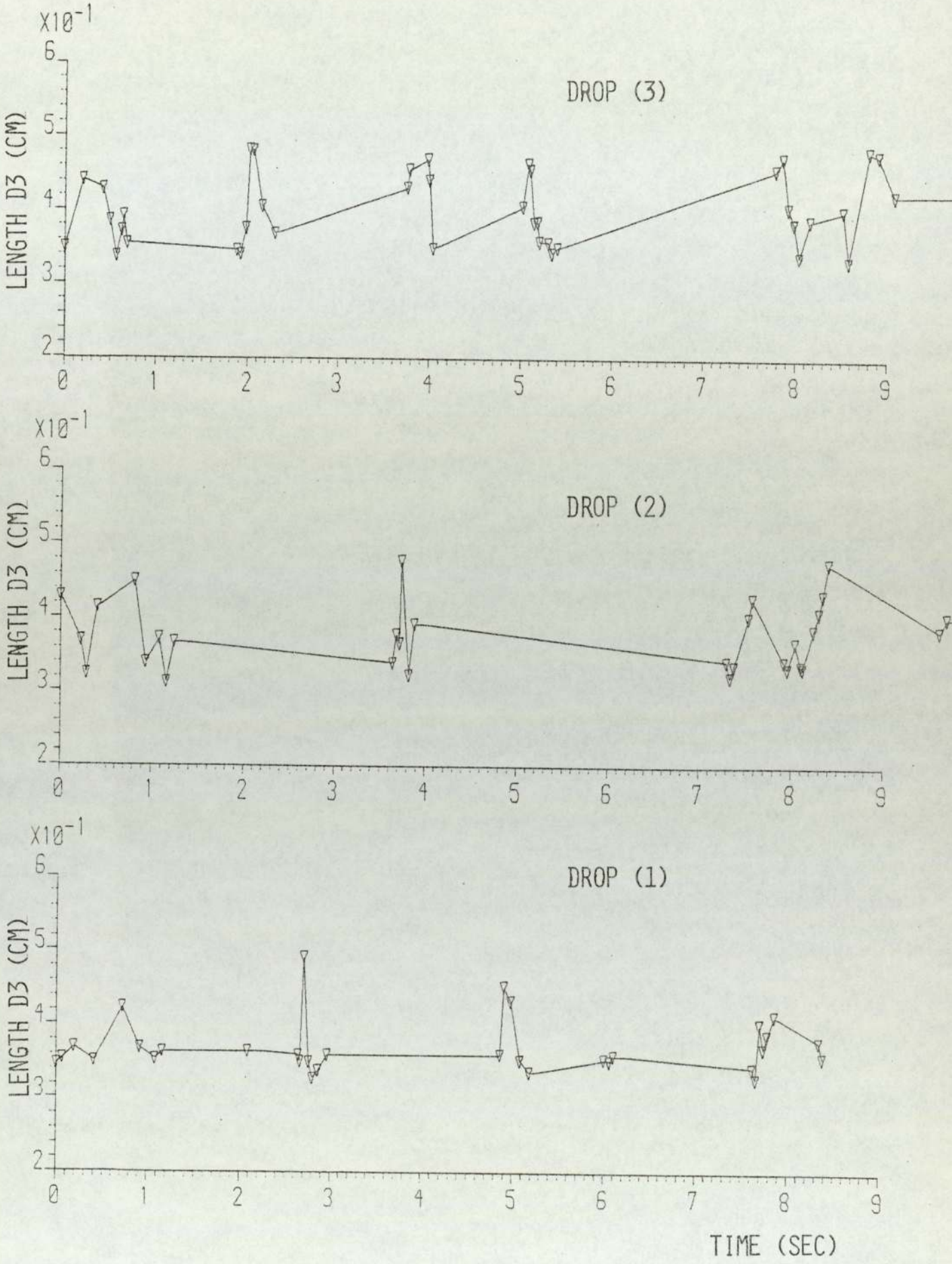

FIG.H.135 LENGTH D3 VS. TIME, RUN-57.

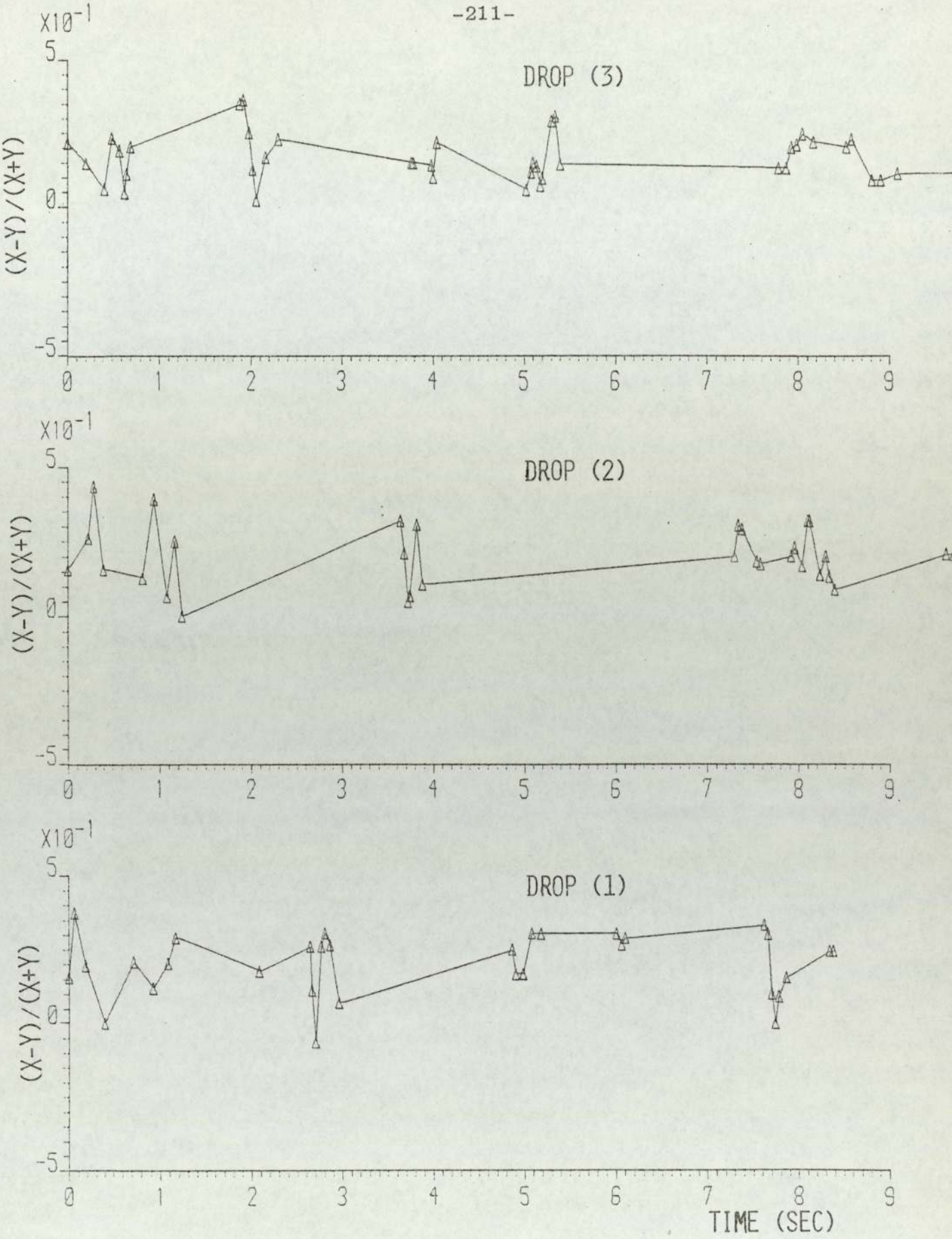

FIG.H.136 DEFORMATION RATIO VS. TIME, RUN-57.

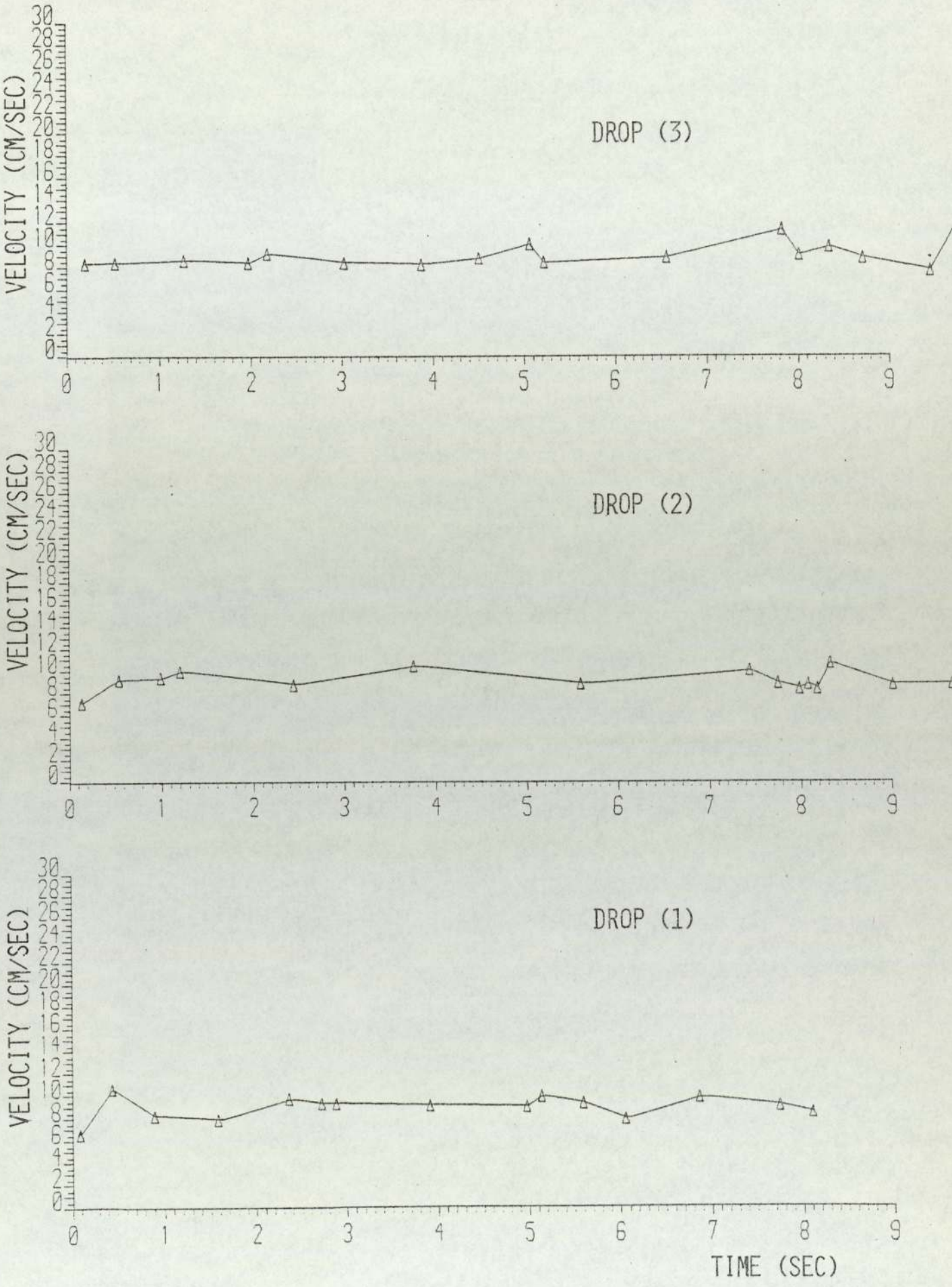

FIG.H.137 INSTANTANEOUS VELOCITY VS. AVERAGE TIME, RUN-57.

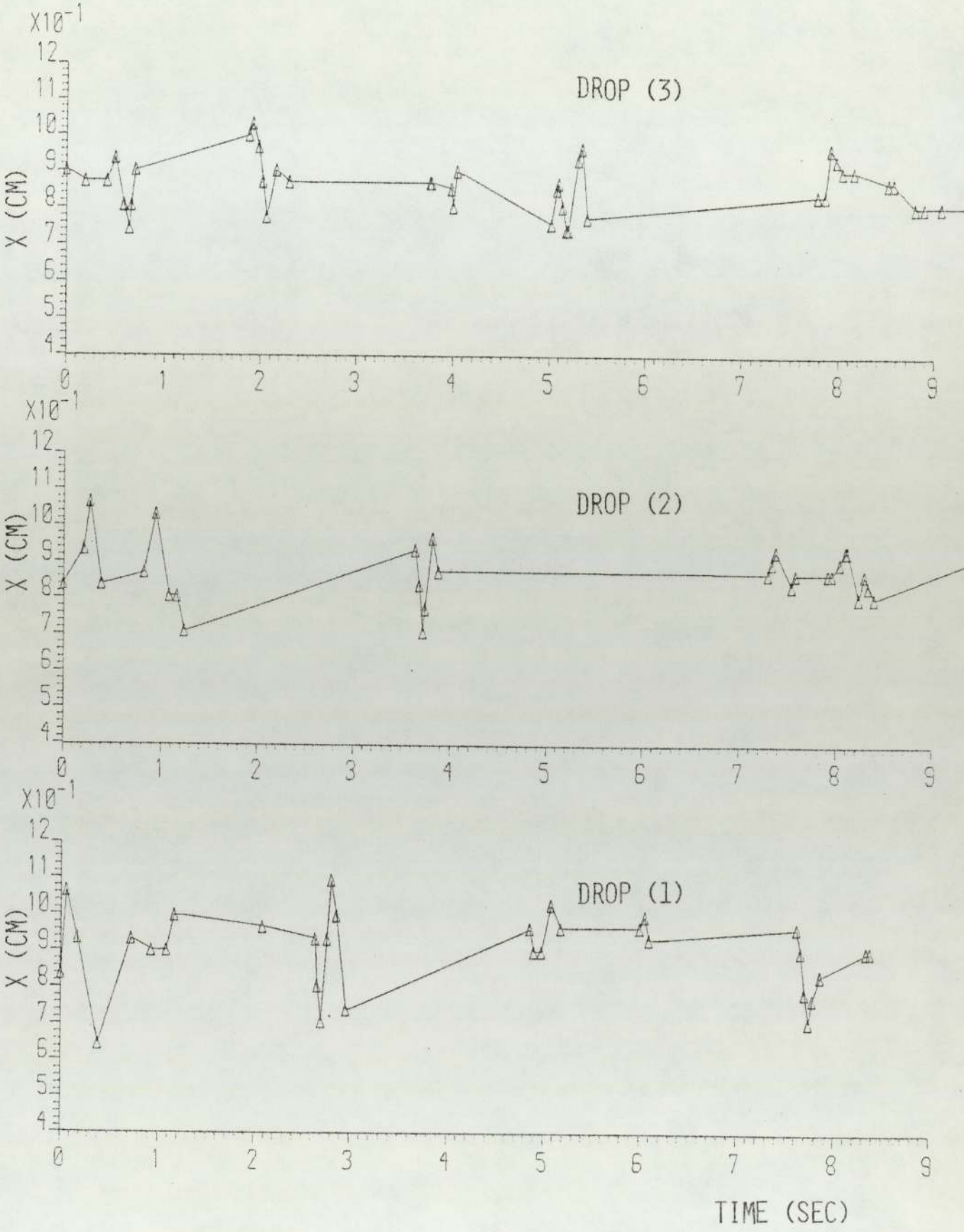

FIG.H.138 X VS. TIME, RUN-57.

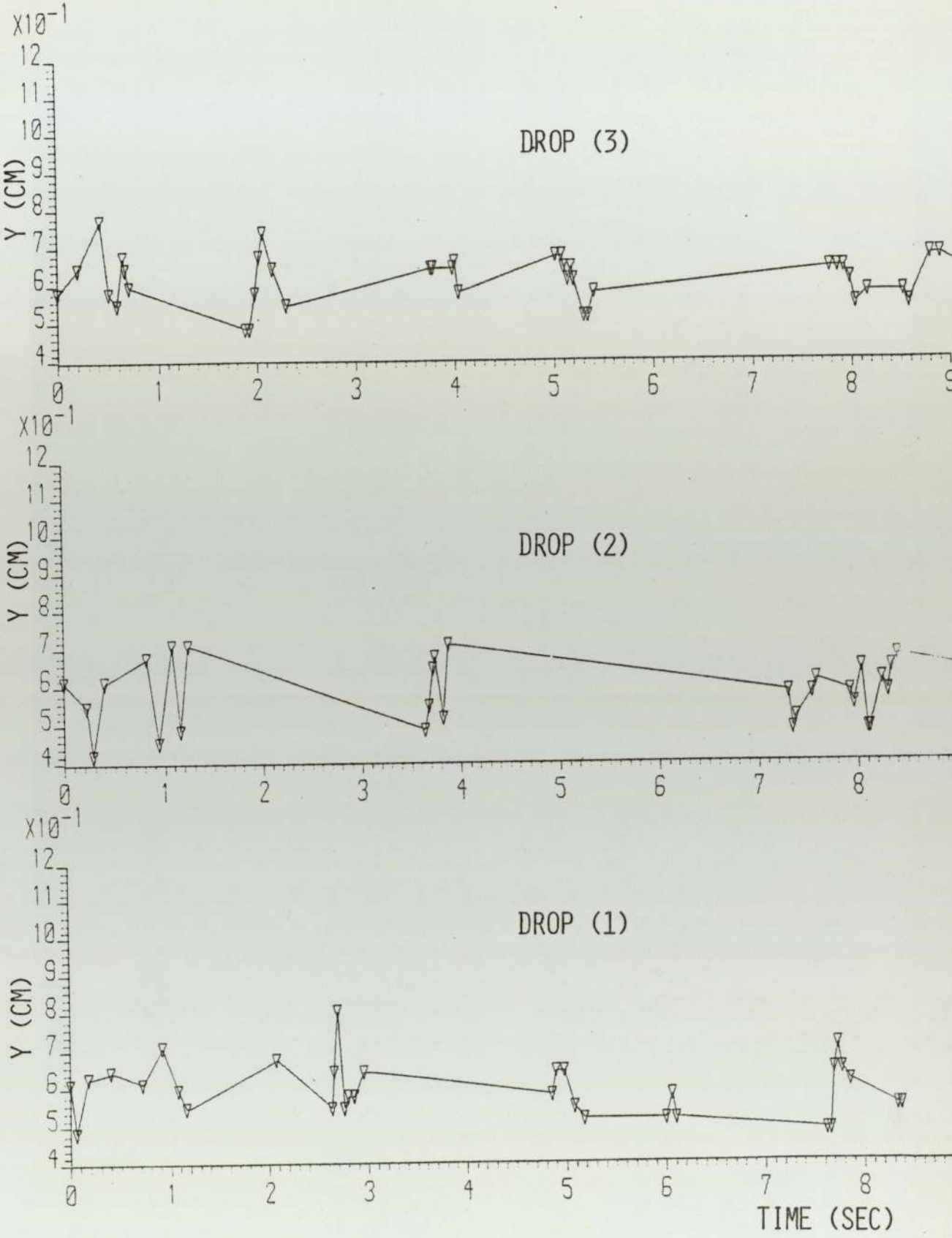

FIG. H.139 Y VS. TIME, RUN-57.

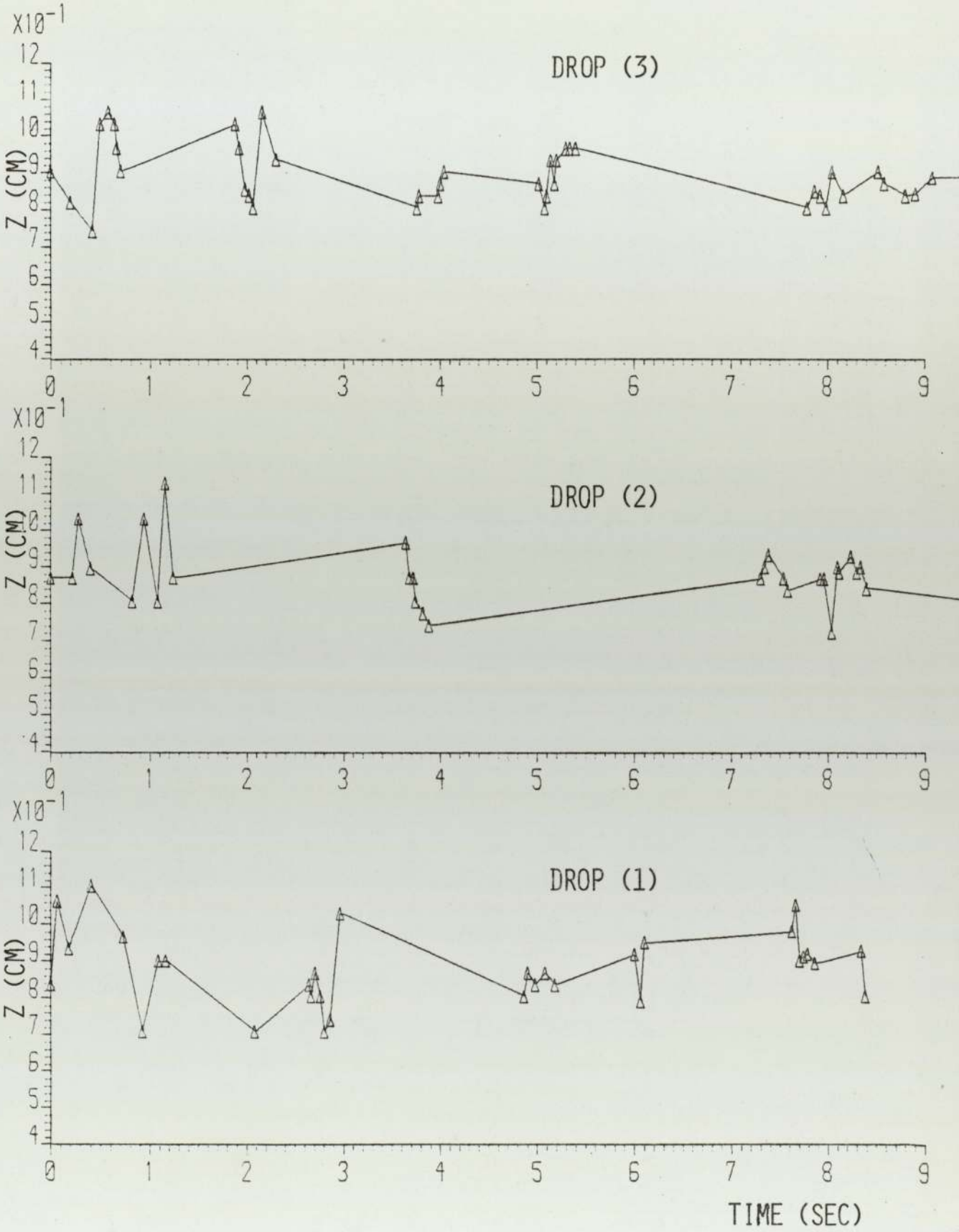

FIG. H.140 Z VS. TIME, RUN-57.

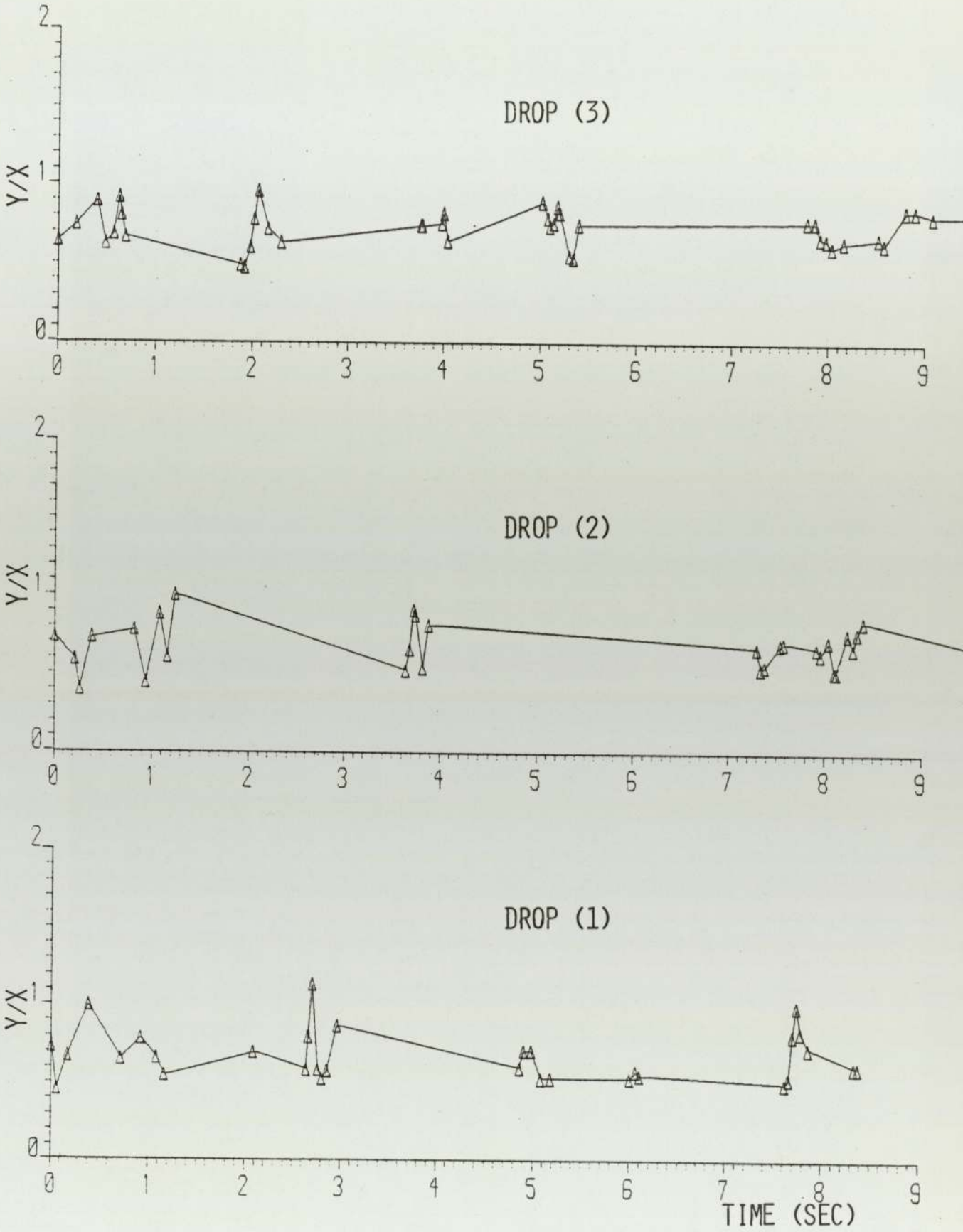

FIG. H.141 AXES RATIO VS. TIME, RUN-57.

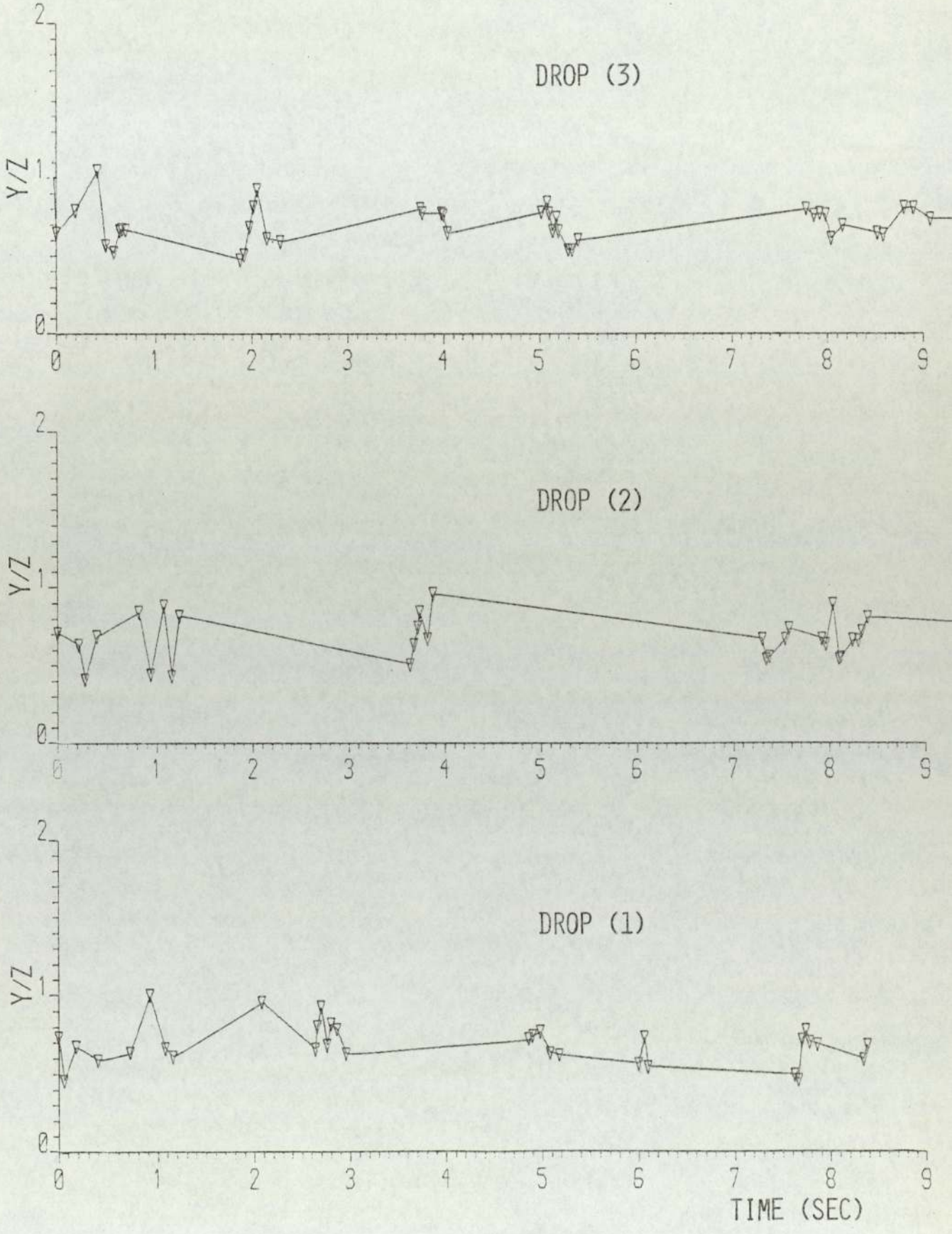

FIG.H.142 AXES RATIO VS. TIME, RUN-57.

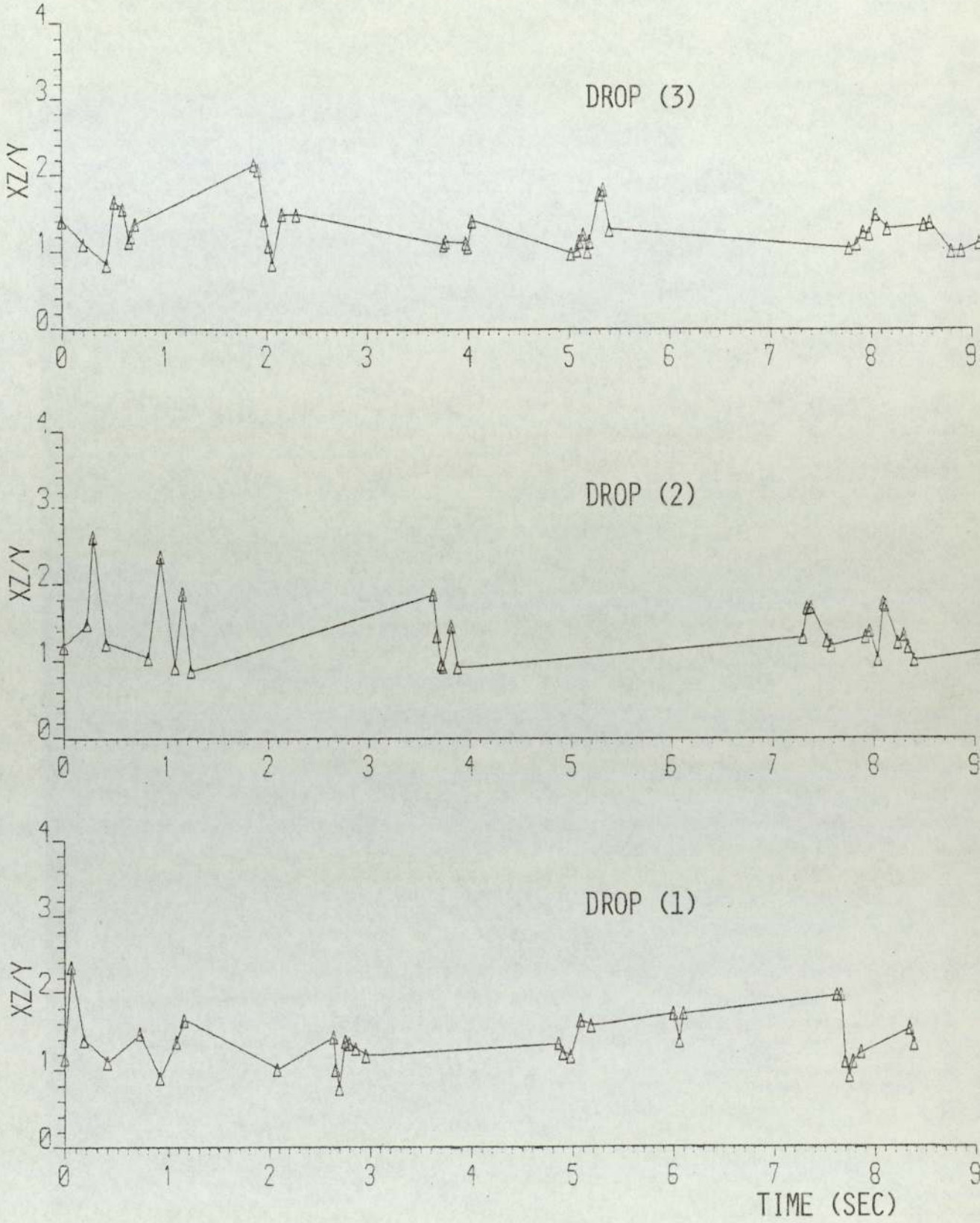

FIG. H.143 AXES RATIO VS. TIME, RUN-57.

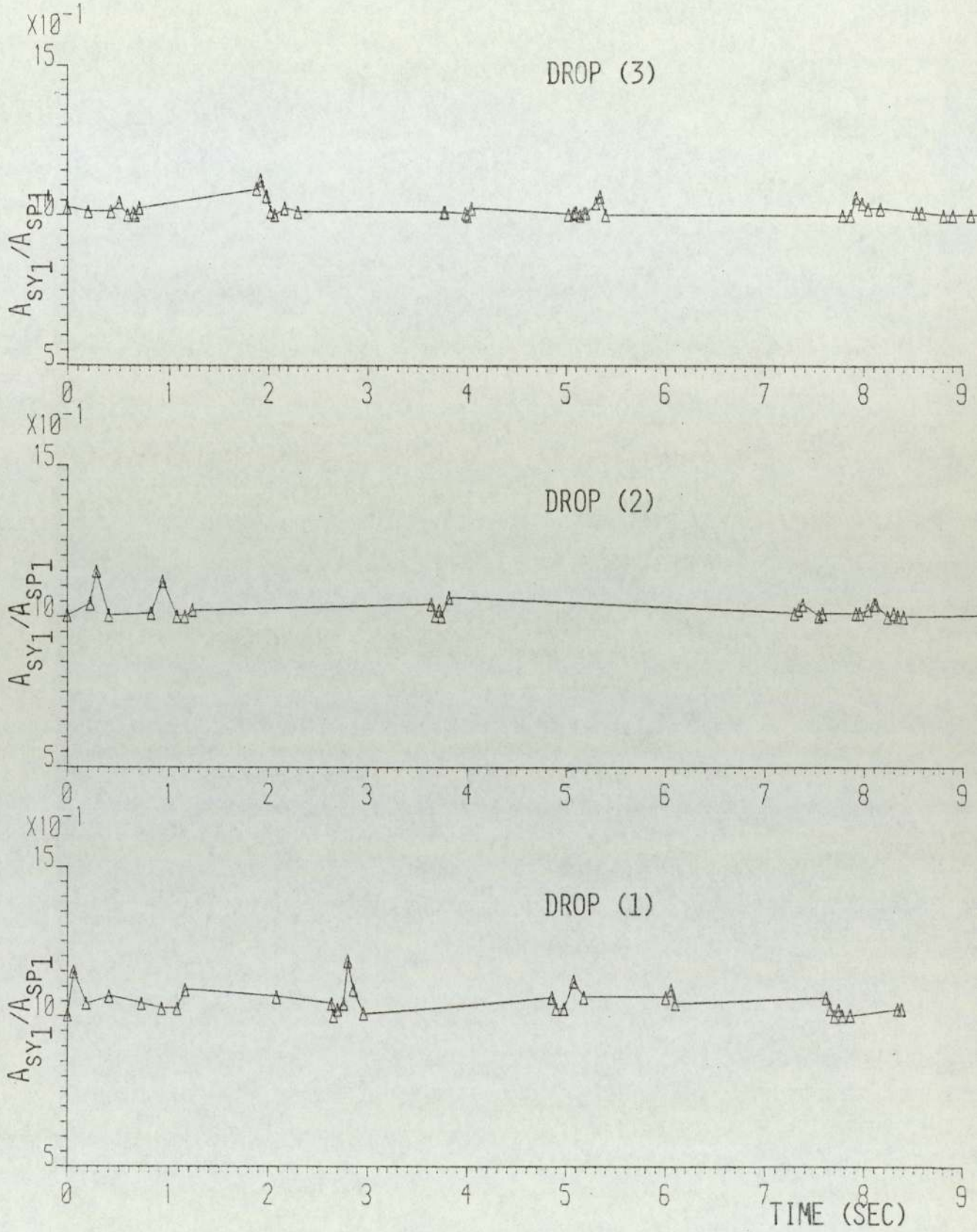

FIG. H.144 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-57, BASED ON DISPLACED VOLUME.

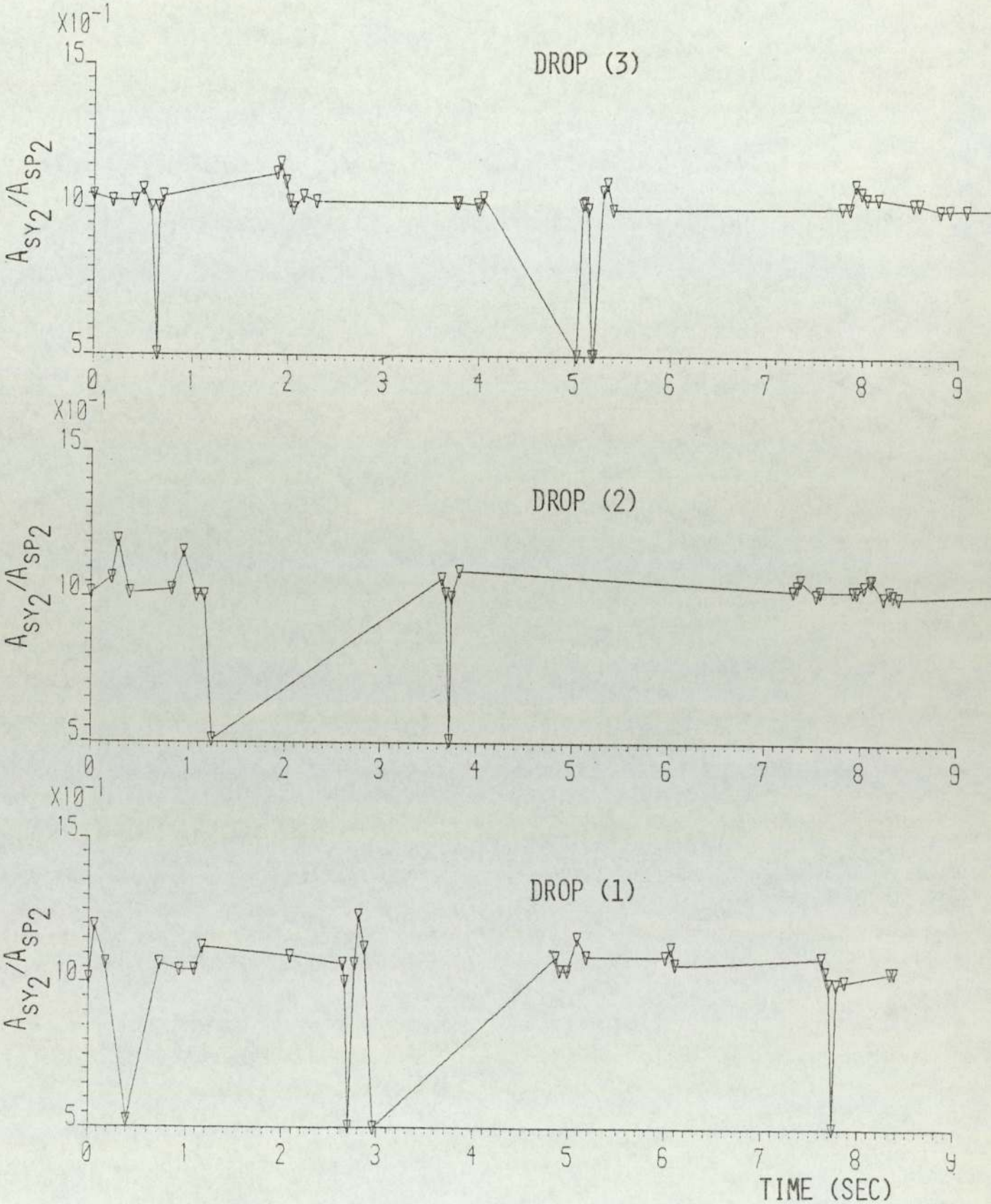

FIG. H.145 SYMMETRICAL SPHEROID AREA RATIO VS. TIME, RUN-57, BASED ON MEAN VOLUME.

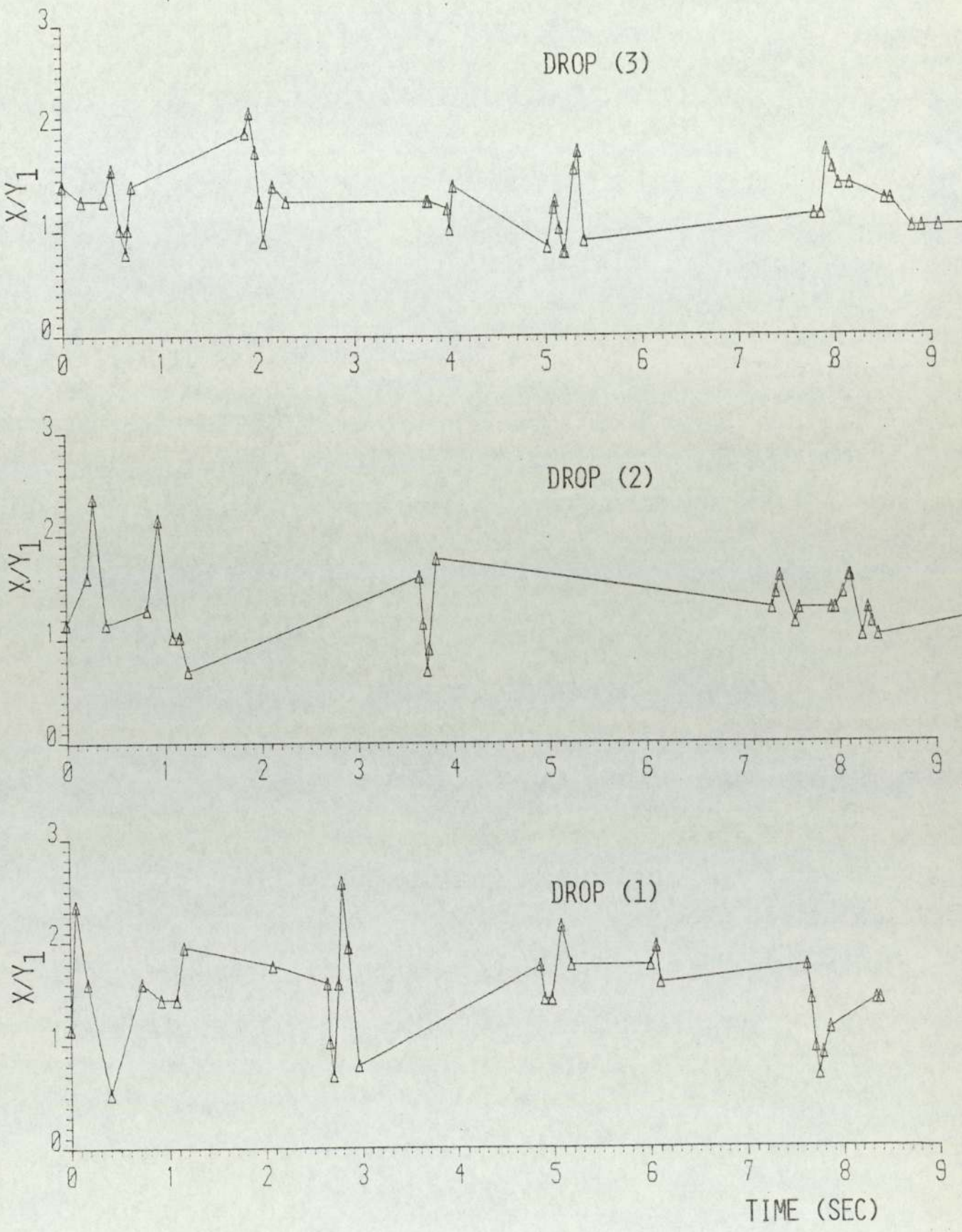

FIG. H.146 AXES RATIO VS. TIME, RUN-57.

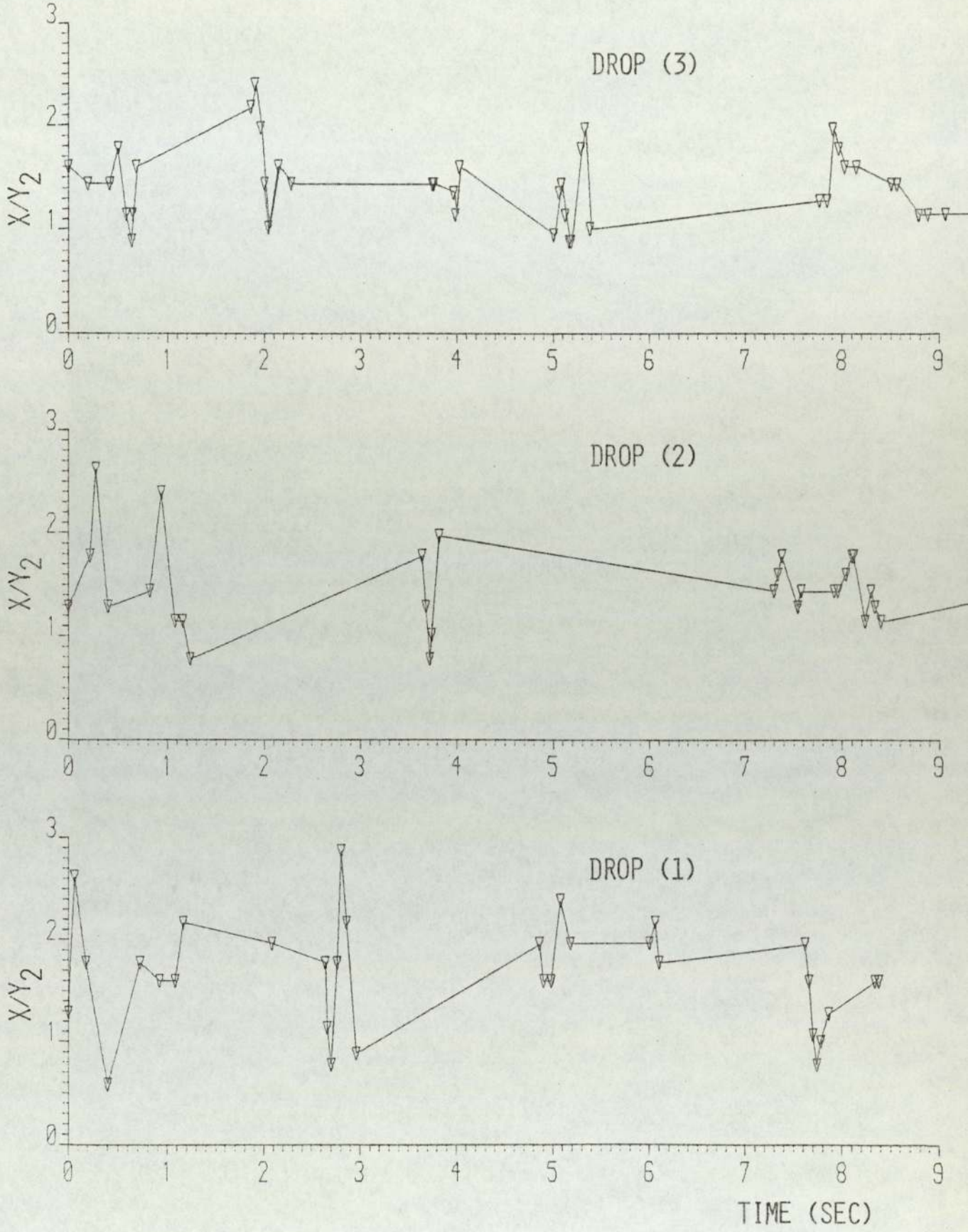

FIG. H.147 AXES RATIO VS. TIME, RUN-57.

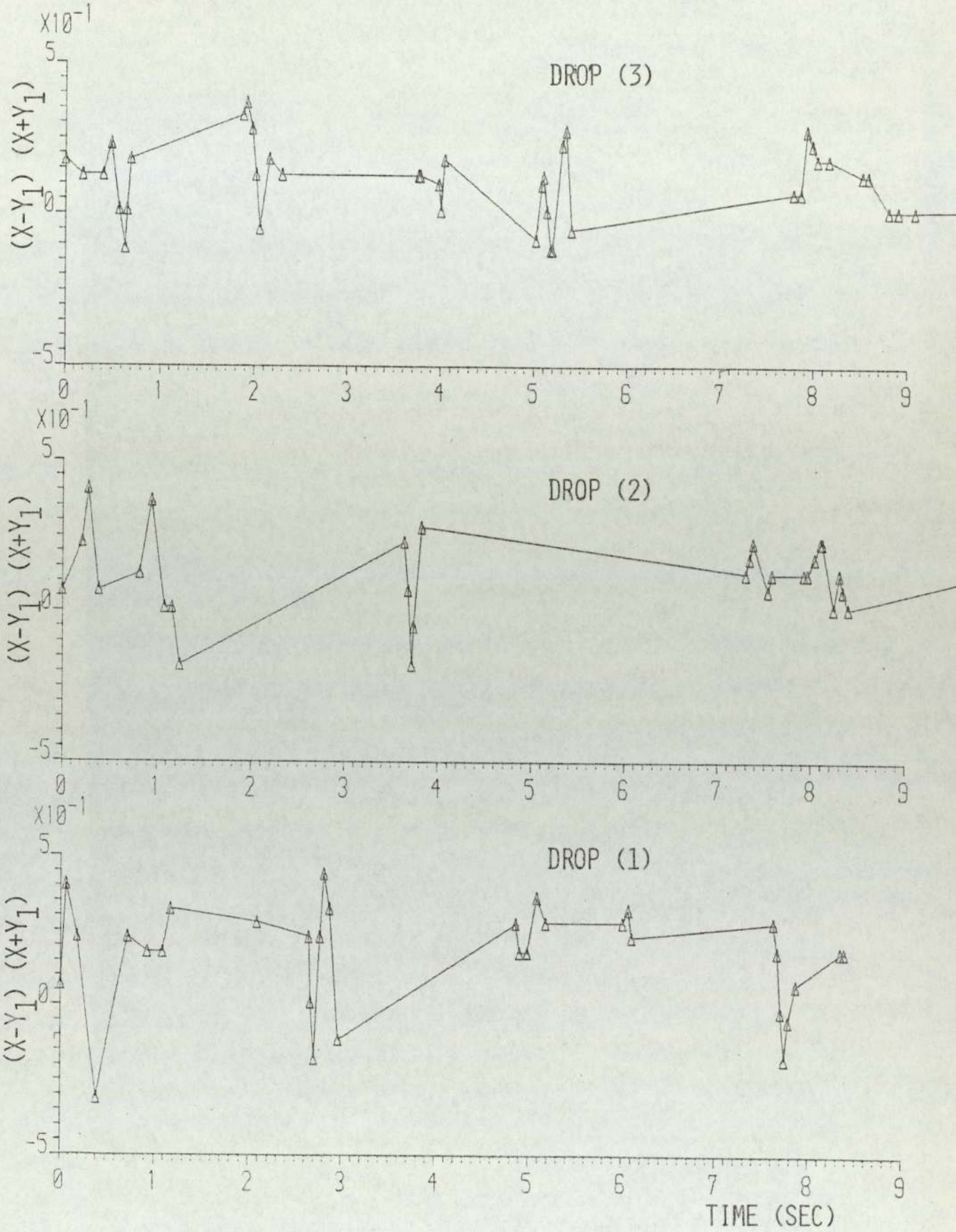

FIG. H.148 DEFORMATION RATIO VS. TIME, RUN-57.

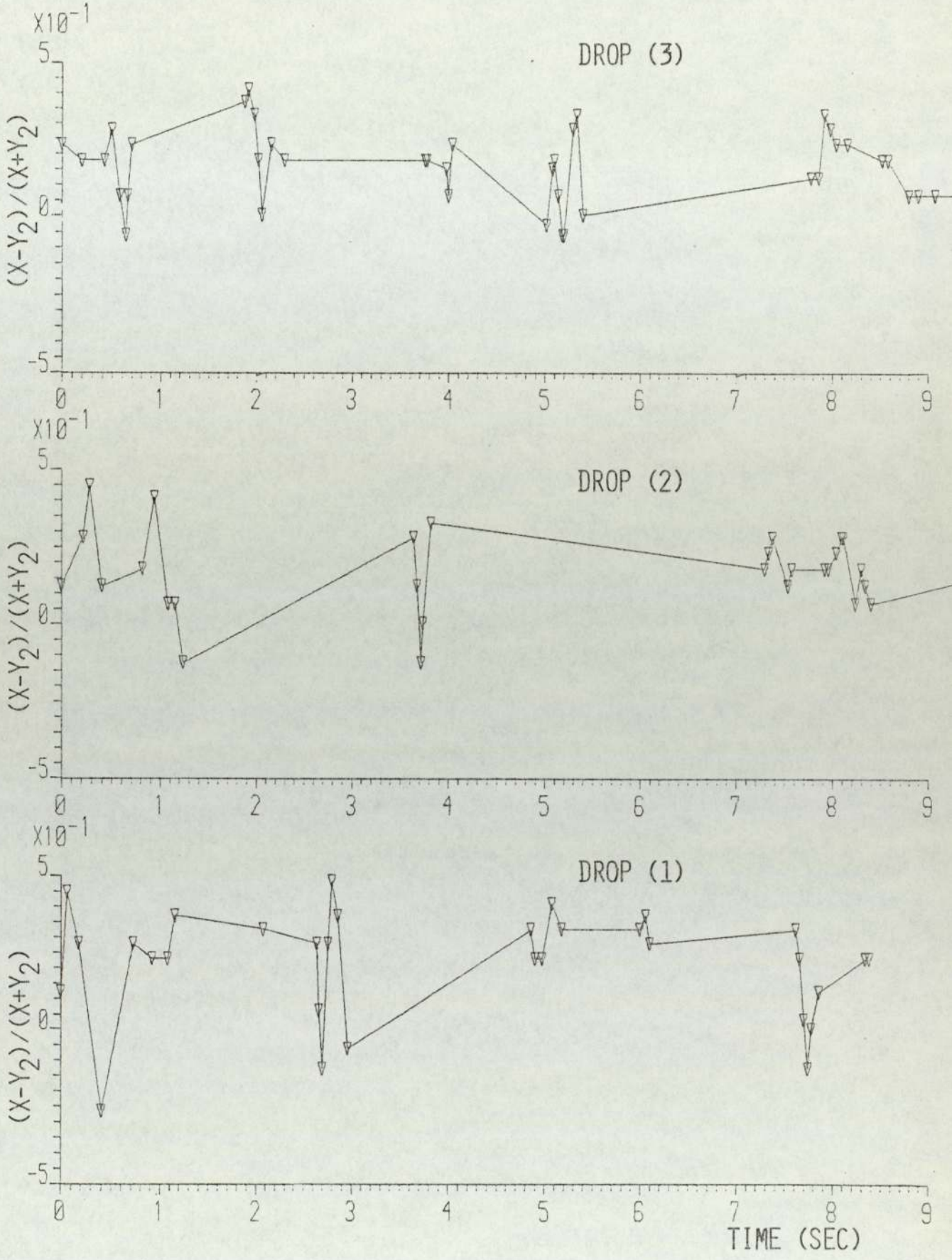

FIG. H.149 DEFORMATION RATIO VS. TIME, RUN-57.

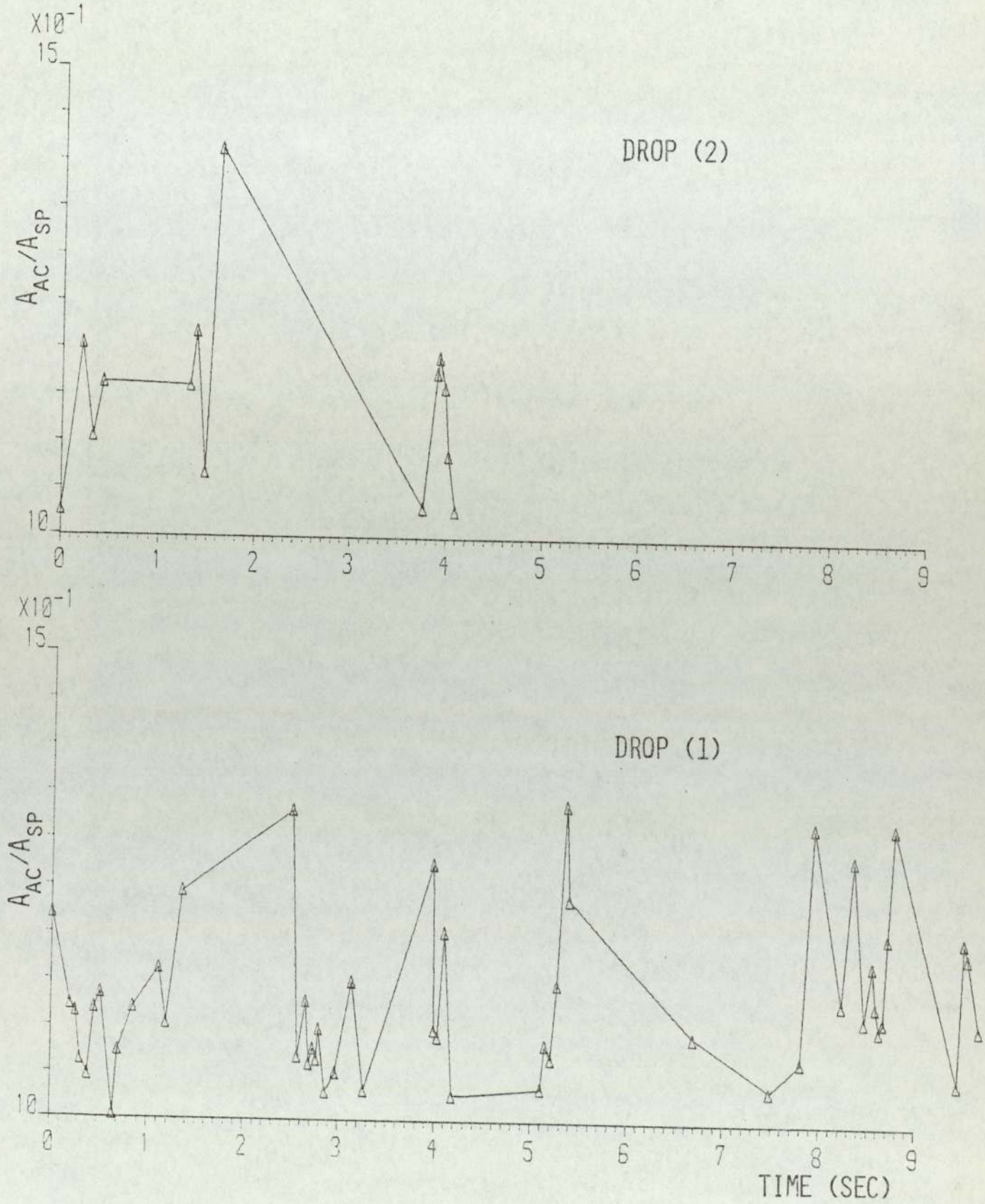

FIG. H.150 AREA RATIO VS. TIME, RUN-58.

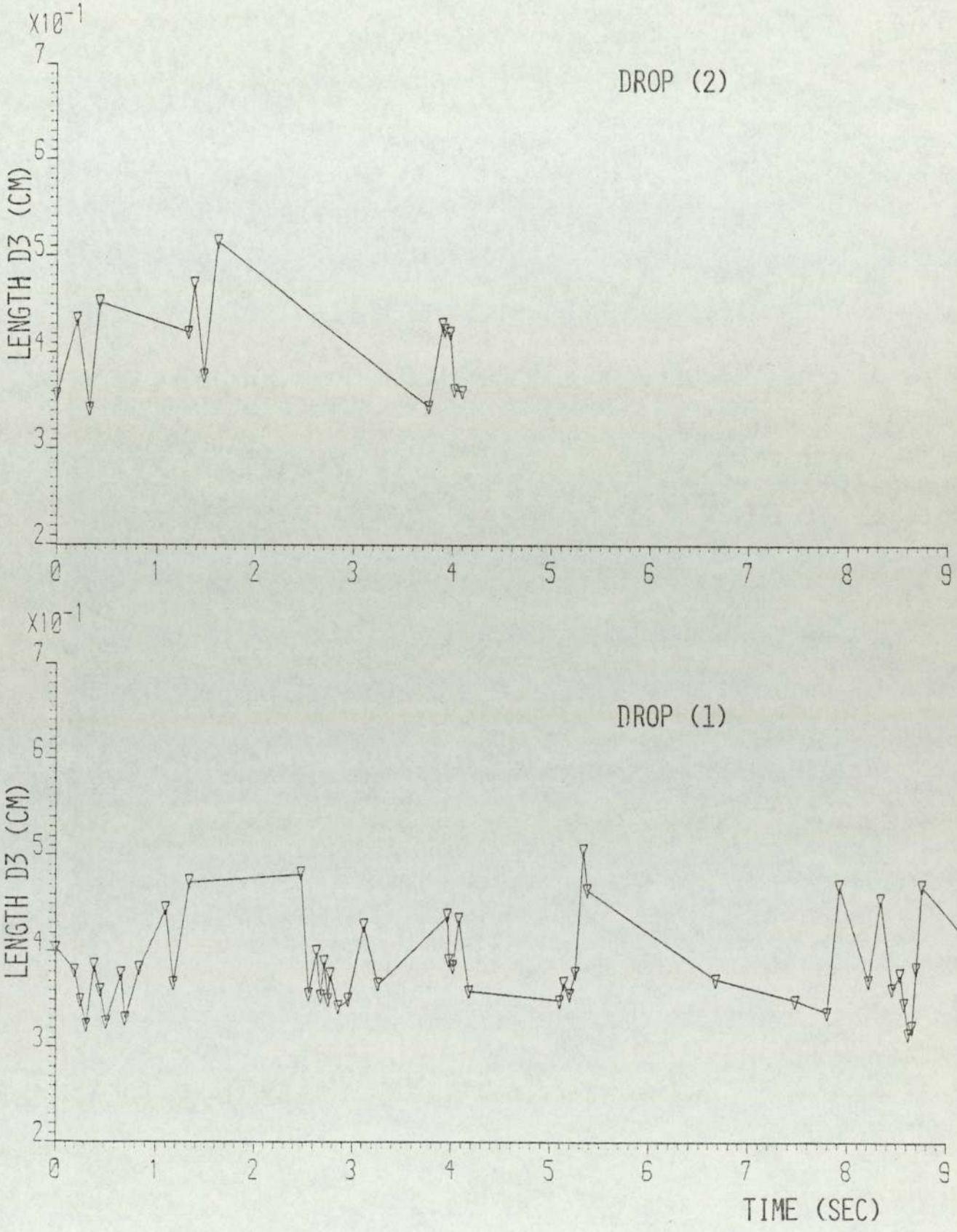

FIG. H.151 LENGTH D3 VS. TIME, RUN-58.

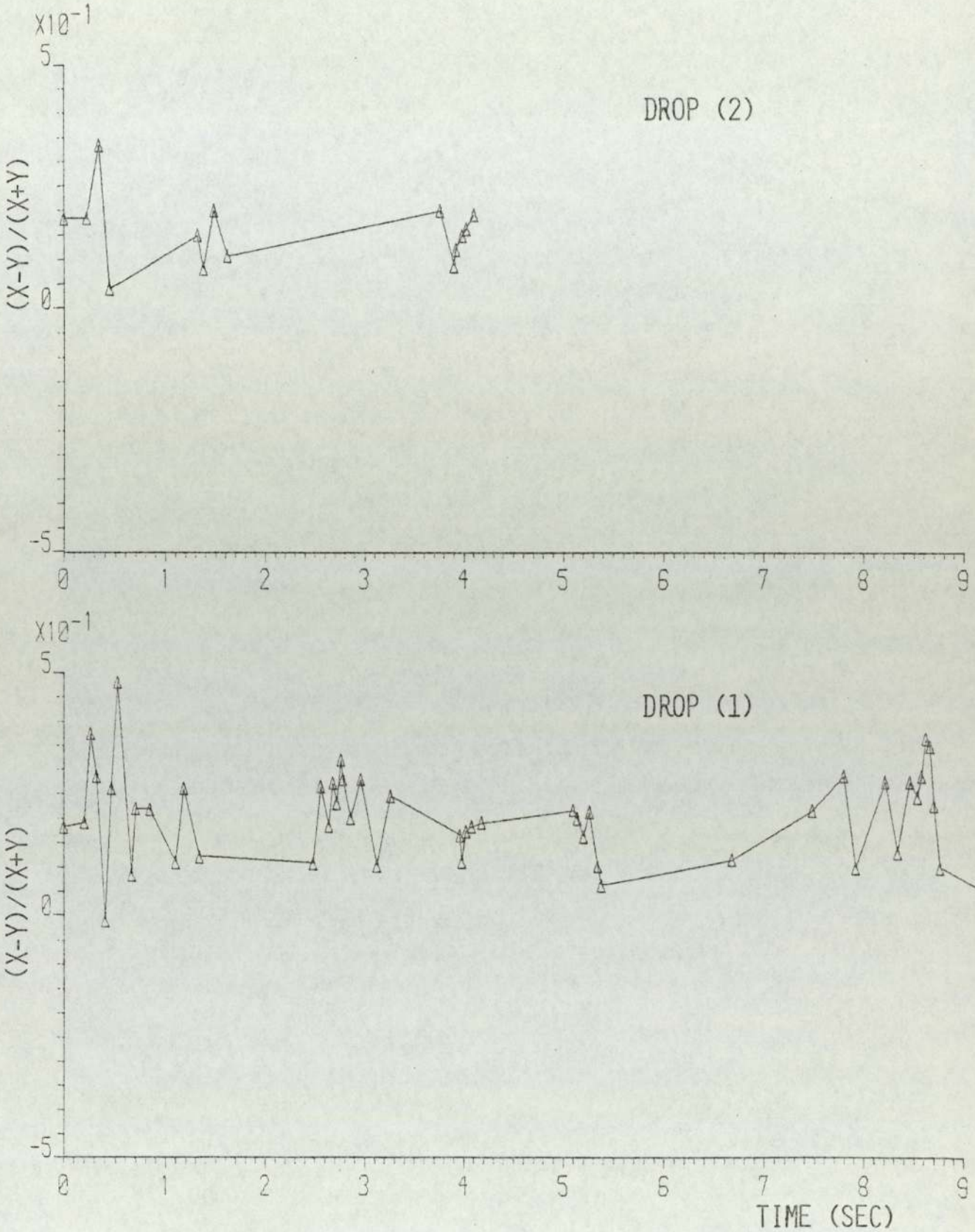

FIG.H.152 DEFORMATION RATIO VS. TIME, RUN-58.

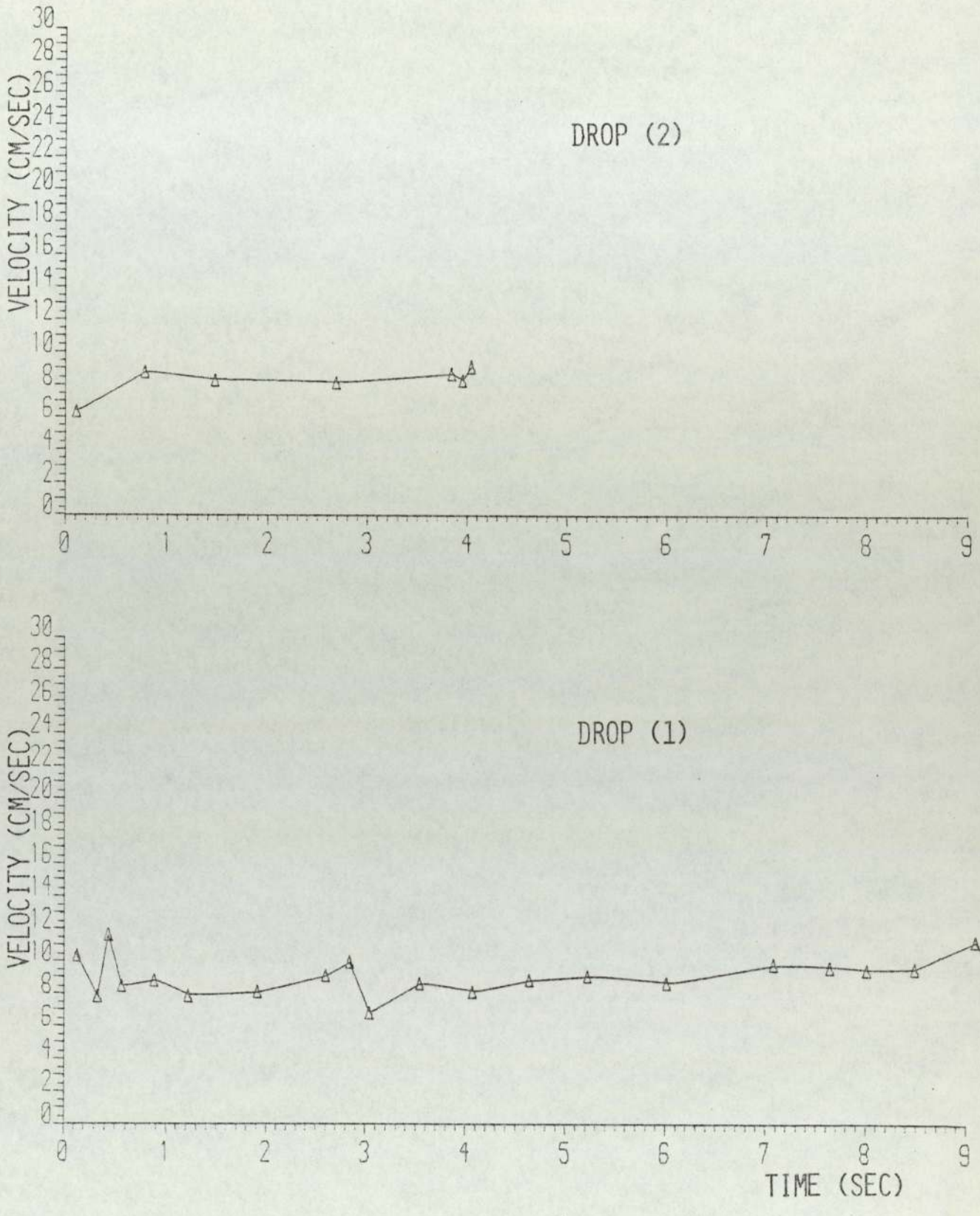

FIG. H.153 INSTANTANEOUS VELOCITY VS. AVERAGE PERIOD TIME, RUN-58.

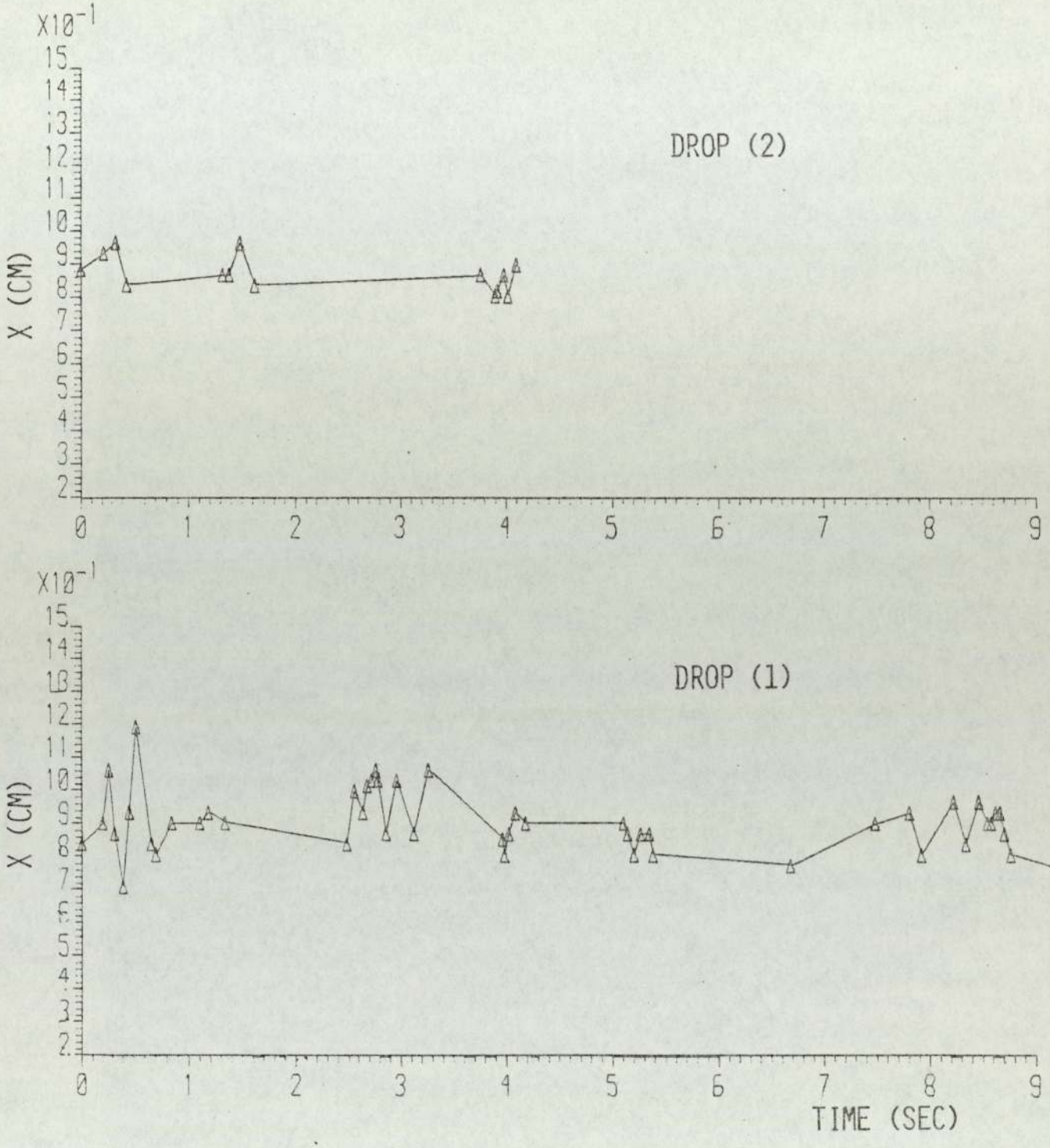

FIG. H.154 X VS. TIME, RUN-58.

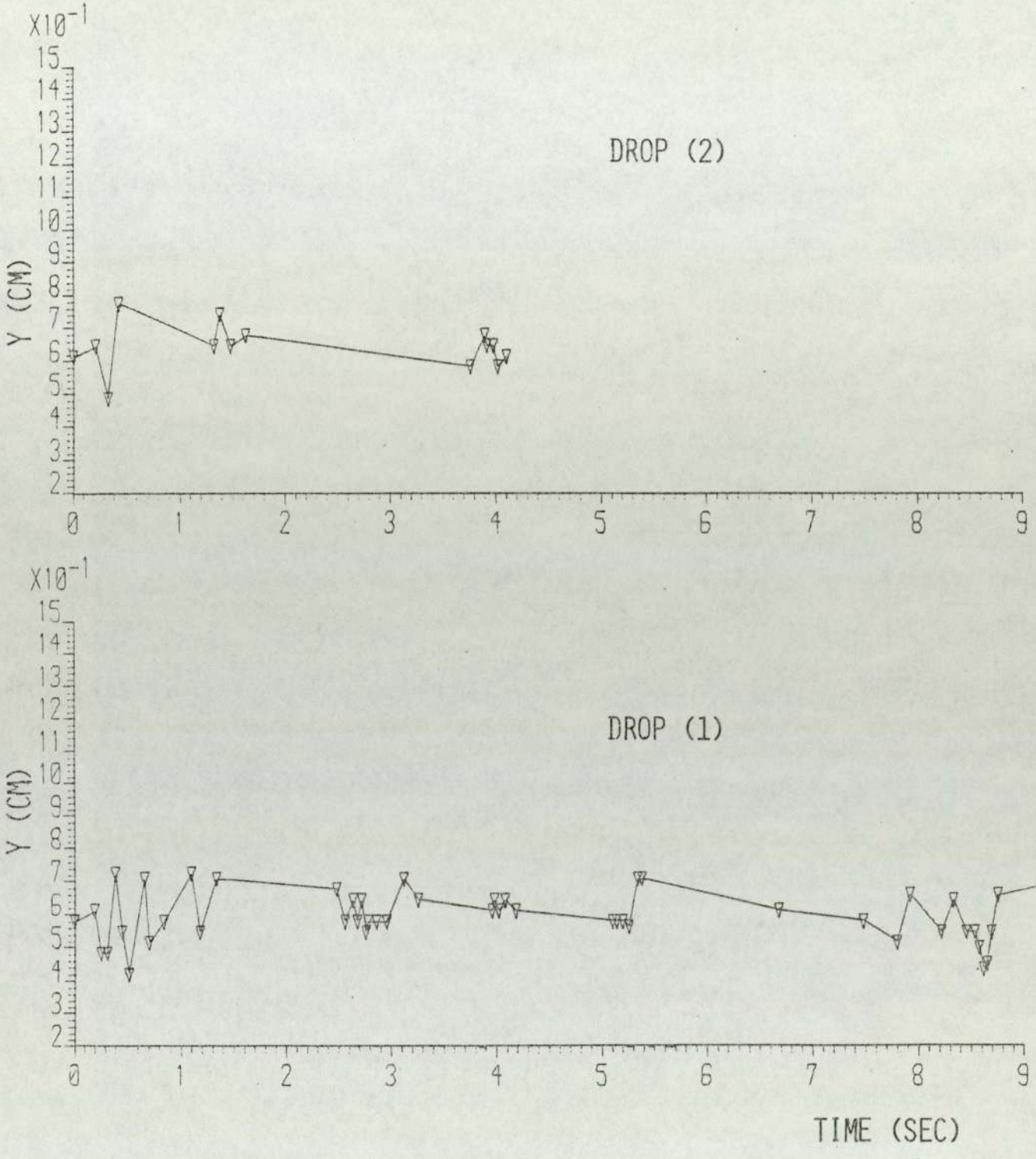

FIG. H.155 Y VS. TIME, RUN-58.

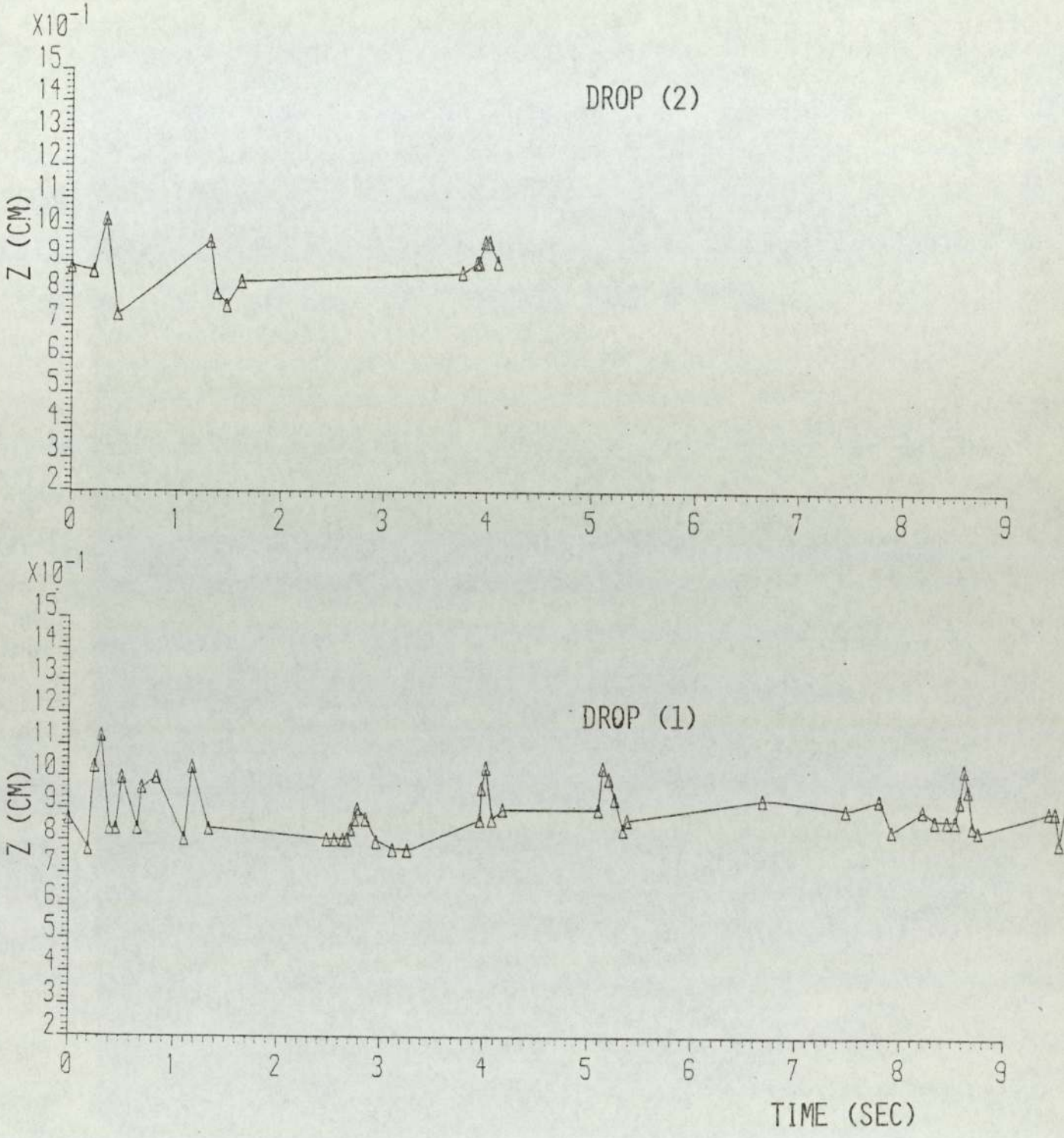

FIG. H.156 Z VS. TIME, RUN-58.

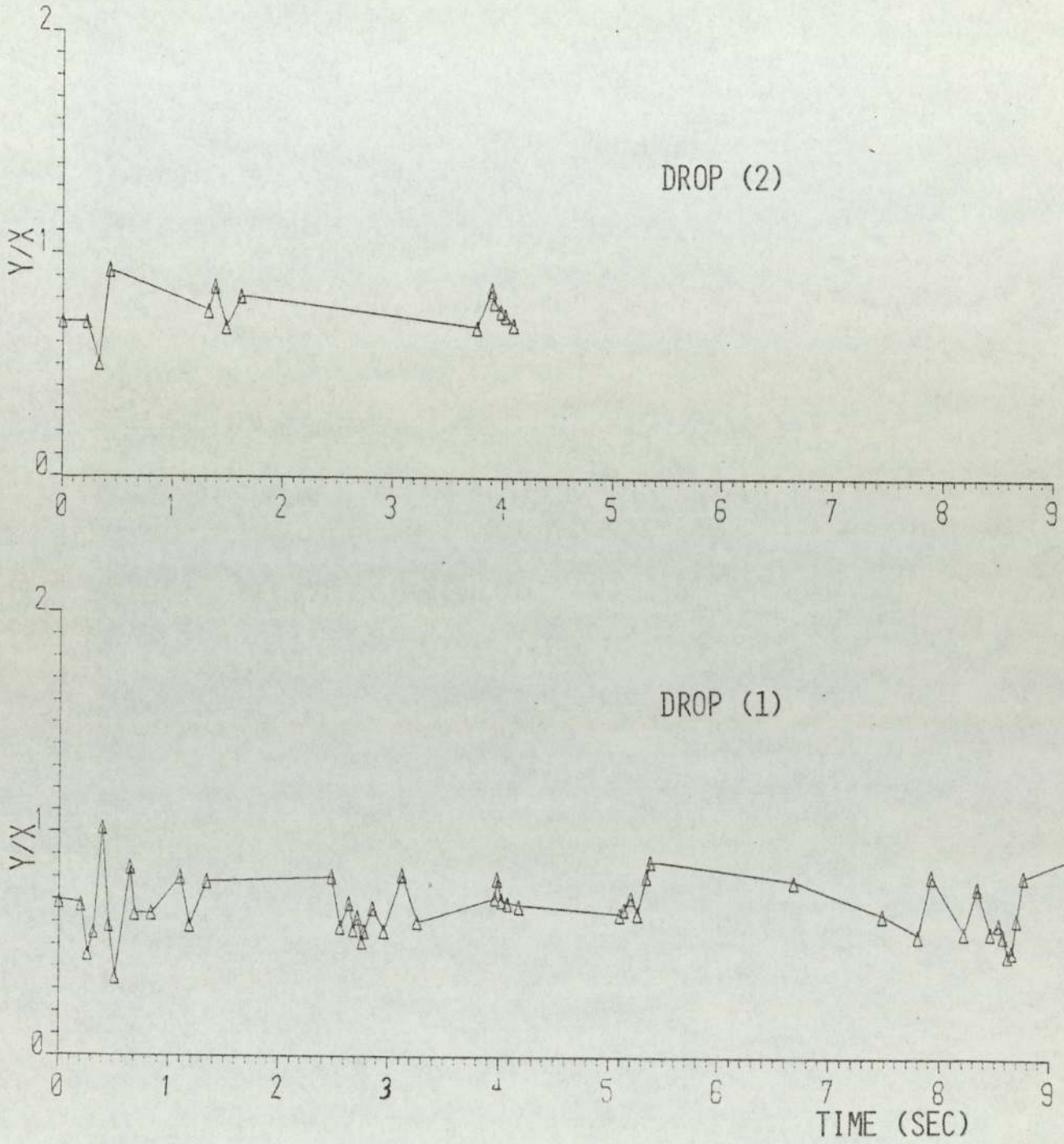

FIG. H.157 AXES RATIO VS. TIME, RUN-58.

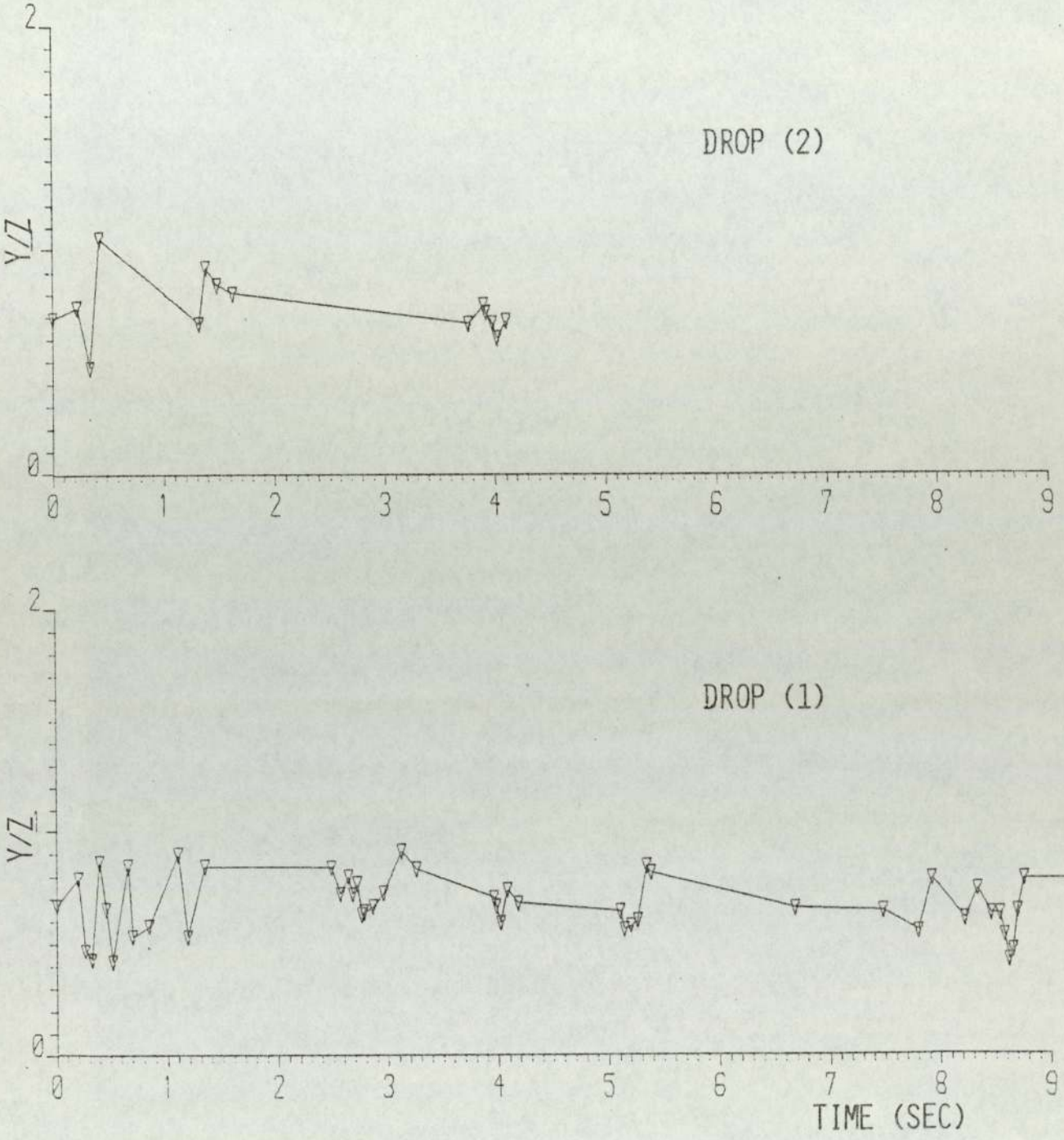

FIG.H.158 AXES RATIO VS. TIME, RUN-58.

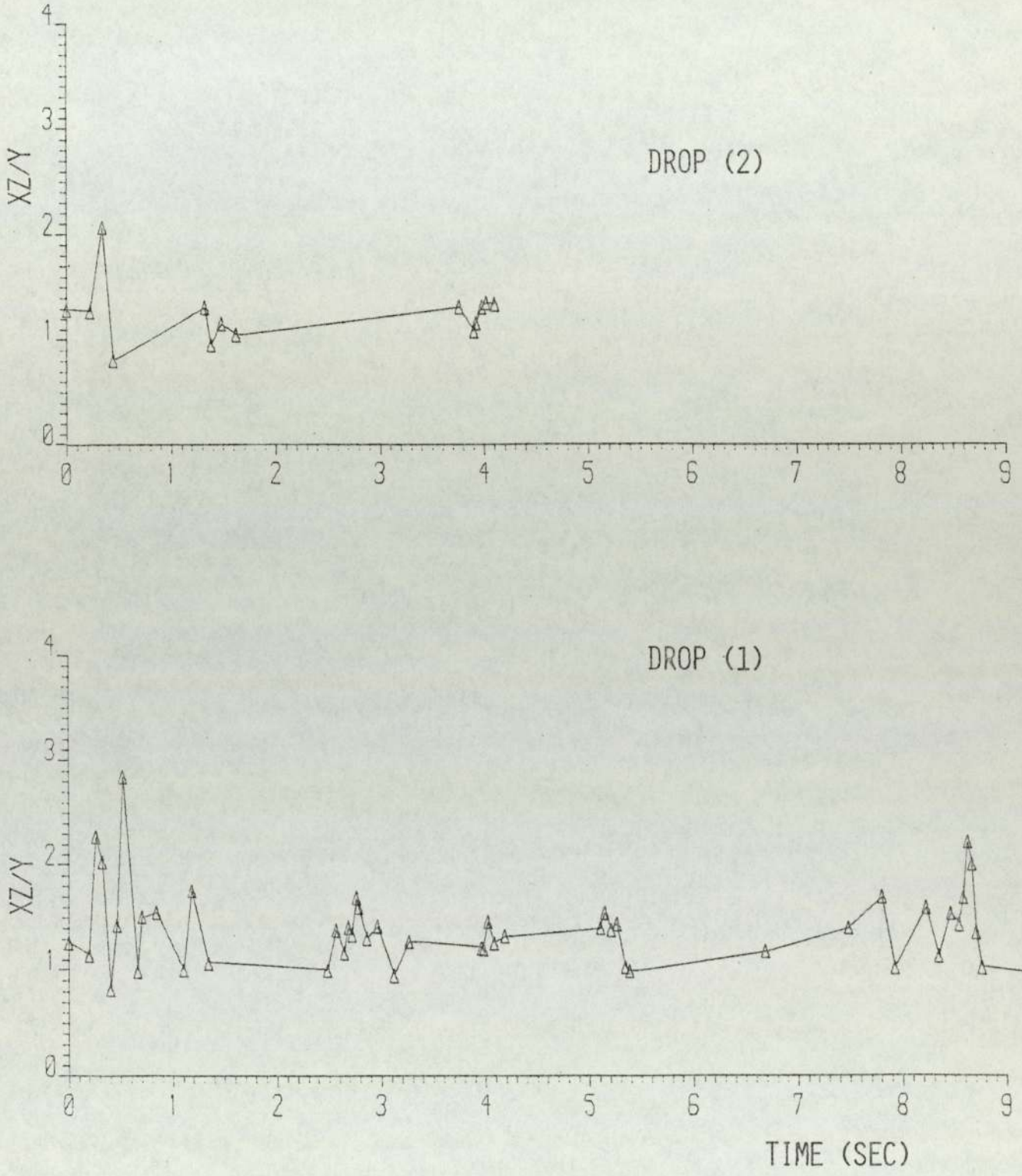

FIG. H.159AXES RATIO VS. TIME, RUN-58.