GODDARD MONITOR
PROGRAMS

prepared for
National Aeronautics and Space Administration
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International Business Machines Corporation

in association with
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CASE FILE COPY
# TABLE OF CONTENTS

## Section 1. INTRODUCTION

| 1.1 | The Mercury Mission | 1-1 |
| 1.2 | Real Time Input/Output: Data Communications Channel | 1-4 |
| 1.3 | Mercury Program System | 1-13 |
| 1.4 | Scope of the Manual | 1-21 |

## Section 2. BASIC MONITOR CONTROL PROGRAMS

| 2.1 | Main Controller Priority Program (M0PRIO) | 2-2 |
| 2.2 | Real Time Channel Main Controller Program (M0RTCC) | 2-7 |
| 2.3 | Main Controller Save Program (M0SAVE) | 2-11 |
| 2.4 | Main Controller Return Program | 2-15 |
| 2.5 | Main Controller Diagnostic Program | 2-19 |
| 2.6 | Main Controller Queue Program (M0QUEU) | 2-23 |
| 2.7 | Main Controller Unqueue Program (M0UNQU) | 2-27 |
| 2.8 | Turn On Macro (TRNON) | 2-31 |
| 2.9 | Turn Off Macro (TRNOF) | 2-35 |
| 2.10 | Queue Macro (QUEUE) | 2-39 |
| 2.11 | Unqueue Macro (UNQUE) | 2-41 |
| 2.12 | Enable Macro (QENBA)/Enable Program (MYENBA) | 2-43 |
| 2.13 | Disable Macro (QENBZ)/Disable Program (MYENB0) | 2-47 |
TABLE OF CONTENTS (Cont’d)

<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-51</td>
<td>2.14</td>
<td>Present Sense Line Macro (QPSLF)/Present Sense Line Program (MYPSSLF)</td>
</tr>
<tr>
<td>2-55</td>
<td>2.15</td>
<td>Save Macro (SAVE)</td>
</tr>
<tr>
<td>2-59</td>
<td>2.16</td>
<td>Reference Macro (REFR)</td>
</tr>
</tbody>
</table>

Section 3. DATA COMMUNICATIONS CHANNEL INPUT CONTROL

<table>
<thead>
<tr>
<th>Page</th>
<th>3.1</th>
<th>High Speed Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-2</td>
<td>3.2</td>
<td>Monitor B-GE High-Speed Input Trap Processor (MTHSGB)</td>
</tr>
<tr>
<td>3-7</td>
<td>3.3</td>
<td>Monitor Prefix To I0HSGB (MPHSGB)</td>
</tr>
<tr>
<td>3-11</td>
<td>3.4</td>
<td>Monitor Radar Data Suffix to I0HSGB (MFHSGB)</td>
</tr>
<tr>
<td>3-15</td>
<td>3.5</td>
<td>Monitor Telemetry Suffix to I0HSGB (MFML6A)</td>
</tr>
<tr>
<td>3-19</td>
<td>3.6</td>
<td>Monitor IP 7090 High-Speed Input Trap Processor (MTHS09)</td>
</tr>
<tr>
<td>3-25</td>
<td>3.7</td>
<td>Monitor Prefix to I0HS09 (MPHS09)</td>
</tr>
<tr>
<td>3-29</td>
<td>3.8</td>
<td>Monitor Radar Data Suffix to I0HS09 (MFHS09)</td>
</tr>
<tr>
<td>3-33</td>
<td>3.9</td>
<td>Monitor Telemetry Suffix to I0HS09 (MFHS08)</td>
</tr>
<tr>
<td>3-37</td>
<td>3.10</td>
<td>Low Speed Input</td>
</tr>
<tr>
<td>3-43</td>
<td>3.11</td>
<td>Monitor Teletype Input Trap Processor (MTTTIN)</td>
</tr>
<tr>
<td>3-48</td>
<td>3.12</td>
<td>Monitor Prefix to I0TTIN and I0MANI (MPTTIN)</td>
</tr>
<tr>
<td>3-51</td>
<td>3.13</td>
<td>Monitor Suffix to I0TTIN (MFTTIN)</td>
</tr>
<tr>
<td>3-55</td>
<td>3.14</td>
<td>Monitor Suffix to I0MANI (MFMANI)</td>
</tr>
<tr>
<td>3-59</td>
<td>3.15</td>
<td>Monitor Time of Lift-Off Suffix to I0MANI (MFMAN1)</td>
</tr>
<tr>
<td>3-63</td>
<td>3.16</td>
<td>Monitor Abort/Orbit Switch Suffix to I0MANI (MFMAOS)</td>
</tr>
<tr>
<td>3-67</td>
<td>3.17</td>
<td>Monitor Retrofire Suffix to I0MANI (MFMAN2)</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS (Cont'd)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.18</td>
<td>Monitor R and V Suffix to IOMANI (MFMAN5)</td>
<td>3-75</td>
</tr>
<tr>
<td>3.19</td>
<td>Timing Control</td>
<td>3-79</td>
</tr>
<tr>
<td>3.20</td>
<td>Monitor Initial WWV Trap Processor (MTWWVI)</td>
<td>3-83</td>
</tr>
<tr>
<td>3.21</td>
<td>Monitor WWV Trap Processor (MTWWWV)</td>
<td>3-87</td>
</tr>
<tr>
<td>3.22</td>
<td>Monitor Half-Second Trap Processor (MTHFSC)</td>
<td>3-91</td>
</tr>
<tr>
<td>3.23</td>
<td>Monitor Minute Processor (MYMINS)</td>
<td>3-97</td>
</tr>
<tr>
<td>3.24</td>
<td>Monitor Pass Number Determination Subroutine (MSPASN)</td>
<td>3-99</td>
</tr>
<tr>
<td>3.25</td>
<td>Monitor Teletype Input Check Subroutine (MSTICK)</td>
<td>3-103</td>
</tr>
<tr>
<td>3.26</td>
<td>Monitor Real Time Channel Error Trap Processor (MTERTC)</td>
<td>3-107</td>
</tr>
</tbody>
</table>

### Section 4. CONTROL DURING LAUNCH/ABORT

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>General Control During Launch/Abort</td>
<td>4-1</td>
</tr>
<tr>
<td>4.2</td>
<td>Monitor Prefix to CCGEB1 (MPCCGB)</td>
<td>4-11</td>
</tr>
<tr>
<td>4.3</td>
<td>Monitor Suffix to CCGEB1 (MFCCGB)</td>
<td>4-17</td>
</tr>
<tr>
<td>4.4</td>
<td>Monitor Bad-Data Suffix to CCGEB1 (MFCCGE)</td>
<td>4-19</td>
</tr>
<tr>
<td>4.5</td>
<td>Monitor Prefix to CC7091 and CCRAWR (MPCCIP)</td>
<td>4-23</td>
</tr>
<tr>
<td>4.6</td>
<td>Monitor Suffix to CC7091 (MFCCIP)</td>
<td>4-29</td>
</tr>
<tr>
<td>4.7</td>
<td>Monitor Raw Radar Data Suffix to CCRAWR (MFCCRW)</td>
<td>4-33</td>
</tr>
<tr>
<td>4.8</td>
<td>Monitor Prefix to the Strip Chart Processor (MPSTRP)</td>
<td>4-37</td>
</tr>
<tr>
<td>4.9</td>
<td>Monitor Suffix to the Strip Chart Processor (MFSTRP)</td>
<td>4-41</td>
</tr>
<tr>
<td>4.10</td>
<td>Monitor Prefix to Main Launch Computations (MPLCCM)</td>
<td>4-45</td>
</tr>
<tr>
<td>4.11</td>
<td>Monitor Suffix to CCRTYL and CCRTMI (MFLRT1)</td>
<td>4-55</td>
</tr>
<tr>
<td>4.12</td>
<td>Monitor Suffix to CCMEAB (MFLRT2)</td>
<td>4-61</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (Cont’d)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.13</td>
<td>Monitor Suffix to CCMAIN and CCMISS (MFLNML)</td>
<td>4-67</td>
</tr>
<tr>
<td>4.14</td>
<td>Monitor Launch-Output Updating Subroutine (MLUPDT)</td>
<td>4-71</td>
</tr>
<tr>
<td>4.15</td>
<td>Monitor Suffix to CCHOLD and CCHOMI (MFLHLD)</td>
<td>4-77</td>
</tr>
<tr>
<td>4.16</td>
<td>Monitor Abort Suffix to MFHLD (MFLABT)</td>
<td>4-85</td>
</tr>
<tr>
<td>4.17</td>
<td>Monitor High-Abort Control Processor (MYSEEK)</td>
<td>4-89</td>
</tr>
<tr>
<td>4.18</td>
<td>Monitor Prefix to CCABRT (MPABRT)</td>
<td>4-97</td>
</tr>
<tr>
<td>4.19</td>
<td>Monitor Suffix to CCABRT (MFABRT)</td>
<td>4-101</td>
</tr>
<tr>
<td>4.20</td>
<td>Monitor Orbit Suffix to MFLHLD (MFLORB)</td>
<td>4-105</td>
</tr>
</tbody>
</table>

Section 5. CONTROL DURING PHASE CHANGE AND RESTART

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Control During Prelaunch</td>
<td>5-1</td>
</tr>
<tr>
<td>5.2</td>
<td>Mercury System Tape Writer Program (MXSTW1)</td>
<td>5-3</td>
</tr>
<tr>
<td>5.3</td>
<td>Error Correction Code Writer Subroutine (MSWECC)</td>
<td>5-11</td>
</tr>
<tr>
<td>5.4</td>
<td>Mercury System Tape Loader (MXLOAD)</td>
<td>5-17</td>
</tr>
<tr>
<td>5.5</td>
<td>Error Correction Code Reader Subroutine (MSRECC)</td>
<td>5-23</td>
</tr>
<tr>
<td>5.6</td>
<td>Main Controller Initialization Program (M0INIT)</td>
<td>5-25</td>
</tr>
<tr>
<td>5.7</td>
<td>Monitor Initialization Processor (MYINIT)</td>
<td>5-29</td>
</tr>
<tr>
<td>5.8</td>
<td>Monitor Station Characteristics Tape Processor (MYSCRD)</td>
<td>5-33</td>
</tr>
<tr>
<td>5.9</td>
<td>Monitor Station Characteristics Tape Trap Processor (MTENST)</td>
<td>5-41</td>
</tr>
<tr>
<td>5.10</td>
<td>Control During Launch-to-High Abort/Orbit</td>
<td>5-45</td>
</tr>
<tr>
<td>5.11</td>
<td>Monitor System Tape Queueing Processor (MYQSYS)</td>
<td>5-46</td>
</tr>
<tr>
<td>5.12</td>
<td>Monitor System Tape Processor (MYRSYS)</td>
<td>5-49</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS (Cont'd)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.13</td>
<td>Monitor System Tape Trap Processor (MTRSYS)</td>
<td>5-59</td>
</tr>
<tr>
<td>5.14</td>
<td>Monitor Restart Tape Writer Processor (MYWRSS)</td>
<td>5-63</td>
</tr>
<tr>
<td>5.15</td>
<td>Monitor Restart Tape Writer Trap Processor (MTWRSS, MTWRS1)</td>
<td>5-67</td>
</tr>
<tr>
<td>5.16</td>
<td>Control During Orbit-to-Re-entry</td>
<td>5-71</td>
</tr>
<tr>
<td>5.17</td>
<td>Monitor Orbit-to-Re-entry Interphase Processor (MYREST)</td>
<td>5-73</td>
</tr>
<tr>
<td>5.18</td>
<td>Monitor Re-entry Restart Tape Processor (MYRRRS)</td>
<td>5-83</td>
</tr>
<tr>
<td>5.19</td>
<td>Monitor Re-entry Restart Tape Trap Processor (MTRRRS)</td>
<td>5-91</td>
</tr>
<tr>
<td>5.20</td>
<td>Restart</td>
<td>5-95</td>
</tr>
<tr>
<td>5.21</td>
<td>Monitor Orbit Restart Tape Processor (MYSRST)</td>
<td>5-97</td>
</tr>
<tr>
<td>5.22</td>
<td>Monitor Orbit Restart Tape Trap Processor (MTSRST)</td>
<td>5-105</td>
</tr>
</tbody>
</table>

Section 6. CONTROL DURING ORBIT/RE-ENTRY

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Basic Computing Cycle</td>
<td>6-1</td>
</tr>
<tr>
<td>6.2</td>
<td>Monitor Prefix to EOLED1 (MPLED1)</td>
<td>6-11</td>
</tr>
<tr>
<td>6.3</td>
<td>Monitor Prefix to EOLED1 (MPLED2)</td>
<td>6-15</td>
</tr>
<tr>
<td>6.4</td>
<td>Monitor Suffix to EOLED1 (MFLED1)</td>
<td>6-19</td>
</tr>
<tr>
<td>6.5</td>
<td>Monitor Prefix to D0DIFC (MPDIFC)</td>
<td>6-27</td>
</tr>
<tr>
<td>6.6</td>
<td>Monitor Prefix to D0DIFC (MPDIFK)</td>
<td>6-31</td>
</tr>
<tr>
<td>6.7</td>
<td>Monitor Suffix to D0DIFC (MFDIFC)</td>
<td>6-33</td>
</tr>
<tr>
<td>6.8</td>
<td>Monitor Numerical Integration Generator (MYGEN1)</td>
<td>6-39</td>
</tr>
<tr>
<td>6.9</td>
<td>Monitor Numerical Integration Generator (MYGEN2)</td>
<td>6-41</td>
</tr>
<tr>
<td>6.10</td>
<td>Monitor Numerical Integration Generator (MYGEN3)</td>
<td>6-44</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS (Cont’d)

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.11</td>
<td>Monitor Prefix to NOCPNI (MPCPNI)</td>
<td>6-45</td>
</tr>
<tr>
<td>6.12</td>
<td>Monitor Suffix to NOCPNI (MFCPNI)</td>
<td>6-49</td>
</tr>
<tr>
<td>6.13</td>
<td>Monitor Prefix to R5RARF (MPRARF)</td>
<td>6-59</td>
</tr>
<tr>
<td>6.14</td>
<td>Monitor Suffix to R5RARF (MFRARF)</td>
<td>6-65</td>
</tr>
<tr>
<td>6.15</td>
<td>Monitor Prefix to O5ORMC (MPORMC)</td>
<td>6-69</td>
</tr>
<tr>
<td>6.16</td>
<td>Monitor Suffix to O5ORMC (MFORMC)</td>
<td>6-73</td>
</tr>
<tr>
<td>7.1</td>
<td>High-Speed Output.</td>
<td>7-1</td>
</tr>
<tr>
<td>7.2</td>
<td>Monitor Prefix to O0LANA (MPLANA)</td>
<td>7-11</td>
</tr>
<tr>
<td>7.3</td>
<td>Monitor Suffix to O0LANA (MFLANA)</td>
<td>7-13</td>
</tr>
<tr>
<td>7.4</td>
<td>Monitor Prefix to O0ORRE (MPORRE)</td>
<td>7-15</td>
</tr>
<tr>
<td>7.5</td>
<td>Monitor Suffix to O0ORRE (MFORRE)</td>
<td>7-19</td>
</tr>
<tr>
<td>7.6</td>
<td>Monitor High-Speed Output to Cape Canaveral Processor (MYHSOD)</td>
<td>7-21</td>
</tr>
<tr>
<td>7.7</td>
<td>Monitor Trap Processor for High-Speed Output to Cape Canaveral (MTHSOD)</td>
<td>7-27</td>
</tr>
<tr>
<td>7.8</td>
<td>Monitor High-Speed Output to Goddard Processor (MYHSOP)</td>
<td>7-31</td>
</tr>
<tr>
<td>7.9</td>
<td>Monitor Trap Processor for High-Speed Output to Goddard (MTHSOP)</td>
<td>7-35</td>
</tr>
<tr>
<td>7.10</td>
<td>Teletype Output; Acquisition Data</td>
<td>7-37</td>
</tr>
<tr>
<td>7.11</td>
<td>Monitor Acquisition Data Processor (MYACQD)</td>
<td>7-41</td>
</tr>
<tr>
<td>7.12</td>
<td>Monitor Subchannel 10 Teletype Output Processor (MYTTOX)</td>
<td>7-51</td>
</tr>
<tr>
<td>7.13</td>
<td>Monitor Subchannel 11 Teletype Output Processor (MYTTOY)</td>
<td>7-57</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS (Cont’d)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.14</td>
<td>Acquisition Data Macro (AJACQ)</td>
<td>7–61</td>
</tr>
<tr>
<td>7.15</td>
<td>Teletype Output Macro (QTTYA)</td>
<td>7–65</td>
</tr>
<tr>
<td>7.16</td>
<td>Monitor Teletype Output Trap Processors (MTTTOX, MTTTOY)</td>
<td>7–69</td>
</tr>
<tr>
<td>7.17</td>
<td>Teletype Output Test Macro (QTTYA)</td>
<td>7–73</td>
</tr>
<tr>
<td>7.18</td>
<td>Monitor Teletype Output Logging Processors (MYTTXO, MYTTYO)</td>
<td>7–77</td>
</tr>
<tr>
<td>7.19</td>
<td>Sense Output to Output Status Console</td>
<td>7–81</td>
</tr>
<tr>
<td>7.20</td>
<td>Monitor Sense Output Processor (MYSENS)</td>
<td>7–84</td>
</tr>
<tr>
<td>7.21</td>
<td>Monitor Sense Output Trap Processor (MTSENS)</td>
<td>7–87</td>
</tr>
</tbody>
</table>

### Section 8. ON-LINE MESSAGES AND LOGGING

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.1</td>
<td>The On-Line Message System</td>
<td>8–1</td>
</tr>
<tr>
<td>8.2</td>
<td>Monitor On-Line Message Processor (MYMESS)</td>
<td>8–15</td>
</tr>
<tr>
<td>8.3</td>
<td>Binary Number Card Image Macro (BINNO)</td>
<td>8–21</td>
</tr>
<tr>
<td>8.4</td>
<td>Monitor Message Check Trap Processor (MTMSCK)</td>
<td>8–25</td>
</tr>
<tr>
<td>8.5</td>
<td>Monitor Message Check Processor (MYMSCK)</td>
<td>8–29</td>
</tr>
<tr>
<td>8.6</td>
<td>Monitor End-of-Printing Trap Processor (MTENPR)</td>
<td>8–51</td>
</tr>
<tr>
<td>8.7</td>
<td>The Logging Process</td>
<td>8–55</td>
</tr>
<tr>
<td>8.8</td>
<td>Monitor Logging Subroutine (MSLOGG)</td>
<td>8–61</td>
</tr>
<tr>
<td>8.9</td>
<td>Monitor Logging Processor (MYSTLT)</td>
<td>8–69</td>
</tr>
<tr>
<td>8.10</td>
<td>Monitor End-of-Logging Trap Processor (MTENLG)</td>
<td>8–73</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS (Cont'd)

**Section 9. MONITOR SYMBOL REFERENCE LISTS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.1</td>
<td>Programs</td>
<td>9-3</td>
</tr>
<tr>
<td>9.2</td>
<td>Communications Cells</td>
<td>9-11</td>
</tr>
<tr>
<td>9.3</td>
<td>Tables</td>
<td>9-23</td>
</tr>
</tbody>
</table>

**Appendix--SPECIAL SYSTEMS FEATURES BULLETIN:**
IBM 7281 I DATA COMMUNICATIONS CHANNEL
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Duplexed IBM 7090 Computer Facility (Partial View)</td>
<td>1-5</td>
</tr>
<tr>
<td>1-2</td>
<td>IBM 7281 I Data Communications Channel</td>
<td>1-7</td>
</tr>
<tr>
<td>1-3</td>
<td>Control Panel, Output Status Console</td>
<td>1-9</td>
</tr>
<tr>
<td>1-4</td>
<td>Goddard Duplexed Input/Output Transmission</td>
<td>1-11</td>
</tr>
<tr>
<td>1-5</td>
<td>Monitor Control of Mercury Program System</td>
<td>1-15</td>
</tr>
<tr>
<td>1-6</td>
<td>Basic Monitor Control</td>
<td>1-17</td>
</tr>
<tr>
<td>2-1</td>
<td>M0PRIO Program Flow Chart</td>
<td>2-5</td>
</tr>
<tr>
<td>2-2</td>
<td>M0RTCC Program Flow Chart</td>
<td>2-10</td>
</tr>
<tr>
<td>2-3</td>
<td>M0SAVE Program Flow Chart</td>
<td>2-14</td>
</tr>
<tr>
<td>2-4</td>
<td>M0RTRN Program Flow Chart</td>
<td>2-17</td>
</tr>
<tr>
<td>2-5</td>
<td>M0DIAG Program Flow Chart</td>
<td>2-21</td>
</tr>
<tr>
<td>2-6</td>
<td>M0QUEU Program Flow Chart</td>
<td>2-26</td>
</tr>
<tr>
<td>2-7</td>
<td>M0UNQU Program Flow Chart</td>
<td>2-29</td>
</tr>
<tr>
<td>2-8</td>
<td>TRNON Macro Flow Chart</td>
<td>2-33</td>
</tr>
<tr>
<td>2-9</td>
<td>TRNOF Macro Flow Chart</td>
<td>2-37</td>
</tr>
<tr>
<td>2-10</td>
<td>QUEUE Macro Flow Chart</td>
<td>2-40</td>
</tr>
<tr>
<td>2-11</td>
<td>UNQUE Macro Flow Chart</td>
<td>2-42</td>
</tr>
<tr>
<td>2-12</td>
<td>QENBA Macro Flow Chart</td>
<td>2-45</td>
</tr>
<tr>
<td>2-13</td>
<td>QENBZ Macro Flow Chart</td>
<td>2-49</td>
</tr>
<tr>
<td>2-14</td>
<td>QPSLF Macro Flow Chart</td>
<td>2-53</td>
</tr>
<tr>
<td>Figure</td>
<td>Illustration</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>2-15</td>
<td>SAVE Macro Flow Chart</td>
<td>2-57</td>
</tr>
<tr>
<td>2-16</td>
<td>Basic Monitor Tables</td>
<td>2-63</td>
</tr>
<tr>
<td>3-1</td>
<td>Data Flow: High-Speed Input from Cape Canaveral B-GE</td>
<td>3-3</td>
</tr>
<tr>
<td>3-2</td>
<td>Data Flow: High-Speed Input from Cape Canaveral IP 7090</td>
<td>3-5</td>
</tr>
<tr>
<td>3-3</td>
<td>MTHSGB Program Flow Chart</td>
<td>3-9</td>
</tr>
<tr>
<td>3-4</td>
<td>MPHSGB Program Flow Chart</td>
<td>3-13</td>
</tr>
<tr>
<td>3-5</td>
<td>MFHSGB Program Flow Chart</td>
<td>3-18</td>
</tr>
<tr>
<td>3-6</td>
<td>MFML6A Program Flow Chart</td>
<td>3-22/3-23</td>
</tr>
<tr>
<td>3-7</td>
<td>MTHS09 Program Flow Chart</td>
<td>3-27</td>
</tr>
<tr>
<td>3-8</td>
<td>MPHS09 Program Flow Chart</td>
<td>3-31</td>
</tr>
<tr>
<td>3-9</td>
<td>MFHS09 Program Flow Chart</td>
<td>3-35</td>
</tr>
<tr>
<td>3-10</td>
<td>MFHS08 Program Flow Chart</td>
<td>3-40/3-41</td>
</tr>
<tr>
<td>3-11</td>
<td>Data Flow: Teletype Input Radar Messages</td>
<td>3-44</td>
</tr>
<tr>
<td>3-12</td>
<td>Data Flow: Manually Inserted Paper Tape Messages</td>
<td>3-46</td>
</tr>
<tr>
<td>3-13</td>
<td>MTTTIN Program Flow Chart</td>
<td>3-50</td>
</tr>
<tr>
<td>3-14</td>
<td>MPTTIN Program Flow Chart</td>
<td>3-53</td>
</tr>
<tr>
<td>3-15</td>
<td>MFTTIN Program Flow Chart</td>
<td>3-58</td>
</tr>
<tr>
<td>3-16</td>
<td>MFMAN1 Program Flow Chart</td>
<td>3-61</td>
</tr>
<tr>
<td>3-17</td>
<td>MFMAN1 Program Flow Chart</td>
<td>3-65</td>
</tr>
<tr>
<td>3-18</td>
<td>MFMAOS Program Flow Chart</td>
<td>3-69</td>
</tr>
<tr>
<td>3-19</td>
<td>MFMAN2 Program Flow Chart</td>
<td>3-72</td>
</tr>
<tr>
<td>3-20</td>
<td>MFMAN5 Program Flow Chart</td>
<td>3-77</td>
</tr>
</tbody>
</table>
LIST OF ILLUSTRATIONS (Cont'd)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-21</td>
<td>DCC Timing Control</td>
<td>3-81</td>
</tr>
<tr>
<td>3-22</td>
<td>MTWWVI Program Flow Chart</td>
<td>3-85</td>
</tr>
<tr>
<td>3-23</td>
<td>MTWWWV Program Flow Chart</td>
<td>3-89</td>
</tr>
<tr>
<td>3-24</td>
<td>MTHSFC Program Flow Chart</td>
<td>3-95/3-96</td>
</tr>
<tr>
<td>3-25</td>
<td>MYMINS Program Flow Chart</td>
<td>3-98</td>
</tr>
<tr>
<td>3-26</td>
<td>MSPASN Subroutine Flow Chart</td>
<td>3-101/3-102</td>
</tr>
<tr>
<td>3-27</td>
<td>MSTICK Subroutine Flow Chart</td>
<td>3-105</td>
</tr>
<tr>
<td>3-28</td>
<td>MTERTC Program Flow Chart</td>
<td>3-107</td>
</tr>
<tr>
<td>4-1</td>
<td>Launch/Abort Control Diagram</td>
<td>4-4/4-8</td>
</tr>
<tr>
<td>4-2</td>
<td>MPCCGB Program Flow Chart</td>
<td>4-14/4-15</td>
</tr>
<tr>
<td>4-3</td>
<td>MFCCGB Program Flow Chart</td>
<td>4-18</td>
</tr>
<tr>
<td>4-4</td>
<td>MFCCGE Program Flow Chart</td>
<td>4-21</td>
</tr>
<tr>
<td>4-5</td>
<td>MPCCIP Program Flow Chart</td>
<td>4-26/4-28</td>
</tr>
<tr>
<td>4-6</td>
<td>MFCCIP Program Flow Chart</td>
<td>4-31</td>
</tr>
<tr>
<td>4-7</td>
<td>MFCCRW Program Flow Chart</td>
<td>4-35</td>
</tr>
<tr>
<td>4-8</td>
<td>MPSTRP Program Flow Chart</td>
<td>4-39</td>
</tr>
<tr>
<td>4-9</td>
<td>MFSTRP Program Flow Chart</td>
<td>4-44</td>
</tr>
<tr>
<td>4-10</td>
<td>MPLCCM Program Flow Chart</td>
<td>4-50/4-53</td>
</tr>
<tr>
<td>4-11</td>
<td>MFLRT1 Program Flow Chart</td>
<td>4-58/4-59</td>
</tr>
<tr>
<td>4-12</td>
<td>MFLRT2 Program Flow Chart</td>
<td>4-65/4-66</td>
</tr>
<tr>
<td>4-13</td>
<td>MFLNML Program Flow Chart</td>
<td>4-69</td>
</tr>
<tr>
<td>4-14</td>
<td>MLUPDT Subroutine Flow Chart</td>
<td>4-75/4-76</td>
</tr>
</tbody>
</table>
LIST OF ILLUSTRATIONS (Cont'd)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Program/Flow Chart</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-15</td>
<td>MFLHLD Program Flow Chart</td>
<td>4-81/4-83</td>
</tr>
<tr>
<td>4-16</td>
<td>MFLABT Program Flow Chart</td>
<td>4-88</td>
</tr>
<tr>
<td>4-17</td>
<td>MYSEEK Program Flow Chart</td>
<td>4-93/4-95</td>
</tr>
<tr>
<td>4-18</td>
<td>MPABRT Program Flow Chart</td>
<td>4-99</td>
</tr>
<tr>
<td>4-19</td>
<td>MFABRT Program Flow Chart</td>
<td>4-103</td>
</tr>
<tr>
<td>4-20</td>
<td>MFLORB Program Flow Chart</td>
<td>4-111/4-112</td>
</tr>
<tr>
<td>5-1</td>
<td>MXSTW1 Program Flow Chart</td>
<td>5-5/5-9</td>
</tr>
<tr>
<td>5-2</td>
<td>Input and Output Tapes for MXSTW1</td>
<td>5-10</td>
</tr>
<tr>
<td>5-3</td>
<td>MSWECC and MSRECC Flow Charts</td>
<td>5-15</td>
</tr>
<tr>
<td>5-4</td>
<td>MXLOAD Program Flow Chart</td>
<td>5-18</td>
</tr>
<tr>
<td>5-5</td>
<td>MSLOAD Program Flow Chart</td>
<td>5-19/5-21</td>
</tr>
<tr>
<td>5-6</td>
<td>M0INIT Program Flow Chart</td>
<td>5-28</td>
</tr>
<tr>
<td>5-7</td>
<td>MYINIT Program Flow Chart</td>
<td>5-32</td>
</tr>
<tr>
<td>5-8</td>
<td>Station Characteristics Tape Reading Cycle</td>
<td>5-37</td>
</tr>
<tr>
<td>5-9</td>
<td>MYSCRD Program Flow Chart</td>
<td>5-39/5-40</td>
</tr>
<tr>
<td>5-10</td>
<td>MTENST Program Flow Chart</td>
<td>5-43</td>
</tr>
<tr>
<td>5-11</td>
<td>MYQSYS Program Flow Chart</td>
<td>5-48</td>
</tr>
<tr>
<td>5-12</td>
<td>MYRSYS Program Flow Chart</td>
<td>5-53/5-58</td>
</tr>
<tr>
<td>5-13</td>
<td>MTRSYS Program Flow Chart</td>
<td>5-61</td>
</tr>
<tr>
<td>5-14</td>
<td>MYWRRS Program Flow Chart</td>
<td>5-66</td>
</tr>
<tr>
<td>5-15</td>
<td>MTWRRS - MTWRS1 Program Flow Chart</td>
<td>5-69</td>
</tr>
<tr>
<td>5-16</td>
<td>MYREST Program Flow Chart</td>
<td>5-78/5-81</td>
</tr>
</tbody>
</table>

xii
### LIST OF ILLUSTRATIONS (Cont'd)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-17</td>
<td>MYRRRS Program Flow Chart</td>
<td>5-88</td>
</tr>
<tr>
<td>5-18</td>
<td>MTRRRS Program Flow Chart</td>
<td>5-93</td>
</tr>
<tr>
<td>5-19</td>
<td>MYSRST Program Flow Chart</td>
<td>5-101/5-104</td>
</tr>
<tr>
<td>5-20</td>
<td>MTSRST Program Flow Chart</td>
<td>5-107/5-108</td>
</tr>
<tr>
<td>6-1</td>
<td>Basic Orbit Computing Cycle</td>
<td>6-3/6-5</td>
</tr>
<tr>
<td>6-2</td>
<td>Orbit-to-Re-entry Phase Change</td>
<td>6-8</td>
</tr>
<tr>
<td>6-3</td>
<td>Basic Re-entry Computing Cycle</td>
<td>6-9</td>
</tr>
<tr>
<td>6-4</td>
<td>MPLED1 Program Flow Chart</td>
<td>6-14</td>
</tr>
<tr>
<td>6-5</td>
<td>MPLED2 Program Flow Chart</td>
<td>6-17</td>
</tr>
<tr>
<td>6-6</td>
<td>MFLED1 Program Flow Chart</td>
<td>6-24/6-25</td>
</tr>
<tr>
<td>6-7</td>
<td>MPDIFC Program Flow Chart</td>
<td>6-29/6-30</td>
</tr>
<tr>
<td>6-8</td>
<td>MPDIFK Program Flow Chart</td>
<td>6-32</td>
</tr>
<tr>
<td>6-9</td>
<td>MFDFC Program Flow Chart</td>
<td>6-36/6-38</td>
</tr>
<tr>
<td>6-10</td>
<td>MYGEN1 Program Flow Chart</td>
<td>6-40</td>
</tr>
<tr>
<td>6-11</td>
<td>MYGEN2 Program Flow Chart</td>
<td>6-43</td>
</tr>
<tr>
<td>6-12</td>
<td>MPCPNI Program Flow Chart</td>
<td>6-48</td>
</tr>
<tr>
<td>6-13</td>
<td>MFCPNI Program Flow Chart</td>
<td>6-52/6-57</td>
</tr>
<tr>
<td>6-14</td>
<td>MPRARF Program Flow Chart</td>
<td>6-62/6-63</td>
</tr>
<tr>
<td>6-15</td>
<td>MFRARF Program Flow Chart</td>
<td>6-67/6-68</td>
</tr>
<tr>
<td>6-16</td>
<td>MPORMC Program Flow Chart</td>
<td>6-71</td>
</tr>
<tr>
<td>6-17</td>
<td>MFORMC Program Flow Chart</td>
<td>6-75</td>
</tr>
<tr>
<td>7-1</td>
<td>Data Flow: High-speed Output During Launch</td>
<td>7-4</td>
</tr>
</tbody>
</table>

xiii
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-2</td>
<td>Data Flow: High-Speed Output During Orbit, Re-entry and Abort</td>
<td>7-9</td>
</tr>
<tr>
<td>7-3</td>
<td>MPLANA Program Flow Chart</td>
<td>7-12</td>
</tr>
<tr>
<td>7-4</td>
<td>MFLANA Program Flow Chart</td>
<td>7-14</td>
</tr>
<tr>
<td>7-5</td>
<td>MPORRE Program Flow Chart</td>
<td>7-17</td>
</tr>
<tr>
<td>7-6</td>
<td>MFORRE Program Flow Chart</td>
<td>7-20</td>
</tr>
<tr>
<td>7-7</td>
<td>MYHSOD Program Flow Chart</td>
<td>7-24/7-26</td>
</tr>
<tr>
<td>7-8</td>
<td>MTHSOD Program Flow Chart</td>
<td>7-29</td>
</tr>
<tr>
<td>7-9</td>
<td>MYHSOP Program Flow Chart</td>
<td>7-33</td>
</tr>
<tr>
<td>7-10</td>
<td>MTHSOP Program Flow Chart</td>
<td>7-36</td>
</tr>
<tr>
<td>7-11</td>
<td>Data Flow: Teletype Output</td>
<td>7-38</td>
</tr>
<tr>
<td>7-12</td>
<td>General Flow Diagram, MYACQD</td>
<td>7-44</td>
</tr>
<tr>
<td>7-13</td>
<td>MYACQD Program Flow Chart</td>
<td>7-45/7-49</td>
</tr>
<tr>
<td>7-14</td>
<td>MYTTOX Program Flow Chart</td>
<td>7-54/7-55</td>
</tr>
<tr>
<td>7-15</td>
<td>MYTTOY Program Flow Chart</td>
<td>7-59</td>
</tr>
<tr>
<td>7-16</td>
<td>AJACQ Macro Flow Chart</td>
<td>7-64</td>
</tr>
<tr>
<td>7-17</td>
<td>QTTYA Macro Flow Chart</td>
<td>7-67</td>
</tr>
<tr>
<td>7-18</td>
<td>MTTTOX Program Flow Chart</td>
<td>7-71</td>
</tr>
<tr>
<td>7-19</td>
<td>MTTTOY Program Flow Chart</td>
<td>7-72</td>
</tr>
<tr>
<td>7-20</td>
<td>QTTYB Macro Flow Chart</td>
<td>7-75</td>
</tr>
<tr>
<td>7-21</td>
<td>MYTTXO Program Flow Chart</td>
<td>7-79</td>
</tr>
<tr>
<td>7-22</td>
<td>MYTTYO Program Flow Chart</td>
<td>7-80</td>
</tr>
<tr>
<td>7-23</td>
<td>Data Flow: Transmission to Output Status Console</td>
<td>7-83</td>
</tr>
</tbody>
</table>
### LIST OF ILLUSTRATIONS (Cont’d)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-24</td>
<td>MYSENS Program Flow Chart</td>
</tr>
<tr>
<td>7-25</td>
<td>MTSSENS Program Flow Chart</td>
</tr>
<tr>
<td>8-1</td>
<td>On-Line Message Cycle</td>
</tr>
<tr>
<td>8-2</td>
<td>MYMESS Program Flow Chart</td>
</tr>
<tr>
<td>8-3</td>
<td>BINNO Macro Flow Chart</td>
</tr>
<tr>
<td>8-4</td>
<td>MTMSCK Program Flow Chart</td>
</tr>
<tr>
<td>8-5</td>
<td>General Flow Diagram, MUMSCK Processor</td>
</tr>
<tr>
<td>8-6</td>
<td>MYMSCK Program Flow Chart</td>
</tr>
<tr>
<td>8-7</td>
<td>MTENPR Program Flow Chart</td>
</tr>
<tr>
<td>8-8</td>
<td>Logging Cycle</td>
</tr>
<tr>
<td>8-9</td>
<td>MSLOGG Logging Block and Calling Sequence</td>
</tr>
<tr>
<td>8-10</td>
<td>MSLOGG Subroutine Flow Chart</td>
</tr>
<tr>
<td>8-11</td>
<td>MYSTLT Program Flow Chart</td>
</tr>
<tr>
<td>8-12</td>
<td>MTENLG Program Flow Chart</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1</td>
<td>DCC Reference Table.</td>
</tr>
<tr>
<td>2-2</td>
<td>Monitor Tables.</td>
</tr>
<tr>
<td>2-3</td>
<td>Monitor Tables.</td>
</tr>
<tr>
<td>2-4</td>
<td>Monitor Tables.</td>
</tr>
<tr>
<td>5-1</td>
<td>Station Characteristics Block Contents</td>
</tr>
<tr>
<td>5-2</td>
<td>Restart Tape Record.</td>
</tr>
<tr>
<td>6-1</td>
<td>Standard Integration Parameters</td>
</tr>
<tr>
<td>7-1</td>
<td>Launch, High-Abort Output Table (TMLANA).</td>
</tr>
<tr>
<td>7-2</td>
<td>Orbit and Re-entry Output Table (TMORRE).</td>
</tr>
<tr>
<td>7-3</td>
<td>Monitor Control of Output Status Console Indicators</td>
</tr>
<tr>
<td>8-1</td>
<td>On-Line Messages.</td>
</tr>
</tbody>
</table>
The objective of Project Mercury programming is the realization of an efficient and reliable computer program capable of accurately tracking in real time a manned capsule in orbital space flight. This tracking program, the Mercury Program System, must continuously monitor the capsule's flight to provide the Mercury Control Center at Cape Canaveral with sufficient information to allow complete mission surveillance and control.

The Goddard Computing and Communications Center, as the focal point of the worldwide Mercury tracking and data transmission network, contains the hardware and the IBM 7090 computer programs necessary to support an actual or simulated Mercury mission.

1.1 THE MERCURY MISSION

The Mercury-Atlas mission encompasses several sequential flight phases—periods of time when the project's computers are utilized for specific operations pertinent to the various mission stages.

Prelaunch extends for approximately 16 hours over a two-day period, from the start of launch vehicle checkout through the moment of lift-off. During this period, checks and preparations are made to ensure that all elements and components of the launch vehicle, capsule and the overall tracking, communications and computational system are ready at an acceptable operational level.
The launch phase commences when the Atlas rocket rises two inches above the launch pad. During the launch phase the rocket is guided by the Burroughs-General Electric (B-GE) Guidance System computer at Cape Canaveral. B-GE and the Impact-Predictor (IP 7090) computer, which receives data from either the Azusa tracking system or the AN/FPS-16 radars, transmit tracking data and capsule telemetry over high-speed lines to the Goddard computers. Approximately 140 seconds after lift-off, upon ground command the rocket's booster engine is cut off (BECO) and detached (staging). Approximately 15 seconds later an escape tower for emergency separation of the capsule and rocket is jettisoned from the capsule (TOWS). The sustainer engine continues to propel the capsule until the proper velocity and angle for insertion is attained (approximately five minutes after lift-off), whereupon the guidance system initiates sustainer engine cut-off (SECO). Posigrade rockets on the capsule fire to separate the capsule from the sustainer (CAPS).

Five seconds after insertion, the capsule assumes a retrofire attitude to allow immediate re-entry in case conditions at insertion are judged inadequate for at least one orbit or in case an astronaut or capsule emergency condition exists. At this point the mission enters the hold phase while the Flight Dynamics Officer at the Mercury Control Center evaluates the capsule's orbital flight characteristics and determines the GO NO-GO decision. When the GO decision is given, the capsule assumes orbital attitude. The orbit phase begins with the capsule at an approximate altitude of 100 miles and a velocity of five miles per second.

During the launch phase the Goddard computers must provide the Mercury Control Center with such critical information as the capsule's height, velocity ratio, flight path angle and retrofire times with associated impact points for impending abort conditions. Finally, the computers give a GO NO-GO recommendation and provide the capsule's flight parameters when the decision is made. In addition, acquisition data is generated and transmitted to the Bermuda tracking station.

A premature termination of the launch phase may result in a low abort (below 100,000 feet), a medium abort (below tower separation) or a high abort. For any abort situation, the computers must provide impact point information to effect a rapid recovery of the astronaut.

The orbit phase continues for one, two or three orbits with the capsule encircling the earth approximately every 90 minutes. During orbit, the Goddard computers transmit acquisition data to the Mercury radar and telemetry stations. The radar stations provide tracking data directly to the Goddard computers which enables more precise refining of the orbit. The orbital computations include various retrorocket firing times for emergency recovery areas and nominal recovery areas for the end of each orbit.

For a three-orbit mission, approximately four and one-half hours after lift-off retrofire occurs and the capsule re-enters the atmosphere. The impact point is plotted and refined to monitor continuously the descending capsule.
All logical decisions affecting the capsule's flight as well as all predictions of the capsule's future location, including the impact point, are dependent upon the IBM 7090 computer's knowledge of the exact present position and velocity of the capsule. Only a real time system could provide this knowledge to the computer. A real time transmission device, the Data Communications Channel, was specifically developed to enable the transmission of vast quantities of real time data directly into computer core storage, and a real time program, the Mercury Program System, was designed to handle the complex data processing required to support the Mercury mission.
1.2 INPUT/OUTPUT TRANSMISSION: DATA COMMUNICATIONS CHANNEL

In general, the most critical data must be handled in real time. To accomplish this, a real time transmission device, the IBM 7281 I Data Communications Channel (DCC), replaces channel F of the normal input/output system on each Goddard IBM 7090 (see Figures 1-1, 1-2). This provides for direct sub-channel connection of a variety of input/output devices operating at various transmission rates. Real time data is read in and out of assigned buffer areas in computer core storage simultaneously with the execution of the main unit central processing and the operation of the other data channels (in Project Mercury channels A, B and C are used). A program interrupt occurs automatically whenever the assigned buffer area has been filled or emptied, depending upon whether an input or an output operation is taking place.

When an interrupt occurs, processing control is taken from the main program and given to those instructions in lower core memory specified by the particular interrupt. After the computer has serviced the subchannel and has satisfied the resulting conditions imposed upon the system, the pre-interrupt processing state is restored (insofar as is possible, because an immediate consequence of the interrupt may be an alteration in the processing sequence or data flow) and processing control is returned to the main program at the exact point from which it was exempted.

A multiplexor-sequerencer within the DCC examines subchannels in turn, gives priority to the higher-speed subchannel as required, requests program interrupts, and provides controls needed for subchannel operation. Data transfer through any subchannel occurs only when the sequencer is examining, i.e., is positioned at, this subchannel.

Subchannels may be turned on (activated) or turned off (deactivated) independently upon instruction from the main program, and subchannels must be activated to transfer data or initiate program interrupts (traps). Further, a main program instruction must enable the DCC for trapping before an interrupt request is honored. If the DCC is disabled, traps are remembered and executed when enabled, but no data transfer takes place until the trap request is granted. Disabling the DCC has no effect, therefore, on data transmission unless there is a waiting trap.

When any of the subchannels requests a trap, all DCC data transfers are stopped until the trap is granted. For example, at any given time in the mission it may be essential that a program or a routine be completed without interruption. In programming terminology such a program would "run disabled," i.e., it would begin with an instruction to disable the DCC (and all other data channels). Normal data transfer through the DCC continues in this case. However, if an input buffer area is filled or an output buffer area is emptied, the particular subchannel involved requests a trap. At this point the DCC becomes inhibited and all data transfer ceases. Data could be lost to the system if a program's priority demands uninterrupted execution, although in actual usage the speed of
FIGURE 1-1. DUPLEXED IBM 7090 COMPUTER FACILITY (PARTIAL VIEW)
the IBM 7090 computer virtually precludes the loss of data in this manner. The trap is remembered and, after the routine is completed, an enabling instruction is given, the trap request is granted, and the transfer of data by the DCC continues. Therefore, the DCC may interrupt the main program only to the extent that the main program allows. The DCC controls the transmission of data; the main program controls the action of the DCC.

The Mercury Program System uses 27 subchannels composed of the following four types:

a) The High-Speed subchannels for input (subchannels 1 and 2) receive a 16-bit character in parallel every eight milliseconds. This character is divided into two eight-bit parts and each is stored in separate core storage locations. For output the high-speed subchannels (subchannels 3 and 4) transmit data serially at a rate of 1000 bits per second. Three of the four high-speed subchannels are used for transmission between Goddard and the Mercury Control Center at Cape Canaveral. High-speed subchannels take priority over slower-speed subchannels.

b) The Low-Speed subchannels, the teletype subchannels for input (subchannels 14 through 29), receive five-bit characters in parallel from teletype equipment at a rate of as many as six characters per second. This type of subchannel is also used for paper tape input (subchannel 30). For output (subchannels 10 and 11), a low-speed subchannel selects one of eight terminal units and transmits a five-bit character in parallel to the selected unit at a rate of up to ten characters per second.

c) The Sense subchannel for input (not used in the Mercury Program System) receives an eight-bit character in parallel at a rate not to exceed one character every 500 microseconds. For output (subchannel 31), the sense subchannel allows the computer program to set up eight voltages and/or relays to control external equipment or display devices.

d) The Timing Control subchannel (subchannel 7) is the basic timing control mechanism for the system and provides an automatic program interrupt every one-half second. With all modifications the electronic clock requires three subchannels to: increment a core storage location every 8-1/3 milliseconds; interrupt the program after a program-specified number of either half-second or 8-1/3-millisecond increments, up to a maximum of 255 (subchannel 9 which at present is not used for the Mercury mission); and be synchronized with an external timing pulse every minute (subchannel 8).

The specific function of the individual subchannels is described in the following paragraphs. The underscored subchannel number preceding the explanation
refers to the sequencer position and, since the sequencer examines each subchannel sequentially, it refers also to each subchannel’s relative priority.

**Subchannel 1:** High-speed input 1 receives data from the Burroughs-General Electric Guidance System computer at Cape Canaveral. As its priority indicates, this subchannel transmits data of extreme importance. Since the B-GE computer receives tracking information from the launch vehicle only, its data pertinent to capsule tracking terminates with capsule separation.

**Subchannel 2:** High-speed input 2 receives data from the AN/FPS-16 radars at Cape Canaveral and the downrange stations. A manual selector switch at the Cape routes the transmission of either raw AN/FPS-16 radar data or IP 7090-processed AN/FPS-16 or Azusa quantities to Goddard. The high-speed transmission to Goddard of Cape Canaveral radar information effectively stops at the time of capsule insertion.

**Subchannel 3:** High-speed output 1 transmits Goddard-processed data to Cape Canaveral where it is used to drive control center displays. This output line is used continuously throughout the mission.

**Subchannel 4:** High-speed output 2 transmits data to the local digital-to-analog convertors where it is used to drive Goddard displays. This output line is in continuous use throughout the mission.

**Subchannels 5 and 6:** Not used; open.

**Subchannel 7:** The one-half second trap subchannel provides a program interrupt every one-half second. Since much of the computer's output transmission is based on a time period, the incrementing (or decrementing, if a countdown method is used) of core storage locations for each half-second trap enables the computer to keep count of time and to deliver output on specified schedules. The continuous functioning of the half-second trap is essential in a real time system. Although the four high-speed subchannels have higher priority, the maximum time required to service these, under the worst possible conditions, would not interfere with the half-second time count.

In synchronization with the operation of subchannel 7, a core storage location is incremented from 0 to 59 to keep count of the number of elapsed 8-1/3-millisecond periods since the last one-half-second trap (60 intervals of 8-1/3-milliseconds span a half second). After the 60th interval the cell is reset to zero. This storage cell* enables the computer to define more precisely the chronology of events on the taped logging record.

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*The sign bit of this storage cell tells the computer whether it is or is not transmitting externally. If the sign of this cell is positive in computer A, the corresponding cell in computer B must be negative. The bit is controlled from the Output Status Console.
FIGURE 1-3. CONTROL PANEL, OUTPUT STATUS CONSOLE
Subchannel 8: The WWV trap receives a pulse from the National Bureau of Standards radio station WWV every minute. This signal initiates a program interrupt which enables the computer to increment a one-minute count and to ascertain the accuracy of the computer's internal time count.

Subchannel 9: The interval timer subchannel is available but, at present, has no function in Project Mercury.

Subchannel 10: Low-speed output 1 (teletype subchannel X) selects and transmits teletype acquisition data to the following stations: Bermuda, Atlantic Ship, Hawaii, Guaymas and Corpus Christi.

Subchannel 11: Low-speed output 2 (teletype subchannel Y) selects and transmits teletype acquisition data to the following stations: Cape Canaveral, Grand Canary Island, Kano, Zanzibar, Indian Ocean Ship, Muchea, Woomera, Canton Island, Point Arguello, White Sands and Eglin.

Subchannels 12 and 13: Not used; open.

Subchannel 14: Low-speed input 1 receives radar data (range, azimuth and elevation) and telemetry summaries from the Cape Canaveral, Grand Bahama Island, and the San Salvador Island tracking stations.

Subchannels 15 and 16: Low-speed inputs 2 and 3 receive smoothed radar values from the IBM 709 computer at Bermuda. The two subchannels receive the same data from Bermuda, but through two different geographic routes.

Subchannel 17: Low-speed input 4 receives radar data and telemetry summaries from the Bermuda tracking station.

Subchannel 18: Low-speed input 5 receives radar data and telemetry summaries from the Grand Canary Island tracking station and telemetry summaries only from the Zanzibar and Kano tracking stations.

Subchannel 19: Low-speed input 6 receives radar data and telemetry summaries from the Muchea, Woomera, and the Hawaii tracking stations, and telemetry summaries only from the Canton Island tracking station.

Subchannel 20: Low-speed input 7 receives radar data and telemetry summaries from the Point Arguello tracking station.

Subchannel 21: Low-speed input 8 receives radar data from the White Sands tracking station.

Subchannel 22: Low-speed input 9 receives radar data from the Eglin Air Field tracking station.
FIGURE 1-4. GODDARD DUPLEXED INPUT/OUTPUT TRANSMISSION
Subchannel 23: Low-speed input 10 receives radar data and telemetry summaries from the Grand Canary Island tracking station, and telemetry summaries only from the Mid-Atlantic Ship.

Subchannel 24: Low-speed input 11 receives telemetry summaries only from the Indian Ocean Ship, and radar data and telemetry summaries from the Woomera and Muchea tracking stations.

Subchannel 25: Low-speed input 12 receives radar data and telemetry summaries from the Hawaii tracking station.

Subchannel 26: Low-speed input 13 receives radar data and telemetry summaries from the Guaymas and Corpus Christi tracking stations.

Subchannel 27: Low-speed input 14 receives radar data and telemetry summaries from the Corpus Christi tracking station.

Subchannel 28: Low-speed input 15 is available for use as a patching spare, if necessary.

Subchannel 29: Not used; open.

Subchannel 30: Low-speed input 17 is the paper tape input subchannel for all manually-inserted messages. Manual input information includes: the GMT of two-inch lift-off; a message indicating that either abort or orbit has been entered by the capsule; the number of retrorockets fired and the time of firing; range and velocity vectors for integration; and, in the future, capsule clock information. The messages are punched on paper tape and inserted into the computer via subchannel 30.

Subchannel 31: The sense output subchannel transmits to the Output Status Console (see Figure 1-3) an eight-bit output from a specified word in computer core storage. Each of the eight bits controls an indicator on the Output Status Console—a 1 turns on the particular indicator; a 0 turns it off.

The Output Status Console is common to both computers. It contains two sets of seven white lights and two sets of amber lights. The four left lights indicate the launch, abort, orbit and re-entry phases. Three of the remaining four lights indicate selected radar input during launch/abort phase. The amber light indicates bad or missing data during launch/abort and has an associated audible tone.

The sense output subchannel transmits immediately after it is activated, and then requests a trap. When the trap request is granted, the subchannel must be deactivated to prevent further transmission.

Subchannel 32: Not used; open.

The relationship between the duplexed IBM 7090 computers, the Data Communications Channels and the Output Status Console is illustrated in Figure 1-4.
1.3 MERCURY PROGRAM SYSTEM

Fundamentally, the role of the Mercury Program System is fourfold:

a) To provide to the Mercury Control Center on a continuous basis the present and the predicted future position of the capsule.

b) To indicate to the Mercury Control Center the time at which the retrorockets would have to be fired to bring the capsule down in pre-specified areas.

c) To provide accurate, timely acquisition data to the various telemetry and tracking stations of the Mercury network.

d) To furnish impact predictions before, during and after re-entry until recovery.

At many times, several of these functions are competing with one another for the computer's time. At any time, each must be satisfied without sacrifice of any of the others that are critical; that is, the computer must deliver several competing quantities on a rigorous schedule. Producing output on this schedule would be a difficult task even if the incoming data were arriving smoothly at regular intervals. When input is not only irregular, but not even a schedule, the system must become considerably more complex. Furthermore, the input is not only irregular in schedule, but it is also of irregular quality. Such data must be absorbed by the system without producing errors or delays. In addition, since errors may arise in the computer, the system must either be able to detect and correct these errors or detect and indicate them to personnel. If the errors cannot be corrected automatically, the system must be capable of restarting with a minimum of manual assist and quickly adjusting to real time computations. If the system is to function on a continuous basis, the system must be conscious of its changing responsibilities throughout the mission. It must, for example, be prepared to modify its data requirements depending upon the results of previous computations. Finally, the various programs involved must be closely integrated and coordinated, while the system itself remains extremely flexible and adaptable to change.

The programs which, when assembled and compiled, together compose the Mercury Program System are classified as Monitor or processing programs. As the name implies, the Monitor programs provide system supervision; the processing programs perform the mathematical computations. The dynamic programming of a monitor concept brings to a complex and expansive system an inherent advantage in flexibility. The processing programs operate as programs independently of Monitor in the same sense that subroutines operate independently of the main program. These processors need know only the location of available input data and the required locations for storing the calculated results. Consequently, the production of the processing programs may proceed separately from, and be completely independent of, the philosophy of the system.
1.3.1 The Mercury Monitor

The control of the Mercury Program System (see Figure 1-5) depends upon the input data, upon the results of computations by the program itself, and upon a preset priority table which is capable of continuous effective modification. In non-real-time computer programs, control normally proceeds along the lines of flow prescribed by the program being executed. When real time trapping is introduced into the system, control is no longer restricted to the preset line of flow. When operating in any trapping mode, a signal is generated when a specific condition is met. Upon receipt of the signal, control immediately transfers to a predetermined location regardless of the preset lines of flow which would otherwise have been used.

There are three states in which a computer may be operating. It may be enabled, disabled, or inhibited. When the computer is enabled, traps may occur. When disabled or inhibited, traps cannot occur even though an interrupt signal has been received. The computer may be enabled or disabled by executing the appropriate instruction; the inhibited state, however, is not entered through programming. When a trap occurs, the computer is immediately inhibited, thereby permitting no further traps until the computer is re-enabled by the program.

All input/output data transmission occurs through the Data Communications Channel and other data channels simultaneously with the execution of the main program. Only when an input buffer is filled, an output buffer emptied, a half-second interval elapses, or the one-minute pulse from WWV occurs, must the present computer program be interrupted. This situation gives rise to the primary control mechanism in the Mercury Monitor, the program trap.

When the Mercury Program System is executing any of the non-trap processors, two possibilities exist: the processor may be completed or a trap may interrupt and take control from the processor. If the computer is enabled for trapping on a given data channel, all trap requests on that channel are honored immediately. The trap may be necessary to accept input transmission or to terminate output transmission, or the trap may be the result of a timing signal. The trap processor, operating while the computer is inhibited from trapping, generates control information for the Monitor controller programs and, if necessary, the trap processor relocates data. When the trap processor has completed, control passes to the basic priority routine, M0PRIO. If, in the original example, the non-trap processor had completed, control also returns to M0PRIO. When any trap or ordinary processor is completed, control always returns to M0PRIO.

The main priority routine, M0PRIO, together with M0SAVE, M0RTCC, M0RTRN and M0DIAG comprise the Monitor system's main controller programs (See Figure 1-6). When a trap takes control from a processor, M0SAVE stores the pre-trap condition of the processor so that it may be restored and completed at some future time. If the trap had been produced by the Data Communications
FIGURE 1-5. MONITOR CONTROL OF MERCURY PROGRAM SYSTEM
Channel, M0RTCC determines which of the subchannels of the DCC is responsible for the trap. After the trap processor is executed, control passes to M0PRIO.

The transfer of control from M0PRIO is determined from the priority table, TMPRIO (see Table 2-2). Each processor is represented in this table by a routine entry and associated control indicator bits, A,B,C,D, etc. The A, or in-process, indicator for a processor is turned on when that processor is entered, and turned off when the processor is completed. The B, or ready, indicator is turned on when input data is available for that processor, and turned off when that processor is entered, if no other input data remains. If input data may at times be supplied to a processor at a rate exceeding the processor’s ability to accept this data, input queue tables are provided. But, generally, the B indicator is turned off as the A indicator is turned on. The C, D, ... K, or suppression, indicators are turned on when for any reason a processor must not be entered, and are turned off when this restriction is no longer present. Since a processor may be suppressed for various reasons, there are as many suppression indicators as there are reasons for suppression. The control indicators in the Monitor priority table, TMPRIO, are turned on and off only by the Monitor programs: the Monitor processors, the Monitor trap processors, the Monitor prefixes and suffixes to the non-monitor processors.

When M0PRIO receives control, it scans the priority table, TMPRIO, in sequence seeking the highest priority program from which none of the suppression indicators (C,D, ... K) is on. If such a situation exists, M0PRIO examines the in-process and ready indicators, A and B, respectively. If neither is on, M0PRIO continues to examine the suppression indicators for the remaining entries in TMPRIO. If M0PRIO finds an unsuppressed program with indicators A and/or B on, indicator A takes precedence over indicator B. That is, a program may be interrupted any number of times, but must be completed before new input data may be accepted. If M0PRIO finds that every unsuppressed program has neither its in-process nor its ready indicator on, the Mercury Program System has, in effect, caught up with the data transmission and must wait for the next trap to continue processing.*

While waiting for the next trap, the computer executes a special machine diagnostic program, M0DIAG. This program is entered only if all processors lack input data or are suppressed and, since M0DIAG is always entered at the initial location, the computer condition at the point of interrupt need not be remembered. That is, when M0DIAG is interrupted by a trap, there is no need to save the pre-trap processing conditions.

Control enters each non-Monitor processor through its Monitor prefix; control leaves each non-Monitor processor through its Monitor suffix. The Monitor programs, through their control of input/output transmission and system timing,

*Time studies have shown that during the orbit phase the Mercury Program System spends three-fourths of the time waiting in M0DIAG.
COMPUTER IS DISABLED FROM TRAPPING

MOSAVE SAVES MACHINE CONDITION

MORTCC (DCC TRAPS ONLY) DETERMINES WHICH SUBCHANNEL CAUSED TRAP

SPECIFIED TRAP PROCESSOR. WHEN COMPLETED MAY AFFECT SOME INDICATORS IN THE PRIORITY TABLE

MORDIA MACHINEDIAGNOSTIC PROGRAM IS EXECUTED WHILE WAITING FOR TRAP

MOPRIO SEARCHES PRIORITY TABLE FOR APPROPRIATE EXIT

MORTRN RESTORES MACHINE CONDITION FOR RETURN TO INTERRUPTED PROCESSOR

TRAP OCCURS

PREFIX FOR PROCESSOR J

ORDINARY PROCESSOR J

SUFFIX FOR PROCESSOR J

ORDINARY PROCESSOR K

ORDINARY PROCESSOR J

PREFIX FOR PROCESSOR J

ORDINARY PROCESSOR J

SUFFIX FOR PROCESSOR J

ORDINARY PROCESSOR K

EXIT FROM MOPRIO DEPENDS UPON THE PRIORITY TABLE.

GIVEN: PROCESSOR J HAS HIGHER PRIORITY THAN PROCESSOR K.

MOPRIO EXITS TO: (A) WHEN J IS HIGHEST UNSUPPRESSED PROCESSOR
(B) WHEN K IS HIGHEST UNSUPPRESSED PROCESSOR (THE INTERRUPTED PROCESSOR, J, MUST BE SUPPRESSED)
(C) WHEN NO PROCESSOR HAS BEEN INTERRUPTED OR IS READY, OR WHEN ALL INTERRUPTED OR READY PROCESSORS ARE SUPPRESSED.

FIGURE 1.6. BASIC MONITOR CONTROL
are the direct link between the external world and real-time data processing (see Figure 1-5). The Monitor programs extend this link to the processing programs via the Monitor prefixes and suffixes, which provide the direct communication between the Monitor and non-Monitor programs. When the prefix receives control, the A indicator is turned—the processor is now "in process." If no other input data is available and waiting for the processor, the B indicator is turned off. After the processor is completed, the suffix turns off the A indicator and, if the output data from this processor serves as input to another processor, the B indicator for that processor is turned on. Control always returns to M0PRIO.

1.3.2 Data Channels A, B and C

The input of real-time data occurs through the Data Communications Channel. To provide maximum versatility in the operational tracking program, the IBM 7090 data channels A, B and C are utilized to perform the following functions:

a) Write the Mercury system tape, initially load the first phase of the Mercury Program System for launch, and later load the new programs required for the orbit and re-entry phases and, if necessary, the programs required for orbital restarts.

b) Load the Station Characteristics tape into computer core storage during the prelaunch initialization of the Mercury Program System.

c) Write and maintain a restart tape with the proper parameters for orbital and re-entry restarts and for the phase change from orbit to re-entry.

d) Provide the Mercury Program System with prepared messages for on-line printing throughout the mission.

e) Provide for post-flight and other analyses a permanent log tape record of all input/output transmission via the Data Communications Channel and of all on-line message prints.

To promote maximum efficiency of tape input/output (and on-line printer) operations and to ensure minimum delay of the central processing unit, the simultaneous input/output/compute capability of the IBM 7090 system is used for all data channel operations while the Mercury Program System is operating in real time. That is, no data channel commands are given which would logically disconnect an input/output device at the termination of transmission without an accompanying data channel trap. This requires two programs for every input/output transmission process: the Monitor processor (MYXXXX) which initiates the transmission and the Monitor trap processor (MTXXXX) which services the trap following the completion of transmission.

When two or more transmission processors share the same data channel, certain restrictions must be observed. Prior to initiating transmission the processor must:
a) Suppress every other processor which may initiate transmission over the same data channel.

b) Set the low core trap control location with a transfer instruction addressed to the trap processor appropriate for the data transmitted.

c) Suppress itself, if necessary to prevent successive entry and transmission until after the trap processor has signaled the completion of the current transmission cycle.
1.4 SCOPE OF THE MANUAL

The Monitor programs for the duplexed IBM 7090 computers supervise the logical flow of all data processing and associated transmission for the Mercury Program System.

The basic Monitor control programs are described in Section 2. The Monitor control of Data Communications Channel input and the associated programs are described in Section 3. Section 4 contains the programs which control the launch and abort phases of a Mercury mission. Section 5 discusses the programs which control the phase changes and the restart operations. Section 6 contains the programs which control processing during the orbit and re-entry phases of a Mercury mission. The Monitor control of Data Communications Channel output and the associated programs are described in Section 7. Section 8 contains the programs which control the on-line message prints and the logging cycle. Section 9 provides a series of reference listings for the programs, communication cells and tables utilized in Monitor control.

The mathematical or processing programs for the Mercury Program System are described only briefly in this manual. Detailed descriptions of these programs appear in Goddard Processing Programs, MC 105.
Section 2

BASIC MONITOR CONTROL PROGRAMS

The basic Monitor control functions for the Mercury Program System are exercised by the main controller programs, by the queueing and unqueueing programs and by the associated system macros. The Main Controller Priority Program, M0PRI0, gives control to other programs in the Mercury Program System on the basis of a dynamic priority table in which the priority indicators are controlled by the Monitor Macros, TRNOF and TRNON. These macros are used throughout the Mercury Program System by various monitor programs—processors, trap processors, prefixes and suffixes to the processor programs.

When a non-trap processor is interrupted, the Save Macro, SAVE, gives control to the Main Controller Save Program, M0SAVE, which preserves the condition of the interrupted processor. The Real Time Channel Main Controller Program, M0RTCC, interprets all interrupts occurring on the Data Communications Channel. When the trap processor which services the interrupt is completed, priority conditions permitting, M0PRI0 gives control to the Main Controller Return Program, M0RTRN, which restores the conditions and returns control to the program at the interrupt point. When a program must be free from interruption the Disable Macro, QENBZ, and its associated Disable Program, MYENB0, are executed. When conditions permit interrupt, the Enable Macro, QENBA, and its associated Enable Program, MYENBA, are executed.

When input data may be held in waiting for a program, the execution of the Queue Macro, QUEUE, and its associated Queue Program, M0QUEU, places an entry in the input queue table for that program. When the program is free to accept new data, the execution of the Unqueue Macro, UNQUE, and its associated Unqueue Program, M0UNQU, extracts the oldest waiting input from the first location in the queue table.

The Reference Macro, REFR, is executed only in the compilation of the Mercury Program System and generates the queue tables and the basic Monitor tables used by the main controller programs and the system macros.

The programs and macros listed above are described in detail on the following pages.
2.1 CONTROLLER PRIORITY PROGRAM (MOPRIO)

The Monitor priority program, MOPRIO, is the center of the Monitor control system and gives precedence to the routines of the Mercury Program System according to a priority table which is continuously modified by mission conditions.

The flow chart for the MOPRIO program is shown in Figure 2-1.

2.1.1 Input Requirements

Input to MOPRIO consists of:

a) N—the total number of routines listed as entries in the Monitor reference table, TMREFR.

b) TMPRIO—the Monitor priority table, N cells, in order by priority number, containing in the address the location of the first instruction (the entry) of the routine. Bits S, 1, 2-9 contain the indicator bits, A, B, C, D, E, F, G, H, J and K. An indicator is on if the bit specified by the indicator is a 1, off if the bit is a zero. When indicator A is on, the routine has been initiated—the routine is in-process. When indicator B is on, input data is ready for the routine—the routine is ready. When any one of the indicators C through K is on, there is a reason why the routine should not be given control. The routine is suppressed.

c) TMSAVE—the Monitor save table, N cells, in order by routine number, containing in the address the location of the block in TMPANL which is used to store the machine condition when a trap occurs during the execution of that routine.

d) TMFRPR—the Monitor priority table, N cells, in order by priority number, containing in the address the routine number corresponding to the routine of the particular priority.

e) M0RTRN—the location of the Monitor Return program.

f) M0DIAG—the location of the Monitor Diagnostic program.

(The following three masks are used to determine if the specified indicator bits are on.)

g) TMNMSK-1+Y—mask, 177 400 000 000; indicators C through K (Y=11, TMNMSK-1+Y = TMNMSK+10).

h) TMNMSK-1+Z—mask, -200 000 000 000; indicators A or B (Z = 12, TMNMSK-1+Z = TMNMSK+11).
i) TMNMSK-1+A — mask, -000 000 000 000; indicator A(A = 1, TMNMSK-1+A = TMNMSK).

j) ADDUM— the address of an 11-cell storage block within M0PRIO. When a trap takes program control from M0DIAG, this block holds the machine condition as TMPANL holds the machine condition when a routine is interrupted.

k) Macro Used—QENBA.

2.1.2 Output Requirements

M0PRIO (1) selects either one of the routines in the Mercury Program System or the diagnostic program, M0DIAG, (2) places an appropriate entry in MCSAVE and (3) transfers control, directly or indirectly, to the selected routine.

If control returns to an interrupted routine, M0PRIO places the TMPANL location for that routine in MCSAVE and gives control to M0RTRN. M0RTRN restores the machine condition and transfers control to the interrupted routine at the exact point of the trap.

If control may be given to a routine at its initial location, M0PRIO places the TMPANL location for that routine in MCSAVE and transfers control directly to the selected routine.

If control may not be given to any routine, M0PRIO places the location of ADDUM in MCSAVE and transfers control directly to M0DIAG.

2.1.3 Method

M0PRIO receives control under one of two conditions: either a trap or an ordinary (non-trap) processor has been completed. Since all trap processors are executed while the computer is completely inhibited, and since M0PRIO has no way of knowing from where program control came, the first operation by M0PRIO is to enable the computer for trapping.

M0PRIO examines the indicators in TMPRI0 from the first entry, seeking the highest priority routine for which none of the suppression indicators (C through K) is turned on. If such a situation exists, M0PRIO examines the in-process and ready indicators, A and B, respectively. If neither is on, M0PRIO continues to examine the suppression indicators for the remaining entries in TMPRI0. If M0PRIO finds that every unsuppressed routine has neither its in-process nor its ready indicator on, there is nothing for the Mercury Program System to do. M0PRIO gives program control to M0DIAG.

If M0PRIO finds an unsuppressed routine with indicators A and/or B on, indicator A takes precedence over indicator B. That is, a routine may be interrupted any number of times, but it must be completed before new input data may
be accepted. The address of the save block in TMPANL is placed in MCSAVE and control transfers to the routine directly (indicator B on, indicator A off) or indirectly (indicator A on, indicator B may be on or off) via M0RTRN.

### 2.1.4 Usage

M0PRIO is entered at the completion of any routine or trap processor; the program exits to a previously interrupted routine, a new routine, or to M0DIAG.

a) **Storage Required**—34 locations

b) **M0PRIO uses:**

1) Macro—QENBA
2) Parameters—N, Y, Z and A
3) Communication Cell—MCSAVE
4) Tables—TMPRIO, TMSAVE, TMREFR, TMFRPR and ADDUM
5) Masks—TMNMSK+Y-1, TMNMSK+Z-1 and TMNMSK+A-1

c) **Time Required:**

1) Exit to M0DIAG—1.005 + 0.009S milliseconds
2) Exit to new routine—0.047 + 0.026P + 0.009S millisecond
3) Exit to M0RTRN—0.052 + 0.026P + 0.009S millisecond

where:

\[ S = \text{the number of examined routines for which one (or more) of the suppression indicators is on.} \]

\[ P = \text{the priority of the routine which receives control from M0PRIO.} \]
ENTRY

MOPRIO

QENBA
(ENABLE)

SET P=P+I

P=1 TO
EXAMINE PRIORITY TABLE

SET
P=P+1

ANY SUPPRESSION BITS ON FOR
ROUTINE P
(Cp THROUGH Kp)

ROUTINE NOT
SUPPRESSED—WAS
IT INTERRUPTED
OR IS IT READY?
(Ap OR Bp ON?)

NO

YES

WAS ROUTINE INTERRUPTED?
(Ap ON?)

NO, ENTRY AT START

GET ROUTINE NUMBER (M)
FROM TMFRPR

PLACE TMPANL
LOCATION FOR SAVE OR
RESTORE IN MCSAVE

M O D I A G

M O R T R N

D I R E C T E D TO
SELECTED ROUTINE

NO

YES

PLACE SAVE LOCATION (ADDUM)
IN MCSAVE

P=N?

ENTER AT THE COMPLETION OF
ANY TRAP OR ORDINARY
PROCESSOR

SET
a=a1

SET
a=a2

a1

a

a2

FIGURE 2-1. MOPRIO PROGRAM FLOW CHART
2.2 REAL TIME CHANNEL MAIN CONTROLLER PROGRAM (MORTCC)

All program interrupts resulting from data transmission through the DCC are interpreted by the real time channel control program, MORTCC.

The flow chart for the MORTCC program is shown in Figure 2-2.

2.2.1 Input Requirements

Input to MORTCC consists of:

a) Location 00003—control word set by the hardware when a DCC trap occurs. The address part contains the location counter at the instant the trap occurred; bits 4-8 contain the number of the DCC subchannel responsible for the trap.

b) Location 00004—this location supplies the instruction following a DCC trap and must contain a transfer to MORTCC (the instruction is actually TTR MORTCC).

c) KMSK48—mask, 047 000 000 000, used to clear a word of all bits except 4 through 8, inclusive.

d) TMRTCC—the Monitor real time channel reference table containing an entry for each DCC subchannel used by the Mercury Program System. The entries are arranged in inverse subchannel order. For each entry the decrement contains the location of the DCC core storage buffer serviced by this subchannel and the address contains the location of the trap processor which services the buffer. (See Table 2-1.)

e) Macro Used—SAVE.

The computer is inhibited during the execution of MORTCC.

2.2.2 Output Requirements

The appropriate trap processor is given control with the accumulator containing the subchannel number in the decrement and the location of the associated core storage buffer in the address.

2.2.3 Method

MORTCC begins by saving the machine condition with the execution of the SAVE macro and the MOSAVE program. MORTCC then examines location 00003 to determine which DCC subchannel is responsible for the trap. With this information, MORTCC places the subchannel number in the decrement of the accumulator and the subchannel's buffer block location into the address of the accumulator. Control is transferred directly to the specified trap processor.
2.2.4 Usage

M0RTCC is entered from location 00004 following a DCC trap, and exits to the selected trap processor.

a) Storage Required—11 locations

b) M0RTCC uses:

1) Macro—SAVE
2) Communication Cell—MCX4RA
3) Table—TMRTCC
4) Mask—KMSK48

c) Time Required—if DCC trap interrupted:

1) M0PRIO—0.078 millisecond
2) M0RTRN—0.087 millisecond
3) Any other routine—0.207 millisecond (maximum)
<table>
<thead>
<tr>
<th>Symbolic Location</th>
<th>DCC Buffer</th>
<th>Trap Processor</th>
<th>Sub-channel</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMRTCC</td>
<td>3</td>
<td>17</td>
<td>21</td>
<td>35</td>
</tr>
<tr>
<td>+ 1</td>
<td>TMT117</td>
<td>MTSENS</td>
<td>31</td>
<td>To Sense Output Console</td>
</tr>
<tr>
<td>+ 2</td>
<td>TMT116</td>
<td>MTTTIN</td>
<td>30</td>
<td>Paper Tape Output (17)</td>
</tr>
<tr>
<td>+ 3</td>
<td>TMT115</td>
<td>MTTTIN</td>
<td>29</td>
<td>Teletype Input 16</td>
</tr>
<tr>
<td>+ 4</td>
<td>TMT114</td>
<td>MTTTIN</td>
<td>28</td>
<td>Teletype Input 15</td>
</tr>
<tr>
<td>+ 5</td>
<td>TMT113</td>
<td>MTTTIN</td>
<td>27</td>
<td>Teletype Input 14</td>
</tr>
<tr>
<td>+ 6</td>
<td>TMT112</td>
<td>MTTTIN</td>
<td>26</td>
<td>Teletype Input 13</td>
</tr>
<tr>
<td>+ 7</td>
<td>TMT111</td>
<td>MTTTIN</td>
<td>25</td>
<td>Teletype Input 12</td>
</tr>
<tr>
<td>+ 8</td>
<td>TMT110</td>
<td>MTTTIN</td>
<td>24</td>
<td>Teletype Input 11</td>
</tr>
<tr>
<td>+ 9</td>
<td>TMT109</td>
<td>MTTTIN</td>
<td>23</td>
<td>Teletype Input 10</td>
</tr>
<tr>
<td>+ 10</td>
<td>TMT108</td>
<td>MTTTIN</td>
<td>22</td>
<td>Teletype Input 9</td>
</tr>
<tr>
<td>+ 11</td>
<td>TMT107</td>
<td>MTTTIN</td>
<td>21</td>
<td>Teletype Input 8</td>
</tr>
<tr>
<td>+ 12</td>
<td>TMT106</td>
<td>MTTTIN</td>
<td>20</td>
<td>Teletype Input 7</td>
</tr>
<tr>
<td>+ 13</td>
<td>TMT105</td>
<td>MTTTIN</td>
<td>19</td>
<td>Teletype Input 6</td>
</tr>
<tr>
<td>+ 14</td>
<td>TMT104</td>
<td>MTTTIN</td>
<td>18</td>
<td>Teletype Input 5</td>
</tr>
<tr>
<td>+ 15</td>
<td>TMT103</td>
<td>MTTTIN</td>
<td>17</td>
<td>Teletype Input 4</td>
</tr>
<tr>
<td>+ 16</td>
<td>TMT102</td>
<td>MTTTIN</td>
<td>16</td>
<td>Teletype Input 3</td>
</tr>
<tr>
<td>+ 17</td>
<td>TMT101</td>
<td>MTTTIN</td>
<td>15</td>
<td>Teletype Input 2</td>
</tr>
<tr>
<td>+ 18</td>
<td>- - -</td>
<td>MTERTC</td>
<td>14</td>
<td>Teletype Input 1</td>
</tr>
<tr>
<td>+ 19</td>
<td>- - -</td>
<td>MTERTC</td>
<td>13</td>
<td>None, DCC Error</td>
</tr>
<tr>
<td>+ 20</td>
<td>TMYBOX</td>
<td>MTTTOY</td>
<td>12</td>
<td>None, DCC Error</td>
</tr>
<tr>
<td>+ 21</td>
<td>TMXBOX</td>
<td>MTTTOX</td>
<td>11</td>
<td>Teletype Output 2</td>
</tr>
<tr>
<td>+ 22</td>
<td>TMINTV</td>
<td>MTINTV</td>
<td>10</td>
<td>Teletype Output 1</td>
</tr>
<tr>
<td>+ 23</td>
<td>- - -</td>
<td>MTWWVI</td>
<td>09</td>
<td>Interval Timer</td>
</tr>
<tr>
<td>+ 24</td>
<td>TM8.3M</td>
<td>MTHFSC</td>
<td>08</td>
<td>WWV Minute Pulse</td>
</tr>
<tr>
<td>+ 25</td>
<td>- - -</td>
<td>MTERTC</td>
<td>07</td>
<td>Half-Second Trap</td>
</tr>
<tr>
<td>+ 26</td>
<td>- - -</td>
<td>MTERTC</td>
<td>06</td>
<td>None, DCC Error</td>
</tr>
<tr>
<td>+ 27</td>
<td>TMHSOP</td>
<td>MTHSOP</td>
<td>05</td>
<td>None, DCC Error</td>
</tr>
<tr>
<td>+ 28</td>
<td>TMHDOD</td>
<td>MTHSOD</td>
<td>04</td>
<td>Local Plotter</td>
</tr>
<tr>
<td>+ 29</td>
<td>TMHSO9</td>
<td>MTHS09</td>
<td>03</td>
<td>MCC Output to displays</td>
</tr>
<tr>
<td>+ 30</td>
<td>TMHSGB</td>
<td>MTHSGB</td>
<td>02</td>
<td>High-Speed Input 2</td>
</tr>
<tr>
<td>+ 31</td>
<td>- - -</td>
<td>MTERTC</td>
<td>01</td>
<td>High-Speed Input 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None, DCC Error</td>
</tr>
</tbody>
</table>
MC 103

LOC 4

TRAP TRANSFER TO MORTCC

MORTCC

SAVE MACRO

Determine Which Subchannel Caused Trap

Place Subchannel Number in AC3-17 Subchannel Buffer Location in AC 21-35

TO TRAP PROCESSOR

LOCATION 3 SET BY TRAP.

S.C. # LOC COUNTER

4-8

TMRTCC

SUBCHANNEL BUFFER LOCATION TRAP PROCESSOR LOCATION

Figure 2-2. MORTCC Program Flow Chart
2.3 MAIN CONTROLLER SAVE PROGRAM (MOSAVE)

Every time a program interrupt occurs, the machine condition must be preserved if control is to return to the interrupted program at the exact point of the interrupt. MOSAVE receives control from the SAVE macro following a program interrupt and stores the machine condition in a specified block within TMPANL.

The flow chart for MOSAVE is shown in Figure 2-3.

2.3.1 Input Requirements

Input to MOSAVE consists of:

a) M0PRI0, AD5—the locations corresponding to the first and last locations in M0PRI0.

b) M0RTRN, AC6—the locations corresponding to the first and last locations in M0RTRN.

c) MCX4RA—communication cell containing in the decrement the contents of index register 4 and in the address the contents of the location counter when the trap occurred.

d) MCSAVE—communication cell containing the location in TMPANL of the block in which is stored the machine condition when an interrupt occurs. This address is set by M0PRI0 just prior to the transfer of program control to the selected routine.

e) MCTRAP—communication cell containing non-zero data if the interrupted program was attempting to disable from trapping when the trap occurred.

f) COMMON—five common cells for storing and saving the temporary results of library subroutines which are shared by two or more routines in the Mercury program.

The computer is inhibited during the execution of MOSAVE.

2.3.2 Output Requirements

If MOSAVE has received control after an interrupt of M0PRI0 or M0RTRN, there is no output. Otherwise, an eleven-cell block provided in TMPANL for the interrupted routine is filled as shown on the flow diagram for MOSAVE.

2.3.3 Method

The SAVE macro sets up the calling sequence, which includes the contents of both index register 4 and the location counter when the interrupt occurred,
and transfers control to MOSAVE. By examining the saved location counter value MOSAVE determines whether the trap took control from MOPRIO or MORTRN. If either of these two programs was interrupted, there is no need to save the machine condition—both programs are entered only at the initial instruction—and control is given directly to the appropriate trap processor. Otherwise MOSAVE stores the machine condition in the reserved block in the TMPANL table taking the address of this block from the communication cell, MCSAVE.

Three tests are performed in the process of saving the machine condition in TMPANL. If the divide check indicator is on, it is turned off and a notation is made in the tag of the fourth word of the TMPANL block. If the overflow indicator is on, it is turned off and a notation is made in the prefix of the fourth word of the TMPANL block. The third test is an examination of MCTRAP. If MCTRAP contains non-zero data, the interrupted program was attempting to disable when the trap occurred, and a notation is made in the tag in the third word of the TMPANL block.

The block in TMPANL contains eleven locations. The last five contain the common locations from library subroutines shared by two or more routines in the Mercury program. In order to conserve core storage, standard library subroutines were rewritten to provide five common cells for the storage of temporary results. Before this change each routine incorporated within itself every library subroutine it used to prevent the destruction by a trap of temporary results which were outside the panel locations. With the common storage feature temporary results are accessible to the MOSAVE program and could be saved for any routine. Consequently, library subroutines may be used by any routine in any order without interfering with the use of the subroutine by any other routine.

The information contained in and the arrangement of the storage block in TMPANL are illustrated on the flow diagram for this program.

2.3.4 Usage

MOSAVE is entered from the SAVE macro.

a) Calling Sequence:

TSX MOSAVE, 4

Return

b) Storage Required—43 locations

c) MOSAVE uses:

1) Communication Cells—MCX4RA, MCSAVE and MCTRAP

2) Tables—TMPANL and COMMON

2-12
3) Locations—M0PRIO, AD6 and M0RTRN, AC6

d) Time Required:

1) If M0PRIO is interrupted—0.037 millisecond

2) If M0RTRN is interrupted—0.046 millisecond

3) Maximum—0.165 millisecond
MOSAVE

Was
M0PRI0
interrupted?

Yes
No

Was
M0TRN
interrupted?

No

Yes

Get TMPANL
block location
from MOSAVE

Save
machine
condition

If
MCTRAP \neq 0,
set
I = 1

If
divide
check
indicator
on,
set
II = 1

If
AC
overflow
indicator
on,
set
III = 1

Otherwise
set
I, II, III = 0

Save
the
5
common
cells
for
the
LBR
subroutines

MCSAVE

21
35

LOCATION OF SAVE
BLOCK IN TMPANL

Figure 2-3. MOSAVE Program Flow Chart
2.4 MAIN CONTROLLER RETURN PROGRAM (M0RTRN)

When M0PRIO determines that the highest priority assignment consists of completing a routine that has been previously interrupted by a trap, control is first given to M0RTRN. This program restores the conditions of the interrupted routine exactly as they were immediately prior to the trap.

The flow chart for M0RTRN is shown in Figure 2-4.

2.4.1 Input Requirements

Input to M0RTRN consists of:

a) MCSAVE—the location in TMPANL of the eleven-cell block in which the machine condition was saved when the interrupt occurred; this cell is set by M0PRIO before control transfers to M0RTRN.

b) K00000—constant, 0.

c) KTGMSK—constant, 000 000 700 000, used to keep the contents of the tag while eliminating everything else in a computer word.

d) Macro Used—QENBZ.

2.4.2 Output Requirements

The machine condition is restored and the interrupted routine begins from the point of the interrupt as if it had not occurred.

M0RTRN is essentially the converse of M0SAVE and provides a restoration of: AC, Q, P, 1-35, MQ, S, 1-35, XR1, XR2, XR4, the sense indicators, the divide check indicator, the overflow indicator, location 00000 and library subroutine locations COMMON through COMMON + 4 inclusive.

If the routine had been trapped while attempting to disable, the computer will be disabled by M0RTRN before control returns to the trapped routine.

2.4.3 Method

M0RTRN receives control from M0PRIO with the location of the TMPANL save block in MCSAVE. The last five words which hold the contents of the common locations from the shared library subroutines are restored. Index register 4 is restored. If the divide check or the overflow indicators should be on, M0RTRN restores these indicators. Index registers 1 and 2, the entire accumulator and the multiplier-quotient registers are restored. If the routine should be disabled upon return, M0RTRN executes the QENBZ macro. Location 00000 and the sense indicators are restored and control returns to the trapped routine.
2.4.4 Usage

M0RTRN is entered from M0PRIQ; M0RTRN exits to the selected routine.

a) Storage Required—45 locations

b) M0RTRN uses:
   1) Macro—QENBZ
   2) Communication Cell—MCSAVE
   3) Tables—TMPANL and COMMON
   4) Constant—K00000
   5) Mask—KTGMSK

c) Time Required:
   1) Minimum—0.122 millisecond
   2) Maximum—0.207 millisecond
MORTRN

GET LOCATION OF SAVED BLOCK FROM MCSAVE

RESTORE MACHINE CONDITION FROM SAVE BLOCK

IF II = 1, TURN ON DIVIDE CHECK INDICATOR

IF III = 1, TURN ON AC OVERFLOW INDICATOR

IF I = 1, DISABLE COMPUTER

RETURN TO INTERRUPTED ROUTINE

MCSAVE

LOCATION OF SAVED BLOCK IN TMPANL

FIGURE 2-4. MORTRN PROGRAM FLOW CHART
2.5 MAIN CONTROLLER DIAGNOSTIC PROGRAM (M0DIAG)

When M0PRIO is unable to give control to any other program in the Mercury Program System, control is given to M0DIAG and remains there until a program interrupt occurs.

In the current system, M0DIAG performs only one function—reducing the amount of non-critical data written on the log tape. The Mercury Program System, loaded minutes before lift-off, receives test patterns and other data over the high-speed lines from Cape Canaveral. This data is processed and the results transmitted to the Mercury Control Center for display. By storing transfer instructions in strategic locations within the programs which log high-speed input/output data, M0DIAG can eliminate non-essential data from the log tape.

The flow chart for the M0DIAG program is shown in Figure 2-5.

2.5.1 Input Requirements

The sole input to M0DIAG consists of the sense switch 1 setting. The sense switch 1 must be depressed to inhibit logging of high-speed data. The sense switch must be restored to allow logging of high-speed data.

2.5.2 Output Requirements

With sense switch 1 down M0DIAG places transfer instructions within the MPHSGB, MPHS09 and MYHSOD programs. These instructions bypass the logging subroutine. With sense switch 1 up M0DIAG restores the original instructions in the MPHSGB, MPHS09 and MYHSOD programs.

2.5.3 Method

M0DIAG disables the computer and examines the setting of sense switch 1. Instructions are set to inhibit or restore logging of high-speed data depending upon the sense switch setting. The computer is enabled and the program halts to wait for the next trap.

2.5.4 Usage

M0DIAG is entered from M0PRIO; M0DIAG exits to the lower core location specified by the trap.

a) Storage Required—27 locations

b) M0DIAG uses:

1) Macros—QENBA and QENBZ
2) Locations—BCJME +1 (in MPHS09),

BBJME +1 (in MPHSGB),

BJAA1 +1 (in MYHSOD) and

BJSS2 +1 (in MYHSOD).

**RESTRICTION:** Any change made in the symbolic locations of the MPHS09, MPHSGB and MYHSOD programs without compensating changes in M0DIA4G could produce undesirable effects.

c) Time Required:

1) Sense Switch 1 up—0.177 millisecond

2) Sense Switch 1 down—0.186 millisecond
FIGURE 2-5. MODIAG PROGRAM FLOW CHART
2.6 MAIN CONTROLLER QUEUE PROGRAM (M0QUEU)

For some routines in the Mercury Program System, situations exist where input data is supplied to a routine at a rate exceeding the routine's ability to accept it or to dispose of the computed output. Furthermore, a rate of output determined by the output computations may not be desirable since output devices frequently cannot operate at speeds comparable to an IBM 7090 computer and generally operate asynchronously with data processing.

To preserve this input, queue blocks, or tables, allow for the stacking of data until such time as the restrictions of the situation permit processing or transmission. M0QUEU stores entries in the queue tables.

The flow chart for the M0QUEU program is shown in Figure 2-6.

2.6.1 Input Requirements

Input to M0QUEU consists of:

a) XR4—contains the 2's complement of the location counter at the instruction which transfers control to M0QUEU.

b) 1,4—contains in the address the location (DL) of the word to be placed in the queue table and in the decrement the routine number (N) which specifies the routine to be queued. (For routines whose input requirements for execution exceed the capacity of one core location, DL is the address of a block of input data. For those routines whose input consists of data contained within a single location, DL may be the actual location of the data, that is, the data itself is contained within the queue table. In either case the QUEUE macro and the M0QUEU program operate identically; the distinction of DL is the responsibility of the routines which use queue tables.)

c) 2,4—the return address at the completion of M0QUEU.

d) TMQKEY+N-1—contains in the decrement the current number of entries in the queue table and in the address the location of the queue table for routine N.

e) TMQKY2+N-1—contains in the decrement the 2's complement of the maximum number of queue entries for routine N.

f) TMREFR+N-1—contains the location of the entry in the priority table, Tmprio, for routine N.

g) TMNMSK+B-1—mask, 200 000 000 000, used to turn on indicator B in Tmprio for routine N (B = 2, TMNMSK+B-1 = TMNMSK+1).

h) KD0001—constant, 000 001 000 000.
The computer must be disabled during the execution of MOQUEU.

2.6.2 Output Requirements

If the queue table is full upon entry, there is no output—the new entry is lost.

If the queue table is not full:

a) TMQKEY+N-1—the current number of queue entries in the decrement is incremented by one.

b) QPN—the word in location DL is stored as an entry in the queue table, QPN. The location in the queue table is determined by the sum of the queue table location and the number of current entries in the queue, that is, A(TMQKEY+N-1) + D(TMQKEY+N-1). QPN is the queue for routine N (having priority PN).

c) TMPRIO+PN-1—indicator B for routine N is turned on.

No provision is made by MOQUEU to save the machine condition. The contents of all index registers as well as the accumulator are destroyed by this program.

2.6.3 Method

The QUEUE macro supplies the calling sequence and transfers control to MOQUEU. The current entry count is compared to the maximum allowable number of entries in the queue table. If the queue table is not already full, the location of the input data is stored in the first empty location, the count of entries is increased by one, and the B indicator for the program using the queue table as input, is turned on. Control then returns to the program which entered MOQUEU.

If the comparison determines that the queue table was already full, control returns immediately to the source program.

2.6.4 Usage

MOQUEU is entered from the QUEUE macro.

a) Calling Sequence:

TSX MOQUEU,4
PZE DL, 0, N
Return

b) Storage Required—17 locations
c) M0QUEU uses:

1) Parameter—B
2) Tables—TMQKEY, TMQKY2, TMREFR and TMPRIO
3) Constant—KD0001
4) Mask—TMNMSK+B-1

Time Required:

1) Queue table full—0.039 millisecond
2) Queue table empty—0.070 millisecond
3) Queue table neither full nor empty—0.074 millisecond
MOQUEU

ROUTINE NUMBER (N) COMPLEMENTED, STORED IN XR1

GET MAXIMUM NUMBER OF QUEUE ENTRIES FROM TMQKY2

GET CURRENT NUMBER OF QUEUE ENTRIES FROM TMQKEY

IS THE QUEUE TABLE EMPTY?

YES

IS THE QUEUE TABLE FULL?

NO

ADD 1 TO CURRENT QUEUE ENTRY COUNT IN TMQKEY

STORE DATA LOCATION (DL) IN FIRST OPEN ENTRY IN QUEUE

TURN ON B INDICATOR FOR ROUTINE N

TRA 2,4

DATA IS LOST WHEN QUEUE TABLE IS FULL

TRA 2,4

FIGURE 2.6. MOQUEU PROGRAM FLOW CHART
2.7 MAIN CONTROLLER UNQUEUE PROGRAM (M0UNQU)

M0UNQU supplies input data for those routines which have queue tables.

The flow chart for the M0UNQU program is shown in Figure 2-7.

2.7.1 Input Requirements

Input to M0UNQU consists of:

a) XR4—contains the 2's complement of the location counter at the instruction which transfers control to M0UNQU.

b) 1,4—contains in the decrement the routine number (N) for the routine which M0UNQU is to supply input data and in the address the location (DL) into which the first entry in the queue table is placed. (For routines whose input requirements for execution exceed the capacity of one core location, DL is the address of a block of input data. For those routines whose input consists of data contained within a single location, DL may be the actual location of the data, so that the queue tables contain the actual input data. The distinction of DL is the responsibility of the routines which use the queue tables.)

c) 2,4—the return address at the completion of M0UNQU.

d) TMQKEY+N-1—contains in the decrement the current number of entries in the queue table and in the address the location of the queue table for routine N.

e) TMREFR+N-1—contains in the address the location of the entry in the priority table, TMPRIO, for routine N.

f) TMFMSK-1+B—mask, -177 777 777 777, used to turn off indicator B in TMPRIO for routine N (B = 2, TMFMSK-1+B = TMFMSK+1).

g) KD7777—constant, 077 777 000 000.

h) K00001—constant, 1.

The computer must be disabled during the execution of M0UNQU.

2.7.2 Output Requirements

The first entry in the queue table, QN, is placed in the specified location, DL. The contents of the decrement (the queue entry count) of TMQKEY+N-1 are decreased by one.

If the queue table has been emptied, indicator B for routine N (TMPRIO+PN-1) is turned off.
If the queue table contains further input entries, each entry in the queue table is advanced one location so that the oldest entry is always the first location in the queue table.

No provision is made by M0UNQU to save the machine condition. The contents of all index registers and the accumulator are destroyed by this program.

2.7.3 Method

The UNQUE macro supplies the calling sequence and transfers control to M0UNQU. The first entry in the queue table is placed in the location specified by the calling sequence. The current entry count is reduced by one. If the queue is now empty, indicator B in the priority table is turned off. If the queue is not empty, each entry is advanced one location toward the front of the table and indicator B for this routine in the priority table remains on to designate that more input data remains. Control returns to the source routine.

2.7.4 Usage

M0UNQU is entered from the UNQUE macro.

a) Calling Sequence:

    TSX M0UNQU,4
    PZE DL, 0, N
    Return

b) Storage Required—20 locations

c) M0UNQU uses:

1) Parameter—B

2) Tables—TMQKEY, TMREFR, TMQKY2 and TMPRio

3) Constants—KD7777 and K00001

4) Mask—TMFMSK+B-1

d) Time Required:

1) One entry in queue table—0.057 millisecond

2) More than one entry—(0.017E + 0.035) millisecond (where E is the number of entries in the queue table)
UNQUE

MOUNQU

ROUTINE NUMBER (N) COMPLEMENTED, STORED IN XR1

STORE FIRST ENTRY FROM QUEUE TABLE INTO INPUT LOCATION (DL)

REDUCE QUEUE COUNT IN TMQKEY BY 1

IS THE QUEUE TABLE NOW EMPTY?

TURN OFF B INDICATOR FOR ROUTINE N

MOVE EACH ENTRY IN QUEUE TABLE ONE LOCATION FORWARD

TRA 2,4

UNIQUE MACRO DL, N
(1,4) TSX MOUNQU, 4
(2,4) PZE DL, 0, N
RETURN

FIGURE 2-7. MOUNQU PROGRAM FLOW CHART
2.8 TURN ON MACRO (TRNON)

The TRNON macro turns on an indicator in the Monitor priority table and is used throughout the Monitor programs.

The flow chart for the TRNON macro is shown in Figure 2-8.

2.8.1 Input Requirements

The TRNON macro is defined:

- **TRNON**
  - **MACRO**
  - **ALPHA, I**
  - **CAL**
  - **ORS**
  - **TMNMSK+ALPHA-I**
  - **END**

where the parameters are

a) **ALPHA**—the indicator to be turned on. The indicators are located in the first ten bits (S, 1 through 9) of the entries in the Monitor priority table, TMPRIO. There are ten indicators: A, B, C, D, E, F, G, H, J, and K. A is numerically equal to 1 (the first bit), B is equal to 2 (the second bit), etc. ... K is equal to 10 (the tenth bit).

b) **I**—the routine number of the routine (program) controlled by the TRNON macro.

c) **TMNMSK+ALPHA-I**—mask with a zero in every bit position except that corresponding to the indicator designated by ALPHA. There are ten masks in the table, one for each value of ALPHA.

d) **TMREFR+I-I**—contains in the address the location of the entry in TMPRIO for routine I.

2.8.2 Output Requirements

An indicator is turned on for routine I in the priority table (TMPRIO+P{I-1}).

2.8.3 Method

The mask containing a zero in every bit position except that of the indicator to be turned on is supplied by the TMNMSK table. The mask is matched by an ORS instruction to the routine's location in the table TMPRIO and the designated indicator is turned on.

2.8.4 Usage

Entry to TRNON has no restrictions; the macro exits to the second location following the entry.
a) Storage Required—two locations

b) TRNON uses:
   1) Parameters—ALPHA and I
   2) Tables—TMREFR and TMPRIO
   3) Mask—TMNMSK+ALPHA-1

c) Time Required—0.011 millisecond
FIGURE 2-8. TRNON MACRO FLOW CHART

ENTRY

TRNON

GET TRNON
MASK FROM
TMNMSK +
ALPHA -1

"ORS" MASK TO
TMPrio ENTRY
TO TURN ON
INDICATOR
ALPHA

EXIT
2.9 TURN OFF MACRO (TRNOF)

The TRNOF macro turns off an indicator in the Monitor priority table and is used throughout the Monitor programs.

The flow chart for the TRNOF macro is shown in Figure 2-9.

2.9.1 Input Requirements

The TRNOF macro is defined:

```
TRNOF CAL ALPHA, I
ANS* TMFMSK+ALPHA-I
TMREFR+I-1
END
```

where the parameters are

a) ALPHA—the indicator to be turned off. The indicators are located in the first ten bits (S,1 through 9) of the entries in the Monitor priority table, TMPRIO. There are ten indicators A, B, C, D, E, F, G, H, J, K. A is numerically equal to 1 (the first bit), B is equal to 2 (the second bit), etc. ... K is equal to 10 (the tenth bit).

b) I—the routine number of the routine controlled by the TRNOF macro.

c) TMFMSK+ALPHA-I—mask with a 1 in every bit position except that corresponding to the indicator designated by ALPHA. There are ten masks in the table—one for each value of ALPHA.

d) TMREFR+I-1—contains in the address the location of the entry in TMPRIO for routine I.

2.9.2 Output Requirements

An indicator is turned off for routine I in the priority table (TMPRIO+PI-1).

2.9.3 Method

The mask containing a 1 in every bit position except that of the indicator to be turned off is supplied by the TMFMSK table. The mask is matched by an ANS instruction to the routine’s location in TMPRIO and the designated indicator is turned off.

2.9.4 Usage

Entry to TRNOF has no restriction; the macro exits to the second location following the entry.
a) Storage Required—two locations

b) TRNOF Uses:
   1) Parameters—ALPHA and I
   2) Tables—TMREFR and TMPRIO
   3) Mask—TMFMSK+ALPHA-1

c) Time Required—0.013 millisecond
ENTRY

GET TRNOF MASK FROM TMFMSK + ALPHA

"ANS" MASK TO TMPRIO TO TURN OFF INDICATOR ALPHA

EXIT

FIGURE 2-9. TRNOF MACRO FLOW CHART
2.10 QUEUE MACRO (QUEUE)

The QUEUE macro establishes the calling sequence for, and transfers control to MOQUEU which services the queue tables.

The flow chart for the QUEUE macro is shown in Figure 2-10.

2.10.1 Input Requirements

The QUEUE macro is defined:

```
QUEUE MACRO N, DL
TSX M0QUEU,4
PZE DL, 0, N
END
```

where the parameters are

a) $N$—the routine number which identifies the routine to be queued.

b) $DL$—the location of the word to be stored as an entry in the queue table.

The computer must be disabled during the execution of the QUEUE macro.

2.10.2 Output Requirements

Control is transferred to M0QUEU with the data location (DL) in the address and the routine number ($N$) in the decrement of the second word of the calling sequence. Index register 4 contains the 2's complement of the location counter at the transfer instruction.

2.10.3 Method

Since the second word of the calling sequence is established during the compilation, QUEUE executes only one instruction, a transfer (TSX) to M0QUEU.

2.10.4 Usage

Entry to QUEUE has no restrictions, other than that the computer must be disabled; QUEUE exits to M0QUEU.

a) Storage Required—two locations

b) QUEUE uses the parameters, DL and N.

c) Time Required—0.004 millisecond
SET UP CALLING SEQUENCE FOR MQQUEU (DONE BY COMPILER)

FIGURE 2-10. QUEUE MACRO FLOW CHART
2.11 UNQUEUE MACRO (UNQUE)

The UNQUE macro establishes the calling sequence for, and transfers control to M0UNQU.

The flow chart for the UNQUE macro is shown in Figure 2-11.

2.11.1 Input Requirements

The UNQUE macro is defined:

```
UNQUE MACRO N, DL
TSX M0UNQU,4
PZE DL, O, N
```

where the parameters are

a) N—the routine number which identifies the routine to be unqueued.

b) DL—the locations into which the first entry in the queue table for routine N is placed.

The computer must be disabled during the execution of the UNQUE macro.

2.11.2 Output Requirements

Control is transferred to M0UNQU with the data location (DL) in the address and the routine number (N) in the decrement of the second word of the calling sequence. Index register 4 contains the 2's complement of the location counter at the transfer instruction.

2.11.3 Method

Since the second word of the calling sequence is established during the compilation, UNQUE executes only one instruction, a transfer (TSX) to M0UNQU.

2.11.4 Usage

Entry to UNQUE has no restrictions, other than that the computer must be disabled; UNQUE exits to MOUNQU.

a) Storage Required—two locations

b) UNQUE uses the parameters, DL and N.

c) Time Required—0.004 millisecond
MC 103

FIGURE 2-11 UNQUE MACRO FLOW CHART
2.12 ENABLE MACRO (QENBA)/ENABLE PROGRAM (MYENBA)

The QENBA macro enables the computer for data channel traps through the execution of the MYENBA program. The QENBA macro is used throughout the Mercury Program System, but generally following the completion of a routine for which the computer is disabled.

The flow chart for the QENBA macro is shown in Figure 2-12.

2.12.1 Input Requirements

The QENBA macro is defined:

```
QENBA  MACRO
   STZ      MCTRAP
   XEC      MYENBA
   END
```

where MYENBA is defined by:

a) MYENBA  ENB  K40007

b) K40007—constant, 000 000 040 007

2.12.2 Output Requirements

The computer is enabled for data channel traps on channels A, B, C and the DCC. The MCTRAP communication cell is set to zero. This communication cell is used by MOSAVE and its function is explained in the QENBZ macro write-up (Subsection 4.13).

2.12.3 Method

The communication cell, MCTRAP, is set to zero and the program MYENBA is executed. MYENBA consists of an enable (ENB) from a location in which bits 21, 33, 34, and 35 contain 1's. These bits enable channels A, B, C and F (where channel F represents the DCC).

2.12.4 Usage

Entry to QENBA has no restrictions, except that the macro may not be used from the time a trap occurs until the completion of the trap processor. QENBA exits to the second location following entry.

a) Storage Required—two locations

b) QENBA uses:

1) Program—MYENBA
2) Communication cell—MCTRAP

3) Constant—K40007

c) Time Required—0.011 millisecond
MC 103

STORE ZERO IN MCTRAP

EXECUTE PROGRAM MYENBA

ENABLE COMPUTER

ENTRY

QENBA

EXIT

FIGURE 2-12. QENBA MACRO FLOW CHART
2.13 DISABLE MACRO (QENBZ)/DISABLE PROGRAM (MYENB0)

The QENBZ macro disables the computer from trapping through the execution of the MYENB0 program. The QENBZ macro is used throughout the Mercury Program System whenever any series of instructions must be completed without interruption. The most common examples of routines which run disabled are MSLOGG, MOQUEU and M0UNQU.

The flow chart for the QENBZ macro is shown in Figure 2-13.

2.13.1 Input Requirements

The QENBZ macro is defined

QENBZ    MACRO
STL    MCTRAP
XEC    MYENB0
NOP
END

where MYENB0 is defined by:

a) MYENB0   ENB       K00000

b) K00000—constant, 0

2.13.2 Output Requirements

The computer is disabled from data channel traps; the MCTRAP communication cell is set to non-zero.

2.13.3 Method

The communication cell, MCTRAP, is set to non-zero and the program MYENB0 is executed. MYENB0 consists of an enable (ENB) from a location containing all zeros.

MCTRAP, used in conjunction with QENBZ, QENBA and M0SAVE, is non-zero when the computer is disabled or when the program is attempting to disable through the execution of the QENBZ macro. Under certain conditions a trap may occur during the instruction to disable (ENB K00000). Before the trap processor is given control, the condition of the interrupted program is saved for the return and, if MCTRAP is non-zero, M0SAVE makes a notation in the save block in TMPANL. When priority considerations allow control to return to the interrupted program, M0RTRN determines from the notation set by M0SAVE whether the computer should be disabled before return.

The no operation instruction (NOP) is further protection against a trap interrupting a routine which should run disabled. After the NOP instruction has
been completed a trap signal does not interrupt the program (however, trap requests are remembered until the computer is enabled).

2.13.4 Usage

Entry to QENBZ has no restriction; QENBZ exits to the third location following entry.

a) Storage Required—three locations

b) QENBZ uses:

1) Program—MYENB0
2) Communication cell—MCTRAP
3) Constant—K00000

c) Time Required—0.015 millisecond
QENBZ

ENTRY

STORE NON-ZERO DATA IN MCTRAP

EXECUTE PROGRAM MYENB0

DISABLE COMPUTER

WAIT 2 CYCLES TO ENSURE DISABLING

EXIT

FIGURE 2-13. QENBZ MACRO FLOW CHART
2.14 PRESENT SENSE LINE MACRO (QPSLF)/PRESENT SENSE LINE PROGRAM (MYPSLF)

The QPSLF macro activates and/or deactivates the individual subchannels of the Data Communication Channel through the execution of MYPSLF program. The QPSLF macro is used throughout the Mercury Program System to initiate or terminate transmission through the DCC.

The flow chart for the QPSLF macro is shown in Figure 2-14.

2.14.1 Input Requirements

The QPSLF macro is defined:

```
QPSLF       MACRO
XEC         MYPSLF
END
```

where MYPSLF is defined:

a) MYPSLF PSLF MCACTV (Note: PSLF [Present Sense Lines on channel F] is recognized by the Mercury SOS, but is not a standard SCAT instruction. The operation code for PSLF is -0666.)

b) MCACTV—communication cell used to activate and/or deactivate subchannels of the DCC. Bits 1-32 correspond to subchannels 1-32, respectively. A 1 in bit position 1 activates (turns on) subchannel 1 of the DCC; a zero in bit position 2 deactivates (turns off) subchannel 2 of the DCC, etc. The 3-bit octal number (0-7) contained in bits 33-35 specifies the unit terminal address in the activation of the teletype output subchannels, 10 and 11. A 1 in the S bit position of the mask turning on the 8.3 millisecond clock restarts the clock from zero.

2.14.2 Output Requirements

Any or all of the DCC subchannels are activated and/or deactivated according to the bit configuration of MCACTV.

2.14.3 Method

The QPSLF macro executes the single instruction program, MYPSLF, which presents sense lines on Channel F (the DCC physically replaces data channel F) from the location MCACTV.

2.14.4 Usage

Entry to QPSLF has no restrictions; QPSLF exits to the first location following entry.
a) Storage Required—one location

b) QPSLF uses:
   1) Program—MYPSLF
   2) Communication cell—MCACTV

c) Time Required—0.007 millisecond
FIGURE 2-14. QPSLF MACRO FLOW CHART

ENTRY

QPSLF

EXECUTE PROGRAM MYPSLF

PRESENT SENSE LINES ON CHANNEL F (DCC) FROM MCACTV

MYPSLF

EXIT
2.15 SAVE MACRO (SAVE)

Every time a program interrupt occurs, the machine condition must be preserved if control is to return to the interrupted program at the exact point of the interrupt. The SAVE macro prepares information for, and transfers control to, the saving routine, MOSAVE. All non-DCC trap processors execute the SAVE macro before processing data. For DCC trap processors SAVE is executed by M0RTCC.

The flow chart for the SAVE macro is shown in Figure 2-15.

2.15.1 Input Requirements

The SAVE macro is defined:

```
SAVE MACRO CW
SXD MCX4RA,4
LXA CW,4
SXAX MCX4RA,4
TSX MOSAVE,4
END
```

where the single parameter, CW, is the decimal equivalent of the absolute location of the cell set by the IBM 7090 computer when a trap occurs. CW is 0 for floating-point traps, 3 for DCC traps, 10 for channel A traps, 12 for channel B traps, and 14 for channel C traps. The location specified by CW contains in the address the value of the location counter when the trap occurred. For DCC traps bits 4 through 8 of location 00003 also contain the number of the subchannel responsible for the trap.

The computer is inhibited during the execution of the SAVE macro.

2.15.2 Output Requirements

The output of SAVE consists of a single communication cell MCX4RA, which contains in the address the contents of the location counter when the trap occurred and in the decrement the contents of index register 4. Index register 4 contains the 2's complement of the location counter at the instruction which transfers control to MOSAVE.

2.15.3 Method

The SAVE macro stores the contents of index register 4 into the decrement of MCX4RA. With index register 4 available for data relocation, SAVE uses it to move the location counter value at the interrupt from CW into the address of MCX4RA. SAVE then transfers program control to MOSAVE and sets index register 4 to the 2's complement of the current value of the location counter.
2.15.4 Usage

Entry to SAVE is made by a transfer instruction in lower core, following a trap; SAVE exits to M0SAVE.

a) Storage Required—four locations

b) SAVE uses:

1) Parameter—CW

2) Communication cell—MCX4RA

c) Time Required—0.017 millisecond
SAVE MACRO MUST BE FIRST EXECUTED PROGRAM AFTER EVERY TRAP.
LOCATION COUNTER READING SET IN CONTROL WORD (CW) BY THE COMPUTER WHEN TRAP OCCURS.

FIGURE 2-15. SAVE MACRO FLOW CHART
2.16 REFERENCE MACRO (REFR)

The REFR macro constructs the basic Monitor tables for the Mercury Program System: TMPRIO, TMREFR, TMFRPR, TMSAVE, TMQKEY, TMQKY2 and the blocks for queueing.

2.16.1 Input Requirements

The REFR macro is defined:

```
MACRO N, ENTRY, P, QNAME, QLENG
QNAME
```

where the parameters are defined:

a) N—the routine number which is relative to the position of the routine in the reference table. Each ordinary (non-trap) processor in the Mercury Program is represented by both a routine number and a priority number. The location TMREFR + N - 1 contains in the address the location of the routine in the priority table, TMPRIO.

b) ENTRY—the location of the first instruction of the routine, stored in address position of the routine’s location in TMPRIO.

c) P—the priority number of a routine which is its relative location (TMPRIO + P - 1) in the priority table, TMPRIO. The highest priority routine (P = 1) would, therefore, have the symbolic location TMPRIO.

d) QNAME—the name of the input queue block for each routine (formed by replacing NAME in the definition by the priority number. For example, Q1 is the name of the queue block for the highest priority routine and QP is the name of the queue block for the Pth priority routine).

e) QLENG—the queue length, i.e., the number of input entries to a routine that may be stacked and held in waiting until the routine is available.
While every routine has a QNAME and a QLENG, for many routines the queue length is zero which means that the queue block does not physically exist.

To use the REFR macro, the following locations must be defined: TMPRIO, TMREFR, TMFRPR, TMSAVE, TMQKY2, and TMPANL by a BSS of the appropriate length.

2.16.2 Output Requirements

The following tables are generated as output from REFR:

a) TMREFR—the Monitor reference table, N cells, in order by routine number containing in the address the location of the routine in TMPRIO.

b) TMPRIO—the Monitor priority table, N cells, in order by priority number containing in the address the location of the first instruction (the entry) of the routine. The first ten bits in each location of TMPRIO contain the priority indicator bits.

c) TMFRPR—the Monitor priority reference table, N cells, in order by priority number containing in the address the routine number corresponding to the particular priority routine.

d) TMSAVE—the Monitor save table, N cells, in order by routine number containing in the address the location of the block in TMPANL which is used to store the machine condition when a program trap interrupts this routine. The machine condition is restored from the TMPANL table before the routine may be re-entered.

e) TMQKEY—the Monitor queue table, N cells, in order by routine number containing in the address the location of the queue block for this routine. A routine with a queue length of zero will have an entry location in TMQKEY equal to the next location after the last non-zero queue block previously generated. (The decrement of the cells in TMQKEY are used to keep a running count of the current entries in the routine's queue block.)

f) TMQKY2—the Monitor queue length table, N cells, in order by routine number containing in the decrement the 2's complement of the routine's queue block length.

g) Queue blocks are generated as specified by the input data.

2.16.3 Method

The REFR macro is composed entirely of pseudo-instructions* and is executed for each ordinary processor, or routine, in the Mercury Program System.

*A discussion of the pseudo-instructions used in the Mercury Program System is contained in Program System Standards, MC 102.
The pseudo-instruction `QNAME BSS QLENG` assigns the symbolic location `QNAME` to the current value of the location counter and the location counter is incremented by the number of cells specified by `QLENG`.

The pseudo-instruction `ORG TMREFR+N-1` sets the location counter to the value specified by `TMREFR+N-1`, and the following pseudo-instruction `PZE TMPRI0+P-1` defines the contents of the location thus specified. Six pairs of `ORG` and `PZE` pseudo-instructions produce this result:

<table>
<thead>
<tr>
<th>Symbolic Location</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMREFR+N-1</td>
<td>PZE</td>
</tr>
<tr>
<td>TMPI0+P-1</td>
<td>TMPI0+P-1</td>
</tr>
<tr>
<td>TMSAVE+N-1</td>
<td>PZE</td>
</tr>
<tr>
<td>TMQKEY+N-1</td>
<td>PZE</td>
</tr>
<tr>
<td>TMQKY2+N-1</td>
<td>PZE</td>
</tr>
</tbody>
</table>

By incorporating both a reference and a priority table the Mercury System Program allows for maximum flexibility. A rigid reference table provides a permanent location for any program in the system, while the priority table may change as experience dictates the need for change.

2.16.3 Usage

`REFR` does not actually appear in the Mercury tracking program and has no timing considerations. After compilation the `REFR` macro exists only in effect. Given the following definitional information, the `REFR` macro will arrange the Monitor tables as shown in Tables 2-2, 2-3 and 2-4 and in Figure 2-16.

<table>
<thead>
<tr>
<th>N</th>
<th>ENTRY</th>
<th>P</th>
<th>QNAME</th>
<th>QLENG</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNHSOD</td>
<td>MYHSOD</td>
<td>1</td>
<td>Q1</td>
<td>0</td>
</tr>
<tr>
<td>MNHSOP</td>
<td>MYHSOP</td>
<td>2</td>
<td>Q2</td>
<td>0</td>
</tr>
<tr>
<td>MNLANA</td>
<td>MPLANA</td>
<td>3</td>
<td>Q3</td>
<td>0</td>
</tr>
<tr>
<td>MNHS09</td>
<td>MPH09</td>
<td>4</td>
<td>Q4</td>
<td>0</td>
</tr>
<tr>
<td>MNHSGB</td>
<td>MPHGB</td>
<td>5</td>
<td>Q5</td>
<td>0</td>
</tr>
<tr>
<td>MNCCGB</td>
<td>MPCCB</td>
<td>6</td>
<td>Q6</td>
<td>0</td>
</tr>
<tr>
<td>MNCCIP</td>
<td>MPCCP</td>
<td>7</td>
<td>Q7</td>
<td>0</td>
</tr>
<tr>
<td>MNSSTRP</td>
<td>MSPRP</td>
<td>8</td>
<td>Q8</td>
<td>2</td>
</tr>
<tr>
<td>MNNTXO</td>
<td>MNTXXO</td>
<td>9</td>
<td>Q9</td>
<td>0</td>
</tr>
<tr>
<td>MNNTYO</td>
<td>MNTYO</td>
<td>10</td>
<td>Q10</td>
<td>0</td>
</tr>
<tr>
<td>MNNTXO</td>
<td>MNTXO</td>
<td>11</td>
<td>Q11</td>
<td>10</td>
</tr>
<tr>
<td>MNTTOY</td>
<td>MNTTOY</td>
<td>12</td>
<td>Q12</td>
<td>10</td>
</tr>
<tr>
<td>MNORRE</td>
<td>MPORRE</td>
<td>13</td>
<td>Q13</td>
<td>0</td>
</tr>
<tr>
<td>MNORMC</td>
<td>MPRORMC</td>
<td>14</td>
<td>Q14</td>
<td>0</td>
</tr>
<tr>
<td>MNRARF</td>
<td>MPRARF</td>
<td>15</td>
<td>Q15</td>
<td>10</td>
</tr>
<tr>
<td>MNSEEK</td>
<td>MYSEEK</td>
<td>16</td>
<td>Q16</td>
<td>0</td>
</tr>
</tbody>
</table>

2-61
<table>
<thead>
<tr>
<th>ENTRY</th>
<th>P</th>
<th>QNAME</th>
<th>QLENG</th>
<th>EQU</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNABRT</td>
<td>MPABRT</td>
<td>17</td>
<td>Q17</td>
<td>0</td>
</tr>
<tr>
<td>MNTTIN</td>
<td>MPTTIN</td>
<td>18</td>
<td>Q18</td>
<td>10</td>
</tr>
<tr>
<td>MNMINS</td>
<td>MYMINS</td>
<td>19</td>
<td>Q19</td>
<td>0</td>
</tr>
<tr>
<td>MNACQD</td>
<td>MYACQD</td>
<td>20</td>
<td>Q20</td>
<td>0</td>
</tr>
<tr>
<td>MNSTLT</td>
<td>MYSTLT</td>
<td>21</td>
<td>Q21</td>
<td>0</td>
</tr>
<tr>
<td>MNMESS</td>
<td>MYMESS</td>
<td>22</td>
<td>Q22</td>
<td>25</td>
</tr>
<tr>
<td>MNMSCK</td>
<td>MYMSCK</td>
<td>23</td>
<td>Q23</td>
<td>0</td>
</tr>
<tr>
<td>MNCARD</td>
<td>MYCARD</td>
<td>24</td>
<td>Q24</td>
<td>0</td>
</tr>
<tr>
<td>MNSRST</td>
<td>MYSRST</td>
<td>25</td>
<td>Q25</td>
<td>0</td>
</tr>
<tr>
<td>MNLCMM</td>
<td>MLPCCM</td>
<td>26</td>
<td>Q26</td>
<td>1</td>
</tr>
<tr>
<td>MNSENS</td>
<td>MSENS</td>
<td>27</td>
<td>Q27</td>
<td>10</td>
</tr>
<tr>
<td>MNWRRS</td>
<td>MYWRRS</td>
<td>28</td>
<td>Q28</td>
<td>0</td>
</tr>
<tr>
<td>MNQSYS</td>
<td>MYQSYS</td>
<td>29</td>
<td>Q29</td>
<td>5</td>
</tr>
<tr>
<td>MNRSYS</td>
<td>MYRSYS</td>
<td>30</td>
<td>Q30</td>
<td>0</td>
</tr>
<tr>
<td>MNLED2</td>
<td>MPLLED2</td>
<td>31</td>
<td>Q31</td>
<td>20</td>
</tr>
<tr>
<td>MNLED1</td>
<td>MPLLED1</td>
<td>32</td>
<td>Q32</td>
<td>10</td>
</tr>
<tr>
<td>MNCNPI</td>
<td>MPCNPI</td>
<td>33</td>
<td>Q33</td>
<td>10</td>
</tr>
<tr>
<td>MNRRRS</td>
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TABLE 2-3. MONITOR TABLES
## TABLE 2-4. MONITOR TABLES

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### MONITOR QUEUE LENGTH TABLE

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</table>

*The decrement (3-17) of each location in TMQKEY contains the current number of entries (up to the maximum allowable) waiting as input to the routine. As REFR generates TMQKEY the decrement is zero for all locations. For those programs which have a maximum queue length of zero, the decrement of TMQKEY never changes.

**When the macro constructs the TMQKEY table, every QNAME (Q1, Q2, Q3, ..., QP) generates a symbolic location. If, however, the queue specified by QNAME does not physically exist, i.e., has zero length, its absolute location will not be unique. In the development of the queue tables the location counter is incremented only when a real (non-zero length) queue is defined in the macro parameters. In the tables above, Q1 through Q7 do not physically exist. They are assigned the same location in core, but the location counter is not stepped until after Q8 has been assigned the same location (shown as Y in the table), when the compiler finds a non-zero value in the variable field of the BSS pseudo-instruction. The queues of zero length are never referred to in the program.
Section 3
DATA COMMUNICATIONS CHANNEL
INPUT CONTROL

The Data Communications Channel (DCC) provides for the input of real time data together with the timing control signals to the Mercury Program System. All input utilizes the internal trapping feature of the IBM 7090, i.e., a program interrupt occurs at the completion of the data transmission or when the timing signal is received. All interrupts produced by the DCC are interpreted by the Real Time Channel Main Controller Program, M0RTCC. This controller executes the SAVE macro, which uses the Main Controller Save Program, M0SAVE, to preserve the condition of the interrupted program; M0RTCC then transfers control to the Monitor trap processor appropriate for the input information.

The Monitor programs which control DCC input are described in detail in this section. These programs may be divided into four groups:

a) The high-speed input programs, which control the data input during the launch phase; are described in Subsections 3.1 through 3.9.

b) The low-speed input programs, which control the data input during the orbit and re-entry phases, are described in Subsections 3.10 through 3.18.

c) The timing control programs, which are used throughout the Mercury mission, together with those programs intimately related to time periods but not readily classified in other parts of this manual, are described in Subsections 3.19 through 3.25.

d) The program which accepts control following an erroneous DCC trap is described in Subsection 3.26.
3.1 HIGH-SPEED INPUT

From the moment of lift-off until the termination of powered flight the primary input data to the Mercury Program System is transmitted from Cape Canaveral to the Goddard Communications Center directly over high-speed lines. This data enters the computers in real time via subchannels 1 and 2 of the Data Communications Channel. Both of these subchannels receive data over duplexed lines at a rate of 1000 bits per second. Two transmission cycles are required to transmit one complete message frame -- a first and second subframe -- and both subframes are sent in duplicate, referred to as the subframe and the subframe image, over the duplexed sublines to insure reliability. The first subframe contains telemetry and other discrete signals and the capsule clock settings. The remainder of the first subframe and the entire second subframe consist of identification flags, validity bits, parity checks, etc., and the tracking data: either computed position and velocity components with the associated time (one set of vectors per complete frame) or, on subchannel 2 only, raw radar readings of range, azimuth and elevation (four sets of range, azimuth and elevation per complete frame). The Monitor control of the high-speed input data is described in general in the following paragraphs.

3.1.1 Subchannel 1 Input

The highest priority subchannel of the Data Communications Channel receives input from the Burroughs-General Electric (B-GE) Guidance Computer System at Cape Canaveral. This special-purpose computer, operating in conjunction with radar and telemetry data received from the launch vehicle, tracks a beacon in the vehicle, checks the flight trajectory and generates the commands necessary to achieve optimum launch and insertion performance.

The Monitor control of subchannel 1 input (illustrated in Figure 3-1) commences with the DCC trap which signals the arrival of one subframe of the message frame. This subframe, received in duplicate, consists of 192 bits in 12 eight-bit bytes, each byte right justified in a computer storage word. The trap gives control (via M0RTCC, see Subsection 2.2) to the Monitor B-GE High-Speed Input Trap Processor, MTHSGB, which moves the input to free the subchannel 1 input blocks for the following subframe, generates a logging time tag and informs M0PRIO that new data is available for processing by IOHSGB.

When priority conditions permit -- and only the high-speed output processors, the launch/abort output computations program and IOHS09 (because subchannel 2 has a faster input cycle than subchannel 1) have higher priority -- M0PRIO enters the B-GE input processing program via the Monitor prefix, MPHSGB.

MPHSGB logs the input data and determines whether or not the input may be processed by IOHSGB. If the mission has entered the hold, the medium-abort or the high-abort phase, only the first subframe, i.e., the telemetry and discrete event information, is valid for processing since the vectors define the trajectory
INPUT FROM CAPE CANAVERAL B-GE. ONE COMPLETE FRAME
TRANSMITTED IN DUPLICATE (TWO SUBFRAMES AND SUBFRAME
IMAGES) EVERY 500 MILLISECONDS.

**Figure 3-1. Data Flow: High-Speed Input from Cape Canaveral B-GE**
of the launch vehicle. If the mission has entered the low-abort phase, no subchannel 1 input is valid. If none of the above conditions applies, both subframes are processed.

IOHSGB, described in detail in MC 105, Goddard Processing Programs, processes the data and transfers control to either of the two Monitor suffixes, MFHSGB or MFML6A. When the input data to IOHSGB consists of the second subframe following a first subframe input, i.e., after one complete frame has been processed, IOHSGB exits to its radar data suffix, MFHSGB. This suffix, primarily concerned with data flow, determines whether or not the input data was accepted by IOHSGB. If the data was acceptable, MFHSGB examines the discrete signals for the indication of lift-off, unless lift-off has already been reported. A valid lift-off indication results in an on-line message stating the time of the event. Furthermore, the launch processing programs are not given control until the time of lift-off is available to the system. MPHSGB also sets priority indicators for the control of launch processing. The launch processing control scheme is described in detail in Section 4.

When the input data is rejected by IOHSGB for any reason or when the data input is a first subframe, IOHSGB exits to its telemetry suffix, MFML6A. This suffix, primarily concerned with mission events and changes in control flow, also examines the telemetry for the indication of lift-off. When the lift-off indication is received, MFML6A queues input to turn on the launch light on the Output Status Console and to print the on-line message giving the lift-off time. In the event of an abort MFML6A must also examine the telemetry data from both subchannels 1 and 2 for information about retrofire. When necessary, MFML6A provides retrorocket information for the Monitor programs which control a high-abort situation.

MTHSGB, MPHSGB, MFHSGB and MFML6A are described in detail in Subsections 3.2 through 3.5. IOHSGB is described in detail in MC 105, Goddard Processing Programs.

3.1.2 Subchannel 2 Input

The second high-speed subchannel of the DCC receives input from either the IBM Impact Predictor (IP) 7090 computer or the Cape downrange AN/FPS-16 radars. This input data, as with the B-GE data, is multiplexed with capsule telemetry and discrete event information and a complete message of the first and the second subframes in duplicate is transmitted to Goddard every 400 milliseconds. The IP 7090-processed data, which may originate either from the Azusa or the AN/FPS-16 tracking systems, consists of an R and V vector with an associated time. The raw radar data consists of four sets of range, azimuth and elevation at one-tenth of a second intervals.

The Monitor control of subchannel 2 input (illustrated in Figure 3-2) is similar to that of subchannel 1 input and commences with the DCC trap which signals the arrival of one subframe of the message frame. This subframe,
INPUT FROM CAPE CANAVERAL IP 7090. ONE COMPLETE FRAME TRANSMITTED IN DUPLICATE (TWO SUBFRAMES AND SUBFRAME IMAGES) EVERY 400 MILLISECONDS.

DCC SUBCHANNEL

SUBFRAME 2
DCC TRAP WHEN 24 WORDS OR END-OF-MESSAGE RECEIVED

SUBFRAME 1

INPUT FROM CAPE CANAVERAL IP 7090.

OUTPUT

MPHSO9
LOGS DATA, CHECKS PHASE TO SEE IF DATA CAN BE PROCESSED

I0HSO9
CHECKS INPUT FOR VALIDITY, SETS TABLES AND CELLS FROM MESSAGE DATA

EXIT AFTER 1ST (TELEMETRY) SUBFRAME OR WHEN ERROR OCCURS IN SUBFRAME SEQUENCE

MFHSO9
CHECK FOR LIFT-OFF TIME, SET CONTROLS FOR FURTHER PROCESSING

EXIT ONLY AFTER 2ND SUBFRAME FOLLOWS FIRST

SUBCHN2
CONTAINS IP 7090-COMPUTED R AND V VECTORS, OR RAW AN/FPS-16 RADAR DATA

EACH SUBFRAME REQUIRES A SEPARATE ENTRY TO I0HS09. 1ST SUBFRAME CONTAINS CAPSULE T/M AND DATA

2ND SUBFRAME CONTAINS IP 7090-COMPUTED R AND V VECTORS, OR RAW AN/FPS-16 RADAR DATA

FIGURE 3-2. DATA FLOW: HIGH-SPEED INPUT FROM CAPE CANAVERAL IP 7090
received in duplicate, consists of 192 bits in 12 eight-bit bytes, each byte right justified in a computer word. The trap gives control (via MORTCC, see Subsection 2.2) to the Monitor IP 7090 High-Speed Input Trap Processor, MTHS09, which moves the input to free the subchannel 2 input blocks for the following subframe, generates a logging time tag and informs MOPRIO that new data is available for processing by the IP 7090 input processing program, IOHS09.

When priority conditions permit, MOPRIO enters IOHS09 via the Monitor prefix, MPHS09. MPHS09 logs the input data and determines whether or not the input may be processed by IOHS09. If the mission has entered the low-abort phase, AN/FPS-16 data available on subchannel 2 is the only data valid for processing. If the mission has entered the high-abort phase, only the first subframe, i.e., the capsule telemetry and discrete event information, is valid for processing. Otherwise, control is given to IOHS09 to process the message unless either the numerical integration program or the re-entry displays program has been interrupted.

IOHS09, described in detail in MC 105, Goddard Processing Programs, processes the input and transfers control to either of the two Monitor suffixes, MFHS09 or MFHS08. When the input data to IOHS09 consists of the second subframe following a first subframe input, i.e., after one complete frame has been processed, IOHS09 exits to its radar data suffix, MFHS09. This suffix, primarily concerned with data flow, updates the selected source indicator if the input data processed by IOHS09 reflects the selected source. If lift-off has occurred, if the input was accepted and if the mission has not entered the low-abort phase, MFHS09 sets priority indicators for the control of launch processing. The launch processing control scheme is described in detail in Section 4.

When the input is rejected by IOHS09 for any reason or when the data input is a first subframe or of the raw AN/FPS-16 type, IOHS09 exits to its telemetry suffix, MFHS08. This suffix, primarily concerned with mission events and changes in control flow, examines the telemetry for the indication of lift-off. When the lift-off indication is received and has not previously been reported, MFHS08 queues input to turn on the launch light on the Output Status Console and to print an on-line message giving the lift-off time. When necessary, MFHS08 provides retrorocket information for the Monitor programs which control a high-abort situation.

MTHS09, MPHS09, MFHS09 and MFHS08 are described in detail in Subsections 3.6 through 3.9. IOHSGB is described in detail in MC 105, Goddard Processing Programs.
3.2 MONITOR B-GE HIGH-SPEED INPUT TRAP PROCESSOR (MTHSGB)

MTHSGB handles the B-GE high-speed input data received on DCC subchannel 1. The input data is moved from the DCC input table into a storage buffer so that a new B-GE message may be received on subchannel 1.

The flow chart for the MTHSGB trap processor is shown in Figure 3-3.

3.2.1 Input Requirements

Input to MTHSGB consists of:

a) TMHSGB, TMXSGB — the two subchannel 1 input tables of 24 cells, each cell containing an eight-bit quantity, right justified. TMHSGB and TMXSGB receive in duplex the output from the B-GE computer multiplexed with capsule telemetry and other discrete event data. TMHSGB contains the subframe (either first or second) and TMXSGB contains the subframe image.

b) MCHFSC — contains the current GMT in fixed-point half seconds.

c) TM8.3M — contains the number of 8-1/3 millisecond intervals since the last exact half second.

3.2.2 Output Requirements

Output from MTHSGB consists of:

a) TMHSL1 — a 48-cell table containing in the first 24 cells the contents of TMHSGB and the last 24 cells the contents of TMXSGB.

b) MCHST1 — contains the logging time tag for the input message.

3.2.3 Method

MTHSGB stores the TMHSGB and TMXSGB input tables into TMHSL1 and then computes the logging time tag associated with this data. The time tag is stored in MCHST1 and the B indicator for I0HSGB is turned on so that the new input can be processed.

3.2.4 Usage

MTHSGB is entered from M0RTCC following a trap on DCC subchannel 1; MTHSGB exits to M0PRIO.

a) Storage Required — 13 locations

b) MTHSGB uses:
1) Macro — TRNON
2) Parameters — B and MNHSGB
3) Communication cells — MCHFSC and MCHST1
4) Tables — TM8.3M, TMHSGB, TMHSL1 and TMXSGB

c) Time Required — 0.545 millisecond
FIGURE 3-3. MTHSGB PROGRAM FLOW CHART
3.3 MONITOR PREFIX TO IOHSGB (MPHSGB)

MPHSGB logs the B-GE input data just received and sets indicators for control of IOHSGB.

The flow chart for the MPHSGB prefix is shown in Figure 3-4.

3.3.1 Input Requirements

Input to MPHSGB consists of:

a) TMHSL1 — a 48-cell table generated in MTHSGB, containing in duplicate, one subframe of capsule telemetry and discrete event data or processed high-speed radar data from the Burroughs-GE. Each cell contains an eight-bit character, right justified.

b) MCFINI — indicates, when non-zero, the low-abort phase has ended.

c) MCNGEN — indicates, when non-zero, either the hold, low-abort or medium-abort phase has been entered.

d) MCHST1 — contains the logging time tag for the input message.

e) MCTABT — indicates, when non-zero, the high-abort phase has been entered.

3.3.2 Output Requirements

MPHSGB controls the flow of IOHSGB in one of three possible ways:

a) If the mission is in the hold, the medium-abort or high-abort phase, only the first subframe of a B-GE message frame is valid for processing. After the first frame has been processed, MPHSGB turns off the A indicator and returns control to MOPRIO.

b) If the mission is in the low-abort phase, neither B-GE subframe is valid for processing. MPHSGB turns off the A indicator for IOHSGB and returns control to MOPRIO.

c) If none of the above conditions applies, MPHSGB transfers control to IOHSGB

3.3.3 Method

MPHSGB disables the computer and logs the B-GE high-speed input data, using the MSLOGG subroutine. Following logging, tests are performed on the communication cells MCFINI, MCNGEN and MCTABT to determine if the mission has left the launch phase, i.e., entered the hold, low-abort, medium-abort
or high-abort phase. If not, control is given to IOHSGB. If the mission is in the hold, the medium-abort or the high-abort phase, the first subframe may be processed. (The positional values are worthless since they represent the launch vehicle's trajectory but capsule telemetry in the first subframe is valid.) For second subframe input of B-GE data in these phases, the A indicator for IOHSGB is turned off and control returns to M0PRIO. If the mission is in the low-abort phase, MPHSGB turns off the A indicator for IOHSGB and returns control to M0PRIO (none of the input is valid). During the launch phase, MPHSGB transfers control to IOHSGB to process the input.

3.3.4 Usage

MPHSGB is entered from M0PRIO; MPHSGB exits to IOHSGB or to M0PRIO.

a) Storage Required — 37 locations

b) MPHSGB uses:

1) Subroutine — MSLOGG

2) Macros — QENBA, QENBZ, TRNOF and TRNON

3) Parameters — A and MNHSGB

4) Communication cells — MCFINI, MCHST1, MCNGEN and MCTABT

5) Table — TMHSL1

6) Constants — K00048 and K00012

c) Time Required — 2.27 milliseconds
FIGURE 3-4. MPHSGB PROGRAM FLOW CHART
3.4 MONITOR RADAR DATA SUFFIX TO IOHSGB (MFHSGB)

MFHSGB determines if and how the data processed by IOHSGB should be handled.

The flow chart for the MFHSGB suffix is shown in Figure 3-5.

3.4.1 Input Requirements

Input to MFHSGB consists of:

a) MCNGEN — indicates, when zero, that B-GE data is needed. When non-zero, MCNGEN indicates the mission is in the hold, low-abort or the medium-abort phase, and the B-GE data is not needed.

b) MCSGEB — indicates, when non-zero, the B-GE data is from the selected source and that the selected source indicator, MCSELS, must be updated. When B-GE is not the selected source, MCSELS is not changed.

c) MCLFTM — contains, when non-zero, the GMT of lift-off in floating-point seconds.

d) MCCOM1 — indicates, when zero, that the data processed in IOHSGB is acceptable. When MCCOM1 is non-zero, the data is either old or used and is not accepted.

e) TMH1TM + 1 — if bit position 33 contains a 1, the two-inch lift-off has occurred.

f) MCMST1 — contains the time tag of the first B-GE data frame. This time tag is generated by MTHSGB and is the time tag used for logging.

g) MCHFSC — contains the current GMT in fixed-point half seconds.

h) MCGTLO — contains the GMT of lift-off in fixed-point seconds.

i) MCTDEL — contains the time delay in half seconds before entering the launch programs after lift-off has been reported. MCTDEL is added to MCHFSC and the result is stored in MCTMWT as the time to enter the launch program.

3.4.2 Output Requirements

Output from MFHSGB consists of:

a) MCSELS — contains the latest indication of whether or not B-GE is the selected source of high-speed input data. MFHSGB stores the
contents of MCSGEB in MCSELS: a 1 indicates that B-GE is the selected source, a zero indicates that it is not.

b) MCTMWT — contains the GMT to enter the launch programs.

c) MCTGP1 — contains the time that the last acceptable B-GE data had been processed by IOHSGB. This time if obtained from MCHFSC and is the present time, if IOHSGB had just processed acceptable data.

d) TMREST + 21 — the time of lift-off is stored in the restart table.

3.4.3 Method

If lift-off has occurred, but the program has not been informed, MFHSGB determines the lift-off time and queues an on-line message to print the GMT of lift-off. MFHSGB queues the sense processor with a mask to turn on the launch light on the Output Status Console. (GMT of lift-off is computed by taking the B-GE data-frame time tag, MCMST1, and making an adjustment for transmission delay. This time is stored in MCLFTM in fixed-point seconds and in MCGTLO in floating-point seconds.)

If lift-off has occurred and the B-GE data is valid, the current half-second time is saved. If B-GE is not the selected source, the F indicator for the coordinate conversion program, CCGEB1, is turned off and the B indicator for CCGEB1 is turned on. However, if B-GE is the selected source, the F indicator for CCGEB1 remains on.

The A indicator for IOHSGB is turned off and control transfers to M0PRI0.

3.4.4 Usage

MFHSGB is entered from IOHSGB; MFHSGB exits to M0PRI0.

a) Storage Required — 56 locations

b) MFHSGB uses:

1) Macros — QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters — A, B, F, MNCCGB, MNHSGB, MNMESS and MNSENS

3) Communication cells — MCCOM1, MCGTLO, MCHFSC, MCLFTM, MCMST1, MCNGEN, MCSELS, MCSGEB, MCTDEL, MCTGP1 and MCTMWT

4) Tables — TMH1TM and TMREST
5) Constants — K00004, K00377, KCH233, KCH232, K8.3M3 and K0.650

c) Time Required:

1) Minimum — 0.026 millisecond

2) Maximum — 0.35 millisecond
FIGURE 3-5. MFHSGB PROGRAM FLOW CHART
3.5 MONITOR TELEMETRY SUFFIX TO I0HSGB (MFML6A)

MFML6A receives control from I0HSGB when the high-speed B-GE input contained telemetry information — the first subframe — or when the input contained unacceptable computed data. This suffix controls the program flow dependent upon the information received in the telemetry message.

The flow chart for the MFML6A suffix is shown in Figure 3-6.

3.5.1 Input Requirements

Input to MFML6A consists of:

a) MCTEL1 — indicates, when zero, that valid telemetry has been received.

b) MCLFTM — when non-zero, contains the GMT of lift-off in floating-point seconds.

c) MCHFSC — contains the current GMT in fixed-point half seconds.

d) MCTDEL — contains the integer count of half seconds to delay, when lift-off is reported, before entering the launch programs.

e) MCTORI — indicates, when non-zero, the need to check for retrofire telemetry information.

f) MCTRF1 — contains in floating-point seconds the time of the first indication received on DCC subchannel 1 that the retrorockets have fired.

g) MCTRF2 — contains in floating-point seconds the time of the first indication received on DCC subchannel 2 that the retrorockets have fired.

h) MCACTV — mask used to activate/deactivate the DCC subchannels.

i) MCNRF2 — contains the number of retros reported fired, as received by DCC subchannel 2.

j) TMH1TM — data buffer, containing the discrete signals of lift-off, BECO and SECO and telemetry indications plus the time tag associated with each of the two sets of signals.

k) TMTML1 — contains telemetry data from B-GE.

3.5.2 Output Requirements

Output from MFML6A consists of:
a) **MC\textsubscript{GTLO}** — contains the GMT of lift-off in fixed-point seconds.

b) **MC\textsubscript{TMTWT}** — contains in fixed-point half seconds the GMT to enter the launch programs.

c) **MC\textsubscript{NRF1}** — contains the number of retros fired, from data received over subchannel 1.

d) **MC\textsubscript{TAL1}** — counter set to delay 30 seconds before entering abort phase.

e) **MC\textsubscript{NTRF}** — the total count of retros fired, using indicators from both subchannels 1 and 2.

f) **MC\textsubscript{TMRF}** — contains the time in fixed-point seconds the first retro fired.

g) **TM\textsubscript{REST} + 21** — contains the GMT of lift-off in fixed-point seconds.

3.5.3 **Method**

If lift-off has not occurred, the A indicator for I0\textsubscript{HSGB} is turned off and control transfers to M\textsubscript{OPRIO}. On the first indication of lift-off, an on-line message is queued to print the GMT of lift-off and an input mask is queued for the sense processor to turn on the launch light of the Output Status Console. This is done only once.

After lift-off has been established, the normal flow of the suffix is mainly concerned with shifting telemetry data in the TTTML1 buffer and, with computing the number of retrorockets fired and the time of firing of the first retrorocket.

If the mission is in the high-abort phase, the high-speed input subchannels for both B-GE and IP 7090 data are deactivated and the B indicator for MYSEEK is turned on after either firing of all three retros has been detected or 30 seconds after the firing of the first retro.

For all conditions the A indicator for I0\textsubscript{HSGB} is turned off and control returns to M\textsubscript{OPRIO}.

3.5.4 **Usage**

MFML6A is entered from I0\textsubscript{HSGB}; MFML6A exits to M\textsubscript{OPRIO}.

a) Storage Required — 113 locations

b) MFML6A uses:

1) Macros — Q\textsubscript{ENBA}, Q\textsubscript{ENBZ}, Q\textsubscript{PSLF}, QUEUE, TRNOF and TRNON
2) Parameters — A, B, MNHSGB, MNMESS, MNSEEK and MNSENS

3) Tables — TMH1TM, TMREST and TMTML1

4) Communication cells — MCACTV, MCGTLO, MCLFTM, MCHFSC, MCNRF1, MCNRF2, MCNTRF, MCTAL1, MCTEL1, MCTDEL, MCTMRF, MCTMWT, MCTORI, MCTRFR1 and MCTRFR2

5) Constants — K10000, K0.400 and KCH233

6) Mask — KMTRRM

c) Time Required:

1) Minimum — 0.042 millisecond

2) Maximum — 0.78 millisecond
FIGURE 3-6. MFML6A PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 3-6. MFML6A PROGRAM FLOW CHART (Sheet 2 of 2)
3.6 MONITOR IP 7090 HIGH-SPEED INPUT TRAP PROCESSOR (MTHS09)

MTHS09 handles the IP 7090 high-speed input data received on DCC subchannel 2. The input data is moved from the DCC input table into a storage buffer so that a new IP 7090 message may be received on subchannel 2.

The flow chart for the MTHS09 trap processor is shown in Figure 3-7.

3.6.1 Input Requirements

Input to MTHS09 consists of:

a) TMHS09, TMXS09 — the two subchannel 2 input tables of 24 cells, each cell containing an eight-bit quantity, right justified. TMHS09 and TMXS09 receive in duplex the output from the IP 7090 computer (or alternately raw AN/FPS-16 radar data) multiplexed with capsule telemetry data. TMHS09 contains the subframe (either first or second) and TMXS09 contains the subframe image.

b) MCHFSC — contains the current GMT in fixed-point half seconds.

c) TM8.3M — contains the number of 8-1/3 millisecond intervals since the last exact half second.

3.6.2 Output Requirements

Output from MTHS09 consists of:

a) TMHSL2 — a 48-cell table containing in the first 24 cells the contents of TMHS09 and in the last 24 cells the contents of TMXS09.

b) MCHST2 — contains the logging time tag for the input message.

3.6.3 Method

MTHS09 stores the TMHS09 and TMXS09 input tables into TMHSL2 and then computes the logging time tag associated with this data. The time tag is stored in MCHST2 and the B indicator for IOHS09 is turned on so that the new input may be processed.

3.6.4 Usage

MTHS09 is entered from M0RTCC following a trap on DCC subchannel 2; MTHS09 exits to M0PRIO.

a) Storage Required — 13 locations

3-25
b) MTHS09 uses:
   1) Macro — TRNON
   2) Parameters — B and MNHS09
   3) Communication cells — MCHFSC and MCHST2
   4) Tables — TM8.3M, TMHS09, TMHSL2 and TMXS09

c) Time Required — 0.56 millisecond
FIGURE 3-7. MTHS09 PROGRAM FLOW CHART
3.7 MONITOR PREFIX TO IOHS09 (MPHS09)

MPHS09 logs the IP 7090 input data just received and sets indicators for control of IOHS09.

The flow chart for the MPHS09 prefix is shown in Figure 3-8.

3.7.1 Input Requirements

Input to MPHS09 consists of:

a) MCORIP — indicates, when non-zero, the re-entry displays are in process.

b) MCNIIP — indicates, when non-zero, numerical integration is in process.

c) TMHSL2 — a 48-cell table generated in MTHS09, containing one sub-frame of capsule telemetry information and/or either processed or raw high-speed radar data from the IP 7090 at Cape Canaveral. Each cell contains an eight-bit character, right justified.

d) MCFINI — indicates, when non-zero, the low-abort phase has ended.

e) MCTABT — indicates, when non-zero, the high-abort phase has been entered.

f) MCHST2 — logging time tag for the input message, generated in MTHS09.

3.7.2 Output Requirements

MPHS09 controls the flow of IOHS09 in one of three possible ways:

a) If the mission is in the low-abort phase, only the AN/FPS-16 data, either IP 7090-processed or raw, is valid for processing. MPHS09 turns off the A indicator for IOHS09 and returns control to M0PRIO.

b) If the mission is in the high-abort phase, only the first subframe, i.e., capsule telemetry, is valid for processing. After the first frame has been processed, MPHS09 turns off the A indicator for IOHS09 and returns control to M0PRIO.

c) If none of the above conditions applies, MPHS09 transfers control to IOHS09 to process the input unless either integration or the re-entry displays computations have been interrupted.
3.7.3 Method

MPHS09 disables the computer and logs the IP 7090 high-speed input data, using the MSLOGG subroutine. Following logging, tests are performed on the communication cells MCFINI and MCTABT to determine if the mission has entered either the low or high-abort phases. If not, control is given to 10HS09. If the mission is in the high-abort phase, the first subframe only may be processed by 10HS09. For second subframe input of IP 7090 data in the high-abort phase, the A indicator for 10HS09 is turned off and control returns to M0PRIO. If the low-abort phase has ended or if integration or re-entry displays computations have been interrupted, MPHS09 turns off the A indicator for 10HS09 and returns control to M0PRIO.

3.7.4 Usage

MPHS09 is entered from M0PRIO; MPHS09 exits to 10HS09 or M0PRIO.

a) Storage Required — 41 locations

b) MPHS09 uses:

1) Subroutine — MSLOGG

2) Macros — QENBA, QENBZ, TRNOF and TRNON

3) Parameters — A and MNHS09

4) Communication cells — MCFINI, MCHST2, MCNIIP, MCORIP and MCTABT

5) Table — TMHSL2

6) Constants — K00048 and K00012

c) Time Required — 2.26 milliseconds
FIGURE 3-8. MPHS09 PROGRAM FLOW CHART
3.8 MONITOR RADAR DATA SUFFIX TO I0HS09 (MFHS09)

MFHS09 determines if and how the data processed by I0HS09 should be handled.

The flow chart for the MFHS09 suffix is shown in Figure 3-9.

3.8.1 Input Requirements

Input to MFHS09 consists of:

a) MCWCH2 — indicates the source of the data processed by I0HS09. A 2 specifies raw AN/FPS-16; a 3 specifies IP 7090-processed Azusa data; a 4 specifies IP 7090-processed AN/FPS-16 data.

b) MCNGEN — indicates, when non-zero, the mission is in the hold, the low-abort or the medium-abort phase.

c) MCS709 — indicates, when non-zero, the IP 7090 is the selected source for high-speed input.

d) MCLFTM — contains, when non-zero, the recorded GMT of lift-off in floating-point seconds.

e) MCCOM2 — indicates, when zero, that the data processed by I0HS09 is acceptable. When MCCOM2 is non-zero, the data is either old or used and is not accepted.

f) MCHFSC — contains the current GMT in fixed-point half seconds.

g) MCLMBT — indicates, when non-zero, the mission is in the medium-abort phase.

3.8.2 Output Requirements

Output from MFHS09 consists of:

a) MCSELS — indicates the selected source for high-speed input data. This cell is updated, if necessary, by MFHS09: MCSELS contains zero if no selected data (from either subchannel 1 or 2) has yet arrived; a 1, if the selected source is B-GE data; a 2, if the selected source is raw AN/FPS-16 radar data; a 3, if the selected source is IP 7090-processed Azusa data; a 4, if the selected source is IP 7090-processed AN/FPS-16 data.

b) MCTGP2 — contains the time that the last acceptable IP 7090 data had been processed by I0HS09. MCTGP2 is updated to the present time if I0HS09 had just processed acceptable data.
3.8.3 Method

If the input data just processed by I0HS09 represents the selected source, MCSELS is updated from MCWCH2. If the mission has entered the hold, the low-abort or the medium-abort phase, MCSELS is always updated from MCWCH2 since under these conditions subchannel 1 cannot provide selected source data.

If lift-off has occurred and if the processed data is acceptable, the current time is used to update MCTGP2.

If the input data just processed was not from the selected source, the F indicator for the coordinate conversion program, CC7091, is turned off and the B indicator for CC7091 is turned on. If the data was selected, the B indicator for CC7091 is turned on.

For every entry to MFHS09, the A indicator for I0HS09 is turned off and control is transferred to M0PRIO.

3.8.4 Usage

MFHS09 is entered from I0HS09; MFHS09 exits to M0PRIO.

a) Storage Required — 13 locations

b) MFHS09 uses:

1) Macros — TRNOF and TRNON

2) Parameters — A, B, F, MNCCIP and MNHS09

3) Communication cells — MCCOM2, MCHFSC, MCLFTM, MCLMBT, MCNGEN, MCS709, MCSELS, MCTGP2 and MCWCH2

c) Time Required:

1) Minimum — 0.053 millisecond

2) Maximum — 0.113 millisecond
FIGURE 3-9. MFHS09 PROGRAM FLOW CHART
3.9 MONITOR TELEMETRY SUFFIX TO IOHS09 (MFHS08)

MFHS08 receives control from IOHS09 when the high-speed IP 7090 input contains telemetry information — the first subframe — or when the input contains unacceptable computed data.

The flow chart for the MFHS08 suffix is shown in Figure 3-10.

3.9.1 Input Requirements

Input to MFHS08 consists of:

a) MCTEL2 — indicates, when zero, that telemetry data is valid.

b) MCLFTM — when non-zero, contains GMT of lift-off in floating-point seconds.

c) MCHFSC — contains the current GMT in fixed-point half seconds.

d) MCTDEL — contains the integer count of half seconds to delay after lift-off is reported before entering the launch program.

e) MCTORI — indicates, when non-zero, the need to check for retrofire information.

f) MCWCH2 — indicates the source of the data processed by IOHS09. A 2 specifies raw AN/FPS-16; a 3 specifies IP 7090-smoothed Azusa data; a 4 specifies IP 7090-smoothed AN/FPS-16 data.

g) MCACTV — mask to activate/deactivate the DCC subchannels.

h) MCNRF1 — contains the number of retros reported fired, as received by DCC subchannel 1.

i) MCNRF2 — contains the number of retros reported fired, as received by DCC subchannel 2.

j) MCNGEN — indicates, when non-zero, the mission is in hold, low-abort or medium-abort phase.

k) MCS709 — indicates, when non-zero, that IP 7090 is the selected source for high-speed input.

l) MCTR1 — contains in floating-point seconds the time of the first indication received on DCC subchannel 1 that the retrorockets have fired.

m) MCTR2 — contains in floating-point seconds the time of the first indication received on DCC subchannel 2 that the retrorockets have fired.
n) TMH2TM — two-word table for the new telemetry information. The first word contains the associated GMT in floating-point seconds. The second word contains the telemetry data.

o) TMTML2 — storage table for telemetry information after IOHS09 processing.

3.9.2 Output Requirements

Output from MFHS08 consists of:

a) MCGTLO — contains the GMT of lift-off in fixed-point seconds.

b) MCTMWT — contains the GMT to enter the launch programs.

c) MCNTRF — contains total number of retros fired.

d) MCTMRF — contains time that first retrorocket fired.

e) MCTAL2 — contains the time to enter the abort phase.

f) MCSELS — indicates the selected source for high-speed input data. This cell is updated, if necessary, by MFHS08. MCSELS contains zero if no acceptable data has yet arrived on either subchannel 1 or 2; a 1 if the selected source is B-GE smoothed data; a 2 if the selected source is raw AN/FPS-16 data; a 3 if the selected source is IP 7090-processed Azusa data; a 4 if the selected source is IP 7090-processed AN/FPS-16 data.

3.9.3 Method

If lift-off has been validly reported for the first time, MFHS08 determines the lift-off time and queues an on-line message to print the GMT of lift-off. MFHS08 queues a mask for the sense processor to turn on the launch light on the Output Status Console. The time of lift-off is stored in MCGTLO in fixed-point seconds and in MCLFTM in floating-point seconds. The new telemetry data with its associated time tag is stored in the TMTML2 buffer table.

If the mission has entered the high-abort phase, the number of retros fired is computed and stored into MCNTRF and the time associated with the firing of the first retrorocket is stored into MCTMRF. When the high-abort programs may be entered, the high-speed subchannels of the DCC are deactivated and the B indicator for MYSEEK is turned on.

The selected source indicator, MCSELS, is updated, if necessary (in an abort situation the input on subchannel 2 is forced as the selected source), and the A indicator for 10HS09 is turned off.
3.9.4 Usage

MFHS08 is entered from IOHS09; MFHS08 exits to MOPRIO.

a) Storage Required — 103 locations

b) MFHS08 uses:

1) Macros — QENBA, QENBZ, QPSLF, QUEUE, TRNOF and TRNON

2) Parameters — A, B, MNHS09, MNMESS, MNSEEK and MNSENS

3) Communication cells — MCACTV, MCGTLO, MCHFSC, MCLFTM, MCNGEN, MCNRF1, MCNRF2, MCNTRF, MCSELS, MCS709, MCTABT, MCTAL2, MCTEL2, MCTDEL, MCTMRF, MCTMWT, MCTRFF, MCTRFF2 and MCWCH2

4) Tables — TMH2TM, TMTML2 and TMREST

5) Constants — K00002, K00060 and KCH233

6) Masks — KMNMSK and KMTRRM

c) Time Required:

1) Minimum — 0.048 millisecond

2) Maximum — 0.303 millisecond
FIGURE 3-10. MFHS08 PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 3-10. MFHS08 PROGRAM FLOW CHART (Sheet 2 of 2)
3.10 LOW-SPEED INPUT

The Mercury Program System accepts two types of low-speed teletype-format input via the Data Communications Channel: (1) capsule positional data from the radar sites and (2) special messages composed at Goddard for manual insertion. In general, the Monitor control of low-speed input consists of accepting, packing the teletype characters and storing them in temporary buffers. When any of these temporary buffers is filled, Monitor gives control to the processing programs which convert the data from teletype format into a form suitable for computations. The input processing programs also interpret the data and provide indications used by Monitor to control further data flow and processing.

The two types of low-speed teletype-format input are described in general in the remainder of this subsection and the Monitor programs which control low-speed input processing are described in detail in the subsections following.

3.10.1 Radar Data

When the Mercury capsule comes within range of the radar tracking station, raw radar values of range, azimuth and elevation with the corresponding Greenwich Mean Time are sent via teletype to Goddard Communications and Control Center. These messages, sent at a rate of ten per minute, are the primary input to the Mercury Program System after the capsule has passed out of range of the Cape Canaveral radars. These messages enter the computer via subchannels 14 through 29 of the DCC. Each five-bit teletype character is stored, right justified, in a separate computer storage location, and when six such characters have been entered, the DCC requests a program interrupt on the subchannel supplying the six characters. This trap gives control to the Monitor Teletype Input Trap Processor, MTTTIN, which prefixes a zero to the five-bit character and packs the six characters in a single word. The DCC input buffer for that subchannel is now free to accept six more input characters. When MTTTIN has packed sixty characters, ten computer words, the data is logged and control is given to IOTTIN to process the data by placing an entry in the input queue which defines the radar station by internal station number.

On the first entry to MTTTIN for any ten-word packed-output block, a logging time tag must be constructed; on the last entry to MTTTIN for a ten-word block, the block is logged.

Entry to IOTTIN is made via the Monitor prefix, MPTTIN, which determines whether the input is teletype from remote sites or a manually inserted message (MPTTIN and MTTTIN are common to both the teletype input and manual insertion processing programs). MPTTIN extracts the IOTTIN queue entry, determines the source and, if the message is teletype from the sites, prepares the input parameters for IOTTIN.

IOTTIN determines whether or not the message is acceptable (since non-radar teletype messages, although ignored in computer processing, are also
TELETYPE FORMAT
RADAR DATA FROM
19 TRACKING STATIONS

N = DCC SUBCHANNEL
14 ≤ N ≤ 29
XX = INTERNAL STATION
NUMBER

TMTIXX:
6-WORD
TABLE
CONTAINS
SIX 5-BIT
TELETYPE
CHARACTERS

AASXX:
10-WORD
TABLE
CONTAINS
SIX PACKED
TTY CHARACTERS
PER WORD

TMRMXX:
203-WORD
TABLE, THREE
WORDS FOR
PREFACE, 200
WORDS FOR
UP TO 50
MESSAGE OF
R, A, E AND T

INPUT TO EDITING
PROGRAM WHEN
TRANSMISSION
COMPLETE.

FIGURE 3-11. DATA FLOW: TELETYPE INPUT RADAR MESSAGES
Radar messages are examined for validity and valid data is converted into the format required for later processing. The input radar data is processed past the input level only after transmission is complete. Transmission may be completed three ways: (1) after 50 radar R, A and E points have been accepted by IOTTIN, (2) after an end-of-transmission signal has been received, if less than 50 messages have been received, or (3) if eight minutes have passed since the beginning of transmission and neither of the two preceding events has occurred, an end-of-transmission is forced to complete the input. The first two possibilities are the responsibility of IOTTIN. Monitor, as custodian of the clocks, initiates action when an end-of-transmission must be forced.

IOTTIN exits to the Monitor suffix, MFTTIN, which controls the processing flow. Program control is set for the editing processing program, EOLED1, if and only if transmission is complete and if this input is the first complete radar transmission during this orbit from this tracking location. For example, Bermuda transmits positional data from both the Verlort and AN/FPS-16 radars, but for any orbital pass only the first received complete transmission is processed past the input level. Normally, if a choice exists, the AN/FPS-16 input is preferred to Verlort and the method of transmission accomplishes the preference. For a station containing both radars, the longer range Verlort should initiate transmission to Goddard. When the AN/FPS-16 radar locks on the capsule, Verlort transmission is suspended in favor of the more accurate AN/FPS-16 data. When the AN/FPS-16 can no longer track the capsule, Verlort data is again transmitted. By this time, however, the AN/FPS-16 should have provided 50 radar points and the Verlort data is simply converted and stored by IOTTIN.

Since several stations may provide simultaneous radar data for the low-speed input programs, both because of simultaneous tracking by two or more radars at different locations and because radar data is preserved at the site on paper tape for later transmission or re-transmission, MTTTIN is capable of handling simultaneous input from many stations.

MTTTIN, MPTTIN and MFTTIN are described in detail in subsections 3.11, 3.12 and 3.13, respectively. The low-speed message format and the teletype input processing program, IOTTIN, are described in detail in MC 105, Goddard Processing Programs.

A general flow diagram for the Monitor control of low-speed teletype format radar input is shown in Figure 3-11.

3.10.2 Manually Inserted Messages

Special messages may be prepared according to a prescribed and rigid format for direct entry into the computer via a low-speed subchannel (30) of the Data Communications Channel. These messages provide a means whereby the Mercury Program System may be provided with (1) the Greenwich Mean Time of lift-off, (2) an abort/orbit decision, (3) an R and a V vector with the
PAPER TAPE MESSAGE MANUALLY INSERTED

TMT117
6-WORD TABLE CONTAINS SIX 5-BIT TELETYPE-FORMAT CHARACTERS

DCC SUBCHANNEL

DCC TRAP OCCURS WHEN TMT117 IS FULL

INPUT

MPTTIN:
MOVES DATA AND SETS INDICATORS

OUTPUT

B INDICATOR FOR MPTTIN TURNED ON INITIALLY WHEN AAS17 FULL. THEREAFTER, B INDICATOR TURNED ON WHEN AAS17 FULL OR WHEN WORDS IN AAS17 ARE ENOUGH TO COMPLETE MESSAGE

INPUT

MPITTIN:
SETS CONTROLS & PARAMETERS FOR 1OMANI

OUTPUT

1OMANI:
CONVERTS MSG. SETS INDICATORS BASED ON INPUT

EXIT DEPENDS ON MESSAGE INSERTED

MESSAGE IN ERROR OR INCOMPLETE

EXIT

MFMAN1:
INSERTED GMT OF LIFT-OFF

MFMAOS:
INSERTED ABORT/ORBIT SWITCH

MFMAN2:
INSERTED RETROFIRE # AND TIME

MFMAN3:
INSERTED R AND V VECTORS

FIGURE 3-12. DATA FLOW: MANUALLY INSERTED PAPER TAPE MESSAGES
corresponding time and (4) the number and time of retrorocket firing. Only the last of these messages is required for system operation; the others are intended to extend the flexibility of the system and/or provide a means of protection against failure in the primary information source.

The manually inserted messages are punched on paper tape in standard teletype code and are fed into the computer via subchannel 30. The paper tape messages are processed by MTTTIN in the same manner as standard radar teletype input, with only one minor difference. Where 60 teletype characters, ten packed words, must accumulate before processing radar data, the number of packed words required for processing manually inserted messages is initially six, and may have any value less than six. MPTTIN must determine paper tape input and set parameters necessary to control the processing of the input message. For paper tape input, MPTTIN exits to the Manual Insertion Processing Program, IOMANI.

While IOTTIN and IOMANI share both MTTTIN and MPTTIN, IOMANI has an exclusive set of suffixes -- one suffix for each of the four messages and a suffix for incomplete or rejected messages. These are given below.

<table>
<thead>
<tr>
<th>Suffix</th>
<th>Message</th>
<th>Subsection</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFMANI</td>
<td>Message incomplete or rejected</td>
<td>3.14</td>
</tr>
<tr>
<td>MFMAN1</td>
<td>GMT of lift-off</td>
<td>3.15</td>
</tr>
<tr>
<td>MFMAOS</td>
<td>Abort/orbit (decision) switch</td>
<td>3.16</td>
</tr>
<tr>
<td>MFMAN2</td>
<td>Retrofire</td>
<td>3.17</td>
</tr>
<tr>
<td>MFMAN5</td>
<td>R, V vectors</td>
<td>3.18</td>
</tr>
</tbody>
</table>

The Monitor control of manual insertion is concerned with maintaining the variable length of the input table to allow processing when the message is available. After IOMANI has successfully processed an inserted message, the suffix receiving control must provide control functions based on the information received. These vary from the turning on of the launch light on the Output Status Console and the storing of lift-off time in the restart table for the GMT of lift-off message, to the initiating of the phase change sequence for the retrofire message. For every exit from IOMANI except to MFMANI on an incomplete message and MFMAN5 with sense switch 3 up (meaning accept R and V vectors, but do not use them), an on-line message is provided which describes the information received by IOMANI.

The Monitor programs for low-speed paper tape input are described in the following subsections, as listed above. The Manual Insertion Program, IOMANI, is described in detail in MC 105, Goddard Processing Programs.

A general flow diagram for the Monitor control of low-speed paper tape input is shown in Figure 3-12.
3.11 MONITOR TELETYPE INPUT TRAP PROCESSOR (MTTTIN)

MTTTIN services the traps resulting from input on the 17 teletype input subchannels, 14 through 30, of the Data Communications Channel. MTTTIN packs and stores the input from each subchannel in the associated station block and, when the block is filled, logs the input message. MTTTIN also saves and indicates to the Monitor prefix to the input processing program the teletype line number producing the input trap.

The flow chart for the MTTTIN trap processor is shown in Figure 3-13.

3.11.1 Input Requirements

Upon entry to MTTTIN the decrement of the accumulator must contain the number of the DCC subchannel which produced the trap and the address of the accumulator must contain the location of the input teletype data (TMTI01, TMTI02, .... or TMTI17).

a) TMTI01 through TMTI17 -- one of these six-cell input blocks must contain the input teletype characters. Input on subchannel 14 is stored in TMTI01, where 01 is the line number for teletype input on subchannel 14 .... input on subchannel 30 is stored in TMTI17, where 17 is the line number for teletype input on subchannel 30.

b) TMTTIN -- each of the 17 input subchannels is associated with a word in this block. The address of the TMTTIN entry contains the location of the input block for that subchannel, while the decrement contains the number of words required in the input block before processing can commence.

c) TM8.3M -- contains the number of 8-1/3 millisecond intervals elapsed since the last exact half second.

d) MCHFSC -- contains the current GMT in fixed-point half seconds.

3.11.2 Output Requirements

Output from MTTTIN consists of an accumulation of teletype input characters, packed six characters per 7090 computer word, and stored in the output block defined in the address of TMTTIN. Each teletype input subchannel has a separate block for this purpose, AASXX where XX is the number of the associated line number. Line number 1 is equivalent to subchannel 14, etc. The address of TMTTIN gives the location of the output block for the corresponding line number.

The sign of each word in the TMTTIN table is tested and, if negative, the block located in the address of the TMTTIN word is full and logging is required. A logging flag is set and the sign of the word is reset positive.
3.11.3 Method

Teletype characters are received on DCC subchannels 14 through 30 and are stored, one character per 7090 computer word, in a six-cell block corresponding to the particular subchannel involved. Each of the 17 subchannels has its own six-cell block: TMTI01, TMTI02, .... TMTI17.

Whenever one of the blocks becomes full, a trap occurs on that subchannel and control is transferred to MTTTIN via MORTCC. MTTTIN packs the six input characters into a single word and stores this word into the corresponding output block (AASXX). MTTTIN determines when enough words have been stored in the output block by checking against the decrement of the proper location in TMTTIN. When this occurs, the B indicator for the Monitor prefix to the low-speed input programs -- IOTTIN and IOMANI share the MPTTIN prefix -- is turned on. MTTTIN stores in the decrement of AATTY the line number of the input data which must be processed and this is placed in the input queue for MPTTIN. The block is logged and control transfers to M0PRIO.

3.11.4 Usage

MTTTIN is entered from M0RTCC following a trap on subchannel 14 through 30; MTTTIN exits to M0PRIO.

a) Storage Required — 254 locations

b) MTTTIN uses:

1) Subroutine — MSLOGG

2) Macro — QUEUE

3) Parameter — MNTTIN

4) Communication cell — MCHFSC

5) Tables — TMTTIN, TMTI01, TMTI02, etc. .... TMTI17, and AAS01, AAS02, etc. .... AAS17

c) Time Required:

1) Minimum — 0.177 millisecond

2) Maximum — 0.834 millisecond
FIGURE 3-13. MTTTIN PROGRAM FLOW CHART
3.12 MONITOR PREFIX TO I0TTIN AND I0MANI (MPTTIN)

MPTTIN is the Monitor prefix to I0TTIN — for teletype-format input on subchannels 14 through 29 — and to I0MANI — for teletype-format input on subchannel 30. MPTTIN establishes control information for the processing of the input data.

The flow chart for the MPTTIN prefix is shown in Figure 3-14.

3.12.1 Input Requirements

Input to MPTTIN consists of a word in the MPTTIN input queue table. This word is unqueued by MPTTIN and stored into location ATNO. This input word must contain in the decrement the line number (subchannel number minus 13) for the input information to be processed. In addition, the address of ATNO must be non-zero if eight minutes have elapsed since this input was initiated on this subchannel with no end-of-transmission signal.

If the decrement of ATNO contains 17, the input consists of a paper tape message and the following are input requirements:

a) MCMPTE — contains the maximum number of words processed by MTETTIN per entry to I0MANI.

b) MCWDCT — contains the number of words required to complete this paper tape message.

3.12.2 Output Requirements

If the input message is from paper tape, TMMANI contains paper tape message (the contents of the AAS17 block are stored in TMMANI) and the decrement of TMTTIN + 17 contains the number of packed words that must be collected by MTETTIN on subchannel 30 before again transferring control to MPTTIN for a paper tape message. This number cannot exceed six.

If the input message is from the teletype subchannels, 14 through 29, the decrement of the accumulator must contain the line number.

For every entry MCISTN contains in the address the line number of any subchannel for which no end-of-transmission signal has been received within eight minutes after initiating transmission.

3.12.3 Method

The line number for input data is taken from the input queue table of MPTTIN and placed into the decrement of the accumulator. If this line number is 17 and if the required number of words have been processed for input to I0MANI, exit is to I0MANI with the message word count in the decrement of the accumulator.
and the location of the TMMANI table in the address of the accumulator. If the message is incomplete, the A indicator for MPTTIN is turned off and control returns to M0PRIO.

If the line number is not 17, a test is made to determine if a radar message has exceeded the maximum allowable time interval of eight minutes. If the allowable message transmission time has not been exceeded, exit is to the teletype input processor, I0TTIN, with the teletype line number in the decrement of the accumulator. If the allowable message transmission time were exceeded, the internal station number of the radar station is stored in MCISTN and exit is to the IOSTPR section of I0TTIN. IOSTPR ends the message transmission.

3.12.4 Usage

MPTTIN is entered from M0PRIO; MPTTIN exits to I0TTIN, IOSTPR, I0MANI or returns control to M0PRIO.

a) Storage Required — 54 locations

b) MPTTIN uses:

1) Macros — QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters — A, and MNTTIN

3) Communication cells — MCMPTE, MCWDCT and MCISTN

4) Tables — AAS17, TMMANI and TMTTIN

5) Constant — K00006

c) Time Required:

1) Minimum — 0.111 millisecond

2) Maximum — 0.443 millisecond
FIGURE 3-14. MPTTIN PROGRAM FLOW CHART
3.13 MONITOR SUFFIX TO IOTTIN (MFTTIN)

MFTTIN handles all exit control functions associated with the low-speed teletype input processor, IOTTIN.

The flow chart for the MFTTIN suffix is shown in Figure 3-15.

3.13.1 Input Requirements

The primary input to MFTTIN consists of the accumulator and the multiplier-quotient registers, both set by IOTTIN. The accumulator contains information relative to the termination of teletype transmission by the Mercury tracking stations. If the accumulator contains zero, no station has terminated teletype transmission. If a station has terminated teletype transmission of AN/FPS-16 data, the internal station number is contained in the address of the accumulator. If a station has terminated teletype transmission of Verlort data, the internal station number is contained in the decrement of the accumulator. The multiplier-quotient contains information relative to the initiation of teletype transmission by the Mercury tracking stations. If the MQ contains zero, no station has initiated teletype transmission. If a station has initiated teletype transmission, the internal station number is contained in the address of the MQ.

Other input to MFTTIN consists of:

a) MCMINS — contains the current GMT in fixed-point minutes.

b) TMLSDB — table of 19 cells, containing in order by internal station number an entry for each radar station. The TMLSDB entry locates the radar's input table, TMRMXX, where XX represents the internal station number.

c) TMRM01 . . . TMRM19 — each TMRMXX table corresponds to a radar station and contains 203 locations into which a maximum of 50 radar messages of range, azimuth, elevation and time may be stored. The sign of the first location in the TMRMXX table is negative until the block is filled or an end-of-transmission received; the sign is then set positive and remains positive until the input data has been used or is no longer needed.

d) TMSTCH — table of 25 cells, of which two through 20 contain in order, by internal station number, an entry for each radar station. The TMSTCH entry locates the radar's Station Characteristics block, which is used by MFTTIN to determine whether or not any given radar station has a co-located radar of a different type.

3.13.2 Output Requirements

Output from MFTTIN consists of:
a) TM8DNS — contains, sequentially by internal station number, one cell for each radar station. At the initiation of transmission for each radar station the time contained in the MCMINS communication cell is incremented by eight and this sum is stored in the TM8DNS entry for that radar station as the time at which this transmission must be completed. The TM8DNS table is examined every minute by MSTICK (Subsection 3.25).

b) TMRMXX — the sign of the first cell in the radar input table is set positive to indicate the need for editing, if the sign is negative upon entry to MFTTIN.

3.13.3 Method

Upon entry to MFTTIN it is possible to have a maximum number of two radar stations that have terminated transmission and one that has initiated transmission. Within these limits, any combination of message transmission beginning and/or ending is permissible.

IOTTIN places the internal radar station numbers in the address of the accumulator for end of transmission for AN/FPS-16 radar and in the decrement of the accumulator for Verlort radar. If an indication is received that transmission(s) is (are) complete, appropriate entries are made in the queue tables for EOLED1, to begin editing the radar data, and for MYMESS, to print out an on-line message stating the termination of transmission for a given radar station. If an indication is received that transmission has been initiated, an entry is made only in the queue table for MYMESS.

The sign of the first word of the edited radar message corresponding to the radar completing transmission is tested and, if positive, the message has already been edited, and the edit program is bypassed. If the sign is negative, it is set positive and entries are made in the queue tables of EOLED1 and MYMESS.

After indication that a radar station has ended transmission, tests are made to determine co-located radars by checking the Station Characteristics blocks. If input has been received previously for this radar station within the last 3/4 orbit, MYMESS is queued indicating the end-of-transmission for the radar message. If there has been no input within the above specified time, EOLED1 is queued for editing of the radar message. If there are no co-located radars, EOLED1 is queued for editing of the radar message.

In addition, MFTTIN increments the current time at which a radar message transmission begins by eight minutes. This incremented time is compared every minute with the current time, and if the transmission time exceeds eight minutes, input is queued for IOTTIN to automatically end the message transmission.
3.13.4 Usage

MFTTIN is entered from IOTTIN; MFTTIN exits to MOPRIO.

a) Storage Required — 86 locations

b) MFTTIN uses:

1) Macros — QENBA, QENBZ, QUEUE and TRNOF
2) Parameters — A, MNLED1, MNMESS and MNTTIN
3) Communication cell — MCMINS
4) Tables — TM8MNS, TMLSDB, TMRM01...TMRM19, and TMSTCH
5) Constants — K00001, K00008 and K00047

c) Time Required:

1) Minimum — 0.039 millisecond
2) Average — 0.351 millisecond
3) Maximum — 0.662 millisecond
FIGURE 3-15. MFTTIN PROGRAM FLOW CHART
3.14 MONITOR SUFFIX TO I0MANI (MFMANI)

Whenever I0MANI determines that either a message is in error or that the incoming message is incomplete, I0MANI exits to MFMANI where the proper action is taken.

The flow chart for the MFMANI suffix is shown in Figure 3-16.

3.14.1 Input Requirements

Input to MFMANI consists of the proper information in the accumulator upon entry. A negative accumulator indicates a message rejection, while a positive accumulator indicates a request by I0MANI for more input words. In the latter case, the number of required words is contained in the decrement of the accumulator.

3.14.2 Output Requirements

Three cells — TMTTIN+17, MCMPTE and MCWDCT — are the output of MFMANI, depending upon the conditions of the return from I0MANI.

Location | AC negative | AC positive, X ≤ 6 | AC positive, X > 6
--- | --- | --- | ---
D(TMTTIN +17) | 6 | X | 6
A(MCMPTE) | 6 | X | 6
A(MCWDCT) | 6 | X | X

where X is the number of words requested by I0MANI.

3.14.3 Method

If MFMANI finds the accumulator negative, the message was rejected and the following on-line message is queued: MANUAL INSERTION REJECTED, ENTER MESSAGE AGAIN, MFMANI provides the output listed above, turns off the A indicator for I0MANI and exits to M0PRIO.

If the accumulator is positive upon entry, MFMANI compares the decrement of the accumulator to six, and provides the output listed above on the basis of this comparison. The A indicator for I0MANI is turned off and MFMANI exits to M0PRIO.

3.14.4 Usage

MFMANI is entered from I0MANI; MFMANI exits to M0PRIO.

a) Storage Required — 28 locations
b) MFMANI uses:
   1) Macros — QENBA, QENBZ, QUEUE and TRNOF
   2) Parameters — A and MNTTIN
   3) Communication cells — MCMPTT and MCMWDCT
   4) Table — TMTTIN
   5) Constants — KD0006

c) Time Required:
   1) Minimum — 0.047 millisecond
   2) Maximum — 0.140 millisecond
Incomplete / Words Needed More Than 6?

- Yes: SET X → A (MCWDCT)
  6 → D (TMTTIN+17)
  6 → A (MCMPTE)

- No (≤ 6):
  - Set X → D (TMTTIN+17)
  - X → A (MCMPTE)
  - X → A (MCWDCT)

Queue MNMESS

Queue MNBQA

Set X = 6 to Reset Paper Tape Input Parameters.

Manual Insertion Rejected, Enter the Message Again

**Figure 3-16. MFMANI Program Flow Chart**
3.15 MONITOR TIME OF LIFT-OFF SUFFIX TO I0MANI (MFMAN1)

MFMAN1 receives control from I0MANI after a successful paper tape insertion of the Greenwich Mean Time of lift-off.

The flow chart for the MFMAN1 suffix is shown in Figure 3-17.

3.15.1 Input Requirements

Input to MFMAN1 consists of:

a) MCHFSC — contains the current GMT in fixed-point half seconds.

b) MCGTLO — contains the GMT of lift-off in fixed-point seconds. This is the time contained on the inserted paper tape message.

c) MCLNCH — mask to turn on the launch light on the Output Status Console.

3.15.2 Output Requirements

Output from MFMAN1 consists of:

a) TMREST + 30 — contains the current GMT in fixed-point half seconds.

b) TMREST + 21 — contains the GMT of lift-off in fixed-point seconds.

c) MCLFTM — contains the inserted GMT of lift-off in floating-point seconds.

d) TMTTIN + 17 — contains a 6 in the decrement.

e) MCMPTE — contains a 6 in the address.

f) MCWDCT — contains a 6 in the address.

3.15.3 Method

The method of MFMAN1 is shown in Figure 3-17.

3.15.4 Usage

MFMAN1 is entered from I0MANI; MFMAN1 exits to M0PRI0.

a) Storage Required — 27 locations

b) MFMAN1 uses:
1) Macros — QENBA, QENBZ, QUEUE and TRNOF
2) Parameters — A, MNMESS, MNSENS and MNTTIN
3) Communication cells — MCHFSC, MCGTLO, MCLFTM, MCMPT and MCWDCT
4) Tables — TMREST and TMTTIN
5) Constants — KCH233 and KD0006

c) Time Required:
1) Minimum — 0.192 millisecond
2) Maximum — 0.262 millisecond
FIGURE 3-17. MFMAN1 PROGRAM FLOW CHART
3.16 MONITOR ABORT/ORBIT SWITCH SUFFIX TO IOMANI (MFMAOS)

MFMAOS receives control from IOMANI after a successful paper tape insertion of the abort-orbit switch. The primary purpose of MFMAOS is to effect an on-line message indicating a successful insertion. In addition MFMAOS sets certain cells for MTTTIN and MPTTIN.

The flow chart for the MFMAOS suffix is shown in Figure 3-18.

3.16.1 Input Requirements

Input to MFMAOS consists of the MCMAOS communication cell: a 1 in bit position 35 indicates the orbit switch was inserted; a 1 in bit position 34 indicates the abort switch was inserted.

3.16.2 Output Requirements

Output from MFMAOS consists of:

a) TMTTIN +17 — contains a 6 in the decrement.

b) MCMPTE — contains a 6 in the address.

c) MCWDCT — contains a 6 in the address.

3.16.3 Method

MFMAOS receives control from IOMANI and queues the on-line message defined by the message number 256 + C (MCMAOS). If the orbit switch was entered, MCMAOS contains a 1 and message number 257 is queued: MANUAL INSERTION ACCEPTED ORBIT SWITCH. If the abort switch was entered, MCMAOS contains a 2 and message number 258 is queued: MANUAL INSERTION ACCEPTED ABORT SWITCH.

A 6 is stored in the decrement of TMTTIN +17 and in the address of MCMPTE and MCWDCT. The A indicator for MNTTIN is turned off and control returns to M0PRIO.

3.16.4 Usage

MFMAOS is entered from IOMANI; MFMAOS exits to M0PRIO.

a) Storage Required — 18 locations

b) MFMAOS uses:

1) Macros — QENBA, QENBZ and QUEUE
2) Parameters — N and MNTTIN

3) Communication cells — MCMAOS, MCMPTE and MCWDCT

4) Table — TMTTIN

5) Constant — K00006

c) Time Required:

1) Minimum — 0.109 millisecond

2) Maximum — 0.144 millisecond
FIGURE 3-18. MFMAOS PROGRAM FLOW CHART
3.17 MONITOR RETROFIRE SUFFIX TO IOMANI (MFMAN2)

MFMAN2 receives control from IOMANI after a successful manual insertion of the retrofire message. In addition to effecting the appropriate on-line messages, MFMAN2 initiates the proper programs to handle the transition from orbit to re-entry, MYREST, or from abort to re-entry, MYSEEK. In the abort to re-entry transition, DCC subchannels 1 and 2 are deactivated as high-speed input to the system is no longer needed.

The flow chart for the MFMAN2 suffix is shown in Figure 3-19.

3.17.1 Input Requirements

Input to MFMAN2 consists of:

a) MCREEN — contains the inserted number of retros fired.

b) MCTOFS — contains the inserted time of retrofire in fixed-point seconds.

c) MCTABT — when zero, indicates the orbit phase; when non-zero, indicates the abort phase.

d) MCHFSC — contains the current GMT in fixed-point half seconds.

e) TMAGMT — contains the attitude of the capsule.

3.17.2 Output Requirements

MFMAN2 updates the restart table by storing: MCREEN into TMREST + 22; MCTOFS into TMREST + 23; TMAGMT into TMREST + 24; MCHFSC into TMREST + 30. A 6 is stored in the decrement of TMTTIN + 17 and in the address of MCWDCT and MCMPT. If the phase transition is from abort to re-entry, MCTOFS is stored into MCMARF.

3.17.3 Method

MFMAN2 receives control from IOMANI, disables the computer and queues the on-line message: MANUAL INSERTION ACCEPTED, NO. OF RETRO ROCKETS FIRED IS__. The restart table is updated with the following information: the number of retrorockets fired (MCREEN); the time of retrofire (MCTOFS); the capsule attitude (TMAGMT); the current time (MCHFSC). MFMAN2 then queues the on-line message: MANUAL INSERTION RETRO-FIRE TIME IS___HRS___MINS___SECS

A 6 is stored in the decrement of TMTTIN + 17 and in the address of MCMPT and MCWDCT.
If the phase transition is from abort to re-entry, the time of retrofire is stored in MCMARF, the high-speed input subchannels are deactivated, and the B indicator for MYSEEK is turned on. If the phase transition is from orbit to re-entry, the B indicator for MYREST is turned on.

Finally, the B indicator for MYWRRS is turned on, the A indicator for MNTTIN is turned off and control returns to MOPRIO.

3.17.4 Usage

MFMAN2 is entered from IOMAN1; MFMAN2 exits to MOPRIO.

a) Storage Required — 56 locations

b) MFMAN2 uses:

1) Macros — QENBA, QENBZ, QUEUE, QPSLF, TRNOF and TRNON

2) Parameters — A, B, MNMESS, MNREST, MNTTIN and MNWRRS

3) Communication cells — MCACTV, MCHFSC, MCMARF, MCMPTE, MCREEN, MCTABT, MCTOFS and MCWDCT

4) Tables — TMAGMT, TMREST and TMTTIN

5) Constant — K00006

c) Time Required:

1) Minimum — 0.240 millisecond

2) Maximum — 0.360 millisecond
FIGURE 3-19, MFMAN2 PROGRAM FLOW CHART
3.18 MONITOR R and V SUFFIX TO IOMANI (MFMAN5)

MFMAN5 receives control from IOMANI after the successful manual insertion of a position or velocity vector for the numerical integration program.

The flow chart for the MFMAN5 suffix is shown in Figure 3-20.

3.18.1 Input Requirements

Input to MFMAN5 consists of:

a) MCNRRF — contains an indication of the number of retrorockets fired: 1, 2 or 3.

b) MCMINS — contains the current GMT in fixed-point minutes.

c) MCGTIN — contains the GMT of capsule insertion into orbit in fixed-point seconds.

d) TNINT1 — the orbit integration table.

e) TNINT2 — the re-entry integration table.

f) TIOTRV — table containing the integration parameters.

Sense switch 3 on the computer console must be down, or MFMAN5 takes no action in response to the manual insertion, except to reset controls for the next manual insertion message.

If the accumulator is non-zero, the radius vector has been manually inserted; if the accumulator is zero, the velocity vector has been manually inserted.

3.18.2 Output Requirements

For every entry to MFMAN5 the control cells for manual insertion messages are reset: a 6 is stored in the decrement of TMTTIN + 17 and in the address of MCMPTE and of MCWDCT.

If sense switch 3 is down and the accumulator is non-zero, the only other output is the on-line message: R VECTOR ACCEPTED, ENTER VELOCITY.

If sense switch 3 is down and the accumulator is zero, the integration parameter table, TIOTRV, is updated from the information provided in the two inserted messages, dependent upon the current phase -- either orbit or re-entry. The B indicator for the MYGEN2 program for numerical integration is turned on and the following on-line message is queued: VELOCITY VECTOR ACCEPTED.
If sense switch 3 is up, there is no other output.

3.18.3 Method

If sense switch 3 is not depressed, MFMAN5 takes no action in response to the manually inserted information. (Since any system input via the DCC enters both computers, sense switch 3 provides the means whereby the duplexed computers may be given different input.) The cells used as counters for paper tape input messages, are reset, the A indicator for MNTTIN is turned off and control returns to M0PRI0.

If sense switch 3 is depressed, MFMAN5 sets the controls described in Subsection 3.18.2 before resetting the paper tape input message counter cells, turning off the A indicator for MNTTIN and returning control to M0PRI0.

3.18.4 Usage

MFMAN5 is entered from I0MANI; MFMAN5 exits to M0PRI0.

a) Storage Required — 64 locations

b) MFMAN5 uses:

1) Macros — QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters — A, B, MNGEN2, MNMESS and MNTTIN

3) Communication cells — MCNRRF, MCGTIN, MCMINS, MCMPTF and MCWDCT

4) Tables — TNINT1, TNINT2, TI0TRV and TMTTIN

5) Constants — K00003, K00060, K00087 and K00294

c) Time Required:

1) Minimum — 0.042 millisecond

2) Maximum — 0.354 millisecond
FIGURE 3-20. MFMAN5 PROGRAM FLOW CHART
3.19 TIMING CONTROL

Three subchannels of the Data Communications Channel provide the Mercury Program System with all necessary timing facilities. The timing subchannels of the DCC allow the Mercury Program System to enter and maintain the time base, i.e., Greenwich Mean Time, for Project Mercury and to control the execution of various programs at a program controlled time period. The timing subchannels utilized in the Mercury Program System and their associated Monitor processors are described below:

Subchannel 7, when activated, increments a cell in computer core storage every 8-1/3 milliseconds. When the count reaches 59, the next 8-1/3 milliseconds increment resets the count to zero — 60 increments of 8-1/3 milliseconds comprise a half-second interval — whereupon subchannel 7 causes an automatic interrupt of the computer. By combining an absolute time, i.e., GMT, in half seconds with the 8-1/3 millisecond counter, the Mercury Program System has access to the real time within an accuracy of 8-1/3 milliseconds. The half-second interrupt subchannel is activated when the Greenwich Mean Time is entered into the computer (see subchannel 8, below) and is never deactivated until the processing for the mission is terminated. When the half-second interrupt subchannel is activated, a 1 in the sign bit of the mask addressed by the PSLF instruction resets the 8-1/3 millisecond counter to zero. The sign bit of the PSLF mask must be zero thereafter.

Interrupts on subchannel 7 are serviced by the Monitor Half-Second Trap Processor, MTHFSC. This trap processor controls a half-second timing table which provides a means of timing set intervals within Monitor as well as a means of informing the Monitor Main Controller Priority Program, MOPRIO, at set intervals that the cyclic, or time related, programs should be entered. The Monitor Minute Processor, MYMINS, receives control every time its entry in the half-second timing table is reduced to zero.

MTHFSC and MYMINS are described in detail in Subsections 3.22 and 3.23, respectively. The two subroutines executed by MYMINS — the Monitor Pass Number Determination Subroutine, MSPASN, and the Monitor Teletype Input Check Subroutine, MSTICK — are described in detail in Subsections 3.24 and 3.25, respectively.

Subchannel 8, when activated, interrupts the computer in synchronization with an external timing pulse. The external timing pulse for the Mercury Program System is received from the National Bureau of Standards’ radio station WWV and produces a computer interrupt every minute (accurate to one millisecond). This subchannel is serviced by two trap processors. The Monitor Initial WWV Trap Processor, MTWWVI, receives control with each WWV interrupt until after the GMT time base is entered into the computer. When MTWWVI has established the time base and initializes the timing cells of the Mercury Program System, MTWWVI replaces its own entry in the DCC control table with the entry for the Monitor WWV Trap Processor, MTWWVWI. This
trap processor maintains a minute time cell and examines the other time cells for deviations from the WWV standard.

MTWWVI and MTWWWV are described in detail in Subsections 3.20 and 3.21, respectively.

Subchannel 9, when activated, decrements a specified cell in computer core storage every 8-1/3 milliseconds. When the cell is reduced to zero, subchannel 9 causes an automatic interrupt of the computer and the interrupt deactivates the subchannel. Subchannel 9 may time any interval from 8-1/3 milliseconds (1 in the specified cell) to 4.25 seconds (250 in the specified cell).

Although at present this subchannel is not utilized in the Mercury Program System, provisions have been made to allow its use should the need arise.

A general flow diagram for the DCC Timing Control is shown in Figure 3-21.
**Figure 3-21. DCC Timing Control**

- **No Input; Internal to DCC**
  - DCC Subchannels
  - TM8.3M
    - Signal increments TM8.3M every 8-1/3 milliseconds on 60th increment, cell is reset and trap occurs.
    - MTHFSC
      - Maintains 1/2 sec clock and turns on B indicator for cycled programs
      - Programs controlled by half-second clock, MTHFSC
      - MMTNS
        - Minute processor with Mstick, MSPASN and MTCDD
      - CCGEB1
        - CC7091
        - Coordinate Conv. programs
      - O0LANA
        - O0ORRE
        - H.S. output programs

- **WWV Pulse on Exact Minute**
  - Trap occurs on external signal
  - MTWWVI
    - Initial WWV trap processor used to enter real time (and any restart time)

- **No Input; Internal to DCC**
  - TMINTV
    - Signal decrements n in TMINTV every 8-1/3 milliseconds.
    - When n becomes zero, trap occurs. n set by program, may be 1 to 250.
3.20 MONITOR INITIAL WWV TRAP PROCESSOR (MTWWVI)

MTWWVI provides to the IBM 7090 computer the time base for all data processing and transmission in Project Mercury by entering the Greenwich Mean Time (GMT) into the Mercury Program System.

In the event of a restart operation, MTWWVI also provides a time tag which locates a restart vector on the restart tape.

The flow chart for the MTWWVI trap processor is shown in Figure 3-22.

3.20.1 Input Requirements

MTWWVI requires manual control. The GMT at which time initialization is to take place is manually entered in the computer's console keys. The time is entered octally in the decrement in hours and minutes, right justified. The restart time, if required, is entered octally in hours, minutes and seconds:

<table>
<thead>
<tr>
<th>Present GMT</th>
<th>Restart GMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Console keys</td>
<td>Present GMT</td>
</tr>
<tr>
<td>S 6 HRS 11 12 MINS 17</td>
<td>18 HRS 23</td>
</tr>
</tbody>
</table>

3.20.2 Output Requirements

DCC subchannel 7 is activated and the 8-1/3 millisecond counter reset to zero in synchronization with the half-second trap. In addition MTWWVI stores the current GMT in MCWWWV, in fixed-point 8-1/3 milliseconds; in MCHFSC, in fixed-point half seconds; in MCMINS and MCFMPR, in fixed-point minutes. A restart time, if given, is stored in MCREST in fixed-point seconds.

3.20.3 Method

During the execution of MYINIT, subchannel 8 is activated and every minute thereafter a trap occurs in synchronization with the WWV one-minute timing pulse. M0RTCC gives control to MTWWVI which examines the contents of the console keys. If the sign key is up, MTWWVI transfers control directly to M0Prio.

The time at which initialization is to take place is manually entered into the computer's console keys. If the time initialization is for a program restart, the restart time must also be entered. Within one minute prior to the initialization time thus set in the keys, the sign key must be depressed. When MTWWVI finds the sign key down, the time in the decrement is processed as the current GMT, i.e., the time base for the Mercury Program System. If a restart time was entered in the tag and address of the keys, MTWWVI stores this time in the cell provided.
MTWWVI activates the half-second trap subchannel and resets the 8-1/3 millisecond counter to zero. The MTWWVI entry in the M0RTCC control transfer table is replaced with the entry to MTWWWV, which services all succeeding WWV traps. Two on-line messages are queued: "THE WWV TIME ENTERED IS (GMT)____HRS____MINS____SECS," preceeded by either "NORMAL OPERATION HAS BEGUN" or "THE TIME RESTARTED FROM IS____HRS____MINS____ SECS."

3.20.4 Usage

MTWWVI is entered from M0RTCC following a trap on DCC subchannel 8; MTWWVI exits to M0PRIO.

a) Storage Required — 38 locations

b) MTWWVI uses:

1) Macro — QUEUE

2) Parameter — MNMESS

3) Communication cells — MCFMPR, MCHFSC, MCMINS, MCREST and MCWWWV

4) Table — TMRTCC

5) Constants used — K00060 and K00120

c) Time Required:

1) Minimum — 0.218 millisecond

2) Maximum — 0.301 millisecond

3) If the sign key is up, only 0.009 millisecond is required.
FIGURE 3-22. MTWWWVI PROGRAM FLOW CHART
3.21 MONITOR WWV TRAP PROCESSOR (MTWWWV)

After MTWWWVI enters the time into the Mercury Program System, MTWWWVI replaces its own entry in TMRTCC with the entry for MTWWWV, so that all subsequent WWV traps are serviced by MTWWWV. This trap processor must update the 8-1/3 millisecond count cell and, on alternate entries, queue an on-line message which indicates the expected and the actual quantity of high-speed output data transmitted to Cape Canaveral in the past two minutes.

The flow chart for the MTWWWV trap processor is shown in Figure 3-23.

3.21.1 Input Requirements

Input to MTWWWV consists of:

a) MCWWWV — contains the GMT in fixed-point 8-1/3 milliseconds at the last WWV trap.

b) MCBJMN, MCHOMS — MCBJMN contains the number of the on-line message to be queued by MTWWWV. The four possible messages have a standard format: HS OUTPUT TRANS RATE TO CAPE - EXPECTED N, ACTUAL X, where N depends upon the message number in MCBJMN, which is a function of mission phase, and X is contained in MCHOMS:

<table>
<thead>
<tr>
<th>PHASE</th>
<th>MCBJMN</th>
<th>N</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch</td>
<td>162</td>
<td>240</td>
<td>MCHOMS</td>
</tr>
<tr>
<td>Re-entry</td>
<td>163</td>
<td>40</td>
<td>MCHOMS</td>
</tr>
<tr>
<td>Orbit</td>
<td>164</td>
<td>20</td>
<td>MCHOMS</td>
</tr>
<tr>
<td>Abort</td>
<td>165</td>
<td>120</td>
<td>MCHOMS</td>
</tr>
</tbody>
</table>

MCHOMS provides the variable field for each of the four messages. Its value is computed by MTHSOD, the high-speed output trap processor which services subchannel 3.

3.21.2 Output Requirements

Output from MTWWWV consists of:

a) MCHOMS — the counter for high-speed output to Cape Canaveral is reset to zero on alternate entries.

b) MCWWWV — is updated to contain the present GMT in fixed-point 8-1/3 milliseconds.

3.21.3 Method

MTWWWV examines an internal switch to determine whether or not this entry is odd or even. On every even entry MTWWWV queues an on-line message
which specifies the expected and the actual transmission rate for high-speed data sent to Cape Canaveral over the past two minutes.

On every entry, MTWWVV updates the 8-1/3 millisecond GMT clock cell.

3.21.4 Usage

MTWWVV is entered from M0RTCC following a trap on DCC subchannel 8; MTWWVV exits to M0PRIO.

a) Storage Required — 17 locations

b) MTWWVV uses:

1) Macro — QUEUE

2) Parameter — MNMESS

3) Communication cells — MCBJMN, MCHOMS and MCWWWV

4) Constant — K07200

c) Time Required:

1) Odd entry — 0.035 millisecond

2) Even entry — 0.131 millisecond
FIGURE 3-23. MWWWV PROGRAM FLOW CHART
3.22 MONITOR HALF-SECOND TRAP PROCESSOR (MTHFSC)

Every half second a trap on DCC subchannel 7 gives control to MTHFSC signifying the passage of a half second of real time. MTHFSC updates time cells and initiates programs in the Mercury Program System which are executed with a specified frequency. MTHFSC determines and inform other Monitor programs if the IBM 7090 is in the transmission mode, i.e., is on-line for external transmission. If the computer has left the transmission mode in the past half-second, MTHFSC must provide control functions which depend upon the transmission mode.

The flow chart for the MTHFSC trap processor is shown in Figure 3-24.

3.22.1 Input Requirements

Input to MTHFSC consists of:

a) $M$ — parameter designating the number of entries in the Monitor timing tables, TMCYNO and TMCYCL. $M$ is equal to 5.

b) TMCYCL and TMCYNO — the Monitor Timing tables, when used with the half-second trap processor, provide a means of giving control on a set (but variable) time period to programs in the Mercury Program System. The decrement of the entry in TMCYNO provides the half-second period of a routine. The decrement of the corresponding entry in TMCYCL provides the count of half seconds remaining before control is given to the program. The address of the TMCYCL entry provides the routine number, which locates the program in the Monitor priority table.

The initial settings for TMCYCL and TMCYNO are:

<table>
<thead>
<tr>
<th>Location</th>
<th>Address,, Decrement</th>
<th>Location</th>
<th>Address,, Decrement</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMCYCL</td>
<td>MNCCGB,, 1</td>
<td>TMCYNO</td>
<td>,, 1</td>
</tr>
<tr>
<td>+1</td>
<td>MNCCIP,, 1</td>
<td>+1</td>
<td>,, 1</td>
</tr>
<tr>
<td>+2</td>
<td>MNLANA,, 1</td>
<td>+2</td>
<td>,, 1</td>
</tr>
<tr>
<td>+3</td>
<td>MNORMC,, 12</td>
<td>+3</td>
<td>,, 24</td>
</tr>
<tr>
<td>+4</td>
<td>MNMINS,, 120</td>
<td>+4</td>
<td>,, 120</td>
</tr>
</tbody>
</table>

By changing the contents of the decrement of its entry in TMCYNO, that program's frequency of execution may be changed at will. And, in fact, these frequencies are changed for each change in mission phase. MNLANA and MNORMC are the routine numbers for the output computations processing programs for launch/abort and orbit/re-entry, respectively. The 1 in the decrement of the entry for MNLANA

3-91
designates the half-second period of execution—the time period necessary to update the displays at the Mercury Control Center—during the launch phase. When the abort phase is entered, a 4 is stored in the decrement of the TMCYCL entry and the displays are now updated every other second. MNORMC has an initial period of six seconds for the orbit phase. For the re-entry phase, a 6 is stored in the decrement of the MNORMC entry and the period becomes three seconds. (OOLANA and O5ORMC are mutually exclusive programs. Although the B indicator for O5ORMC is turned on six seconds during the launch and abort phases, it never receives control until the orbit or re-entry phases are entered. This is accomplished by a suppression bit which is not removed until either the orbit or re-entry phases become current. At that time the first three entries in the timing tables are effectively eliminated. See MCHFS1, below).

c) MCHFS1 — communication cell which selectively controls the examination of the timing count for the entries in TMCYCL. MTHFSC examines TMCYCL for as many entries as are specified by MCHFS1, skipping over the (M-MCHFS1) first entries in TMCYCL. The entries, however, are always examined in the order in which they appear in the table. MCHFS1 is set to 1 by the compilation (since MYMINS must receive control every minute). After the Station Characteristics tape has been read, MCHFS1 is set to 5, where it remains throughout the launch phase. If the abort phase is entered, a 3 is stored in MCHFS1, since the coordinate conversion programs are no longer receiving input radar data. For the orbit and re-entry phase, MCHFS1 is reduced to 2.

d) TM8.3M — one-cell table containing the count of elapsed 8-1/3 millisecond intervals since the last half second. The sign bit of this cell is controlled by a toggle switch on the Output Status Console. The switch setting determines which of the duplexed IBM 7090's is transmitting high-speed data to the Mercury Control Center via subchannel 3 and teletype acquisition data to the worldwide tracking sites via subchannels 10 and 11. The sign of TM8.3M is plus if the computer is transmitting.

e) MCSCHG — the sign of MCSCHG corresponds to the sign of TM8.3M at the previous half-second trap. MCSCHG is used to determine whether or not there has been a change in the computer's transmission mode in the past half-second interval.

f) MCHFSC — contains GMT in fixed-point half seconds at the last half-second trap.

g) TMFMSK — table of masks used by MTHFSC to turn off an indicator in the priority table.
h) **TMNMSK** — table of masks used by MTHFSC to turn on the B indicator for every program in TMCYCL whose count is reduced to zero.

i) **TMREFR** — Monitor Reference Table which provides the location in the priority for the programs whose indicators are to be turned on or off.

### 3.22.2 Output Requirements

The half-second clock cell, MTHFSC, is updated and the sign of MCBETA is set to conform to the sign of TM8.3M. If the computer transmission mode has changed from on-line to off-line (MCBETA is negative and MCSCHG is positive) during the past half second, the following operations take place.

a) The priority indicators set for O0LANA, O0ORRE, and MYHSOD by MYHSOD are cleared. In the transmission mode MYHSOD sets indicators in the priority table to suppress these three programs prior to returning control to M0PRIO. This is done to prevent further output computations until the transmission program is free to accept the data, and to prevent further transmission until subchannel 3 is available. In the transmission mode, the trap processor, MTHSOD, which follows transmission on subchannel 3 removes the suppression bits and the high-speed output programs may now be re-entered. When the transmission switch on the Output Status Console is changed, transmission on subchannel 3 stops and the trap processor does not receive control. The output processors include control functions for when the computer is not in the transmission mode, but these processors do not have the facilities to recognize when the computer leaves the transmission mode. MTHFSC simulates the effect of the trap processors and turns off indicators in the priority table. The programs and their corresponding indicators which are turned off, are: MYHSOD, A, B and F; O0LANA, A, B and D; O0ORRE, A, B and C.

b) Similarly, MTHFSC simulates the low-speed output trap processors, MTTTOX and MTTTOY, and turns off the D indicator for both MYTTOX and MYTTOY.

c) High-speed output subchannel 3 and low-speed output subchannels 10 and 11 are deactivated to prevent the transmission of old messages when this computer returns to the transmission mode.

d) The counter, BJALF, used by MYHSOD to indicate the second pass — two passes within MYHSOD are required to transmit a complete message — is reset to zero.

The sign of MCSCHG is now set to conform to MCBETA.
The timing count in the decrement of each examined entry in TMCYCL is reduced by one. If the count for any entry is reduced to zero, the B indicator in the priority table for that program is turned on and the count is reset from the entry in TMCYNO.

3.22.3 Method

MTHFSC receives control from M0RTCC when the half-second trap occurs on DCC subchannel 7. The contents of MCHFSC are incremented by one.

MTHFSC examines TM8.3M, MCBETA, and MCSCHG to determine if the transmission mode had changed in the past half second. The sign of MCBETA is set to conform to the sign of TM8.3M. MCBETA is compared with MCSCHG. If both have the same sign, there has been no change. If MCBETA is positive and MCSCHG is negative, the computer has entered the transmission mode in the past half second, but no action is required by MTHFSC other than changing the sign of MCSCHG. If MCBETA is negative and MCSCHG is positive, the computer has left the transmission mode and controls must be set (see Output Requirements) and the sign of MCSCHG made negative.

MTHFSC examines C (MCHFS1) last entries in the timing table, TMCYCL, skipping over the M-C (MCHFS1) initial entries (where M is a parameter specifying the number of entries in TMCYCL). For each entry examined, the timing count in the decrement is reduced by one. When the timing count is reduced to zero, the B indicator for that routine is turned on, and the count is reset to its original value.

3.22.4 Usage

MTHFSC is entered from M0RTCC following a trap on DCC subchannel 7: MTHFSC exits to M0PRIO.

a) Storage Required — 41 locations

b) MTHFSC uses:

1) Macro — QPSLF
2) Parameters — B, D, M, MNHSOD, MNLANA, MNORRE, MNTTOX and MNTTOY
3) Communication cells — MCACTV, MCBETA, MCHFS1, MCHFSC, MCSCHG and BJALF (in MYHSOD)
4) Tables — TM8.3M, TMCYCL, TMCYNO, TMFMSK, TMNMSK and TMREFR
5) Constants — KD0001 and K00001

c) Time Required:

1) Minimum — 0.089 millisecond
2) Maximum — 0.290 millisecond
FIGURE 3-24. MTHFSC PROGRAM FLOW CHART (Sheet 1 of 2)
**Figure 3-24. MTHFSC Program Flow Chart (Sheet 2 of 2)**
3.23 MONITOR MINUTE PROCESSOR (MYMINS)

Every minute MYMINS updates the minute time cell, executes the Monitor Pass Number Determination Subroutine, MSPASN, and the Monitor Teletype Input Check Subroutine, MSTICK, and initiates the Monitor Acquisition Data Processor, MYACQD.

The flow chart for the MYMINS processor is shown in Figure 3-25.

3.23.1 Input Requirements

Input to MYMINS consists of the MCMINS communication cell which contains the GMT in fixed-point minutes at the last previous entry to MYMINS (one minute ago). MCMINS is originally set by MTWWVI when the time base is entered into the 7090 computer.

3.23.2 Output Requirements

The contents of the minute time cell, MCMINS, are incremented by one. The B indicator for MYACQD is turned on and the MSPASN (see Subsection 3.24) and MSTICK (see Subsection 3.25) subroutines are executed.

3.23.3 Method

The method of MYMINS is shown in Figure 3-25.

3.23.4 Usage

MYMINS is entered from, and exits to M0PRIO.

a) Storage Required—15 locations

b) MYMINS uses:
   1) Subroutines—MSPASN and MSTICK
   2) Macros—TRNOF and TRNON
   3) Parameters—A, B, MNACQD and MNMINS
   4) Communication cell—MCMINS
   5) Constant—K00001

c) Time Required:
   1) Minimum*—0.477 millisecond
   2) Maximum*—0.885 millisecond

*MYMINS requires only 0.070 millisecond. The times given above reflect the times of the executed subroutines.
FIGURE 3-25. MYMINS PROGRAM FLOW CHART
3.24 MONITOR PASS NUMBER DETERMINATION SUBROUTINE (MSPASN)

MSPASN receives control every minute from the Monitor Minute Processor, MYMINS, determines the current orbital pass number and updates a communication cell when the pass number changes.

The flow chart for the MSPASN subroutine is shown in Figure 3-26.

3.24.1 Input Requirements

Input to MSPASN consists of:

a) TMORMC—the 2nd location in this table, if non-zero, contains the current longitude of the capsule. This table is the output from the output computations program, OOORMC.

b) MCNRRF—when non-zero, indicates the re-entry phase has been entered.

c) MCREST—when non-zero, indicates a system restart.

d) MCPASN—communication cell containing in the address the number specifying the current orbital pass. A 1 is initially stored in MCPASN (during compilation).

e) MCGTIN—contains the GMT of capsule insertion into orbit, in fixed-point minutes.

f) MCHFSC—contains the current GMT in fixed-point half seconds.

3.24.2 Output Requirements

If the pass number changes, MSPASN stores the new pass number in the address of MCPASN and of the 12th cell in the TMORMC table.

3.24.3 Method

MSPASN receives control from MYMINS every minute. If the mission has entered the re-entry phase, MSPASN returns control directly to MYMINS. Otherwise, the orbit/re-entry output computations program, OOORMC is suppressed since MSPASN must use the capsule longitude which is computed as output by OOORMC.

If the Mercury Program System is in a restart operation, the time the capsule has been in orbit (the current time minus the time of insertion into orbit) is computed. This time is compared with the estimated minimum time of one orbit. If the orbit time is less than the estimated time of one orbit, a 1 is stored in the pass number indicator cell. If the orbit time is less than the estimated
maximum time of one orbit, the proper pass number is determined by comparing the capsule's longitude to the longitude of Cape Canaveral. Similar comparisons are made for the second and third orbit times, if necessary, until the proper pass number is established.

Whether or not the Mercury Program System has had a restart, the capsule's present longitude is compared to the longitude of Cape Canaveral. If the capsule's longitude is greater or equal to the longitude of Cape Canaveral and if the capsule's longitude at the last minute was less than the longitude of Cape Canaveral, the pass number is incremented by one and the new pass number is stored in MCPASN and in the 12th cell of the OOORRE output table.

For every orbit entry to MSPASN, the capsule longitude cell in MSPASN is updated. The D indicator for OOORRE is turned off to unsuppress the output program and control returns to MYMINS.

3.24.4 Usage

MSPASN is used only by MYMINS.

a) Calling Sequence:

a TSX MSPASN, 4

a + 1 Return

b) Storage Required—66 locations

c) MSPASN uses:

1) Macros—TRNOF and TRNON

2) Parameters—D and MNORRE

3) Communication cells—MCGTIN, MCHFSC, MCNRRF, MCPASN and MCREST

4) Table—TMORMC

d) Time Required:

1) Minimum—0.007 millisecond

2) Maximum—0.057 millisecond
FIGURE 3-26. MSPASN SUBROUTINE FLOW CHART (Sheet 1 of 2).
FIGURE 3-26. MSPASN SUBROUTINE FLOW CHART (Sheet 2 of 2)
3.25 MONITOR TELETYPe INPUT CHECK SUBROUTINE (MSTICK)

MSTICK receives control every minute from the Monitor Minute Processor, MYMINS, to determine if for any low-speed radar data input more than eight minutes have elapsed since transmission began without an end-of-transmission being received. If no end-of-transmission has been received in over eight minutes since the beginning of transmission for any radar station, MSTICK stores in the input queue for IOTTIN a word containing the internal station number of the delinquent station.

The flow chart for the MSTICK subroutine is shown in Figure 3-27.

3.25.1 Input Requirements

Input to MSTICK consists of:

a) TM8MNS—table of 19 cells, each cell consists of an entry for one of the radars in the Mercury tracking network. Each cell initially contains zero, but when teletype input is received from the radar station, the time transmission commenced plus eight minutes is stored in the appropriate TM8MNS entry.

b) MCMINS—contains the current GMT in fixed-point minutes.

3.25.2 Output Requirements

For every radar station that has been transmitting teletype data to Goddard and has not sent an end-of-transmission within eight minutes after the initiation of transmission, MSTICK stores a negative zero in that radar's TM8MNS entry. In addition MSTICK stores an input word containing the radar's internal station number in the address, in the input queue table for IOTTIN.

3.25.3 Method

The method of MSTICK is shown in Figure 3-27.

3.25.4 Usage

MSTICK is used only by MYMINS.

a) Calling Sequence

\[
\begin{align*}
&TX + 1 \\
&\text{RETURN}
\end{align*}
\]

b) Storage Required—27 locations
c) MSTICK uses:
   1) Macros—QENBA, QENBZ and QUEUE
   2) Parameter—MNTTIN
   3) Communication cell—MCMINS
   4) Table—TM8MNS

d) Time Required:
   1) Minimum—0.400 millisecond
   2) Maximum—0.758 millisecond
19 entries, one for each radar. Location of each entry corresponds to internal station number and contains time plus eight minutes station began transmitting. Initially each entry contains zero.

FIGURE 3-27. MSTICK SUBROUTINE FLOW CHART
3.26 MONITOR REAL TIME CHANNEL ERROR TRAP PROCESSOR (MTERTC)

MTERTC receives control only if the Data Communications Channel initiates a trap on one of the unassigned subchannels. This trap processor provides input to the on-line messages processor for a message which states that an erroneous real time trap has occurred and specifies the responsible subchannel.

The flow chart for the MTERTC trap processor is shown in Figure 3-28.

3.26.1 Input Requirements

Upon entry to MTERTC, index register 4 contains the number of the subchannel responsible for the trap.

3.26.2 Output Requirements

MTERTC stores an entry in the input table for MYMESS. This entry designates a standard error message and provides the number of the responsible subchannel.

3.26.3 Method

MTERTC receives control from M0RTCC following a DCC trap on an unassigned subchannel with the number of the subchannel in index register 4. MTERTC stores XR4 into the queue word for the message, AN ERRONEOUS TRAP OCCURRED ON THE DCC, SUB-CH. NO.___, and stores this word for input to MYMESS.

3.26.4 Usage

MTERTC is entered from M0RTCC following a trap on an unassigned DCC subchannel; MTERTC exits to MOPRIO.

a) Storage Required—five locations

b) MTERTC uses:

1) Macro—QUEUE

2) Parameter—MNMESS

c) Time Required—0.107 millisecond
MC-I03

MTERTC

STORE SUB-CHANNEL NO. FROM XR4 INTO QUEUE WORD

M0RTCC

TRAP ON SUBCHANNEL 5, 6, 12, 13 OR 32

QUEUE MYMESS ERROR MSG

"AN ERRONEOUS TRAP OCCURRED ON THE DCC, SUB-CH. NO.__"

M0Prio

FIGURE 3-28. MTERTC PROGRAM FLOW CHART
Section 4

CONTROL DURING LAUNCH/ABORT

When the lift-off signal is received, the Mercury Program System enters the launch, or powered-flight phase of the Mercury mission. This condition continues until the capsule is inserted into orbit, unless mission conditions require an abort. During the launch phase (normally, about five minutes), high-speed tracking data from Cape Canaveral is received, processed and results transmitted every half second to the Mercury Control Center for analysis.

The complexity of conditions which may occur during the launch phase requires a very flexible control system. The Monitor control of the launch/abort phases is presented in general below; the individual programs which constitute the launch/abort control system are described in the following sections.

4.1 GENERAL CONTROL DURING LAUNCH/ABORT

During the powered-flight phases of the Mercury mission, all input to the system is received over two duplexed high-speed lines from Cape Canaveral. As described in Section 3, this data enters the computers' core storage in real time via subchannels 1 (two messages per second) or 2 (five messages every two seconds) of the Data Communications Channel. This data receives initial input and editing processing preparatory to the launch computations. Subchannel 1 provides data from the Burroughs-General Electric (B-GE) Guidance Computer, including discrete event signals, as well as capsule telemetry signals. B-GE data refers to the trajectory of the launch vehicle and, as such, has no significance for the Mercury Program System after the termination of powered flight or when the capsule separates from the launch vehicle (The capsule telemetry signals received over subchannel 1, however, continue to provide valid information and are received and processed by the input program.). Subchannel 2 may transmit either computed quantities from the IBM Impact Predictor (IP 7090) computer or raw data from the AN/FPS-16 radars, capsule telemetry signals accompanying either transmission. The IP 7090-processed data may originate from either the AN/FPS-16 or Azusa tracking networks. However, the Azusa values, like those from the B-GE computer, represent the trajectory of the rocket.

The option of which type of data is to be transmitted to Goddard on subchannel 2 is the responsibility of the Data Quality Monitor operator at Cape Canaveral. Furthermore, during the powered-flight portion of the Mercury mission, the Data Quality Monitor must designate as the selected-source data either subchannel 1 or subchannel 2 input. The launch system's main computations are
generated from only one of the two input sources during powered flight, i.e.,
while the capsule and rocket are a unit; the data used for the main computations
is that from the selected source. The input messages on both subchannels con-
tain codes which designate the selected source for main launch computations.

4.1.1 Control During Launch

Launch computations are divided into three levels of processing:

a) First level—coordinate conversion programs which transform the in-
put data into the Mercury coordinate system and perform editing of
raw radar data, when this type of input is received.

b) Second level—the strip chart programs which perform gross editing
of the input data and generate outputs which consist of the deviations
of the flight path angle and the velocity ratios from their nominal
values. These quantities are displayed on strip charts at the Mercury
Control Center and provide information to the Data Quality Monitor
for evaluation of the selected source.

c) Third level—consists of the main launch processing programs which
compute outputs for the Mercury Control Center's wall map, plot-
boards and digital displays. The third level is also responsible for
initiating the preparation of acquisition data for transmission to the
Bermuda tracking station. Only selected-source data may be input to
the third level of processing.

Launch processing commences when the lift-off signal, detected by the in-
put programs, enters the system. Thereafter, the basic computing cycles for
both subchannels 1 and 2 are initiated at least once each half second. First level
processing is performed on both input messages and, if the input is accepted by
the first level, second level processing is also performed on both. Third level
processing is performed on only the selected-source input. If the selected-source
data has been rejected or did not arrive, third level processing by extrapolation
may be performed if data had been given previously to the third level processors.

The basic cycle normally begins when the input processors complete their
handling of the new data. However, the basic cycles for both subchannels 1 and 2
may be initiated by the half-second clock if input data does not arrive or is re-
jected by the input processors. No actual processing can be done in this case,
but the main launch computations for output can be extrapolated from previous
results if, and only if, data had been previously processed for main launch com-
putations. The third level of processing, the main launch computations, may re-
sult in a phase change for the Mercury mission.

The programs used in the launch computations (Figure 4-1) are listed
below.
First Level Processing

<table>
<thead>
<tr>
<th>Monitor Prefix</th>
<th>Coordinate Conversion Processor</th>
<th>Monitor Suffix (normal)</th>
<th>Monitor Suffix (rejected data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPCCGB</td>
<td>CCGEB1</td>
<td>MFCCGB</td>
<td>MFCCGB</td>
</tr>
</tbody>
</table>

Second Level Processing

<table>
<thead>
<tr>
<th>Monitor Prefix</th>
<th>Strip Charts Processor</th>
<th>Monitor Suffix</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPSTRP</td>
<td>CCSTGE</td>
<td>MFSTRP</td>
</tr>
</tbody>
</table>

Third Level Processing

<table>
<thead>
<tr>
<th>Monitor Prefix</th>
<th>Main Processor (normal)</th>
<th>Main Processor (missing/rejected data)</th>
<th>Monitor Suffix (normal)</th>
<th>Monitor Suffix (low abort entered)</th>
<th>Monitor Suffix (medium abort entered)</th>
<th>Monitor Suffix (hold entered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLCCM</td>
<td>CCMAIN</td>
<td>CCMISS</td>
<td>MFLNML</td>
<td>MFLRT1*</td>
<td>MFLRT2*</td>
<td>MFLHLD*</td>
</tr>
</tbody>
</table>

*Terminates the normal launch phase.

Because the basic cycle may be initiated from more than one source and because data from both subchannels is in some cases handled by the same programs, a system of controls is used to hold new data at the input level until the previous cycle has been completed. At the completion of the first level of processing, the Monitor suffix for the coordinate conversion program suppresses itself by turning on its E indicator in the priority table, TMPRIO. This suppression is removed when the second level of processing, the strip chart processors, is completed for this data input. In addition, if the input data processed by the coordinate conversion program is selected for main computations, the F indicator for the program is also turned on by its Monitor suffix. The F indicator
Figure 4-1. Launch/Abort Control Diagram (Sheet 1 of 5)
FIGURE 4-1. LAUNCH/ABORT CONTROL DIAGRAM (Sheet 2 of 5)
EXIT FROM LAUNCH COMPUTATION CYCLE

LOW ABORT DETECTED

MFLRT2 ENTER MEDIUM-ABORT PHASE

MFLRT1 ENTER LOW-ABORT PHASE

MEDIUM ABORT DETECTED

NORMAL LAUNCH

MFLNML MONITOR SUFFIX NORMAL LAUNCH CYCLE

MISSION ENTERS HOLD PHASE

MLUPDT OUTPUT UPDATING SUBROUTINE

MFLHLHD ENTER HOLD PHASE

END LAUNCH PHASE

END LAUNCH PHASE

END CYCLE

END LAUNCH PHASE

FIGURE 4-1. LAUNCH/ABORT CONTROL DIAGRAM (Sheet 3 of 5)
FIGURE 4-1. LAUNCH/ABORT CONTROL DIAGRAM (Sheet 4 of 5)
BEGIN CYCLE

HOLD COMPUTATION CYCLE

MPCCIP MONITOR PREFIX TO CC7091, CCRAWR

NO DATA ENTRY

CC7091 IP COORDINATE CONVERSION PROCESSOR

CCRAWR EDIT, COORD. CONV. FOR RAW AN/FPS-16

MECCIP MONITOR SUFFIX TO CC7091

MECCRW MONITOR SUFFIX TO CCRAWR

MPLCCM MONITOR PREFIX TO MAIN COMPUTATIONS

MPLCCM MONITOR PREFIX TO MAIN COMPUTATIONS

MLUPDT OUTPUT UPDATING SUBROUTINE

CCHOLD MAIN PROCESSOR, HOLD PHASE

CCHOLD MAIN PROCESSOR, HOLD PHASE

MFLHD MONITOR SUFFIX TO CCHOLD AND CCHOMI

GO

MFLORB ENTER ORBIT PHASE

END HOLD PHASE

MFLABT ENTER HIGH-ABORT PHASE

END HOLD PHASE

No decision

No-go

FIGURE 4.1. LAUNCH/ABORT CONTROL DIAGRAM (Sheet 5 of 5)
for the coordinate conversion program is turned off at the completion of the third level of processing, the main launch computations.

The basic launch computing cycle terminates with the suffix to the main launch computations and if any exit other than the normal suffix is used, the launch phase also terminates.

The Monitor prefixes and suffixes which control the launch system are described in detail in the following subsections. The processing programs, CCGEB1, CC7091, CCRAWR, CCSTGE, CCSTIP, CCST16, CCMAIN and CCMISS are described in detail in MC 105, Goddard Processing Programs.

4.1.2 Control During Low and Medium Abort

If the launch basic computing cycle terminates via the MFLRT1 suffix, the Mercury Program System enters the low-abort phase (abort below 100,000 feet). In this phase only subchannel 2 data is processed, there is no strip chart processing, and the main computations are performed by CCRTYL, or, if input data is rejected or missing, by CCRTMI.

If the launch basic computing cycle terminates via the MFLRT2 suffix, the Mercury Program System enters the medium-abort phase (abort above 100,000 feet, but prior to tower separation). In this phase only subchannel 2 data is processed, there is no strip chart processing, and the main computations are performed by CCMEAB.

The main processors, CCRTYL, CCRTMI and CCMEAB, and the coordinate conversion processors are described in MC 105, Goddard Processing Programs. The Monitor programs used in the low-abort phase are described in detail in the following subsections.

4.1.3 Control During Hold

If the launch basic computing cycle terminates via the MFLHLD suffix, the Mercury Program System enters the hold phase, which is that part of the launch phase after the termination of powered flight but prior to the abort/orbit decision. The hold phase allows the Flight Dynamics Officer at the Mercury Control Center to evaluate flight data as well as the computers' GO NO-GO recommendation. The hold phase terminates when the Mercury Program System receives the Flight Dynamics Officer's decision. During hold, only subchannel 2 data is processed, there is no strip chart processing, and the main computations are performed by CCHOLD or, if the input data is rejected or is missing, by CCHOMI. CCHOLD and CCHOMI exit to MFLHLD. MFLHLD has three possible exits:

a) M0PRIO, to end the computing cycle when no abort/orbit decision has been made.

b) MFLORB, when the decision has been made to orbit.
c) MFLABT, when the decision has been made to abort.

The Monitor prefixes and suffixes which control the launch system during hold are described in this Section. The processing program, CCHOLD and CCHOMI, are described in detail in MC 105, *Goddard Processing Programs*. 
4.2 MONITOR PREFIX TO CCGEB1 (MPCCGB)

MPCCGB links Burroughs-GE data to the coordinate conversion program, CCGEB1, during the launch phase.

The flow chart for the MPCCGB prefix is shown in Figure 4-2.

4.2.1 Input Requirements

Input to MPCCGB consists of:

a) MCLFTM—contains the GMT of lift-off in floating-point seconds.

b) MCTMWT—contains in fixed-point half seconds time at which the launch program may be entered.

c) MCHFSC—contains the current GMT in fixed-point half seconds.

d) MCCOM1—when non-zero, indicates data is invalid or has previously been used for processing.

e) MCNGEN—indicates, when non-zero, the mission has entered the hold, the low-abort or the medium-abort phase.

f) MCSELS—contains the latest indication of what data is from the selected source. Zero indicates that selected data has yet to arrive; a 1, Burroughs-GE processed data is selected; a 2, raw AN/FPS-16 data; a 3, IP 7090-processed Azusa data and a 4, IP 7090-processed AN/FPS-16 data.

g) MCTGP1—contains in fixed-point half seconds the last time that good input data was processed.

h) MCSSIP—when non-zero, indicates selected-source data is being processed.

i) MCSDHA—when non-zero, indicates acceptable selected-source data has already been processed.

j) TMH1DB—a seven-cell table containing a time in floating-point seconds and associated R and V vectors in B-GE units.

k) TMH1TM—discrete data table containing the input time tag, the GMT of lift-off, B-GE discrete signals, and capsule telemetry signals.

4.2.2 Output Requirements

Output from MPCCGB consists of:
4.2.3 Method

When lift-off has occurred and the system has delayed long enough to enter the launch phase, IOHSGB is suppressed while the R and V vectors and the associated time are moved into TMGEB1 and the discrete data stored in the TMGEDS buffer. If the B-GE data is selected, the CC7091 processor is unsuppressed. If a selected data point is already being processed (MCSSIP is non-zero), CCGEB1 is suppressed with its F indicator since CCGEB1 cannot be entered with a selected data point until the interrupted processing of the previous selected data point is completed. Before return is made to M0PRIO, the B indicator for CCGEB1 is turned on and the A indicator turned off.

If the selected-source data is not in progress and MCCOM1 has indicated that the data is acceptable, the selected-source-in-process communication cell, MCSSIP, is updated, the accumulator is set to zero and control transfers to CCGEB1.

If MCCOM1 indicates that the data is bad or missing and the data is non-selected, the A indicator for CCGEB1 is turned off and control returns to M0PRIO. If the data is selected, a check is made to see if there has been a good selected data point processed previously (MCSDHA is non-zero) from which extrapolation can be made. If MCSDHA is non-zero, there is data available for selected-source extrapolation, and the sign of MLCQ1 is set negative to indicate to CCMAIN that extrapolation is in order. CCMAIN is then queued with MLCQ1. The F indicator is turned on and the A indicator off for CCGEB1 and control passes to M0PRIO. Should MCSDHA equal zero, the bad selected point is treated as non-selected since no processing is possible.

4.2.4 Usage

MPCCGB is entered from M0PRIO; MPCCGB exits to CCGEB1 or M0PRIO.

a) Storage Required—85 locations
b) MPCCGB uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, C, F, MNCCGB, MNCCIP, MNHSGB and MNLCCM
3) Communication cells—MCCOM1, MCHFSC, MCLFTM, MCNGEN, MCSDHA, MCSELS, MCSSIP, MCTGP1 and MCTMWT

4) Tables—TMGEB1, TMGEDS, TMH1DP and TMH1TM

5) Constants—K00001 and KD0001

6) Common storage—MLCQ1

c) Time Required:

1) Minimum—0.048 millisecond

2) Maximum—0.406 millisecond
**FIGURE 4-2. MPCCGB PROGRAM FLOW CHART (Sheet 1 of 2)**

4-14
FIGURE 4-2. MPCGB PROGRAM FLOW CHART (Sheet 2 of 2)
4.3 MONITOR SUFFIX TO CCGEB1 (MFCCGB)

MFCCGB receives control when processor CCGEB1 has been successfully completed.

The flow chart for the MFCCGB suffix is shown in Figure 4-3.

4.3.1 Input Requirements

Input to MFCCGB consists of:

a) MLCQ1—common storage cell set up in MPCCGB and used by the QUEUE macro to provide the strip chart processor with the information that the indicated data has been successfully processed in CCGEB1.

4.3.2 Output Requirements

The only output from MFCCGB, other than the indicators set in the priority table, is an entry placed in the input queue for the strip chart processor.

4.3.3 Method

When control is passed to MFCCGB from the CCGEB1 processor, the computer is disabled, the strip chart processor is queued that data was successfully processed and the E indicator for CCGEB1 is turned on. The computer is enabled and a test is made to determine whether or not B-GE data is selected. If this is the case, the F indicator for CCGEB1 is turned on.

The A indicator for CCGEB1 is turned off and control is transferred to M0PADIO.

4.3.4 Usage

MFCCGB is entered from CCGEB1; MFCCGB exits to M0PADIO.

a) Storage Required—17 locations

b) MFCCGB uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, E, F, MNCCGB and MNSTRP

3) Common Storage—MLCQ1

4) Constant—KD0001

c) Time Required:

1) Minimum—0.151 millisecond

2) Maximum—0.158 millisecond
FIGURE 4-3. MFCCGB PROGRAM FLOW CHART
4.4 MONITOR BAD-DATA SUFFIX TO CCGEB1 (MFCCGE)

CCGEB1 exits to MFCCGE when the B-GE input data is unacceptable.

The flow chart for MFCCGE is shown in Figure 4-4.

4.4.1 Input Requirements

Input to MFCCGE consists of:

a) MCSDHA—indicates, when non-zero, that acceptable selected data has already arrived and that extrapolation may be used to replace the bad data.

b) MLCQ1—common storage cell used to queue strip chart processor or CCMAIN and which provides the following information: the address, when non-zero, specifies the data source; the decrement, when non-zero, indicates that the data defined in the address is selected; a negative sign indicates that the data is not acceptable (the reason MFCCGE received control).

4.4.2 Output Requirements

Output from MFCCGE consists of:

a) MCSSIP—set non-zero, if B-GE data, which is bad, is selected and if there is previous good selected data to permit extrapolation. MCSSIP indicates selected-source data is being processed, but has no meaning if there is no selected data to process.

b) MLCQ—internal cell, set non-zero, to indicate bad data.

4.4.3 Method

Control is given to MFCCGE only when the CCGEB1 processor has determined that the input data is bad. MLCQ is set non-zero to indicate bad data.

If there is no previous good selected data available for extrapolation and if B-GE data is selected, MCSSIP is set to zero (bad and unusable selected data is deselected). The A indicator for CCGEB1 is turned off and control returns to M0PRIO.

If there is previous selected data available for extrapolation, MNLCCM is queued with an indication that the CCGEB1-processed data was bad. The F indicator for CCGEB1 is turned on, the A indicator is turned off and control transfers to M0PRIO.
4.4.4 Usage

MFCCGE is entered from CCGEB1; MFCCGE exits to M0PRIO.

a) Storage Required—seven locations

b) MFCCGE uses:
   1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON
   2) Parameters—A, F, MNCCGB and MNLCCM
   3) Communication cells—MCSDHA and MCSSIP
   4) Common Storage—MLCQ and MLCQ1
   5) Constant—KD0001

c) Time Required:
   1) Minimum—0.026 millisecond
   2) Maximum—0.190 millisecond
CCGEB1

MFCCGE

SET MLCQ≠0 TO INDICATE DATA REJECTED

NO

IS DATA SELECTED? D(MLCQ1)=1

YES

DATA AVAILABLE FOR EXTRAPOLATION? MCSDA≠0

NO

CLEAR SELECTED SOURCE (DATA) IN PROCESS IND. 0→MCSSIP

ML4F2

TRNONF A MNCCGB

M0PRIO

ML1F1

SET MLCQ1 TO QUEUE MNLCCM, STORE MLCQ1 INTO MCSSIP

ML3F

QENBZ (DISABLE)

QUEUE MNLCCM WITH MLCQ1

QENBBA (ENABLE)

ML4F1

TRNONF MNCCGB

FIGURE 4-4. MFCCGE PROGRAM FLOW CHART

4-21
4.5 MONITOR PREFIX TO CC7091 AND CCRAWR (MPCCIP)

MPCCIP links the high-speed IP 7090 input to the coordinate conversion programs during the launch phase.

The flow chart for MPCCIP is shown in Figure 4-5.

4.5.1 Input Requirements

Input to MPCCIP consists of:

a) MCLFTM—contains GMT of lift-off in floating-point seconds.

b) MCTMWT—contains in fixed-point half seconds the computed time to enter the launch programs.

c) MCHFSC—contains the current GMT in fixed-point half seconds.

d) MCWCH2—defines the data received on DCC subchannel 2: a 2 specifies raw AN/FPS-16 data (range, azimuth and elevation); a 3, IP 7090-processed Azusa data (position and velocity vectors); a 4, IP 7090-processed AN/FPS-16 data (position and velocity vectors).

e) MCCOM2—indicates, when non-zero, the data was rejected at the input level by IOHS09.

f) MCNGEN—indicates, when non-zero, the mission has entered the hold, the low-abort, or the medium-abort phase.

g) MCNIIP—indicates, when non-zero, numerical integration is in process.

h) MCORIP—indicates, when non-zero, that the computations for the re-entry (from a high abort) displays are in progress.

i) MCSELS—contains the coded identity of the latest selected-source: a zero indicates that good data has not yet arrived; a 1 indicates B-GE data is selected; a 2, raw AN/FPS-16 radar data selected; a 3, IP 7090-processed Azusa data selected; a 4, IP 7090-processed AN/FPS-16 data selected.

j) MCSDHA—indicates, when non-zero, that good selected data has already arrived.

k) MCLMBT—indicates, when non-zero, the mission has entered the medium-abort phase.

l) TCMEAB—contains intermediate and final values for the medium-abort phase.

4-23
m) MCTGP2—contains in fixed-point half seconds the time of processing the last good data received over subchannel 2.

n) MCSSIP—indicates, when non-zero, the selected data is currently being processed.

o) TMH2DB—seven-cell table containing in IP 7090 units an R and a V vector with the associated time in floating-point seconds.

p) TMHRAE—367-cell table contains raw AN/FPS-16 radar data received and processed by IOHS09. The first cell contains the time, the remaining 360 cells contain up to 120 sets of range, azimuth and elevation.

q) TMHEDP—seven-cell table containing the parameters for editing raw radar data. These parameters are maintained by IOHS09 and CCRAWR.

4.5.2 Output Requirements

Output from MPCCIP consists of:

a) TMIP71—a seven-cell table of input data for CC7091 contains the data to undergo reference system transformation, i.e., coordinate conversion. This table receives the contents of TMH2DB.

b) ML0ES—common storage cell containing the contents of MCWCH2 (which indicate the data source: processed Azusa, processed AN/FPS-16 or raw AN/FPS-16).

c) ML0EQ—common storage cell contains the contents of MCCOM2 (which indicates whether or not the data is acceptable).

d) ML0EI—common storage cell used to queue the main launch computations processor or the strip chart processor.

4.5.3 Method

Provided that lift-off has occurred and that the system has delayed long enough to enter the launch programs, the IP 7090-vector quantities are moved into input areas for CC7091. However, if these conditions are not met or if numerical integration or re-entry output computations are in process, no entry can be made to CC7091—the A indicator for CC7091 is turned off and control is returned to M0PRI0.

If none of the prohibiting factors is in effect, MPCCIP must decide whether or not the data is selected. If the input data is unselected, MPCCIP:

1) returns control M0PRI0, if the data is unacceptable and/or the system has entered the hold, the low-abort or the medium-abort phase;
2) gives control to CCRAWR, if raw radar data is selected (previous raw radar data input, since the current input is not selected) and if sufficient data is present to edit and smooth;

3) gives control to CC7091, if the input data, though unselected is nonetheless acceptable.

If the input data is selected, the C and F indicators for CCGEBl are turned off. MCSSIP is examined to determine whether or not selected-source data is in process (that is, has been interrupted by MPCCIP). If selected-source data is being processed, the B and the F indicators for CC7091 are turned on and the A indicator for CC7091 is turned off. If the selected data is not being processed and is raw radar data, control is given to CCRAWR. If the selected source is IP 7090 processed (AN/FPS-16 or Azusa), control is given to CC7091. If the mission has entered the hold, the low-abort or the medium-abort phase, Azusa data is not pertinent as it represents the trajectory of the rocket and not the capsule. If MPCCIP finds the selected data unacceptable, MNLCCM is queued to initiate extrapolation and control returns to M0PRI0.

4.5.4 Usage

MPCCIP is entered from M0PRI0; MPCCIP exits to CC7091, CCRAWR or M0PRI0.

a) Storage Required—84 locations

b) MPCCIP uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, C, F, MNCCGB, MNCCIP, MNLCCM and MNHS09

3) Communication cells—MCCOM2, MCHFSC, MCLFTM, MCLMBT, MCNGEN, MCNIIP, MCOIP, MCSDHA, MCSELS, MCSSIP, MCTGP2, MCTMWT and MCWCH2

4) Tables—TCMEAB, TMHEDP, TMH2DP, TMHRAE and TMIP71

5) Constants—K00001, K00003 and K00009

6) Common Storage—ML0EI, ML0EQ and ML0ES

c) Time Required:

1) Minimum—0.048 millisecond

2) Maximum—0.462 millisecond
FIGURE 4-5. MPCCIP PROGRAM FLOW CHART (Sheet 2 of 3)
FIGURE 4-5. MPCCIP PROGRAM FLOW CHART (Sheet 3 of 3)
4.6 MONITOR SUFFIX TO CC7091 (MFCCIP)

MFCCIP either initiates the strip chart processing of the data received from the IP 7090 computer or, if required, initiates extrapolation of the selected data.

The flow chart for MFCCIP is shown in Figure 4-6.

4.6.1 Input Requirements

Input to MFCCIP consists of:

a) MCNGEN—indicates, when non-zero, that the mission has entered the hold, the low-abort or the medium-abort phase.

b) TCIP71—13-cell table containing the position and velocity vector components in both B-GE units and Mercury units with an associated time. This table is to be used by the strip chart processor.

c) ML0EI—common storage word used to queue the strip chart processor or extrapolation processor.

4.6.2 Output Requirements

Output from MFCCIP consists of TCMANR. This 275-cell table contains constants and data used in main launch computations. MFCCIP moves the vector time tag from the first cell in TCIP71 into the first cell of TCMANR and the CC7091-processed vectors from the last six cells of TCIP71 into the next six cells (the second through seventh) of TCMANR.

4.6.3 Method

When CC7091 gives control to MFCCIP, strip chart processing is initiated unless the mission has entered the hold, the low-abort, or the medium-abort phase. In these phases MFCCIP moves the position and velocity components and their associated time from the TCIP71 table into TCMANR for use by CCMAIN.

4.6.4 Usage

MFCCIP is entered from CC7091; MFCCIP exits to M0PRIO.

a) Storage Required—36 locations

b) MFCCIP uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, E, F, MNCCIP, MNLCCM and MNSTRP
3) Communication cell—MCNGEN
4) Tables—TCIP71 and TCMANR
5) Common storage—ML0EI

c) Time Required:
   1) Minimum—0.148 millisecond
   2) Maximum—0.236 millisecond
FIGURE 4-6. MFCCIP PROGRAM FLOW CHART
4.7 MONITOR RAW RADAR DATA SUFFIX TO CCRAWR (MFCCRW)

MFCCRW receives control after CCRAWR has processed raw AN/FPS-16 radar data. This suffix initiates strip chart processing or if input data was not accepted by CCRAWR, initiates, if possible, extrapolation for the non-acceptable data.

The flow chart for MFCCRW is shown in Figure 4-7.

4.7.1 Input Requirements

Input to MFCCRW consists of:

a) MCNGEN—indicates, when non-zero, the mission has entered the hold, the low-abort or the medium-abort phase.

b) MCSDHA—indicates, when non-zero, that good selected data has previously been processed.

c) TMHRAE—367-cell table contains raw AN/FPS-16 radar data received and processed by IOHS09. The first cell contains the time, the remaining 360 cells contain up to 120 sets of range, azimuth and elevation.

d) ML0EI—common storage cell used to queue the strip chart or extrapolation programs.

4.7.2 Output Requirements

Output from MFCCRW consists of MCSSIP. If the input data was selected, but rejected by CCRAWR and if no previous selected and acceptable data is available from which to extrapolate, MCSSIP is set to zero.

4.7.3 Method

If the mission has entered the hold, the low-abort or the medium-abort phase, or if the input data is selected, but was rejected by CCRAWR, and if there is previously processed selected and acceptable data available, MFCCRW queues an input word for MNLCCM which requests extrapolation based on the previous good data. MFCCRW then turns the F indicator on and the A indicator off for MNCCIP and control is transferred to M0PRIO. The strip chart programs are bypassed.

If the input data is acceptable and this is the normal launch phase, the strip chart processor is queued with input to prepare output data based on the input raw radar values converted by CCRAWR. MFCCRW then turns the E indicator on and the A indicator off for MNCCIP. In addition, if the raw radar data is selected, the F indicator is also turned on. Program control transfers to M0PRIO.
If this is the normal launch phase and if the data is selected, but there is no data available for extrapolation, MCSSIP is set to zero, the F indicator for MNCCGB (which now processes unselected data) is turned off, the A indicator for MNCCIP is turned off and control transfers to M0PRIO. If the data processed by CCRAWR is not selected, only the A indicator for MNCCIP is turned off before control transfers to M0PRIO.

4.7.4 Usage

MFCCRW is entered from CCRAWR; MFCCRW exits to M0PRIO.

a) Storage Required—43* locations

b) MFCCRW uses:
   1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON
   2) Parameters—A, F, MNCCGB, MNCCIP, MNLCCM and MNSTRP
   3) Communication cells—MCNGEN and MCSDHA
   4) Table—TMHRAE
   5) Common storage—ML0EI

c) Time Required:
   1) Minimum—0.055 millisecond
   2) Maximum—0.179 millisecond

*Twenty-nine instructions in MFCCIP are used by MFCCRW; these are not included in storage requirements.
FIGURE 4-7. MFCCRW PROGRAM FLOW CHART
4.8 MONITOR PREFIX TO THE STRIP CHART PROCESSOR (MPSTRP)

The strip chart processing program has three entry points: one for B-GE data (CCSTGE); one for IP 7090 data (CCSTIP); one for raw radar data (CCST16). MPSTRP determines the entry appropriate for the input data and transfers control to the strip chart processor at that location.

Flow chart for MPSTRP is shown in Figure 4-8.

4.8.1 Input Requirements

Input to MPSTRP consists of:

a) An entry in the input queue table for the strip chart processor. This entry contains in the address the input data identification: a 1 for B-GE data; a 2 for raw AN/FPS-16 radar data; a 3 for IP--7090-processed Azusa data; a 4 for IP 7090-processed AN/FPS-16 data. If this input is selected, the decrement of the queue entry contains a 1. Otherwise the decrement contains zero.

b) TMLOUT—a four-cell table containing in reverse order by data identification the entry locations in the strip chart processor for each of the four data inputs. The first cell contains in the address the CCSTIP location, which is the strip chart entry for IP 7090-processed AN/FPS-16 data (identification number 4); the fourth cell contains in the address the CCSTGE location, which is the strip chart entry for B-GE data (identification number 1).

4.8.2 Output Requirements

Output from MPSTRP consists of MSDS. This internal cell contains in the address the input data identification. If this data is selected, the accumulator is cleared.

4.8.3 Method

After the A indicator for MNSTRP has been turned on, the oldest entry in the strip chart processor's input queue table is removed and stored in MSTQ. The address of MSTQ which contains the input data identification is stored in MSDS for the strip chart processor. If the data is not selected, a 1 is placed in the accumulator; if not, the accumulator is cleared. MPSTRP then transfers control to the appropriate entry of the strip chart processor.

4.8.4 Usage

MPSTRP is entered from M0PRI0; MPSTRP exits to CCSTGE, CCSTIP or CCST16 (depending upon the data to be processed).
a) Storage Required—20 locations

b) MPSTRP uses:
   1) Macros—QENBA, QENBZ, TRNON and UNIQUE
   2) Parameters—A and MNSTRP
   3) Table—TMLOUT
   4) Common Storage—MSDS and MSTQ
   5) Constant—KD0001

c) Time Required—0.137 millisecond
FIGURE 4-8. MPSTRP PROGRAM FLOW CHART
4.9 MONITOR SUFFIX TO THE STRIP CHART PROCESSOR (MFSTRP)

MFSTRP receives control after the completion of strip chart processing and moves the results of the processing into the output table (for later conversion and transmission to Cape Canaveral). In addition, MFSTRP directs the launch computation's control flow according to the selection and quality of the processed data.

The flow chart for MFSTRP is shown in Figure 4-9.

4.9.1 Input Requirements

Input to MFSTRP consists of:

a) MCSDHA—indicates, when non-zero, that selected and acceptable data has been received and processed. If the currently selected data is not acceptable, extrapolation can be performed if, and only if, previous selected data has been accepted for main launch computations.

b) TCCOUT—six cells in this table contain information set by the strip chart processor: the first and third cells, respectively, contain the flight path angle \((y - \gamma_{nom})\) and velocity ratios \((V/V_r - V/V_{r\;nom})\) from B-GE data. The second and fourth cells, respectively, contain the same information from the data received on subchannel 2. (Since the strip chart processor accepts only one input at each entry, only one pair of the two values listed above is affected at each entry to MFSTRP). The fifth cell contains an indication of the selected data: a 1 for B-GE data; a 2 for raw AN/FPS-16 data; a 3 for IP 7090-processed data. The 30th cell contains a breakdown of the IP 7090-processed data: zero for Azusa; a 1 for AN/FPS-16.

c) MSTQ—a common storage cell, containing in the address the identification of the data source and in the decrement the indication of whether or not this data is selected.

d) MSDS—a common storage cell whose address field is identical to the address field of MSTQ.

e) The accumulator sign is negative upon entry to MFSTRP if the input data was rejected by the strip chart processor.

4.9.2 Output Requirements

Output to MFSTRP consists of:

a) MCSSIP—set zero, if the data is selected, but was rejected by the processor.
b) TMLANA—this table provides input for OOLANA, the processing program for scaling and packing the high-speed output data. Six cells in TMLANA are set from TCCOUT by MFSTRP. These six cells are described above and occupy the same relative locations in both TCCOUT and TMLANA.

4.9.3 Method

MFSTRP suppresses OOLANA, moves the flight path angle data, velocity ratios and data source from the TCCOUT table into TMLANA and unsuppresses OOLANA. The E indicator is turned off for the coordinate conversion processor corresponding to input data processed for strip charts.

If the data is not selected, the A indicator for MNSTRP is turned off and control transfers to MOPRIO.

If this data is selected and acceptable, or if this data is non-acceptable and data is available for extrapolation, an entry is placed in the input queue for MNLCCM, the A indicator for MNSTRP is turned off and control transfers to MOPRIO.

If the data is selected, but rejected by the strip chart processor, and if no data is available for extrapolation, the selected-source-in-process indicator, MCSSIP, is cleared, the F indicators are turned off for both coordinate conversion processors, the A indicator for MNSTRP is turned off and control transfers to MOPRIO.

4.9.4 Usage

MFSTRP is entered from CCSTIP, CCST16 or CCSTGE; MFSTRP exits to MOPRIO.

a) Storage Required—42 locations

b) MFSTRP uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, C, E, F, MNCCGB, MNCCIP, MNLANA, MNLCCM and MNSTRP

3) Communication cells—MCSDHA and MCSSIP

4) Tables—TCCOUT and TMLANA

5) Common storage—MSDS and MSTQ

6) Constants—K00001 and KD0001

4-42
c) Time Required:

1) Minimum—0.181 millisecond

2) Maximum—0.292 millisecond
FIGURE 4-9. MFSTRP PROGRAM FLOW CHART
4.10 MONITOR PREFIX TO MAIN LAUNCH COMPUTATIONS (MPLCCM)

MPLCCM must decide which of the main launch processing programs may be used depending upon the mission flight phase and the quality of the selected data.

The flow chart for the MPLCCM prefix is shown in Figure 4-10.

4.10.1 Input Requirements

Input to MPLCCM consists of:

a) MCHFSC—contains the current GMT in fixed-point half seconds.

b) TM8.3M—contains the number of 8-1/3 millisecond intervals elapsed since the last exact half second.

c) MCLLBT—indicates, when non-zero, the mission has entered the low-abort phase.

d) MCFINI—indicates, when non-zero, that no additional input data is required in the low-abort phase. When the low-abort calculations are completed—final impact point computed—MCFINI is set non-zero to inform the Mercury Program System to ignore all additional input data so that the output data then continues to reflect the final calculations.

e) MCLMBT—indicates, when non-zero, the mission has entered the medium-abort phase.

f) MCNIIP—indicates, when non-zero, that numerical integration is in process. No entry is made into the main launch processing programs if numerical integration has been interrupted, a medium-abort or a high-abort phase requires the numerical integration.

g) MCLLDLDT—controls the activation/deactivation of low-speed input subchannels of the Data Communications Channel. When MCLLDLDT is non-zero, low-speed input is required and these subchannels are activated.

h) MCTHLD—indicates, when non-zero, the mission has entered the hold phase.

i) MCMAOS—contains, if non-zero, the abort/orbit decision entered into the computer by paper tape.

j) MCSELS—contains the latest indication of the selected data. The 31st location the TCMANR table identifies the selected data at the last
entry to MPLCCM. If these two cells do not agree, the selected source has changed and MPLCCM queues an input mask for the sense processor to change the selected-data light on the Output Status Console. The selected-data codes for MCSELS and TCMANR + 30 with the masks used to change the lights on the Output Status Console are: a 1 indicates B-GE data selected, MCGE.B; a 2 indicates raw AN/FPS-16 radar selected, MCRAWR (Each of the other three masks turns on one of the three selected-data lights on the Output Status Console and turns off the light that is on. To indicate a selection of raw radar data, all of the selected-data lights are turned off.); a 3 indicates IP 7090-processed Azusa data selected, MCAZSA; a 4 indicates IP 7090-processed AN/FPS-16 data, MCFP16.

k) TCMANR—a 275-cell table used by the main launch computations programs. The first cell in the table contains the time tag of the current entry data or, if this entry is a missing-data entry, the first cell of TCMANR contains the time tag for the last previous good data entry.

l) TMGEDS—a four-cell table containing the B-GE discretes and their time tags. The length of this table is defined by the parameter, W.

m) TMTML1—an 18-cell table containing up to nine pairs of capsule telemetry and associated time tag as received over subchannel 1. The length of this table is defined by the parameter, T.

n) TMTML2—an 18-cell table containing up to nine pairs of capsule telemetry and associated time tag as received over subchannel 2. The length of this table is defined by the parameter, T.

4.10.2 Output Requirements

Output from MPLCCM is described in 4.10.3.

4.10.3 Method

MPLCCM extracts the oldest entry in its input queue table and stores this entry in MLCX. From this input word and other indicators MPLCCM determines which of the main computation programs is to be used.

a) If MLCX is zero, MPLCCM has been entered for a system restart and control is immediately transferred to MFLORB.

b) If MLCX is non-zero, the current time in floating-point tenths of seconds is computed from MCHFSC and TM8.3M and stored in MCLTMN.

c) If MCLMBT is non-zero, the mission has entered the medium-abort phase and MPLCCM continues as described in step h). If MCLMBT is zero, MPLCCM examines the sign of the input word in MLCX.
d) If the input word is negative, this entry for main computations is a missing-data entry, i.e., the data selected for main computations either has been rejected or never arrived. For a missing-data entry, MPLCCM computes the time tag for the missing data. This time tag is equal to the current time (MCLTMN) minus the time the last good data was received (MCLGDT) plus the time tag of the last good data received (TCMANR). These times are all in floating-point seconds. The computed time is stored in MCSELM and is saved in the AC. Go to step f).

e) If the input word is positive, the selected data is present. The data source indicator (the address of MLCX) is stored in the address of MCSDHA. The current time in floating-point seconds (MCLTMN) is stored in MCLGDT, to indicate the latest time of entry to main computations with good data. The time tag of the data for the current entry (TCMANR) is placed in the AC.

f) The AC is stored in MCTLTM as the time tag for the current entry. This time tag is used to locate the capsule telemetry input associated with the data input. The D indicators for MNHSGB and MNHS09 are turned on to suppress the input processors while the telemetry buffers, TMTML1 and TMTML2, which they supply, are being searched for the telemetry input corresponding to the data. Both buffers are examined for the telemetry input whose time tag is equal, or most nearly equal, to the time tag of the input data. In the examination, if no identical time tag is found, the closest match with preference given to the latest time is determined. MPLCCM stores the accepted telemetry time tag in TCMANR + 20 and the telemetry input in TCMANR + 21. The B-GE discrete-event word and associated time tag from the TMGEDS buffer are stored in TCMANR + 19 and TCMANR + 18, respectively. The D indicators for MNHSGB and MNHS09 are turned off. The abort/orbit switch in MCMAOS, set by IOMANI after the manually inserted message has been received, is ORed into TCMANR + 21 (the cell contains zero until the paper tape message is supplied to the system. TCMANR + 21 also contains the determined telemetry input, but since both MCMAOS and the telemetry word are consistent—a 1 in bit position 34 for abort, a 1 in bit position 35 for orbit—there is no conflict.). If the current selected source (the address of MLCX) differs from that of the previous MPLCCM entry (TCMANR + 30), the address of MLCX is stored in TCMANR + 30 and a mask (MCFP16, MCAZSA, MCRAWR or MCGE.B) is queued for the sense processor to update the selected-data source indicator on the Output Status Console. If the current entry involves missing data, a mask is queued to turn on the missing data indicators, light and audible tone, on the Output Status Console. If the input data is not missing a mask is queued to turn this indicator off.

g) MPLCCM next examines the various phase indicators to determine which processor is to be used for the main computations. If MCTHLD
is non-zero, the mission has entered the hold phase and MPLCCM transfers control to CCHOLD (with input data) or CCHOMI (missing data). If MCLLBT is non-zero, the mission has entered the low-abort phase and MPLCCM transfers control to CCRYTL (with input data) or CCRTMI (missing data). At this point, all possibilities have been exhausted except that of a normal launch-phase entry to the main launch processors; MPLCCM transfers control to CCMAIN (with input data) or CCMISS (missing data).

h) If numerical integration is not in process (it is imperative that numerical integration generate the table as quickly as possible), CCMEAB receives control with MCNOCH either set to zero to indicate input data or set non-zero to indicate a missing-data entry.

i) With numerical integration in process, MPLCCM clears the selected-source data in-process indicator, MCSSIP, which eliminates any delay in processing the next selected data entering the system. The F indicator for the coordinate conversion program corresponding to the subchannel receiving the latest selected input data (determined by testing the MCSELS communication cell, but not necessarily corresponding to the selected data for this entry to main computations)—MNCCGB for subchannel 1 and MNCCIP for subchannel 2—is turned off. The low-speed input subchannels are activated or deactivated depending upon whether low-speed radar data is (MCLLDT is non-zero) or is not needed. If the abort has progressed to the point where additional high-speed input data is unnecessary, the coordinate conversion programs are suppressed with the G indicator. Finally, the A indicator for MNLCCM is turned off and control is transferred to MOPRIO.

A summary of the control transfers from MPLCCM is given in the following table:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Data</th>
<th>Missing Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch (normal)</td>
<td>CCMAIN</td>
<td>CCMISS</td>
</tr>
<tr>
<td>Low Abort</td>
<td>CCRYTL</td>
<td>CCRTMI</td>
</tr>
<tr>
<td>Medium Abort*</td>
<td>CCMEAB (MCNOCH set to zero)</td>
<td>CCMEAB (MCNOCH set non-zero)</td>
</tr>
<tr>
<td>Hold</td>
<td>CCHOLD</td>
<td>CCHOMI</td>
</tr>
<tr>
<td>Restart in Orbit or Re-entry</td>
<td>MFLORB</td>
<td></td>
</tr>
</tbody>
</table>

*If N.I. in process, MPLCCM clears MCSSIP and transfers control to MOPRIO.
4.10.4 Usage

MPLCCM is entered from M0PRIO; MPLCCM exits to one of nine programs (see above).

a) Storage Required*—158 locations

b) MPLCCM uses:

1) Macros—QENBA, QENBZ, QPSLF, QUEUE, TRNOF, TRNON and UNQUE

2) Parameters—A, D, F, G, MNCCGB, MNCCIP, MNHS09, MNHSGB and MNLCCM

3) Constants—K00007, K00135, K00377, KCH232, KCH233, K8.3M3

4) Tables—TCMANR, TMTML1, TMTML2, TMGEDS and TM8.3M

5) Communication cells—MCHFSC, MCLMBT, MCNIIP, MCMAGS, MCTHLD, MCLLBT, MCSELS, MCFINI, MCLLDT, MCNOCH, MCSDHA, MCLGDT, MCTLTM, MCSELM, MCLTMN, MCSSIP, MCACTV, MCAZSA, MCFP16, MCRAWR and MCGE.B

c) Time Required:

1) Minimum—0.244 millisecond

2) Maximum—0.950 millisecond

*Forty-five instructions in MFLNML are used by MPLCCM; these are not included in the storage requirements.
SELECTED DATA HAS BEEN REJECTED SOMEBWHERE ALONG THE LINE

MISSING DATA ENTRY?

NO

SAVE DATA SOURCE A(MLCX) + MCSDHA

SAVE CURRENT TIME WITH GOOD DATA

MCLTMN - MCLGDT

GET TIME TAG OF CURRENT ENTRY DATA

TCMANR → AC

COMPUTE TIME TAG FOR MISSING DATA: CURRENT TIME - TIME LAST GOOD + TIME TAG LAST GOOD DATA

(MCLTMN - MCLGDT + TCMANR → AC → MCSELM)

SAVE TIME TAG TO CHECK TELEMETRY AC → MCLTM

TRNON D MNHSGB

TRNON D MNHS09

2A

THESE PROGRAMS ARE SUPPRESSED WHILE TELEMETRY EXAMINED

IN MEDIUM-ABORT PHASE? MCLMBT ≠ 0

NO

SAVE CURRENT TIME (MCHFSC + TM8.3M) IN FL PT.

SEC → MCLTMN

MCSELM

MLC1

MLC2

MLC3

FIGURE 4-10. MPLCCM PROGRAM FLOW CHART (Sheet 1 of 4)
SEARCH TELEMETRY BUFFERS, TMTML1 AND TMTML2, FOR DATA WITH TIME TAG EQUAL OR MOST NEARLY EQUAL (GREATER BEFORE LESS) TO TIME IN MCTLTRM.

STORE TELEMETRY WORD → TCMANR + 21, TELEMETRY TIME TAG → TCMANR + 20

STORE B-GE DISCRETE WORD → TCMANR + 19, ITS TIME TAG → TCMANR + 18

TRNOF D MNHSGB

TRNOF D MNH559

*OR* ABORT- ORBIT SWITCH, MCMAS0, → TCMANR + 21

SELECTED SOURCE FOR DATA CHANGED?
A(MLCX): TCMANR = 30

UPDATE INDICATOR:
A(MLCX) → TCMANR + 30

ANY DATA SOURCE CODE A(MLCX) ≠ 0

GET MASK TO CHANGE OUTPUT STATUS CON. LIGHT MCFP16, MCAZSA MCRAWR, MCGE.B

QENBZ (DISABLE)

QUEUE MNSNS CHANGE LIGHT FOR NEW SOURCE

FIGURE 4-10. MPLCCM PROGRAM FLOW CHART (Sheet 2 of 4)
FIGURE 4-10. MPLCCM PROGRAM FLOW CHART (Sheet 3 of 4)
FIGURE 4.10. MPLCCM PROGRAM FLOW CHART (Sheet 4 of 4)
4.11 MONITOR SUFFIX TO CCRYTL AND CCRTMI (MFLRT1)

MFLRT1 receives control from CCRYTL, following normal low-abort computations, or from CCRTMI following low-abort computations extrapolated for missing data. This suffix resets the appropriate communication cells, updates the output, determines whether or not on-line messages are required and controls the deactivation of the low-speed input subchannels of the Data Communications Channel.

The flow chart for the MFLRT1 suffix is shown in Figure 4-11.

4.11.1 Input Requirements

Input to MFLRT1 consists of:

a) MNORRE—routine number of the high-speed output packing and scaling program for orbit and re-entry, OOORRE.

b) MCWCH2—indicates for subchannel 2 the data source: zero indicates no data; a 2, AN/FPS-16 raw radar data; a 3, IP 7090-processed Azusa data; a 4, IP 7090-processed AN/FPS-16 data.

c) MCLLDT—when non-zero, indicates the abort-initiate signal has been received. With the reception of this signal, the low-speed input subchannels should be activated.

d) MCFINI—when non-zero, signals the termination of the low-abort phase.

e) TCCOUT—the output table for the main launch computations. When MFLRT1 prepares the Mercury Program System for the low-abort phase, the first 30 locations in this table are moved into the first 30 locations of TMORMC for re-entry output computations.

4.11.2 Output Requirements

Output from MFLRT1 consists of:

a) MCTHLD—the hold-phase indicator is cleared.

b) MCLLLBT—set non-zero to designate the low-abort phase.

c) MCNGEN—set non-zero to indicate the hold, low-abort or medium-abort phase. Specifically, MCNGEN designates that B-GE data is no longer valid.

d) MCNRRF—set non-zero to indicate the retrorockets have fired.
e) MCBJMN—a 163 is stored in MCBJMN to reference the on-line message for high-speed output transmission rate during the low-abort phase.

f) MCSELS—the contents of MCWCH2 are stored in MCSELS to force the selection of the data received on subchannel 2. Since B-GE data is not valid in the hold, the low-abort or the medium-abort phases, input on subchannel 2 must be selected.

g) MCSSIP—the selected-source in process indicator is cleared to signal the completion of the basic computing cycle.

h) MCPHSE—the phase indicator for logging is set for low-abort; a 2 is stored in the prefix of MCPHSE.

i) TMCYCL, TMCYNO—the entry for O0LANA in the timing table, TMCYCL, is replaced with the entry for O0ORRE and the half-second period is set to 6 (three seconds). The half-second period of the coordinate conversion programs is set to 12 (six seconds).

j) TMORMC—contains in the first 30 locations the information from the first 30 locations in TCCOUT. During normal launch the main computations output, TCCOUT, supplies input for O0LANA. A low-abort situation uses the orbit and re-entry output scaling and packing program, O0ORRE, instead of O0LANA and the input table for O0ORRE is TMORMC.

4.11.3 Method

MFLRT1 terminates the main computations cycle during the low-abort phase. On every entry MFLRT1 clears the hold phase indicator, sets the low-abort indicator and sets the indicator which specifies that B-GE data is not needed (i.e., valid). The C indicator for O0ORRE is turned on, the first 30 locations of TCCOUT are moved into the first 30 locations of TMORMC (for scaling, packing and transmission to Cape Canaveral) and the C indicator for O0ORRE is turned off.

The selected-source in process indicator is cleared and the F indicator for MNCCIP (CC7091 or CCRAWR) turned off. The low-speed input subchannels are deactivated and if the low-abort phase is finished, the G indicators for the coordinate conversion programs are turned on. The A indicator for MNLCCM is turned off and control transferred to M0PRIO.

In addition, on the first entry to MFLRT1 the following operations are performed: the E indicator for O0LANA is turned on (to suppress this processor, permanently); MCNRRF is set non-zero to indicate an abort phase has been entered; the message number for the message stating the quantity of high-speed output transmissions to Cape Canaveral is changed; the input from subchannel 2
is forced as the selected data; the low-speed input subchannels are deactivated; an input word, MCLNRE, is queued for the sense processor to turn on both the LAUNCH and RE-ENTRY lights (indicating low abort) on the Output Status Console; an input word is queued to print the on-line message, LOW ABORT PHASE HAS BEEN ENTERED; the period for the coordinate conversion programs, which trigger the computing cycle, is set to 12 (six seconds); the entry for O0ORRE replaces the entry for O0LANA in the half-second timing tables and is given a period of six (three seconds); and a new constant is supplied to MFCCIP to use in checking for missing data.

4.11.4 Usage

MFLRT1 is entered initially from CCMAIN or CCMISS; every other entry to MFLRT1 is from CCRTYL or CCRTMI. MFLRT1 exits to M0PRIO.

a) Storage Required*—49 locations

b) MFLRT1 uses:

1) Macros—QENBA, QENBZ, QPSLF, QUEUE, TRNOF and TRNON

2) Parameters—A, C, E, F, G, MNCCGB, MNCCIP, MNLANA, MNLCCM and MNORRE

3) Communication cells—MCACTV, MCBJMN, MCFINI, MCTHLD, MCLLBT, MCLLDT, MCNGEN, MCNRRF, MCPHSE, MCSSIP and MCWCH2.

4) Tables—TCCOUT, TMCYCL, TMCYNO and TMORMC

5) Constants—K00001, K000163, K00178, KD0012 and K000P2

6) Mask—KLSACM

c) Time Required:

1) Minimum—0.550 millisecond

2) Maximum (first entry only)—0.845 millisecond

*Thirty-four instructions in MFLNML are used by MPLCCM; these are not included in the storage requirements.
MFLRT1 receives control first time, and first time only, from CCMAIN or CCMISS.

CLEAR HOLD INDICATOR 0 \rightarrow MCTHLD

SET LOW - ABORT PHASE INDICATOR MCLBNT \neq 0

SET "B-GE NOT NEEDED" INDICATOR MCNGEN \neq 0

TRNON C MNLANA

SET RETRO-FIRE INDICATOR MCRRRF \neq 0

CHANGE MSG. NO. FOR H.S. OUTPUT MESSAGE 163 \rightarrow MCBJMN

FORCE SUBCHANNEL 2 DATA SELECTION MCWCM2-MCSELS

SET PHASE IND. FOR LOGGING 2 \rightarrow P(MCPHSE)

QENBZ (DISABLE)

SET MCACTV TO DEACTIVATE L.S. INPUT SUBCHANNELS

QPSLF DEACTIVATE SUBCHANNELS FROM MCACTV

\( a = a_1 \) INITIALLY

\( a = a_2 \)

\( a_1 \)

\( a_2 \)

FIGURE 4–11. MFLRT1 PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 4-11. MFLRT1 PROGRAM FLOW CHART (Sheet 2 of 2)
4.12 MONITOR SUFFIX TO CCMEAB (MFLRT2)

MFLRT2 receives control from CCMEAB after the main computations for the medium-abort phase have been computed. This suffix resets appropriate communication cells, updates the output, determines whether or not on-line messages are required and controls the deactivation of the low-speed input sub-channels of the Data Communications Channel.

The flow chart for MFLRT2 is shown in Figure 4-12.

4.12.1 Input Requirements

Input to MFLRT2 consists of:

a) MCWCH2—indicates for subchannel 2 the data source: zero indicates no data; a 2, AN/FPS-16 raw radar data; a 3, IP 7090-processed Azusa data; a 4, IP 7090-processed AN/FPS-16 data.

b) MCPHSE—the prefix of this cell indicates the mission phase. For the medium-abort phase, the prefix of MCPHSE contains a 3.

c) MCWIDR—when non-zero, specifies the need for numerical integration.

d) MCLLDT—when non-zero, indicates that the abort initiate signal has been received. This signal instructs MFLRT2 to deactivate the low-speed input subchannels.

e) MCFINI—if non-zero, low-abort phase has been ended.

f) TMINRT—an eight-cell table which is moved by MFLRT2 into the last eight locations of TMRARF, which is used as input to the numerical integration program. TMINRT, moved into TMRARF only on the initial entry to MFLRT2, supplies parameters for the numerical integration to generate an re-entry table:

<table>
<thead>
<tr>
<th>Location</th>
<th>Contents</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMINRT</td>
<td>PZE</td>
<td>Location of N,L output, re-entry table</td>
</tr>
<tr>
<td></td>
<td>TNINT2, 0, 0</td>
<td></td>
</tr>
<tr>
<td>+ 1</td>
<td>DEC</td>
<td>Time step</td>
</tr>
<tr>
<td>+ 2</td>
<td>DEC</td>
<td>Indicates seconds for time step (above)</td>
</tr>
<tr>
<td>+ 3</td>
<td>PZE</td>
<td>Backward steps</td>
</tr>
<tr>
<td>+ 4</td>
<td>DEC</td>
<td>Forward steps</td>
</tr>
<tr>
<td>+ 5</td>
<td>DEC</td>
<td>Neglect drag</td>
</tr>
<tr>
<td>+ 6</td>
<td>DEC</td>
<td>R and V table</td>
</tr>
<tr>
<td>+ 7</td>
<td>DEC</td>
<td>Steps per output</td>
</tr>
<tr>
<td></td>
<td>2368</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>
4.12.2 Output Requirements

Output from MFLRT2 consists of:

a) MCNGEN—set non-zero to indicate the hold, low-abort, or medium-abort phase. Specifically, MCNGEN, when non-zero, designates that B-GE data is no longer valid.

b) MCLMBT—set non-zero to designate the medium-abort phase.

c) MCNRRF—set non-zero to indicate a re-entry.

d) MCBJMN—a 163 is stored in MCBJMN to reference the on-line message for high-speed output transmission rate during the medium-abort phase.

e) MCSELS—the contents of MCWCH2 are stored in MCSELS to force the selection of data received on subchannel 2. Since B-GE data is not valid in the medium-abort phase, input on subchannel 2 must be selected.

f) MCPHSE—the phase indicator for logging is set for medium-abort: a 3 is stored in the prefix of MCPHSE.

g) MCSSIP—the selected-source in process indicator is cleared to indicate the completion of the basic computing cycle.

h) TMCYCL and TMCYNO—a 6 is stored in the decrement of the fourth entry, MNORMC, in the half-second timing tables to change the output cycle to three seconds.

i) TMRARF—the last eight cells in the input table for numerical integration are set from TMINRT (described in Subsection 3.12.2).

j) TNINT2—the output table for numerical integration's abort table is cleared.

4.12.3 Method

On every entry, MFLRT2 determines whether or not an integration is required and, if necessary, MFLRT2 places an entry in the input queue for the numerical integration program, NOCPNI. The selected-source in process indicator is cleared to signal the completion of main computations for this processing cycle. The F indicator for MNCCIP, the routine number for the CC7091 and CCRAWR coordinate conversion programs, is turned off and the low-speed input subchannels are deactivated. The A indicator for MNLCCM is turned off and control transfers to MOPRIO.
In addition, on the first entry to MFLRT2 the following operations are performed:

a) A 3 is stored in the prefix of the logging phase indicator, MCPHSE, to indicate the medium-abort phase.

b) MCNGEN is set non-zero to indicate that B-GE data is no longer valid.

c) MCLMBT is set non-zero to indicate the mission has entered the medium-abort phase.

d) MCNRRF is set non-zero to indicate the mission has entered the abort phase.

e) The message number in MCBJMN for the on-line message which states the quantity of high-speed output messages transmitted to Cape Canaveral, is changed.

f) The input on subchannel 2 is forced as the selected data.

g) The G indicator for the B-GE coordinate conversion processor, CCGEB1, is turned on to suppress permanently the use of B-GE data in the medium-abort basic computation cycle.

h) The G indicator for the launch/abort output scaling and packing processor, O0LANA, is turned on to suppress this program (the medium-abort phase uses the orbit/re-entry program, O0ORRE, to perform this function for high-speed output data).

i) The G indicator for MYACQD is turned on to prevent the sending of acquisition data.

j) The C indicator for O5ORMC is turned on to prevent O5ORMC from interrupting the numerical integration which must be completed as soon as possible (the B indicator for the O5ORMC processor has been turned on by MTHFSC every 12 half seconds since the mission began, actually, since the time base was first entered into the computer. However, O5ORMC has never received control due to the E indicator suppression set by M0INIT. When a medium-abort situation is ascertained in the main launch computations, O5ORMC is suppressed with the C indicator, the E indicator suppression is removed and the O5ORMC cycle time halved to six half seconds. The suffix to the numerical integration processor, MFCPNI, as standard operating procedure turns off the C indicator for O5ORMC).

k) The E indicator for O5ORMC is turned off and the period of O5ORMC in the MTHFSC timing tables is set to six half seconds; the input parameters to numerical integration for the medium-abort phase are
moved from the TMINTR table into the last eight cells of TMRARF and the 1800-cell output table for numerical integration, TNINT2, is cleared.

l) A transfer instruction is stored in the suffix to numerical integration, MFCPNI, to bypass the queueing of R5RARF for retrofire times.

m) An input word, MCLNRE, is queued for the sense processor to turn on both the LAUNCH and RE-ENTRY lights indicating medium abort on the Output Status Console.

n) An input word is queued for the message processor to print on-line the message, MEDIUM ABORT PHASE HAS BEEN ENTERED.

o) The low-speed input subchannels are deactivated; and an input word is placed in the input table for numerical integration to request an abort table.

4.12.4 Usage

MFLRT2 is entered initially from CCMAIN or CCMISS; every other entry to MFLRT2 is from CCMEAB. MFLRT2 exits to M0PRI0.

a) Storage Required*—59 locations

b) MFLRT2 uses:

1) Macros—QENBA, QENBZ, QPSLF, QUEUE, TRNOF and TRNON

2) Parameters—A, C, E, F, G, MNACQD, MNCCIP, MNCCGB, MNLCCM, MNMESS, MNORMC and MNSENS

3) Communication cells—MCACTV, MCBJMN, MCFINI, MCLLDT, MCLMBT, MCLNRE, MCNGEN, MCNRRF, MCPHSE, MCSELS, MCSSIP, MCWCH2 and MCWIDR

4) Tables—TMCYCL, TMCYNO, TMINRT, TMRARF and TNINT2

5) Constants—K000P3 and K00163

6) Mask—KLSACM

c) Time Required:

1) Minimum—0.163 millisecond

2) Average—0.276 millisecond

3) Maximum (first entry only)—16.35 milliseconds

*Thirty-four instructions in MFLNML are used by MPLCCM; these are not included in the storage requirements.
FIRST TIME TO ENTER MFLRT2? 

MFLRT2 RECEIVES CONTROL FIRST TIME, AND FIRST TIME ONLY, FROM CCMAIN OR CCMISS

YES

SET MEDIUM-ABORT INDICATOR FOR LOGGING 3 → P(MCPHSE)

SET "B-GE NOT NEEDED" INDICATOR MCNGEN ≠ 0

SET MEDIUM-ABORT INDICATOR MCLMBT ≠ 0

SET RETROFIRE INDICATOR MCNRRF ≠ 0

CHANGE MSG. NO. FOR H.S. OUTPUT MESSAGE 613 + MCBJMN

FORCE SUBCHANNEL 2 DATA SELECTION MCWCH2 + MCSELS

NO

TRNON G MNCCGB

TRNON G MNLANA

TRNON G MNAQD

TRNON C MNORMC

TRNOF E MNORMC

CHANGE H.S. OUTPUT PERIOD TO 3 SECONDS

6 + D(TMCYCL + 3)

6 + D(TMCYNO + 3)

SET PARAMETERS OF INTEGRATION OF ABORT TABLE TMINTR, + 7 + TMRARF + 7 + 14

CLEAR TINT2 TABLE FOR INTEGRATION OUTPUT

SET MFCPNI TO BYPASS RETROTIE INTEGRATION

SET MCACTV TO DEACTIVATE L.S. INPUT SUBCHANNELS

OPSFL DEACTIVATE L.S. INPUT SUBCHANNELS

IS INTEGRATION NEEDED? MCWIDR ≠ 0

YES

QENBZ (DISABLE)

QENBZ (DISABLE)

ML7C1

QUEUE MNSENS, LAUNCH-RE-ENTRY LIGHTS

QUEUE MNMESS, MEDIUM-ABORT MESSAGE

QUEUE MNCNPNI INTEGRATION INPUT

QENBA (ENABLE)

FIGURE 4-12. MFLRT2 PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 4-12. MFLRT2 PROGRAM FLOW CHART (Sheet 2 of 2)
4.13 MONITOR SUFFIX TO CCMAIN AND CCMISS (MFLNML)

MFLNML receives control from CCMAIN, following normal main launch computations, or from CCMISS, after main launch computations extrapolated for missing data. This suffix resets the appropriate communication cells, updates the output and controls the activation/deactivation of the low-speed input subchannels.

The flow chart for the MFLNML suffix is shown in Figure 4-13.

4.13.1 Input Requirements

Input to MFLNML consists of:

a) MCSELS—contains latest indication of selected-source data. A zero indicates no good data ever arrived; a 1, B-GE data; a 2, AN/FPS-16 raw radar data; a 3, IP 7090-smoothed Azusa data; a 4, IP 7090-smoothed AN/FPS-16 data.

b) MCLLDLT—indicates, when non-zero, low-speed input subchannels should be activated.

c) MCFINI—indicates, when non-zero, the low-abort phase has been terminated.

4.13.2 Output Requirements

Output from MFLNML consists of:

a) MCNGEN—reset to zero to indicate B-GE input data is needed. This is absolute, but applies to a situation where from launch a new phase had been entered (i.e., the hold phase) but the system has now returned to the launch phase.

b) MCTHLD—reset to zero. MCTHLD is reset for the same reason as MCNGEN.

c) MCSSIP—reset to zero to indicate selected-source data no longer in process.

The launch output block is updated by the MLUPDT subroutine, see Subsection 4.14.

4.13.3 Method

When control has been given to MFLNML, the hold, low-abort or medium-abort phase indicator, the hold phase indicator, and selected-source in progress indicator are all reset to zero. The launch output is updated using the MLUPDT subroutine.
After the F indicator is turned off for the coordinate conversion processor corresponding to the current selected source, the low-speed input lines are either activated or deactivated, depending upon the contents of MCLLLDT. If the low-abort phase has ended, the G indicators for MNCCIP and MNCCGB are turned on.

The A indicator for MNLCCM is turned off and control is transferred to M0PRIO.

4.13.4 Usage

MFLNML is entered from CCMAIN or CCMISS; MFLNML exits to M0PRIO.

a) Storage Required—37 locations

b) MFLNML uses:

1) Subroutine—MLUPDT

2) Macros—QENBA, QENBZ, QPSLF, TRNOF and TRNON

3) Parameters—A, F, G, MNCCGB, MNCCIP and MNLCCM

4) Communication cells—MCACTV, MCFINI, MCLLLDT, MCNGEN, MCSELS, MCSSIP and MCTHLD

5) Constant—K00001

6) Mask—KLSACM

c) Time Required:

1) Minimum*—0.151 millisecond

2) Maximum*—0.124 millisecond

*Does not include time required by MLUPDT subroutine.
FIGURE 4-13. MFLNML PROGRAM FLOW CHART
4.14 MONITOR LAUNCH-OUTPUT UPDATING SUBROUTINE (MLUPDT)

The MLUPDT subroutine is used by MFLNML and MFLHLD to update the output block from the main launch computations, to initiate the printing of pertinent launch messages and/or to initiate the preparation of acquisition data for transmission to Bermuda.

The flow chart for the MLUPDT subroutine is shown in Figure 4-14.

4.14.1 Input Requirements

Input to MLUPDT consists of:

a) MNOLSY—parameter designating the number of packed words (31) from the OGLSTY processor.

b) MCLMSG—contains up to four 9-bit codes which designate special launch messages. MLUPDT adds the right nine bits from MCLMSG to 221 to obtain the actual message number.

c) MCTALD—when non-zero, indicates that the main launch computations processors have determined the need to send Bermuda acquisition data.

d) MCTLAD—when non-zero, indicates that the acquisition data prepared in the last entry into MLUPDT is currently being sent.

e) TCMANR—main launch computations table, contains in the first location the vector time tag for the data processed on this launch computations cycle. This time tag is stored into MCLIDT for logging when the output is transmitted to the Cape displays. The 30th location in TCMANR contains a code which references locations in the TMLCD1 and TMLCD2 tables, which in turn specify the data source for the TCCOUT output table. Three times stored in the TCMANR table are used if any of the messages designated by the code in MCLMSG require a time: the time of capsule separation is contained in TCMANR + 13; the time of sustainer engine cut-off is contained in TCMANR + 18; TCMANR + 20 contains the time for any other message.

f) TCCOUT—output table for main launch computations. The fifth through 25th and the 29th and 30th locations in this table are moved into TMLANA for conversion, scaling, packing and transmission to the Mercury Control Center. (The fifth and 30th locations of TCCOUT are updated from TMLCD1 and TMLCD2, respectively, just prior to moving the TCCOUT values into TMLANA).

g) TMLABF—a 16-cell table containing four sets of time, range, azimuth and elevation for acquisition of the capsule by the Bermuda radars.
h) TMSTCH—reference table for the station characteristics of the Mercury tracking stations. MLUPDT uses the fifth location to reference the Bermuda AN/FPS-16 station characteristics block from which is obtained the output terminal for transmitting teletype messages to Bermuda.

4.14.2 Output Requirements

Output from MLUPDT consists of:

a) MCACQ1—set by MLUPDT as input for the teletype output processor: contains in the address the location of the acquisition data buffer (TMLSOX) and in the decrement the internal station number (4) of the station which is to be sent the acquisition data.

b) MCLIDT—contains the time tag of the input vector. This time is used for logging.

c) MCTADL—reset to zero, after MLUPDT prepares the controls for sending acquisition data to Bermuda.

d) TMSTAD—contains the acquisition data from the TMLABF table. This table is used as input for the MYTTOX processor.

e) TCCOUT—contains in the fifth and 30th locations codes for the data source.

f) TMLANA—contains the output from the main launch computations. The output includes the flight path angle and the velocity ratios for both subchannel 1 and subchannel 2 input and the selected-data source indications. TMLANA serves as input to OOLANA.

g) TMOX01—table of parameters set by MLUPDT for teletype transmission of acquisition data to Bermuda:

<table>
<thead>
<tr>
<th>Decrement</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMOX01</td>
<td>Internal Station Number</td>
</tr>
<tr>
<td></td>
<td>TTY Output Terminal Number</td>
</tr>
<tr>
<td>+1</td>
<td>_______</td>
</tr>
<tr>
<td>+2</td>
<td>_______</td>
</tr>
<tr>
<td>+3</td>
<td>Number of words to be packed</td>
</tr>
</tbody>
</table>

4.14.3 Method

The MLUPDT subroutine receives control from either MFLNML or MFLHLD
and prepares information for input to TMLANA, the input table for O0LANA. This information includes the computed flight path angle and velocity ratios and the selected-data source indications. While data is being stored in TMLANA, O0LANA is suppressed.

If the launch processors have determined the need for certain special messages, MLUPDT adds the quantity contained in the nine right bits of MCLMSG to the code base of 221 to obtain the message number. If the message requires a time for a variable field, MLUPDT obtains the time from one of three locations in the TCMANR table, depending upon the message involved. MLUPDT then disables the computer, queues MYMESS with an input word for the message, enables and checks for another message request by examining the nine-bit set second from the right in MCLMSG. The message procedure continues until no message remains to be printed. A maximum of four messages may be queued in any entry to MLUPDT.

After the required messages have been queued, MLUPDT determines whether or not launch acquisition data must be sent to Bermuda. Unless the last launch acquisition data has not yet been completely transmitted, MLUPDT, if required, prepares new parameters and the computed acquisition values for input to MYTTOX, which converts the values to teletype coded messages and transmits via the DCC. After the MYTTOX input is prepared, the B indicator for MYTTOX is turned on and control returns to the program using MLUPDT.

4.14.4 Usage

The MLUPDT subroutine is entered from MFLNML or MFLHLD; MLUPDT returns to the location following the transfer entry.

a) Calling Sequence:

\[TSX \ MLUPDT,4\]
\[a + 1 \ Return\]

b) Storage Required—97 locations

c) MLUPDT uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—B, C, MNLANA, MNMESS, MNOLSY and MNTTOX

3) Communication cells—MCACQ1, MCLIDT, MCLMSG, MCTADL and MCTLAD

4) Tables—TCCOUT, TCMANR, TMLABF, TMLANA, TMLCD1, TMLCD2, TMOX01, TMSTAD, and TMSTCH

4-73
5) Constants—K00221, K00225, K00227, K00377, KCH232 and KCH233

6) Mask—KAZ16M

d) Time Required:

1) Minimum—0.392 millisecond

2) Maximum—(0.596 + 0.134 N) millisecond

where N is the number of messages queued by MLUPDT.
FIGURE 4-14. MLUPDT SUBROUTINE FLOW CHART (Sheet 1 of 2)
FIGURE 4-14. MLUPDT SUBROUTINE FLOW CHART (Sheet 2 of 2)
4.15 MONITOR SUFFIX TO CCHOLD AND CCHOMI (MFLHLD)

MFLHLD receives control from CCHOLD, following normal hold-phase computations, or from CCHOMI, after hold-phase computations with missing data. This suffix determines what messages, if any, should be printed out. Depending upon the GO NO-GO decision from Cape Canaveral via telemetry or manual insertion, MFLHLD directs the control of the program.

The flow chart for the MFLHLD suffix is shown in Figure 4-15.

4.15.1 Input Requirements

Input to MFLHLD consists of:

a) MCLFTM—contains GMT of lift-off in floating-point seconds.

b) MCTHLD—indicates, when non-zero, the mission has entered the hold phase. On the first entry to MFLHLD, however, MCTHLD is zero.

c) MCWCH2—indicates for subchannel 2 the data source: zero indicates no data; a 2, AN/FPS-16 raw radar data; a 3, IP 7090-processed Azusa data; a 4, IP 7090-processed AN/FPS-16 data.

d) MCHFSC—contains the current GMT in fixed-point half seconds.

e) MCPNOL—indicates, when zero, a request to print out the GMTRC and, possibly, Gamma (γ) and velocity (V).

f) MCLLDT—when non-zero, indicates the low-speed input subchannels should be activated.

g) MCFINI—when non-zero, indicates the termination of the low-abort phase.

h) TMLANA—input table for OOLANA.

i) TCCOUT—table containing GMTRC (TCCOUT + 13) and Gamma (TCCOUT + 20).

j) TCMANR—table containing data and constants used in CCMAIN.

k) TCCONS—table containing launch variable constants.

4.15.2 Output Requirements

Output from MFLHLD consists of:

a) MCLIDT—contains the vector time tag, if any, for logging the output.
b) MCTORI—when non-zero, specifies the need to check for retrofire information.

c) MCNGEN—when non-zero, indicates the mission has entered the hold, low-abort or medium-abort phase.

d) MCSELS—contains latest indication of selected source; zero indicates good data has yet to arrive; a 1 indicates Burroughs-GE data is selected; a 2, AN/FPS-16 raw radar data; a 3, IP 7090-smoothed Azusa data; a 4, IP 7090-smoothed AN/FPS-16 data.

e) MCPFLD—contains time of last powered flight data. This time is saved by MFLHLD for low-speed data reference (minutes in decrement, seconds in address).

f) MCSSIP—reset to zero to indicate selected-source data is no longer in process.

g) MCCHSE—indicates, when non-zero, a change is needed in the scale for plotboard 4.

h) MCGAMA—contains the flight-path angle used in making the final GO NO-GO decision.

i) TCARVT—table containing the average R and V vectors used in the GO NO-GO recommendation and the time elapsed since launch.

j) TMORMC—table for output computations during orbit and re-entry. If the decision is made to allow the entry into orbit, MFLHLD stores the current capsule latitude and longitude in this table to maintain continuity during the interphase from launch to orbit.

4.15.3 Method

Upon entering MFLHLD, the high-abort and hold phase indicators, the selected-source indicator and the Burroughs-GE data-not-needed indicator, are all reset to zero. The launch computations output table is updated by the MLUPDT subroutine.

From MCPNOL, MFLHLD determines whether or not there are any special (i.e., dependent upon launch computations) messages to be printed. If so, the GMTRC message is queued and, if there is sufficient data for a GO NO-GO recommendation, the velocity and flight-path angle are also printed. These messages are printed only once. If the mission has entered the abort/orbit phase, the average R and V vectors with their time are queued for on-line printing and the missing-data light on the Output Status Console, if on, is turned off. When the GO NO-GO decision is made, the time associated with the last powered-flight data is computed and stored into the MCPFLD communication cell. If the abort/
orbit decision has been made by Cape Canaveral, MFLHLD gives control either to MFLABT for abort or to MFLORB for orbit after delaying for five seconds to allow transmission of the final computations.

If the GO NO-GO decision has not yet been made, the F indicator is turned off for the coordinate conversion program corresponding to the current selected-source data. The low-speed input subchannels are either activated or deactivated depending upon the contents of MCLLDT. If the low-abort phase has terminated, the G indicators for MNCCIP and MNCCGB are turned on. The A indicator is turned off for MNLCCM and control is returned to M0PRIO.

4.15.4 Usage

MFLHLD is entered from CCHOLD or CCHOMI; MFLHLD exits to M0PRIO, MFLABT, or MFLORB.

a) Storage Required*—102 locations

b) MFLHLD uses:
   1) Subroutine—MLUPDT
   2) Macros—QENBA, QENBZ, QPSLF, QUEUE, TRNOF and TRNON
   3) Parameters—A, F, G, MNCCGB, MNCCIP, MNLCCM and MNMESS
   4) Communication cells—MCACTV, MCCHSE, MCFINI, MCGAMA, MCHFSC, MCLIDT, MCLFTM, MCLLDT, MCNGEN, MCPFLD, MCPNOL, MCSELS, MCSSIP, MCTHLD, MCTORI and MCWCH2
   5) Tables—TCARVT, TCCONS, TCCOUT, TCMANR, TMLANA and TMORMC
   6) Mask—KLSACM
   7) Constants—K00000, K00001, K001.0, K00010, K00060, K0060., KCH233 and K.1RAD

c) Time Required:
   1) Minimum**—0.188 millisecond

* Thirty-four instructions in MFLNML are used by MPLCCM; these are not included in the storage requirements.
** Does not include the time required by the MLUPDT subroutine.
2) Maximum*—0.871 millisecond PLUS A 5 SECOND DELAY (After the abort/orbit recommendation has been made, MFLHLD waits five seconds to allow all the computed output to be transmitted to the Mercury Control Center).

* Does not include the time required by the MLUPDT subroutine.
FIGURE 4-15. MFLHLD PROGRAM FLOW CHART (Sheet 1 of 3)
FIGURE 4-15. MFLHLD PROGRAM FLOW CHART (Sheet 2 of 3)
FIGURE 4-15. MFLHLD PROGRAM FLOW CHART (Sheet 3 of 3)
4.16 MONITOR ABORT SUFFIX TO MFLHLD (MFLABT)

MFLABT is the suffix which receives control from MFLHLD after the decision has been made to abort the mission. MFLABT must set controls to enter the high-abort phase and to prepare the Mercury Program System for the interphase operations which commence with the generation of an abort table.

The flow chart for the MFLABT suffix is shown in Figure 4-16.

4.16.1 Input Requirements

Input to MFLABT consists of:

a) M—parameter designating the number of entries in the half-second timing table, TMCYCL.

b) MC1RVT, MC2RVT—contain in their address fields the locations of three components of the range and velocity vectors, respectively, as supplied by the launch program. The address of MC1RVT contains the location, TDRANV; the address of MC2RVT contains the location, TDRANV + 3.

c) TATOWS—eight-cell table containing parameters for the generation of an abort table by the numerical integration program. These parameters are stored into the last eight cells of TDRANV.

d) TDRANV—the 15-cell input table to numerical integration for generating the abort table. The first seven cells of this table contain the abort vectors and their associated time, as supplied by the launch programs. (These values are also used by MFLABT for queueing input to the on-line message processor to print the range and velocity vectors and their time.)

4.16.2 Output Requirements

Output from MFLABT consists of:

a) MCTHLD—the hold-phase indicator, MCTHLD, is cleared.

b) MCTABT—the high-abort phase indicator is set (non-zero).

c) MCPHSE—a 1 is stored in the prefix of MCPHSE to indicate the high-abort phase for the logging programs.

d) MCTRVT—the time tag of the range and velocity vectors supplied by launch, from TDRANV + 6, is stored into MCTRVT for on-line printing.
e) MCHFS1—a 3 is stored into MCHFS1 to control the number of programs examined on a half-second period by MTHFSC. Storing a 3 into MCHFS1 stops MTHFSC from turning on the B indicator for the coordinate conversion programs for high-speed input data.

f) MCBJMN—165 is stored in MCBJMN to reference the message which states the expected and actual high-speed output transmission rate during the high-abort phase.

g) TMCYNO—a 2 is stored in the decrement of TMCYNO×M-3 to set the period of execution of the third entry in TMCYCL to one second. (This entry is currently occupied by O0LANA, which is suppressed. After the abort table is generated, an entry for CCABRT is stored in the third cell of TMCYCL.)

h) TDRANV—15-cell table is set for input to the numerical integration program, N0CPNI. The first seven cells are set by the launch programs; the last eight cells are set from TATOWS by MFLABT. N0CPNI uses this input to generate the abort table.

4.16.3 Method

MFLABT receives control from the launch hold suffix, MFLHLD, after the abort decision has been made. The hold phase indicator is cleared and the high-abort phase indicator set. The C indicator for the acquisition data program, MYACQD, is turned on to suppress the transmission of acquisition data. The C indicator for the high-abort control processor, MYSEEK, is turned on (This suppression is removed by MFCPNI after the abort table has been generated.). The G indicators for the coordinate conversion programs for the high-speed input data are turned on to suppress these programs permanently.

The input table for numerical integration, TDRANV, is completed by moving the eight parameters from the TATOWS table into the last eight locations of TDRANV. The anchor point time is converted into fixed-point seconds with its associated range and velocity vectors is given to the on-line message processor for printing. Input is queued for the sense processor to turn on the abort light on the Output Status Console.

MFLABT then sets the following indicators for the high-abort phase: the phase indicator for logging, the control cell for programs executed at half-second periods, the cell for the message referencing the high-speed output transmission rate, and the half-second period for the third entry in the MTHFSC timing table.

An entry is placed in the queue table for the numerical integration program to generate the abort table, the A indicator MPLCCM is turned off and control transfers to M0PRIO.

4.16.4 Usage
MFLABT is entered from MFLHLD: MFLABT exits to M0PRIO.

a) Storage Required—55 locations

b) MFLABT uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, C, G, MNACQD, MNCCGB, MNCCIP, MNCPNI, MNLCCM, MNMESS, MNSEEK, and MNSENS

3) Communication cells—MNBJMN, MCHFS1, MCHSE, MC1RVT, MC2RVT, MCTABT, MCTHLD and MCTRVT

4) Tables—TATOWS, TDRANV and TMCYNO

5) Constants—K00003, K00165, M000PI and KD0002

c) Time Required—41.7 milliseconds
FIGURE 4-16. MFLABT PROGRAM FLOW CHART
4.17 MONITOR HIGH-ABORT CONTROL PROCESSOR (MYSEEK)

Any abort which occurs after the escape tower has been jettisoned involves in succession the elements of both an abort phase and a re-entry phase. MYSEEK controls the sequence of program activity during the high-abort to re-entry phase change.

Each entry to MYSEEK occurs as a result of one of the following conditions: (1) an abort table based upon the R and V vectors supplied by the launch programs has been generated; (2) a re-entry table predicated upon the retrofire time computed by the launch programs has been generated; (3) the input processing programs have received from the capsule telemetry signals an indication of actual retrofire; and (4) retrofire information, determined externally, has been inserted via paper tape into the computer. In each case MYSEEK directs the program flow in accordance with the information received.

The flow chart for the MYSEEK processor is shown in Figure 4-17.

4.17.1 Input Requirements

Input to MYSEEK consists of:

a) MNABRT—parameter defining the routine number of the CCABRT processor.

b) MCTMRF—when non-zero, contains the time in fixed-point seconds associated with the firing of the first retrorockets, as specified by telemetry signals.

c) MCNTRF—when non-zero, contains the number of retrorockets fired, as specified by telemetry signals.

d) TCCOUT—the time to fire retrorockets (GMTRC), computed by the launch programs, is located in TCCOUT + 13.

e) TMLANA—the capsule’s current latitude, longitude, and emergency recovery area are located in TMLANA + 5, +6 and +17, respectively. These are moved into the TMORMC table by MYSEEK.

f) TMDTBO—contains a correction to be applied to the computed retrofire time to obtain the true time of burnout.

g) TMSSEC—contains in fixed-point seconds the computed time of retrofire.

h) MCMARF—when non-zero, contains the time in fixed-point seconds associated with the firing of retrorockets, as specified by paper tape input.
i) MCREEN—when non-zero, contains the number of retrorockets fired, as specified by paper tape input.

4.17.2 Output Requirements

Output from MYSEEK consists of:

a) MCNRRF—the total number of retrorockets fired, as specified by both telemetry and paper tape input, is stored in this cell. This number cannot exceed three.

b) MCBNOT—contains the calculated time of burnout, TMSSEC plus TMDTBO, if and only if the manually inserted and computed retrofire times and numbers agree.

c) MCBJMN—a 163 is stored in MCBJMN, after a confirmed retrofire, to reference the on-line message for high-speed output transmission rate during the re-entry phase.

d) MCPHSE—the prefix of MCPHSE is set by MYSEEK to 6, when retrofire information from the capsule telemetry signals is transmitted over high-speed lines from Cape Canaveral, indicating the high-abort phase or to 5, after retrofire information is accepted from paper tape, indicating the re-entry phase.

e) TMSSEC—one-cell table which contains the computed time of retrofire. This time to be accepted must corroborate retrofire time received either from capsule telemetry or by paper tape.

f) TMCYCL, TMCYNO—when MYSEEK is entered following the generation of a re-entry table based on the computed GMTRC, the entry in TMCYCL for MNLANA is replaced by an entry for MNABRT to initiate the cycling of the abort processing program, CCABRT. After the retrofire information is confirmed by either paper tape insertion or capsule telemetry signals, the half-second cycle for MNORMC is changed to six to give control to O5ORMC every three seconds.

g) TMORMC—the capsule’s latitude, longitude and recovery area are moved from the TMLANA table into TMORMC, TMORMC + 1, and TMORMC + 29, respectively. This accompanies the change from the launch output processor to the re-entry output processor.

h) TMRARF—after the retrofire is confirmed, MYSEEK stores in TMRARF + 10 the number of seconds (48) to integrate backwards in generating the re-entry table.

i) TNINT1—an 1800-cell table which is used by N0CPNI to store the generated table. MYSEEK clears this table prior to the final exit for the re-
entry table to be generated.

4.17.3 Method

When MYSEEK receives control for the first time, an abort table has just been generated by N0CPNI. MYSEEK tests MCREEN and MCNTRF to determine if retrofire has been reported, respectively, either by paper tape or telemetry. If neither test is positive, i.e., if a retrofire time is not yet available from either source, MYSEEK sets controls for N0CPNI, via R5RARF, to generate a re-entry table based upon the retrofiring at the computed GMTRC.

At the next entry to MYSEEK, both the abort and re-entry tables have been generated, and if retrofire information still is lacking, MYSEEK initiates the cycling of CCABRT to generate abort quantities for output to displays.

The next entry to MYSEEK follows the reception of the retrofiring indication, either by telemetry or paper tape. If the telemetry signal is received first, the time and number of the retrorockets fired as reported by telemetry is compared with the comparable computed quantities. If these differ, MYSEEK sets controls to generate a re-entry table based upon the telemetry-reported retrofire data. On the next entry to MYSEEK the comparison is repeated and, unless the telemetry-reported retrofire information has been amended, the quantities now agree. Otherwise, the cycle repeats and another re-entry table is generated. When the comparison between the computed and the telemetry-reported, i.e., actual, quantities finds complete agreement, the abort computations are terminated and MYSEEK sets controls to initiate driving of the re-entry displays.

The final entry to MYSEEK results from paper tape input. If paper tape input precedes telemetry input, the latter is not used. The paper tape data, as with the telemetry information, is compared with computed data, and when the agreement is determined (the re-entry table based on the paper tape retrofire data has been generated), MYSEEK has satisfied all of its requirements. MYSEEK suppresses itself and transfers control to M0PRIO.

4.17.4 Usage

MYSEEK is entered from, and exits to, M0PRIO.

a) Storage Required—149 locations

b) MYSEEK uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, C, D, E, F, M, MNABRT, MNACQD, MNLANA, MNORMC, MNQSYS, MNRARF, MNSEEK, and MNSENS

3) Communication cells—MCBJMN, MCBNOT, MCMARF, MCNRRF,
MC 103

MCNTRF, MCREEN, and MCTMRF

4) Tables—TCCOUT, TMLANA, TMDTBO, TMSSEC, TMCYNO, TMCYCL, TMORMC, TMRARF and TNINT1

5) Constants—K00060, K00048, KD0006, K000P6, KMCPHS and K00163

c) Time Required:

1) Minimum—0.133 millisecond

2) Maximum (final entry only)—21.80 milliseconds
FIGURE 4-17. MYSEEK PROGRAM FLOW CHART (Sheet 1 of 3)
FIGURE 4-17. MYSEEK PROGRAM FLOW CHART (Sheet 2 of 3)
FIGURE 4-17. MYSEEK PROGRAM FLOW CHART (Sheet 3 of 3)
4.18 MONITOR PREFIX TO CCABRT (MPABRT)

MPABRT supplies the initial conditions for entry into the high-abort main computations processor, CCABRT.

The flow chart for the MPABRT prefix is shown in Figure 4-18.

4.18.1 Input Requirements

Input to MPABRT consists of:

a) MCHFSC—contains the current GMT in fixed-point half seconds.

b) TFESAB—contains the GMT in fixed-point seconds of the first even second after burnout.

c) TNINT1—the third location of this table must contain the time in fixed-point seconds of the first entry in the abort integration table, TNINT1.

4.18.2 Output Requirements

If the current time is earlier than the time for the first values in the abort integration table, MPABRT clears the accumulator and transfers control directly to the CCABRT suffix, MFABRT.

If the abort integration table values are valid, MPABRT determines whether or not the capsule has begun re-entry by comparing the current time to the time, if any, of burnout. The address of MCLOCT contains the location of the appropriate table—TNINT1 for abort, TNINT2 for re-entry—for CCABRT to use in generating the output data.

4.18.3 Method

The method of MPABRT is described in Subsection 4.18.2.

4.18.4 Usage

MPABRT is entered from M0PRI0; MPABRT exits to MFABRT or to CCABRT.

a) Storage Required—18 locations

b) MPABRT uses:

1) Macros—TRNOF and TRNON

2) Parameters—A, B, and MNABRT
3) Communication cells—MCHFSC and MCLOCT

4) Tables—TFESAB, TNINT1 and TNINT2

c) Time Required:

1) Minimum—0.046 millisecond

2) Maximum—0.066 millisecond
FIGURE 4-18. MPABRT PROGRAM FLOW CHART
4.19 MONITOR SUFFIX TO CCABRT (MFABRT)

MFABRT moves the output data generated by CCABRT into the input table for OOLANA, which scales and packs the data for transmission to the Cape Canaveral displays. MFABRT then informs M0PRIO that the OOLANA processor should be given control.

The flow chart for the MFABRT suffix is shown in Figure 4-19.

4.19.1 Input Requirements

Input to MFABRT consists of:

a) TCCOUT—a 30-cell table containing the output data generated by the high-abort processor, CCABRT.

b) TNINT2—the fourth cell in the re-entry table contains the time corresponding to the last entry in the table. If the accumulator is non-zero upon entry to MFABRT, this time is used in queueing an on-line message.

4.19.2 Output Requirements

MFABRT moves the data from the 30 cells of TCCOUT into the TMLANA table for input to OOLANA and then turns on the B indicator for OOLANA.

In addition, if the accumulator is non-zero upon entry, MFABRT queues an on-line message to state: SPLASH * GMT EXCEEDS TIME OF LAST ENTRY IN REENTRY TABLE (Time). The time in the message is obtained by MFABRT from TNINT2 + 3.

4.19.3 Method

MFABRT tests the accumulator and, if it is non-zero, obtains the time of the last entry in the re-entry table and queues a message which states that the limits of the re-entry table have been exceeded, i.e., the capsule’s altitude has fallen below 60,000 ft. The output table, TCCOUT, is moved into TMLANA for scaling, packing and transmission to the Mercury Control Center and the B indicator for OOLANA is turned on (OOLANA formerly occupied the TMCYCL entry which now belongs to CCABRT. Consequently, OOLANA still effectively operates on a half-second period, but following CCABRT.). The A indicator for CCABRT is turned off and control transfers to M0PRIO.

4.19.4 Usage

MFABRT is entered from CCABRT or MPABRT; MFABRT exits to M0PRIO.
a) Storage Required—21 locations

b) MFABRT uses:
   1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON
   2) Parameters—A, B, MNABRT, MNLANA and MNMESS
   3) Tables—TCCOUT, TMLANA and TNINT2

c) Time Required:
   1) Minimum—0.427 millisecond
   2) Maximum—0.548 millisecond
"SPLASH* GMT EXCEEDS LAST ENTRY IN RE-ENTRY TABLE (TIME)"

GET TIME FROM RE-ENTRY TABLE, TNINT2 + 3 AND STORE IN QUEUE WORD FOR ON-LINE MESSAGE

QENBZ (DISABLE)

QUEUE MNMESS, MESSAGE NO. 253

QENBA (ENABLE)

MOVE CCABRT OUTPUT TABLE INTO INPUT TABLE FOR OOLANA
TCCOUT → TMLANA

TRNON B MNLANA

TRNOF A MNABRT

MOPRIO

FIGURE 4-19. MFABRT PROGRAM FLOW CHART
4.20 MONITOR ORBIT SUFFIX TO MFLHLD (MFLORB)

MFLORB is the phase change program which receives control after the decision has been made to orbit the capsule. MFLORB must prepare the appropriate communication cells and tables used in the orbit phase, perform initial computations, set controls for the orbit system computations, and initiate action in the following areas:

a) Print an indication of phase change and the insertion vectors.
b) Turn on orbit light and turn off launch light on Output Status Console.
c) Read edit and differential correction programs from the system tape.
d) Write critical values, i.e., insertion conditions, time of lift-off on the restart tapes.
e) Generate initial orbit table based on vectors computed by launch programs.
f) Maintain priority indicators to direct control of the orbit system.

MFLORB, when used for a system restart, must re-initialize the Mercury Program System for orbital processing.

The flow chart for the MFLORB suffix is shown in Figure 4-20.

4.20.1 Input Requirements

Input to MFLORB consists of:

a) MCPFLD—contains the GMT of capsule insertion into orbit as computed by the launch programs. The minutes are contained in the decrement, the seconds in the address.
b) MCGTLO—contains the GMT in fixed-point seconds of lift-off.
c) MC1RVT—communication cell used as an input queue word for printing on-line the R vector at insertion.
d) MC2RVT—communication cell used as a queue word for printing on-line the V vector at insertion.
e) MCTRVT—communication cell used as a queue word for printing on-line the time of the R and V vectors.
f) MCHFSC—contains the current GMT in fixed-point half seconds.
g) MCLNOR—communication cell used as a mask for queueing the sense processor to turn the orbit light on and the launch light off on the Output Status Console.

h) MCREST—when non-zero, indicates MFLORB has been entered for a system restart. MCREST contains the restart time.

i) MCSRST—when non-zero, indicates the restart tape is being processed.

j) MCMAN5—when non-zero, indicates a paper tape message is being read into the computer.

k) MCTLST—contains the time associated with the manually inserted R and V vectors. This time is used as a queue word for printing on-line the restart time when using manually inserted vectors for restart.

l) TDRANV—contains the vector components and time at insertion, computed by launch, and set up in the standard integration parameters format. This table is used for input to the numerical integration program to generate the initial orbit table.

m) TDNIPM—contains the last eight values of the standard integration parameters. These values are set to generate the initial orbit table.

n) TMNTRF—contains the nominal times-to-fire for the ends of the orbits. These times are expressed in seconds elapsed since insertion.

o) TMTFEA—contains the nominal times-to-fire for the emergency areas. These times are expressed in seconds elapsed since insertion.

4.20.2 Output Requirements

Output from MFLORB consists of:

a) MCGTIN—contains the GMT of insertion in fixed-point seconds.

b) MCMAN5—set non-zero, if a restart from vectors inserted via paper tape is taking place.

c) MCTRVT—contains the time associated with the R and V vectors and is used for the queue control word for the on-line message processor.

d) MCTOFS—contains the present capsule setting of GMT for retrofire in fixed-point seconds.

e) MCHFSI—a 2 is stored in MCHFSI to control the number of entries examined by MTHFSC in the timing table, TMCYCL. In the orbit phase, only O5ORMC and MYMINS of the TMCYCL entries operate on a
half-second cycle.

f) MCTHLD—the hold phase indicator is cleared by MFLORB.

g) MCTLST—from MFLORB, MCTLST contains the time of the launchcomputed orbit elements—the R and V vectors. Normally, MCTLST contains the time of the last observation used by the differential correction processor.

h) MCBJMN, MCHOMS—164 is stored in MCBJMN to reference the online message which states the expected high-speed output transmission rate for the orbit phase. MCHOMS, the MYHSOD counter for the actual high-speed output transmission rate, is reset to zero.

i) TMETRS—contains the present capsule (GMT-to-retrofire) setting: minutes in the address, seconds in the decrement.

j) TMGMT2—contains the GMT of lift-off: minutes in the address, seconds in the decrement.

k) TMNTRF—table containing the GMT for the nominal times-to-retrofire for the ends of orbits.

l) TMTFEA—table containing the GMT for the nominal times-to-retrofire for the emergency areas.

m) TDRANV—15-cell table which provides input to numerical integration to generate the initial orbit table. The last eight cells contain parameters set by MFLORB for the initial orbit table.

n) TMREST—contains the data to be written on the restart tape, see Table 5-1.

4.20.3 Method

When MFLORB receives control from MFLHLD, the hold phase has been terminated by the abort/orbit decision and the decision has been made to orbit the capsule. MFLORB must now prepare the Mercury Program System for the orbit phase. When MFLORB receives control from MPLCCM, the orbit phase, and possibly the re-entry phase, had been entered but because of computer malfunction, a system restart is required (the restart operations are described in Section 5). For every entry MFLORB deactivates the high-speed input subchannels and activates the low-speed input subchannels. The coordinate conversion programs, which process the high-speed input data, are permanently suppressed with the G indicator. The hold phase indicator, MCTHLD, is cleared. The manual insertion indicator, MCMAN5, is set non-zero (MCMAN5 is used later if manually inserted range and velocity vectors are required to initiate a restart).
MFLORB now determines the nature of the entry. If the entry is for a normal launch-to-orbit interphase, control continues as described in d).

a) If the entry was the result of a system restart, MFLORB turns on the B indicator for MYSRST which searches the restart tape for the record containing the pertinent data appropriate for the given restart time. MFLORB meanwhile cycles on a test for a completion of the searching and reading of the restart tape. When the restart tape search has been completed, MFLORB receives control at the point of the test. The C indicator for MYRSYS is turned off (MYRSYS had been suppressed since it uses the MSRECC subroutine also required by the restart tape program).

MFLORB now determines whether or not the tape search was successful.

b) If the search was successful, MFLORB determines whether or not the re-entry phase had been entered: (1) If the re-entry phase had been entered, MFLORB sets the re-entry phase indicator, MCRERE, non-zero and stores a 2 into the half-second cycle control cell, MCHFS1, to provide control to O5ORMC and MYMINS at the required half-second intervals. The C indicator, an interphase suppression, for O5ORMC is turned on and the E indicator, a launch suppression, turned off. MYQSYS is queued to load the orbit and re-entry programs for edit and differential correction. The B indicator for MYREST, the program which accomplishes the orbit/re-entry phase change, is turned on. The indicator for manual insertion vectors is cleared, the A indicator for MPLCCM is turned off and control transfers to MOPRIO. (2) If the current entry is for a restart in the orbit phase, the orbital insertion time is obtained from the restart tape and is stored for the on-line message and in the MCGTIN communicator. Control continues as described under e) below.

c) If the restart tape search was unsuccessful, MFLORB cycles on a test for completion of the manual insertion of the initial orbit vectors (when the restart tape cannot be read, the programs request that the orbit vectors be manually inserted via the paper tape subchannel of the DCC). When the vectors have been entered, MFLORB stores the associated time, i.e., the time of insertion, in MCGTIN and in the cell provided for printing on-line the insertion vectors. The nominal capsule clock setting is adjusted for the current GMT and stored in MCTOFS and TMETRS.

d) If MFLORB has been entered for a normal launch-to-orbit interphase, the time of insertion into orbit, as computed by the launch programs, is converted into the proper format and is stored in MCGTIN. The nominal capsule clock setting is adjusted for the current GMT and stored in MCTOFS and TMETRS.
e) MFLORB now adjusts the nominal time-to-fire for the current GMT and stores this value in TMNTRF and TMTFEA. The computer is disabled and the on-line message processor is queued with four entries: to print the insertion range vector, the insertion velocity vector, the associated time tag, and the message, ORBIT PHASE HAS BEEN ENTERED. The sense processor is queued to turn the Output Status Console's launch light off and orbit light on. The computer is enabled and, if MFLORB is processing a restart, the initial parameters for numerical integration are set in the last eight cells of the TDRANV table.

Negative zero is stored in the prefix of MCPHSE to indicate the phase for logging. A 2 is stored in the MTHFSC control cell for the half-second cycled programs. The C indicator for O5ORMC is turned on and the E indicator turned off. The control cell for the message which states the expected and actual high-speed output rate, is set for the orbit phase.

MFLORB queues MYGEN1 to set controls for the generation of the initial orbit table and MYQSYS to set controls for loading the edit and differential correction programs into core storage. If the restart tape must be prepared, MFLORB moves the restart values from their respective core locations into the restart table and the B indicator is turned on for MYWRRS to write the tape. The indicator for manual insertion of vectors is reset to zero, the A indicator for MPLCCM is turned off and control transfers to M0PRIO.

4.20.4 Usage

MFLORB is entered from MFLHLD or MPLCCM; MFLORB exits to M0PRIO.

a) Storage Required—161 locations

b) MFLORB uses:

1) Macros—QENBA, QENBZ, QPSLF, QUEUE, TRNOF and TRNON

2) Parameters—A, B, C, E, G, MNCCGB, MNCCIP, MNLCCM, MNORMC, MNQSYS, MNREST, MNRSYS and MNSRST

3) Communication cells—MCACTV, MCBJMN, MCGTIN, MCGTLO, MCHFSI, MCHOMS, MCLNOR, MCMAN5, MCPFLD, MCPHSE, MCRERE, MCREST, MCSRST, MCTHLD, MCTLST, MCTOFS, MCTRVT, MC1RVT and MC2RVT

4) Tables—TDNIPM, TDRANV, TMETRS, TMGMT2, TMNTRF, TMREST and TMTFEA

5) Constants—K00002, K00003, K00015, K00060, K00080 and KM0000
6) Mask--KLSACM

c) Time Required--1.22 milliseconds
FIGURE 4-20. MFLORB PROGRAM FLOW CHART (Sheet 1 of 2)
Figure 4-20. MFLORB Program Flow Chart  (Sheet 2 of 2)
Section 5
CONTROL DURING PHASE CHANGE
AND RESTART

The nominal Mercury orbital mission proceeds from prelaunch to impact via the launch, hold, orbit and re-entry phases. During launch, exceptions to the nominal sequence may involve a low abort (below 100,000 feet), a medium abort (below tower separation) or a high abort (after tower separation). Once insertion into orbit has been attained, there is no exception to the nominal sequence; that is, orbit yields only to re-entry. During orbit and re-entry, situations may arise, due to error in computations or mechanical malfunction, which require a restart of the Mercury Program System.

These phase change and restart operations, excepting the launch-to-low abort and the launch-to-medium abort, share a common characteristic: all require either the Mercury System tape or the restart tape; some require both.

The Monitor programs which control the initialization, the phase change and the restart operations are described in this section.

5.1 CONTROL DURING PRELAUNCH

Prior to loading the Mercury Program System for an actual mission, the final modifications are made to the program (for example, temporary instructions required for simulated testing are removed) and the system tape is written in absolute binary with special error correcting codes and the program is preceded by a self-loading sequence.

The final modifications to the program are incorporated by MXMRGE, an external program which provides the capabilities for modifying a squeeze tape. (MXMRGE is described in MC 107, External System Programs.) The output of MXMRGE is a job tape for an SOS compilation or execution. MXSTW1 edits the SOS B1 tape to produce a self-loading file as the first file on the Mercury System tape. It then writes the remainder of the Mercury System tape with the error correction codes using the MSWECC subroutine. The self-loading tape is now placed on tape unit A1. When the Load Tape button is pressed, the self-loading sequence brings in the first file containing the loading program MXLOAD. This program reads in the next file on the tape, record by record, with the MSLOAD subroutine; it removes the error correcting codes using the MSRECC subroutine, and stores the record in the proper location in core storage.

When the Mercury System tape has been read successfully into the IBM 7090 core storage, initialization of the Mercury Program System begins. After
the GMT time base has been entered into the system, the Monitor Initialization Processor, MYINIT, turns on the B indicator for the Monitor Station Characteristics Tape Processor, MYSCRD. MYINIT meanwhile loops in an examination of location TMSTCH for the indication that the Station Characteristics tape has been read successfully. The next one-minute WWV signal interrupts MYINIT and M0PRIO gives control to the higher priority program, MYSCRD. When MYSCRD receives control, the Station Characteristics tape reading cycle begins. This cycle is illustrated in Figure 5-8.

On the first entry MYSCRD initiates the reading of the first Station Characteristics record from tape into a temporary storage block in core. Control returns via M0PRIO to the interrupted processor, MYINIT, which continues to loop examining TMSTCH. When the transmission is completed, the Monitor Station Characteristics Tape Trap Processor, MTENST, receives control. MTENST checks for errors in reading the tape and, if no errors occurred, turns on the B indicator for the next entry into MYSCRD.

M0PRIO again gives control to MYSCRD where the record read is used as input to MSRECC, the monitor subroutine which examines the record and removes the error correction codes. After executing the subroutine, MYSCRD moves the corrected station block into the permanent Station Characteristics table in core storage. MYSCRD initiates transmission to read the second Station Characteristics record from the tape into the temporary storage block. MYSCRD again exits to M0PRIO. When transmission of the record is completed, the trap gives control to the trap processor MTENST.

The cycle continues until the last Station Characteristics block is read from tape. On the last entry to MYSCRD the final Station Characteristics block is processed and placed in the permanent table. MYSCRD now clears TMSTCH, queues the on-line message cycle to print a message indicating the Station Characteristics tape has been read successfully, and transfers control to M0PRIO. When MYINIT receives control, it finds TMSTCH equal to zero, and completes the initialization of the Mercury Program System.

These programs—MXSTW1, MSWECC, MXLOAD, MSLOAD, MSRECC, M0INIT, MYINIT, MYSCRD and MTENST—are described in detail in this section.
5.2 MERCURY SYSTEM TAPE WRITER PROGRAM (MXSTW1)

MXSTW1 writes a self-loading Mercury System tape. The flow chart for the MXSTW1 program is shown in Figure 5-1.

5.2.1 Input Requirements

Input to MXSTW1 is the Mercury System s quoze tape, including all modifications intended for the final running program. MXSTW1 requires the MSWECC subroutine (see subsection 5.3) and the Share subroutine for converting binary-coded-decimal to card image for on-line printing.

5.2.2 Output Requirements

The output from MXSTW1 consists of an absolute self-loading Mercury System tape, illustrated in Figure 5-2.

5.2.3 Method

When SOS loads its System Mediary Input tape (SYSMIT) from B1 into the computer, a transfer card (TCD) gives control to MXSTW1. MXSTW1 writes a self-loading file (MXLOAD) as the first file on the Mercury System tape and then writes the files containing the Mercury Program System. The latter files includes error correcting codes.

5.2.4 Usage

a) Operator's Procedures:

1) Ready the standard SOS system tapes, with A3 as the input tape.

2) Ready the on-line printer.

3) Press CLEAR and LOAD TAPE.

4) SOS writes its SYSMIT tape on B1 and transfers control to the MXSTW1 program. The program halts after printing an on-line message designating the control transfer.

5) Ready a blank tape on A6.


7) MXSTW1 provides an on-line printout stating that the Mercury System tape has been successfully written. (A duplicate tape may be
written by placing a blank on A6 and pressing START.) The Mercury System tape is now placed on A1 and, when LOAD TAPE is pressed, it loads itself into the computer.

b) Error Conditions—Errors during the execution of MXSTW1 result in program halts. On-line messages identify the error condition and specify error correcting procedures.
MESSAGE 1 = MERCURY MONITOR SYSTEM TAPE WRITER. THIS PROGRAM EDITS ERASE 1 OF THE IBMONITOR AND WRITES IT ON THE MERCURY SYSTEM TAPE (A6).

MESSAGE 2 = SET ERASE 1 OF IBMONITOR TO B1 AND SET A BLANK TAPE ON A6 FOR THE MERCURY SYSTEM TAPE.
READ SET RECORD COUNT OF ZERO IN XR1

READ RECORD, UP TO 264 WORDS, FROM MXRASE INTO BLOCK BEGINNING WITH "FILE"

PLACE PREFIX, TAG, AND ADDRESS OF FILE + 1 INTO A.C.

INCROMENT FILE COUNT IN XR4

STORE XR1 IN DECREMENT OF NEXT ENTRY IN "TABLE" TABLE (THIS TABLE HAS ONE ENTRY FOR EACH FILE)

AC = 0?

YES

READ RECORD, UP TO 264 WORDS, FROM MXRASE INTO BLOCK BEGINNING WITH "FILE"

END-OF-FILE READ?

YES

NO

INCREMENT RECORD COUNT IN XR1

FIGURE 5-1. MXSTW1 PROGRAM FLOW CHART (Sheet 2 of 5)
ERR1

PRINT ON-LINE MESSAGE 3

HALT AND TRANSFER TO START

END

REWIND MXRA SE.
LOOP TO SPACE MXRA SE PAST FIRST FOUR FILES

WRITE 3 WORD SELF LOADER THEN LOADING PROGRAM, MXLOAD, ON MXSVST

DELAY UNTIL CHANNEL A DISCONNECTS

TEST

XR1 GREATER THAN THE NUMBER OF FILES?

YES

GRECO

NO

PLACE XR1 INTO ADDRESS OF A.C. OR "TABLE" ENTRY (CURRENT FILE NUMBER) INTO DECREMENT OF A.C.

NO

STORE AC INTO "FILE." PLACE DECREMENT OF AC INTO XR2.

YES

REDUNDANCY ON CHANNEL A?

NO

EXECUTE MSWECC TO PRODUCE HAMMING CODES

WRITE CONTROL WORD (FOUR WORDS WITH HAMMING CODES) ON MXSVST

STORE FILE COUNT (XR4) INTO DECREMENT OF "TEST." SET XR1 = 1

DELAY UNTIL CHANNEL A DISCONNECTS

MESSAGE 3 = TAPE CHECK WRITING FIRST FILE MXSVST. PRESS START TO REWRITE.

FIGURE 5-1. MXSTW1 PROGRAM FLOW CHART (Sheet 3 of 5)
READ PAST FIRST RECORD OF FILE ON MXRASE

DELAY UNTIL CHANNEL B DISCONNECTS

READ RECORD, UP TO 264 WORDS, FROM MXRASE INTO BLOCK BEGINNING WITH FILE

DELAY UNTIL CHANNEL B DISCONNECTS

REDUNDANCY ON CHANNEL B?

YES

PRINT ON-LINE MESSAGE 4

HALT AND TRANSFER TO START

EXECUTE MSWECC TO PRODUCE HAMMING CODES

WRITE 264 WORD RECORD FROM BLOCK BEGINNING WITH "FILE" ON MXSYS.

DELAY UNTIL CHANNEL A DISCONNECTS

HAS THE LAST RECORD IN THIS FILE BEEN READ IN?

NO

WRITE END-OF-FILE ON MXSYS. INCREMENT XR1 BY ONE.

YES

ERR2

MESSAGE 4 = TAPE CHECK READING MXRASE. PRESS START TO RESTART

FIGURE 5-1. MXSTW1 PROGRAM FLOW CHART (Sheet 4 of 5)
Figure 5-1. MXSTW1 Program Flow Chart (Sheet 5 of 5)
FIGURE 5-2. INPUT & OUTPUT TAPES FOR MXSTW1
5.3 ERROR CORRECTION CODE WRITER SUBROUTINE (MSWECC)

MSWECC writes information on tape with certain check words interleaved with the original record in such a way that automatic double error detection and automatic single error detection and correction is possible for each of the 36 bit positions of an IBM 7090 computer word.

The flow chart for the MSWECC subroutine is shown in Figure 5-3.

5.3.1 Input Requirements

MSWECC requires an input of N consecutive words in core storage, where N is less than 503.

5.3.2 Output Requirements

MSWECC expands the input block N with interleaved check words to produce an expanded block, the size of which is given by the formula below (the size is placed in the address of the AC):

\[ 2^{K-1} + K + 1 \leq N < 2^K - K \]

where N is equal to the original block length and K is equal to the number of check words. The following table gives the values for the length of the output block (one additional word is required for parity checking):

<table>
<thead>
<tr>
<th>N</th>
<th>K</th>
<th>Storage Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2 - 4</td>
<td>3</td>
<td>6 - 8</td>
</tr>
<tr>
<td>5 - 11</td>
<td>4</td>
<td>10 - 16</td>
</tr>
<tr>
<td>12 - 26</td>
<td>5</td>
<td>18 - 32</td>
</tr>
<tr>
<td>27 - 57</td>
<td>6</td>
<td>34 - 64</td>
</tr>
<tr>
<td>58 - 120</td>
<td>7</td>
<td>66 - 128</td>
</tr>
<tr>
<td>121 - 247</td>
<td>8</td>
<td>130 - 256</td>
</tr>
<tr>
<td>248 - 502</td>
<td>9</td>
<td>258 - 512</td>
</tr>
</tbody>
</table>

5.3.3 Method

An example will best illustrate the method of MSWECC and MSRECC: If the original message is

1 0 1 0 1 0 1 0 1 0 1 0 1

room is made for the check bits by spacing in the following way:

<table>
<thead>
<tr>
<th>position</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit</td>
<td>X</td>
<td>X</td>
<td>1</td>
<td>X</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>X</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
That is, the check bits go in the positions 1, 2, 4, and 8.

Thirteen may be considered as the sum of 8, 4, and 1; and the 13th bit is used in parity sums which make up the 8th, 4th, and 1st positions but does not enter the parity sum which goes into position 2. Similarly, bit 5 enters into sums 1 and 4; bit 10 enters into sums 8 and 2; and bit 15 enters into all four sums. Any bit enters into a unique combination of sums, since any number from 1 to 15 can be broken down into a sum of 8, 4, 2, and 1 in only one way if each is used at most once. The exact formulas for calculating the parity sums are:

\[
\begin{align*}
C_1 &= D_3 + D_5 + D_7 + D_9 + D_{11} + D_{13} + D_{15} \\
C_2 &= D_3 + D_6 + D_7 + D_{10} + D_{11} + D_{14} + D_{15} \\
C_4 &= D_5 + D_6 + D_7 + D_{12} + D_{13} + D_{14} + D_{15} \\
C_8 &= D_9 + D_{10} + D_{11} + D_{12} + D_{13} + D_{14} + D_{15}
\end{align*}
\]

where the plus sign (exclusive or) represents addition without carries. For the message above

\[
\begin{align*}
C_1 &= 1 + 0 + 0 + 1 + 1 + 1 + 1 = 1 \\
C_2 &= 1 + 1 + 0 + 0 + 1 + 0 + 1 = 0 \\
C_4 &= 0 + 1 + 0 + 0 + 1 + 0 + 1 = 1 \\
C_8 &= 1 + 0 + 1 + 0 + 1 + 0 + 1 = 0
\end{align*}
\]

and the encoded message reads:

<table>
<thead>
<tr>
<th>position</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>bit</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

This is the form in which the message is stored or transmitted.

The decoding process is performed by MSRECC after the message is received but before it is used. The check sums are generated according to the same pattern (including the check position in each sum). An error can be detected because all sums are zero if there is no error. If a one-bit error has occurred, it can be located by the pattern of sums which are affected.
The pattern for single error detecting code, illustrated above, shows that each bit yields a unique pattern when it is in error. For example, if bit 14 changes from a zero to a 1, it yields the following:

```
position  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
bit       1  0  1  1  0  1  0  1  0  1  0  1  1  1
```

It also produces the following sums:

\[ K_1 = 1 + 1 + 0 + 0 + 1 + 1 + 1 + 1 = 0 \]
\[ K_2 = 0 + 1 + 1 + 0 + 0 + 1 + 1 + 1 = 1 \]
\[ K_4 = 1 + 0 + 1 + 0 + 0 + 1 + 1 + 1 = 1 \]
\[ K_8 = 0 + 1 + 0 + 1 + 0 + 1 + 1 + 1 = 1 \]

Since the only bit which enters into the three erroneous sums, \( K_2 \), \( K_4 \), and \( K_8 \), is \( D_{14} \) \((2 + 4 + 8 = 14)\), it is the erroneous one and must be changed from 1 to 0 to restore the message. (This technique also corrects erroneous check bits.)
If two bits are in error, the above method does not work. However, the code has been extended by adding a single check bit in the first position (position 0) to make it double error detecting. Since zero may be thought of as being part of each number \((13 = 8 + 4 + 1 + 0; \ 5 = 4 + 1 + 0; \ 10 = 8 + 2 + 0; \ etc.)\), this bit, \(C_0\), is the sum of all other bits, but does not enter into any other sums itself. With this arrangement none of the check bits is used in calculating any of the others. (See above illustration of double error detecting codes.) Thus, on any single error, the \(K_0\) sum (over all bits) will be 1. On a double error, however, \(K_0\) will be zero, but some of the other \(K\)'s will not be zero. Therefore, by checking \(K_0\) before attempting a correction, it can be determined whether this is an uncorrectable double error \((K_0 = 0)\) or a correctable single error \((K_0 = 1)\).

### 5.3.4 Usage

a) Calling Sequence:

\[
\begin{align*}
\text{TSX} & \quad \text{MSWECC, 4} \\
\text{PZE} & \quad A, 0, N \\
\text{Normal Return}
\end{align*}
\]

(where \(A\) is the first location of the input block and \(N\) is the block length)

b) Storage Required—171 locations.

c) Time Required—\((1.0 + 0.11 \ N)\) milliseconds, where \(N\) is defined above.
EXPAND MESSAGE TO ALLOW FOR CHECK SUMS. PUT ZEROS IN WORDS 1, 2, 4, 8, 16 . . . . ETC

GENERATE SUMS ACCORDING TO PATTERN AND INSERT IN OPEN WORDS

MESSAGE ENCODED

DECODE

GENERATE SUMS ACCORDING TO PATTERN

MESSAGE CORRECT AS IS

ALL SUMS = 0?

NO

MAKE CORRECTION INDICATED BY PATTERN OF ONES IN CHECK SUMS (SEPARATE CORRECTION IN WORD, 36 IN ALL)

DOouble ERROR IN ANY POSITION? (Kg = 0?)

NO

MESSAGE READY FOR USE

YES

MESSAGE IN ERROR

COMPRESS MESSAGE TO ORIGINAL SIZE, LEAVING OUT WORDS 0, 1, 2, 4, 8, 16 . . . . ETC

FIGURE 5-3. MSWECC AND MSRECC FLOW CHARTS
5.4 MERCURY SYSTEM TAPE LOADER (MXLOAD)

MXLOAD receives control at the completion of the Load Tape sequence and using the MSLOAD subroutine completes the loading of the Mercury System tape. The flow charts for the MXLOAD program and the MSLOAD subroutine are shown in Figures 5-4 and 5-5, respectively.

5.4.1 Input Requirements

MXLOAD requires the MSLOAD subroutine, which in turn requires the MSRECC subroutine. The auxiliary Mercury System tape must be placed on tape unit A4.

5.4.2 Output Requirements

MXLOAD completes the loading of the Mercury System tape and transfers control to M0INIT.

5.4.3 Method

MXLOAD checks for an indication of redundancy while the MXLOAD and associated loading programs were being read into the computer. If a redundancy has occurred, MXLOAD rewinds the tape and attempts to load the first file once again. Another redundancy check will produce a halt in the program.

If the redundancy does not persist (or did not happen), MXLOAD transfers to MSLOAD to read in the second file of the Mercury System tape. MSLOAD reads in a record at a time, executes MSRECC to remove the error correction codes, and, if no uncorrectable errors are found by MSRECC, MSLOAD stores the record in the proper core storage location.

If uncorrectable errors are detected in reading the primary system tape, MXLOAD attempts to read in the auxiliary tape. If uncorrectable errors are detected in reading the system auxiliary tape, MXLOAD comes to a halt. If a further attempt at reading the primary tape is requested, the Start button must be pressed to repeat the cycle.

5.4.4 Usage

MXLOAD is entered from the instruction placed in core location 00003 by the load tape sequence. MXLOAD exits to M0INIT following a successful loading of the Mercury System tape.

a) Storage Required—401 locations

b) Error corrections—any halt signifies an error. If another attempt at reading the system tape is desired, the Start button is pressed.
LOAD TAPE SEQUENCE

LOADER IORT MXLOAD, 0, M0RTCC - MXLOAD
+1 TCOA 1
+2 TRA MXLOAD

MXLOAD

REDUNDANCY IN READING LOADER FROM TAPE?

YES

NO

READM

READ IN AND CHECK SYSTEM MSLOAD

NORMAL RETURN

M0INIT

ERROR RETURN

ERROR

RETURN

RESYS

SET ERROR INDICATOR

TRY TO READ AUXILIARY SYSTEM TAPE MSLOAD

ERROR RETURN

NORMAL RETURN

M0INIT

RLOAD

REWIND AND TRY TO READ AGAIN

NO

REDUNDANCY AGAIN?

YES

HALT. TRANSFER WHEN START PRESSED

FIGURE 5-4. MXLOAD PROGRAM FLOW CHART
ENTRY

1A

SAVE XRS
SET RETURN
SET TAPE ADDR
FILNO → A (FILER)

TURN OFF
REDUNDANCY
INDICATOR
IF ON

RST

READ RECORD.
ADDRESS OF LAST WORD
INTO XR2

ADDRESS OF LAST WD
> BUFF + 4

IS ADDRESS OF LAST WORD
> BUFF

RST

READ RECORD.
ADDRESS OF LAST WD → XR2

ADDRESS OF LAST WORD
≤ BUFF

ADDRESS OF LAST WORD
≤ BUFF

REWOIND TAPE
AND SKIP PAST
1ST FILE

READ RECORD
ADDRESS OF
LAST WORD
IN XR2

ADDRESS OF
LAST WD
≤ BUFF + 3
OR > BUFF + 4

YES

NO

= ERROR EXIT
BUFF = BUFFER FOR
READING IN

IF AUX ≠ 0, USE
AUXILIARY TAPE

E

E

2A

FIGURE 5-5. MSLOAD PROGRAM FLOW CHART (Sheet 1 of 3)
FIGURE 5-5. MSLOAD PROGRAM FLOW CHART (Sheet 2 of 3)
C(BUFF) \rightarrow XR1

READ RECORD, ADDRESS OF LAST WORD \rightarrow XR2

ARE THERE EXACTLY 263 WORDS IN RECORD?

YES

EXECUTE MSRECC TO REMOVE CHECK CODES

ERROR

NORMAL RETURN

STORE RECORD IN PROPER CORE LOCATION

LAST RECORD

YES

TEST REDUNDANCY AND SET UP ERROR RETURN IF ON.

EXIT

RETURN TO MXLOAD

FIGURE 5-5. MSLOAD PROGRAM FLOW CHART (Sheet 3 of 3)
5.5 ERROR CORRECTION CODE READER SUBROUTINE (MSRECC)

MSRECC uses the check words formed by MSWECC to detect a double error or to detect and correct a single error in an IBM 7090 computer word. The flow chart for the MSRECC subroutine is shown in Figure 5-3.

5.5.1 Input Requirements

MSRECC requires as input the expanded record which was produced by MSWECC.

5.5.2 Output Requirements

MSRECC examines the check sums and, if no errors or only single errors are observed in any of the 36 bit positions of the computer word, the check sums are removed and the original record is reconstructed. No notification is made of the corrected single errors. Double errors produce an error return from the subroutine.

5.5.3 Method

The method of MSRECC is given in subsection 5.3.3.

5.5.4 Usage

MSRECC is entered from, and exits to, either MXLOAD, MYSCRD, MYRSYS, MYRRRS, or MYSRST.

a) Calling Sequence:

TSX MSRECC, 4

PZE A, 0, N' (where A is the first location of the input block and N' is the total block length including parity and check words)

Error return

Normal return

b) Storage Required—219 locations.

c) Time Required—(1.0 + 0.11N + 0.02E) milliseconds where N is the original block length and E is the number of errors.
5.6 MAIN CONTROLLER INITIALIZATION PROGRAM (M0INIT)

After the Mercury Program System has been read into core storage, various indicators and cells must be set to initial conditions in preparation for the mission computations. M0INIT begins the process of initialization of the Mercury Program System and sets controls for the Monitor Initialization Processor, MYINIT, to complete the process.

The flow chart for the M0INIT program is shown in Figure 5-6.

5.6.1 Input Requirements

Input to M0INIT consists of:

a) The following parameters which specify tape drives for the tapes used in the Mercury Program System:

1) MUTAPA—the primary Message Tape, (A)6
2) MULTP1—the initial Log Tape, (B)6
3) MULTP2—the reserve Log Tape, (B)7
4) MUREST—the primary or auxiliary Restart Tapes, (B or C)9
5) MUSCTP—the Station Characteristics Tape, (A)7

b) TMLSDB—reference table for the input radar data for the remote Mercury tracking stations. TMLSDB contains in order by internal station number an entry for each Mercury radar tracking station. The address field of each entry contains the location of the radar's input table, TMRMXX, where XX may be any value from 01 to 19.

5.6.2 Output Requirements

Upon exit from M0INIT the following locations are set with the indicated initial values.

a) Location 00004—contains a TTR M0RTCC to control real time data channel traps.

b) Location 00010—contains a TTR MTFLPT to control floating-point traps (not used by the Mercury Program System during an actual mission).

c) Location 77777—contains a TTR M0ENDS for ending a run of the Mercury Program System.
d) Locations 07120-07700—the buffer tables for input/output of real time data via the DCC, are cleared.

e) MCDIAG—set to zero; MCDIAG is used to count the entries to M0DIAG.

f) MCCOM1—set non-zero; MCCOM1, when set to zero, indicates good data has arrived over subchannel 1 from the B-GE computer at Cape Canaveral.

g) TMRMXX—the nineteen cells, TMRM01 through TMRM19, are initially set according to the following scheme: a -1 is stored in TMRM01, a -2 is stored in TMRM02, . . . a -19 is stored in TMRM19.

h) MYENBA—the enable/disable instruction used in the QENBA macro. M0INIT sets the address field of MYENBA to enable data channels A, B, C and the DCC (replacing channel F).

5.6.3 Method

M0INIT receives control directly from MXLOAD after phase 1 of the Mercury Program System has been read successfully into core storage. The (transfer) trapping mode indicator is turned off, as is the floating-point trapping mode indicator. All data channels are disabled, the I/O check indicator is turned off, and M0INIT executes a data select instruction for channels A, B and C to clear any remembered traps which may have been waiting of these data channels. All tapes except the primary and auxiliary system tapes used in the Mercury Program System are rewound to their load points.

The DCC buffer areas are cleared. The end-of-file and redundancy tape check indicators are turned off, and the enable mask is set to activate all data channels used in the tracking program when the QENBA macro or the MYENBA instruction is executed. Trap transfer instructions are stored in the appropriate low core locations. MCDIAG is set to zero and MCCOM1 is set non-zero.

The B indicator is turned on for MYINIT so that M0PRIO may give control to MYINIT to complete the initialization of the Mercury Program System. The E indicator for MYACQD is turned on to suppress the acquisition data program during the launch phase. The high-abort program, CCABRT, is suppressed with its C indicator and the orbit-re-entry output computations program, O5ORMC, is suppressed with its E indicator. Three programs—the edit, differential correction and orbit restart-tape search programs—not yet loaded from the System tape into core storage, are suppressed with their D indicators. M0INIT exits to M0PRIO.

5.6.4 Usage

M0INIT is entered from MXLOAD; M0INIT exits to M0PRIO.
a) Storage Required—56 locations

b) MOINIT uses:
   1) Program—MYENBA (used as communication cell)
   2) Macro—TRNON
   3) Parameters—B, C, D, E, MUTAPA, MULTP1, MULTP2, MUREST, MUSCTP, MNINIT, MNACQD, MNABRT, MNLED1, MNDIFC, MNSRST and MNORMC
   4) Communication cells—MCCOM1 and MCDIAG
   5) Tables—TMLSDB, TMRM01 . . . . TMRM19
   6) Constants—K00000, KM0001 and K40007

c) Time Required—3.72 milliseconds
LEAVE TRANSFER AND FLOATING POINT TRAPPING MODES

DISABLE ALL CHANNELS. TURN OFF I/O CHECK INDICATOR

MOVE TAPES ON CHANNELS A, B & C TO CLEAR ANY WAITING TRAPS

REWIND
A6, MSG. TAPE
B6, LOG TAPE 1
B7, LOG TAPE 2
B9, RESTART TAPE
C9, AUX. RESTART

CLEAR ALL DCC INPUT/OUTPUT BUFFER AREAS

REWIND
A7, STA. CHAR. TAPE

MCDIAG COUNTS ENTRIES TO MODIAG. MCCOM1 = 0 IF GOOD DATA RECEIVED FROM B-GE (SUBCH 1)

TURN OFF EOF AND TAPE CHECK INDICATORS

SET MYENBA MASK TO ENABLE ALL CHANNELS

INITIALIZE L.S. RADAR INPUT TABLES:
STORE -XX TMRMXX
WHERE XX = 01, 02, ... 19

SET REAL TIME TRAP LOCATION TTR MORTCC → 00004

SET FLOATING POINT TRAP LOC. TTR MTFLPT → 00010

SET TRANSFER FOR MISSION END TTR MOENDS → 77777

SET MCDIAG = 0 MCCOM1 = 0

FIGURE 5-6. M01NIT PROGRAM FLOW CHART
5.7 MONITOR INITIALIZATION PROCESSOR (MYINIT)

MYINIT continues to prepare the Mercury Program System for data processing and transmission by activating the one-minute WWV pulse subchannel of the Data Communications Channel (which, through the usage of MTWWVI, provides the Mercury Program System with the knowledge of external, i.e., real time), providing controls for loading the Station Characteristics tape, and then activating the high-speed, timing control, and paper tape input subchannels of the DCC.

When control returns to M0PRIO following a normal entry to, and the complete execution of MYINIT, the Mercury Program System is ready to commence processing data. When MYINIT has been entered for a system restart, processing commences with the completion of MYINIT, but additional operations are required to bring the system up to date.

The flow chart for the MYINIT processor is shown in Figure 5-7.

5.7.1 Input Requirements

Input to MYINIT consists of:

a) M—parameter defining the number of routines in the Mercury Program System which receive control at a specified half-second time interval (see MTHFSC, Section 3).

b) MCREST—indicates, when non-zero, MYINIT has been entered for a system restart. When non-zero, MCREST contains the restart time.

c) TMSTCH—indicates, when zero, the Station Characteristics tape has been successfully loaded.

5.7.2 Output Requirements

Output from MYINIT consists of:

a) MCHFS1—the parameter, M, is stored in MCHFS1.

b) The additional output from MYINIT consists of control functions; these are described in Subsection 5.7.3, below.

5.7.3 Method

MYINIT receives control from M0PRIO immediately after the completion of M0INIT, since MYINIT is the only routine with its B indicator on in the priority table and all DCC subchannels are deactivated. MYINIT turns its own A indicator on and B indicator off.
The WWV one-minute pulse subchannel is activated and MYINIT comes to a halt (HTR \* + 1), and processing by MYINIT discontinues until the Start button on the 7090 console is depressed. However, at the next exact minute the WWV trap occurs (see write-up for MTWWVI) and control transfers to MTWWVI via M0RTCC. If the time of initialization, i.e., the current real time, is properly entered in the computer console keys, the GMT time base for the Mercury Program System is entered into the computer. A restart time, if placed in the keys, is also accepted by MTWWVI. Two on-line messages are provided by MTWWVI which notify the computer personnel that the current time is now part of the Mercury Program System. The computer operator now depresses the Start button and MYINIT continues from the point of the halt.

MYINIT then turns on the B indicator for MYSCRD and loops on a zero test of the cell, TMSTCH. Since MTWWVI has activated the half-second trap subchannel of the DCC, MYINIT cycles on the test of TMSTCH for no more than one half of a second. The half-second trap sends control to MTHFSC. At the completion of the half-second trap processor, control transfers to M0PRIO. M0PRIO scans the priority table, finds the B indicator on for MYSCRD, and since MYSCRD has a priority higher than MYINIT, M0PRIO gives control to MYSCRD which reads the Station Characteristics tape into core storage. When the tape is successfully read, MYSCRD sets TMSTCH to zero. (Although MYINIT receives control periodically throughout the cycling which accompanies the loading of the Station Characteristic tape, MYINIT cannot proceed until the tape has been read successfully and TMSTCH set to zero.)

When MYINIT receives control and finds TMSTCH contains zero, MYINIT determines whether or not a restart time was given to MTWWVI together with the initialization time. If a restart time was given, MYINIT suppresses the main launch computations programs, MNLCCM, while queueing MYQSYS with input which requests the restart tape search program be loaded from the System tape. The main launch processor is then queued with an input of zero to indicate restart and the paper tape input subchannel is activated. The A indicator for MYINIT is turned off and control returns to M0PRIO.

Under normal conditions there is no restart time and MYINIT activates the high-speed input subchannels, 1 and 2, and the paper tape input subchannel, 30. The parameter, M, is stored in MCHFS1 for MTHFSC, the A indicator for MYINIT is turned off and control returns to M0PRIO.

5.7.4 Usage

MYINIT is entered from, and exits to, M0PRIO.

a) Storage Required—34 locations

b) MYINIT uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON
2) Parameters—A, B, C, M, MNINIT, MNLCCM, MNQSYS and MNSCRD

3) Communication cells—MCACTV, MCHFS1 and MCREST

4) Table—TMSTCH

c) The time required by MYINTL is indeterminant since it depends upon the time initialization of the system by MTWWVI and upon the processing of the Station Characteristic tape by MYSCRD and MTENST. However, since MYINIT must be executed prior to data processing, the timing considerations have no effect on real time system operation. If only two machine cycles would be required for the halt and the TMSTCH cell contains zero, the time required by MYINIT would be either the maximum of 0.257 millisecond or a minimum of 0.098 millisecond.
FIGURE 5-7. MYINIT PROGRAM FLOW CHART
5.8 MONITOR STATION CHARACTERISTICS TAPE PROCESSOR (MYSCRD)

MYSCRD functions only during the initialization phase of the Mercury Program System. This processor is used in conjunction with its trap processor, MTENST, to read into core storage the Station Characteristics from the Station Characteristics tape. MYSCRD initiates transmission of one record into core storage. When transmission is completed, a trap occurs and MTENST receives control and checks for an error in transmission. MYSCRD receives control again, processes the record just read, and, if more records remain to be processed, MYSCRD initiates transmission of the next record. The cycle continues until all records have been read and processed.

The Station Characteristics tape reading cycle is illustrated in Figure 5-8. The flow chart for the MYSCRD processor is shown in Figure 5-9. The Station Characteristics block is illustrated in Table 5-1.

5.8.1 Input Requirements

Input to MYSCRD consists of:

a) MUSCTP, MUSCTl—parameters designating the unit tape addresses of the primary and auxiliary Station Characteristics tapes, (A) 7 and 8, respectively. The tapes must be written in binary* with error correction codes included. The number of station characteristic records, MNSCNO, and the word length of each record, MNCHAR, are specified as parameters and as such may assume any value. The tape consists of one file.

b) MNCHAR—parameter designating the number of words, i.e., the length, of a Station Characteristics block, after the error correction codes have been removed. MNCHAR has the value of 34.

c) MNSCNO—parameter designating the number of Station Characteristics blocks to be read into core storage. MNSCNO has the value of 24. MNSCNO is one less than the number of records on the Station Characteristics tape, since the first record is an identification record.

d) TMSTCH –25-cell table with the following format:

* The programs used to write and update the Station Characteristics tape are described in MC 107, External System Programs.
### TABLE 5-1. STATION CHARACTERISTICS BLOCK CONTENTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Source</th>
<th>Source Format</th>
<th>Source Unit</th>
<th>Converted Format</th>
<th>Converted Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Geodetic Latitude (φ)</td>
<td>Given</td>
<td>Dec.</td>
<td>DMS*</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>8 Geocentric Latitude (φ')</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 sin φ</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 cos φ</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 ( R_s \sin (φ-φ') )</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 ( R_s \cos (φ-φ') )</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Radius from Earth Center to Sta. ( (R_s) )</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Altitude above Ellipsoid ( (H) )</td>
<td>Given</td>
<td>Dec.</td>
<td>Meters</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>15 Local Vertical Deflection Longitude ( (Δλ) )</td>
<td>Given</td>
<td>Dec.</td>
<td>DMS*</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>16 Local Vertical Deflection Latitude ( (Δφ) )</td>
<td>Given</td>
<td>Dec.</td>
<td>DMS*</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>17 Calibrated Boresight Elevation</td>
<td>Given</td>
<td>Dec.</td>
<td>DMS*</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>18 Calibrated Boresight Azimuth</td>
<td>Given</td>
<td>Dec.</td>
<td>DMS*</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>19 Inertial Longitude at Reference Time</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Air Pressure at Ground Level ( (P_a) )</td>
<td>Given</td>
<td>Dec.</td>
<td>Millibars</td>
<td>Flt. Pt.</td>
<td>Millibars</td>
</tr>
<tr>
<td>21 Temperature at Ground Level ( (T_g) )</td>
<td>Given</td>
<td>Dec.</td>
<td>°C</td>
<td>Flt. Pt.</td>
<td>°K</td>
</tr>
<tr>
<td>22 Water Vapor Content at Ground Level ( (E_g) )</td>
<td>Given</td>
<td>Dec.</td>
<td>Millibars</td>
<td>Flt. Pt.</td>
<td>Millibars</td>
</tr>
<tr>
<td>23 Azimuth Deviation from True North</td>
<td>Given</td>
<td>Dec.</td>
<td>DMS*</td>
<td>Flt. Pt.</td>
<td>Radians</td>
</tr>
<tr>
<td>26 Square Root of Weight 3 (Elevation)</td>
<td>Given</td>
<td>Dec.</td>
<td></td>
<td>Flt. Pt.</td>
<td></td>
</tr>
<tr>
<td>27 Modulus (n-1)</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 R sin (φ-φ')</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 R cos (φ-φ')</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 sin φ'</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 cos φ'</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 Boresight Elevation Correction ( (C_3) )</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 Boresight Azimuth Correction ( (C_2) )</td>
<td>Computed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 Open for Expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*DMS—degrees, minutes and seconds

**Original Input—raw radar reading
The first cell is used as an internal indicator for MYSCRD and as a communication cell by MYINIT. Initially, TMSTCH has the value shown above. In the first pass through MYSCRD, when transmission is initiated to read the identification record, a 5 is stored in TMSTCH. On the second entry to MYSCRD, if the error correction codes are successfully removed from Station Characteristics block, a 6 is stored in TMSTCH. After the last Station Characteristics block has been read and error corrected, TMSTCH is cleared. TMSTCH + 1 contains the location preceding the permanent core location of Station Characteristics block for the first radar station, the Cape Canaveral AN/FPS-16. Symbolically, this location is: TMCHAR-1 (the location of the first word in the block is TMCHAR). TMSTCH + 2 contains the location preceding the permanent core storage location of the Station Characteristics block for the second radar station, the Grand Bahama Island AN/FPS-16; TMCHAR + MNCHAR-1. TMSTCH + 17 contains the location preceding the permanent core storage location of the Station Characteristics block for the last radar station, the Eglin Verlort: TMCHAR + 16* MNCHAR-1. The next two locations in TMSTCH refer to the two Bermuda radars, but specifically refer to the smoothed radar values as transmitted from the Bermuda IBM 709 computer. The last five entries in TMSTCH reference Station Characteristics blocks for the five non-radar telemetry stations in the Mercury network.

e) TMBFBK—a temporary storage buffer into which the Station Characteristics tape records are read and are error corrected prior to being moved to permanent locations.

f) MCSCER—communication cell used by MYSCRD and MTENST in reading the Station Characteristics tape. If MTENST receives control on a trap following an end-of-file, instead of the IORT command, the sign of MCSCER is set negative to indicate this fact to MYSCRD. MCSCER is also used by MYSCRD to indicate whether the primary or auxiliary tape is being used. When the contents of MCSCER are zero,
the primary tape is being read.

5.8.2 Output Requirements

Output from MYSCRD consists of:

a) TMSTCH—the contents of this location may be changed depending upon the entry to MYSCRD (see Input Requirements, above).

b) TMCHAR—the Station Characteristics blocks are stored in their respective locations in TMCHAR.

c) MCSCER—set to indicate which Station Characteristics tape is currently being processed.

5.8.3 Method

MYSCRD initially receives control after its B indicator is turned on by MYINIT. Thereafter, the B indicator for MYSCRD is turned on by MTENST after each trap which follows the reading of a record from the Station Characteristics tape. For every entry MYSCRD turns its own A indicator on and B indicator off. The programs which use channel A, MYMESS, MYCDRD and MYRSYS, and the programs which use the MSRECC subroutine, MYRRRS, MYSRST and MYRSYS, are suppressed and the instruction, TTR MTENST, is stored in the channel A trap control location, 00013.

The nominal sequence of operations by MYSCRD is given below:

a) On the initial entry to MYSCRD, a 5 is stored in TMSTCH, the primary Station Characteristics tape is rewound, and the I/O command is given to read the first, the identification, record into core storage. The A indicator for MYSCRD is turned off and control returns to M0Prio.

b) On the second pass MYSCRD uses the Error Correction Code Reader Subroutine, MSRECC, to remove the error correction codes from the Identification record first read. If a normal return is given from this subroutine, the value for the longitude of aries is taken from the seventh location of the identification record and stored in the provided location, KLAMDO. A 6 is stored in TMSTCH to indicate the first record has been processed. MYSCRD then gives the I/O command to read the first Station Characteristics record into core. The A indicator for MYSCRD is turned off and control returns to M0Prio.

c) On every successive pass except the last, MYSCRD uses the MSRECC subroutine to remove the error correction codes, stores the corrected Station Characteristics block in the preassigned location, and initiates transmission of the next record.
MYINIT
INITIALIZATION
PROCESSOR SETS
CONTROL TO
ENTER CYCLE

MYSCRD:
PROCESSES
RECORD M. READS
RECORD M + 1
FROM TAPE

MTENST:
SETS CONTROL
FOR NEXT
ENTRY INTO
MYSCRD

INDICATOR SET BY MYSCRD

PASS TMSTCH
INITIALLY -377 7
1 000 5
2,3…N 000 6
N+1 000 0

N = NO. OF STATION
CHARACTERISTICS ON TAPE

FIGURE 5-8. STATION CHARACTERISTICS TAPE READING CYCLE
If at any time an end-of-file produces a trap on channel A during the reading of Station Characteristics tape or, if any record read cannot be error corrected by MSRECC, MYSCRD resets the TMSTCH indicator cell, changes the address fields for the instructions which control the Station Characteristics tape and attempts to read the auxiliary Station Characteristics tape. Any further error encountered produces an on-line print which states: NEITHER STATION CHARACTERISTICS TAPE CAN BE ERROR CORRECTED. When this occurs there is no alternative to reloading the system.

On the final entry to MYSCRD, TMSTCH is cleared to signal MYINIT that the Station Characteristics tape has been read successfully and an on-line message provides the same information to the computer personnel. The programs suppressed on the original entry to MYSCRD are unsuppressed and control is transferred to M0PRIO. Barring a system restart, MYSCRD is not used again.

5.8.4 Usage

MYSCRD is entered from, and exits to, M0PRIO.

a) Storage Required—108 locations

b) MYSCRD uses:

1) Subroutine—MSRECC
2) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON
3) Parameters—A, B, E, D, F, MNCDRD, MNCHAR, MNMESS, MNRRRS, MNRSYS, MNSCNO, MNSCRD, MNSRST, MNSCT2 and MNSCTP.
4) Communication cell—MCSCER
5) Tables—TMBFBK, TMCHAR and TMSTCH
6) Constants—K00001, K00005, K00006, KLAMDO, K00084 and K00270
7) Absolute location—00013

c) Time Required:

1) Minimum—0.152 millisecond
2) Maximum—4.87 milliseconds

Most of maximum time given—approximately 4.04 milliseconds—is taken by the MSRECC subroutine. However, time is not extremely critical for MYSCRD since the processor functions only in the pre-launch (or pre-restart) phase.
FIGURE 5-9. MYSRCD PROGRAM FLOW CHART (Sheet 1 of 2)
Figure 5-9. MYSCRD Program Flow Chart (Sheet 2 of 2)
5.9 MONITOR STATION CHARACTERISTICS TAPE TRAP PROCESSOR (MTENST)

MTENST receives control from the channel A trap following the reading of a record from the Station Characteristics tape into core storage. This trap processor checks to determine whether or not an end-of-file caused the trap and sets an indicator for MYSCRD based on this determination.

The flow chart for the MTENST trap processor is shown in Figure 5-10.

5.9.1 Input Requirements

The sole input to MTENST consists of the location set by the computer when the trap occurred, location 00012. A 1 in bit position 15 is indicative of a trap produced by an end-of-file sensed in reading the tape.

5.9.2 Output Requirements

If the trap was the result of an end-of-file, the sign of MCSCER is set negative to indicate this condition to MYSCRD.

5.9.3 Method

MTENST receives control from the channel A trap following the reading of a record (or an end-of-file, if an error occurs) from the Station Characteristics tape into core storage. The trap processor executes the SAVE macro to preserve the condition of the interrupted program.

MTENST examines bit position 15 of location 00012. If the bit is a 1, an end-of-file has been read and MTENST sets the sign of MCSCER negative.

The B indicator is turned on to continue the processing of the Station Characteristics tape by MYSCRD and the suppression bits set by MYSCRD for MYMESS and MYCDRD, which share channel A with MYSCRD, are turned off and program control transfers to M0PRIO.

5.9.4 Usage

MTENST is entered from a trap transfer instruction (TTR MTENST) in the channel A trap control location (00013); MTENST exits to M0PRIO.

a) Storage Required—18 locations

b) MTENST uses:

1) Macros—SAVE, TRNOF and TRNON

2) Parameters—B, E, MNCDRD, MNMESS and MNSCRD
3) Communication cell—MCSCER

4) Absolute location—00012

c) Time Required—0.202 millisecond
FIGURE 5-10. MTENST PROGRAM FLOW CHART
5.10 CONTROL DURING LAUNCH-TO-HIGH ABORT/ORBIT

At the termination of powered flight, a decision must be made as to whether or not the capsule has the flight characteristics for an acceptable orbit. If powered flight terminates prior to tower separation, the capsule cannot attain orbit and a low-abort or a medium-abort phase follows. These are described in Subsections 4.11 and 4.12, respectively.

An abort after tower separation involves in succession the elements of both an abort phase and a re-entry phase and has the following characteristics: (1) the launch programs provide a range and a velocity vector to the numerical integration program, which generates an abort table; (2) in like manner, a re-entry table is generated from the range and velocity vectors at the computed, predicted retrofire time; (3) the input processing programs obtain from capsule telemetry or manually-inserted paper tape messages the actual time of retrofire and from these the re-entry table and the impact point are determined; (4) the edit and differential correction programs are loaded into computer core storage to allow the processing of low-speed data transmitted by teletype from the radar tracking sites; (5) acquisition data is transmitted to the tracking stations. A detailed description of the Monitor programs which control the high-abort phase is given in Subsections 4.16 through 4.19. The Monitor processors which load the edit and differential correction programs are described in the following subsections. A re-entry from high-abort in similar to a re-entry from orbit, except that in the former a restart tape is not written, precluding a restart in a re-entry from high abort.

The normal launch-to-orbit interphase begins when the Monitor Orbit Suffix to MFLHLD, MFLORB, receives control (MFLHLD, described in Subsection 4.14, is a Monitor Suffix to the main launch/hold computations programs). MFLORB sets controls: (1) to provide the numerical integration program with the insertion vectors computed by the launch programs, to generate the initial orbit table; (2) to activate the low-speed input subchannels of the Data Communications Channel to allow input of the tracking data from the Mercury radar network; (3) to load the edit and differential correction programs from the Mercury System Tape; (4) to print on-line messages which define the insertion vectors; (5) to initiate the writing of the first record on the restart tape. MFLORB is described in detail in Subsection 4.20. The write-ups for the Monitor programs which load edit and differential correction and which write the restart tape are given in the following subsections.
5.11 MONITOR SYSTEM TAPE QUEUEING PROCESSOR (MYQSYS)

MYQSYS receives control when one of the programs of the Mercury Program System recognizes the need to load a file from the Mercury System tape.

MYQSYS acts as a queueing processor for the Monitor System Tape Processor, MYRSYS, since the usage of the MYRSYS B indicator by MYRSYS and its trap processor makes unqueueing in MYRSYS itself impractical.

The flow chart for the MYQSYS processor is shown in Figure 5-11.

5.11.1 Input Requirements

Input to MYQSYS consists of an entry in the MYQSYS queue table. This entry contains the number of the file to be loaded from system tape. MYQSYS also requires the five-cell TMSYSR table which contains system constants relating the requested file numbers to the numbers of the on-line messages reporting the requested file numbers.

5.11.2 Output Requirements

Output from MYQSYS consists of the communication cell, MCTSET, which contains in the address the number of the requested file. This cell is set for MYRSYS. The core storage area into which the file is to be loaded is cleared.

5.11.3 Method

MYQSYS receives control from M0PRIO, turns on its A indicator, disables, unqueues the oldest entry from the MYQSYS queue table, and enables the computer. The word from the queue specifies the file to be loaded. MYQSYS uses the file number to reference the message number table, TMRSYS, to obtain the message for the requested file and the designated message is queued.

MYQSYS clears the core area for the file to be read. The B indicator for MYRSYS is turned on to indicate the program is ready to begin loading the requested file. MYQSYS then turns on its C indicator to suppress itself until after the complete file has been successfully loaded (this suppression is removed by MYRSYS after the last record of the file has been loaded). MYQSYS turns off its A indicator and returns control to M0PRIO.

5.11.4 Usage

MYQSYS is entered from, and exits to, M0PRIO.

a) Storage Required—30 locations

b) MYQSYS uses:
1) Macros—QENBA, QENBZ, QUEUE, TRNOF, TRNON and UNQUE
2) Parameters—A, B, C, MNMESS, MNQSYS and MNRSYS
3) Communication cell—MCTSET
4) Table—TMRSYS

c) Time Required—10 milliseconds
FIGURE 5-11. MYQSYS PROGRAM FLOW CHART

ETREQ contains relative TMSYSR location corresponding to requested file.

MyQsys is suppressed until requested file is loaded successfully.

Queue, mnmess (message stating file requested) etreq.

Clear memory area for the file to be loaded.

Trnon B Mnrsys.

Trnon C Mnqsys.

Trnof A Mnqsys.

MoPrio.
5.12 MONITOR SYSTEM TAPE PROCESSOR (MYRSYS)

MYRSYS loads Mercury system programs in real time with a minimum of interference and delay to system operation. It's original raison d'être was, in conjunction with interphase processors, to facilitate the integration of the launch sub-system and the orbit/re-entry sub-system into one system. Since core storage cannot contain both sub-systems simultaneously, MYRSYS accomplishes the sub-system integration by loading two large orbit programs, Edit (E0LED1) and Differential Correction (D0DIFC), over launch processors during interphase following launch. In addition, MYRSYS also loads the restart program, MYSRST, when required*.

The flow chart for the MYRSYS processor is shown in Figure 5-12.

5.12.1 Input Requirements

Input to MYRSYS consists of:

a) MUPRIM—parameter designating the channel A tape drive, 1, containing the primary system tape.

b) MUAUXL—parameter designating the channel A tape drive, 4, containing auxiliary system tape.

c) TMSYSF—five-cell table containing system constants which relate the system files loaded to message numbers for on-line messages reporting what files have been loaded.

d) MCTSET—contains in the address the number of the requested file and in the decrement the usage of primary or auxiliary system tape is indicated by zero or a 1, respectively.

e) MCETRT—communication cell used a switch (see switch Y on the flow chart) which directs control to internal branches of MYRSYS initiating tape motion.

f) MCFILR—contains the number of the requested file.

g) MCMTRS—contains the trap transfer instruction (TTR MTRSYS) to transfer control to MTRSYS on a channel A trap caused by completion of reading a record or a file. This instruction is stored into location 00013 by MYRSYS before tape reading is initiated.

* In the future MYRSYS, with minor modifications, will provide for real time buffering of system programs to expand the versatility of the Mercury Program System.
h) MCSYSF—when non-zero, indicates the edit and differential correction programs have been loaded.

i) Location 00012—contains the contents of the instruction counter when the channel A trap occurred.

5.12.2 Output Requirements

Output from MYRSYS consists of:

a) MCFILR—contains the number of the requested file.

b) MCTSET—if the requested file cannot be successfully loaded from the primary tape, a 1 is stored in the decrement of MCTSET to indicate the auxiliary tape is to be used.

5.12.3 Method

MYRSYS locates requested files regardless of tape position at the time it begins searching. It uses the data channel trap features, i.e., simultaneous input-output/compute ability of the IBM 7090, to avoid system interference or delay. After locating the requested file, MYRSYS only initiates tape motion to read one record, sets a switch $Y$ (see flow chart) for internal control, and immediately transfers control to M0PRIO. M0PRIO is then free to give control to any processor which does not require channel A or the MSRECC subroutine. (The usage of data channel A and MSRECC is normally restricted only for the time required to read one 264-word record). The maximum delay to channel A and MSRECC usage occurs only for the period of time required to space one file while MYRSYS searches for the requested file. Upon completion of reading one record or spacing one file, the consequent trap gives control to MTRSYS which unit suppresses all programs using channel A and MSRECC. MTRSYS turns on the B indicator for MYRSYS, then transfers control to M0PRIO. M0PRIO can then give control to any waiting channel A or MSRECC operations in priority order before again giving control to MYRSYS.

When MYRSYS locates the requested file, the cycle of operations is as follows:

a) MYRSYS—(1) initiates reading of a record, (2) sets switch $Y$ for internal control, and (3) returns control to M0PRIO.

b) Upon completion of reading one record, the trap transfers control to MTRSYS. MTRSYS—(1) check for a legal type of trap, (2) sets communication cell, MCCHAN, for MYRSYS with location plus one of last word read in from the system tape, (3) unsuppresses all other channel A operations and programs using MSRECC, (4) turns on the B indicator for MYRSYS, and (5) transfers control to M0PRIO.
c) After M0PRIO reaches MYRSYS in the priority table, MYRSYS (1) again suppresses all other channel A and MSRECC usage, (2) tests switch \( \gamma \) to determine internal control transfer, and, normally passes control to program branch denoted by switch position, \( \gamma = 5A \), (5) tests MCCHAN to determine if correct record was read, (6) if the above test is successful, the MSRECC subroutine makes any necessary, and possible, corrections of errors in the record read, (7) transfers record from the input buffer to the permanent core location, and (8) initiates reading of the next record until all records in the requested file are properly loaded. If uncorrectable errors are detected by MSRECC, MYRSYS selects the back-up auxiliary system tape and attempts to load from it.

5.12.4 Usage

MYRSYS is entered from, and exits to, M0PRIO.

a) Storage Required—228 locations

b) MYRSYS uses:

1) Macros—QENBA, QENBZ, QUEUE, SAVE, TRNOF and TRNON

2) Parameters—A, B, C, D, E, F, G, MCNCDRD, MNDIFC, MNLCCM, MNLED1, MNMESS, MNMSCK, MNREST, MNRRRS, MNRSYS, MNSCRD, MUAUXL, and MUPRIM

3) Communication cells—MCCHAN, MCETRT, MCFILR and MCTSET

4) Table—TMSYSF

5) Constants—K00001, KD0001, K00267 and K00269

6) Absolute location—00013

c) Times Required:

1) To load one error-corrected record

<table>
<thead>
<tr>
<th></th>
<th>High Density Tape</th>
<th>Low Density Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>105 milliseconds</td>
<td>140 milliseconds</td>
</tr>
<tr>
<td>Minimum</td>
<td>65 milliseconds</td>
<td>105 milliseconds</td>
</tr>
</tbody>
</table>

2) To space one file of 3000 words 500 milliseconds 1000 milliseconds

(The time between the on-line message indicating that a 3000-word file has been requested and the message stating the file has been
loaded ranges in the present Mercury system from 2 to 10 seconds. This includes the time required to read the two messages from the message tape, and all the time consumed by other system programs between the reading of these two messages.)
FIGURE 5-12. MYRSYS PROGRAM FLOW CHART (Sheet 1 of 6)
FIGURE 5-12. MYRSYS PROGRAM FLOW CHART (Sheet 2 of 6)
Figure 5-12. MYRSYS Program Flow Chart (Sheet 3 of 6)
FIGURE 5-12. MYRSYS PROGRAM FLOW CHART (Sheet 4 of 6)
FIGURE 5-12. MYRSYS PROGRAM FLOW CHART (Sheet 5 of 6)
MESSAGE DENOTING WHICH FILE HAS BEEN LOADED SUCCESSFULLY

RESET y = 1A FOR NEXT REQUEST

RESET MEMORY LOCATIONS USED AS BUFFER AND SHARED WITH EOLED1 (H$P4TXI)

DODIFC AND EOLED1 SUPPRESSED IN M0INIT-UNTIL READ IN FOR LAUNCH-TO-HIGH ABORT OR LAUNCH-TO-ORBIT PHASE CHANGE

UNSUPPRESS TO ALLOW UNQUEUEING OF OTHER ENTRIES FOR MYRSYS

FIGURE 5-12. MYRSYS PROGRAM FLOW CHART (Sheet 6 of 6)
5.13 MONITOR SYSTEM TAPE TRAP PROCESSOR (MTRSYS)

MTRSYS receives control from the channel A trap following transmission initiated by MYRSYS to load from the Mercury System tape. MTRSYS determines whether or not trap resulted from a legal operation—an end-of-file read or a command trap—and directs the control of MYRSYS as dictated by this determination.

The flow chart for the MTRSYS trap processor is shown in Figure 5-13.

5.13.1 Input Requirements

Input to MTRSYS consists of:

a) Location 00012—control word set by the computer when a channel A trap occurs. By examining bit positions 15, 16 and 17, MTRSYS determines whether or not the trap was valid for system tape loading.

b) MCTSET—contains in the decrement an indication of the system tape, primary or auxiliary, currently being read.

c) MCFILR—contains in the address the number of the requested file, i.e., the file currently being read.

5.13.2 Output Requirements

Output from MTRSYS consists of:

a) MCCHAN—the contents of the channel A address register are stored in the address of MCCHAN. This enables MYRSYS to determine the number of words read from the system tape.

b) If the channel A trap resulted from any condition other than either a command trap or an end-of-file, MTRSYS queues an on-line message which specifies the error condition. MTRSYS then inverts the right-most bit in the decrement of MCTSET to switch tapes, resets the switch, \( \gamma \) (in MCETRT), to its initial position (\( \gamma = 1 \) A in MYRSYS), and stores the requested file number from MCFILR into the address of MCTSET.

5.13.3 Method

MTRSYS executes the SAVE macro to preserve the condition of the interrupted program and then examines the word set by the computer when the trap occurred. If the examination discloses an illegal trap, MTRSYS queues an online message to that effect, sets MCTSET for MYRSYS to switch tapes and re-initializes the control switch \( \gamma \) (MCETRT) for MYRSYS.
MTRSYS then saves the location plus one (the address register of data channel A) of the last word read into core storage. The suppressions set by MYRSYS to prohibit other data channel A and MSRECC usage are removed by turning off: the F indicator for MYRRRS, the D indicator for MYSRST, the E indicator for MYSCRD, and the G indicator for MYCDRD, MYMESS and MYMSCK. The B indicator for MYRSYS is turned onto to continue the system loading process and control transfers to M0Prio.

5.13.4 Usage

MTRSYS is entered from a trap transfer instruction (TTR MTRSYS) in the channel A trap control location (00013); MTRSYS exits to M0Prio.

a) Storage Required—54 locations

b) MTRSYS uses:

1) Macros—QUEUE, SAVE, TRNOF and TRNON

2) Parameters—B, D, E, F, G, MNCDRD, MNMESS, MNMSCK, MNRRRS, MNRSYS, MNSCRD and MNSRST

3) Communication cells—MCCHAN, MCETRT, MCFILR and MCTSET

4) Absolute location—00012

5) Constants—K00000, K00267, K00269 and KD0001

c) Time Required:

1) Minimum—0.136 millisecond

2) Maximum—0.255 millisecond
LOCATION 10 (00012)
SET BY COMPUTER WHEN TRAP OCCURS. THIS LOCATION GIVES REASON FOR TRAP

B17 = 1, COMMAND TRAP
B16 = 1, TRAP CAUSED BY I/O CHECK
B15 = 1, TRAP CAUSED BY END-OF-FILE

FAMER
SET FAQER FOR MSG 289: LOC 10 HAS ILLEGAL BIT CONFIGURATION WILL TRY AUXILIARY SYST. TAPE

FATER
YES
SET FAQER FOR MSG 267: TRAP DUE TO TAPE CHECK: MACHINE ERROR
NOT ENABLED FOR TAPE CHECK

FAQMS
QUEUE MNSMESS WITH FAQER TO PRINT ERROR MSG.

AUXILIARY SYSTEM TAPE LAST USED?
D(MCTSET) ≠ 0

NO
SET D(MCTSET) = 1 TO LOAD FROM AUXILIARY SYSTEM TAPE

RESET D(MCTSET) = 0 TO LOAD FROM PRIMARY SYSTEM TAPE

Y IN LOC. MCETRT

RESET Y = 1A IN MYRSYS

FIGURE 5-13. MTRSYS PROGRAM FLOW CHART
5.14 MONITOR RESTART TAPE WRITER PROCESSOR (MYWRRS)

MYWRRS initiates transmission to write a record on the restart tape.

The flow chart for the MYWRRS processor is shown in Figure 5-14.

5.14.1 Input Requirements

Input to MYWRRS consists of:

a) MNNWRRB—parameter designating the number of words in the TMREST table (31).

b) MNNWR1—parameter designating the number of data words required by TMRST1 in addition to the number required by TMREST (1).

c) MNNWR2—parameter designating the number of additional words required to incorporate error-correction codes within TMSRT1 (10).

d) MUREST—parameter designating the unit tape address of the restart tape (9).

e) TMREST—MNNWRRB-cell table (see Table 5-2) containing all except one of the values to be written on the restart tape. Entries in the table are initially made by MFML6A, MFHSGB, MFHS08, MFHS09 and MFLORB and may be updated by the suffixes to IOMANI upon receipt of a manually-inserted message. Each time a differential correction is accepted, MFDIFC updates appropriate values in the restart table.

f) MCHFSC—the current GMT in fixed-point half seconds.

g) MCWWWV—contains the current GMT in 8-1/3 milliseconds (updated every minute) during an actual mission. During a simulated mission, MCWWWV is not used as a time cell. Consequently, MCWWWV may be used to determine whether the program is running in an actual or simulated mission. (In a simulated mission, there is no channel C restart tape, Channel C being reserved to handle simulation control functions.)

h) MCRCMD—communication cell containing the data channel command for reading or writing the restart tape.

5.14.2 Output Requirements

Output from MYWRRS consists of:

a) TMRST1—table of MNNWRRB + MNNWR1 + MNNWR2 cells, used by MYWRRS to store the TMREST table (MNNWRRB words). MYWRRS
adds a time tag (MNNWRL word) and presents TMRST1 to the MSWECC subroutine, which expands the data to include error correction hamming codes, increasing the length by MNNWR2 words. This expanded table (Table 5-2) is now written on the restart tape.

b) Location 00015—the trap control location for channel B contains a trap transfer (to MTWRS1) instruction.

c) Location 00017—the trap control location for channel C contains a trap transfer (to MTWRRS) instruction.

5.14.3 Method

The first record on the restart tape is written as part of the normal launch-to-orbit interphase. This record contains the mission conditions at insertion into orbit. Thereafter, with each accepted differential correction certain values are updated and with these updated values MYWRRS writes another record on the restart tape. Manually-inserted messages provide new information for the restart tape, but do not initiate the writing of another record except when vectors are manually accepted. The other updated values obtained from manually-inserted messages are written on the restart tape after the succeeding accepted differential correction.

MYWRRS receives control from M0PRI0 and turns its own A indicator on and B indicator off. MYWRRS then suppresses all other programs which initiate transmission on data channels B or C: MYSTLT, MYRRRS and MYSRST. MYWRRS stores a transfer to MTWRS1 and, if the run is an actual mission, a transfer to MTWRRS in the channel B and C trap locations, respectively. MYWRRS stores in the first cell of the TMRST1 table the current GMT and in the next 31 cells of TMRST1 the contents of the TMREST table. MYWRRS then transfers control to the MSWECC subroutine which expands TMRST1 to include the error correction codes. MYWRRS initiates transmission to write one record on the channel B restart tape and, if unsimulated, also on the channel C restart tape. Immediately after the transmission is initiated, MYWRRS suppresses itself to prevent entry to MYWRRS until the transmission has been completed. The A indicator is turned off and control returns to M0PRI0.

5.14.4 Usage

MYWRRS is entered from, and exits to, M0PRI0.

a) Storage Required—47 locations

b) MYWRRS uses:

1) Subroutine—MSWECC

2) Macros—QENBA, QENBZ, TRNOF and TRNON
3) Parameters—A, B, C, D, G, MNNWRB, MNNWR1, MNNWR2, MNRRRS, MNSRST, MNSTLT, MNWRRS and MUREST

4) Communication cells—MCHFSC, MCRCMD and MCWWVV

5) Tables—TMREST and TMRST1

6) Absolute locations—00015 and 00017

c) Time Required:

1) Minimum—0.593 * millisecond
2) Maximum—0.608 * millisecond

* Does not include time required by MSWECC.
FIGURE 5-14. MYWRRS PROGRAM FLOW CHART
5.15 MONITOR RESTART TAPE WRITER TRAP PROCESSOR
(MTWRRS, MTWRS1)

MTWRRS or MTWRS1 completes the transmission initiated by MYWRRS to write a record on the restart tape.

The flow chart for the MTWRRS, MTWRS1 trap processor is shown in Figure 5-15.

5.15.1 Input Requirements

Input to MTWRRS, MTWRS1 consists of:

a) MCRSTP—contains the number plus one of the record at the read head for the restart tape currently being processed, i.e., the number of the next record to be written or read.

b) MCWWWV—contains the current GMT in 8-1/3 milliseconds (updated every minute) during an actual mission. During a simulated mission, MCWWWV is not used as a time cell. Consequently, MCWWWV may be used to determine whether or not the program is running in an actual or simulated mission. In a simulated mission there is no channel C restart tape, channel C being reserved to handle simulation control functions.

5.15.2 Output Requirements

MTWRRS, MTWRS1, after the restart record has been written on both the channel B and channel C restart tapes (only channel B during a simulated run), updates the tape position indicator, MCRSTP.

5.15.3 Method

In an actual Mercury Mission two entries are required for a complete pass through this trap processor. On the trap that follows the writing of a restart record on the channel B restart tape, control is transferred to MTWRRS. The SAVE macro is executed, the channel B redundancy indicator, if on, is turned off and the D indicator for MYSTLT is turned off (with the record written on the channel B tape, channel B is free to accept transmission for the log tape). If this is the first entry to this trap processor for this restart record, an internal indicator is set for the second pass.

On the trap that follows the writing of the same restart record on the channel C restart tape, control is transferred to MTWRS1. The SAVE macro is again executed and the channel C redundancy indicator, if on, is turned off.

Since the current entry is the second for this restart record, the restart
tape position indicator is updated, and the entry indicator reset for the next entry. An on-line message is queued to state that one record has been written on the restart tape(s). The D indicator for MYWRRS is turned off (MYWRRS suppressed itself on the entry which initiated the transmission just completed). The other programs which use the restart tapes, MYRRRS and MYREST, are unsuppressed: the C indicator for MYRRRS and the G indicator for MYREST are turned off. Control returns to M0Prio.

5.15.4 Usage

MTWRRS is entered from a trap transfer instruction in the channel B trap control location (00015); MTWRS1 is entered from a trap transfer instruction in the channel C trap control location. MTWRRS and MTWRS1 exit to M0Prio.

a) Storage Required—35 locations

b) MTWRRS, MTWRS1 use:

1) Macros—QUEUE, SAVE and TRNOF

2) Parameters—C, D, G, MNREST, MNRRRS, MNSTLT and MNWRRS

3) Communication cells—MCRSTP and MCWWWV

4) Absolute locations—00014 and 00016

5) Constant—K00110

c) Time Required:

1) Minimum—0.070 millisecond

2) Maximum—0.360 millisecond
FIGURE 5-15. MTWRRS-MTWRS1 PROGRAM FLOW CHART
### TABLE 5-2. RESTART TAPE RECORD

<table>
<thead>
<tr>
<th>Location</th>
<th>Contents*</th>
<th>Set from (Writing Tape)</th>
<th>Set to (Reading Tape)</th>
<th>Initially Set by</th>
<th>Updated by</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMRST1</td>
<td>Time of Writing Record on Tape</td>
<td>Generated by MYWRRS</td>
<td>MYWRRS</td>
<td>MYWRRS</td>
<td></td>
</tr>
<tr>
<td>TMREST</td>
<td>Greatest time tag of data used to compute R, V vectors</td>
<td>MCTLST</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 1</td>
<td>X component of Range</td>
<td>TDRANY</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 2</td>
<td>Y component of Range</td>
<td>+ 1</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 3</td>
<td>Z component of Range</td>
<td>+ 2</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 4</td>
<td>X component of Velocity</td>
<td>+ 3</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 5</td>
<td>Y component of Velocity</td>
<td>+ 4</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 6</td>
<td>Z component of Velocity</td>
<td>+ 5</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 7</td>
<td>Vector Time Tag</td>
<td>+ 6</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 8</td>
<td>Location of N.I. Output Table</td>
<td>+ 7</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+ 9</td>
<td>Integration Interval</td>
<td>+ 8</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+10</td>
<td>Units of Integration Interval (above)</td>
<td>+ 9</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+11</td>
<td>Length (Time) to integrate backwards</td>
<td>+10</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+12</td>
<td>Length (Time) to integrate forward</td>
<td>+11</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+13</td>
<td>Whether or not use drag factor</td>
<td>+12</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+14</td>
<td>Both Range and Velocity, only Range</td>
<td>+13</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+15</td>
<td>Integration Steps per Output</td>
<td>+14</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+16</td>
<td>GMT at T₁</td>
<td>TMGMT1</td>
<td>MFLORB</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+17</td>
<td>Elapsed Capsule Time at T₁</td>
<td>TMECT1</td>
<td>MFLORB</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+18</td>
<td>GMT at T₂</td>
<td>TMGMT2</td>
<td>MFLORB</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+19</td>
<td>Elapsed Capsule Time at T₂</td>
<td>TMECT2</td>
<td>MFLORB</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+20</td>
<td>Setting of Capsule Clock (A/D)**</td>
<td>TMETRS</td>
<td>MFLORB</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+21</td>
<td>GMT of Lift-off</td>
<td>MCGTLO</td>
<td>MFMAN1</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+22</td>
<td>Number of Retrorockets fired</td>
<td>MCREEN</td>
<td>MFMAN2</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+23</td>
<td>Time-to-fire Setting (or time-of-firing) GMT</td>
<td>MCTOFS</td>
<td>MFMAN2</td>
<td>MFMAN3</td>
<td></td>
</tr>
<tr>
<td>+24</td>
<td>(Not used)</td>
<td></td>
<td>MFLORB</td>
<td>MFMAN2</td>
<td></td>
</tr>
<tr>
<td>+25</td>
<td>Addr.: Loc. of weight word for last DC</td>
<td>(TDCLLT)</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec.: Loc. of weight table for DC</td>
<td>(TDCLLTB)</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+26</td>
<td>Real Time of D.C.</td>
<td>Generated by MFIIFC</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+27</td>
<td>GMT: Insertion in Orbit</td>
<td>MCGTIN</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+28</td>
<td>GMT: End of Powered Flight (A/D)**</td>
<td>MCPFLD</td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+29</td>
<td>(Not used)</td>
<td></td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
<tr>
<td>+30</td>
<td>(Not used)</td>
<td></td>
<td>MFLORB</td>
<td>MFIIFC</td>
<td></td>
</tr>
</tbody>
</table>

*A restart record as actually written on tape consists of 42 words. The 32 words shown above are expanded to include error-correction codes.

**Minutes in address, seconds in decrement.
5.16 CONTROL DURING ORBIT-TO-RE-ENTRY

The Mercury Program System leaves the normal orbit phase only when informed that the capsule's retrorockets have fired. This information enters the system in only one way, via a manually-inserted paper tape message. The input of the retrofire information sends control to MYREST, the Monitor program which controls the orbit-to-re-entry interphase.

Since the notification of retrofire may be received several minutes after the event had occurred, data received since retrofire has been handled as orbital data. This gives rise to two problems in maintaining continuity while changing phase from orbit to re-entry: (1) the last valid, pre-retrofire range and velocity vectors must be obtained, to define most precisely the position and velocity at which retrofire occurred; (2) the input radar messages, the TMRMXX tables, which have been processed as orbital data by the differential correction program must be updated to contain only post-burnout data and must be re-submitted for differential correction as re-entry data. Furthermore, all future radar input must be screened and all pre-burnout data discarded.

The first problem is solved by searching the restart tape for the latest pre-retrofire vectors. This tape search is accomplished by MYRRRS and MTRRRS while MYREST waits.

The second, more complex problem is solved by MYREST in the following manner: the data which must be re-evaluated on the basis of the system's retrofire knowledge may be in any one of eight stages of processing. The data may be (1) in the process of entering the computer, (2) referenced as input for the low-speed input processing program, I0TTIN, (3) being processed by I0TTIN, (4) referenced as input for the editing program, E0LED1, (5) being processed by E0LED1, (6) referenced as input for the differential correction program, D0DIFC, (7) being processed by D0DIFC, or (8) referenced in the TMSTMS table after completion of differential correction. Data could be lost to the system if the time lag between retrofire and the manually-inserted retrofire information is of such duration (72 minutes) that a block of good data is erased from the TMSTMS table.

Since processing prior to MFLED1 is independent of phase, suppression indicators are set so that entry to MYREST excludes entry to E0LED1 and D0DIFC and vice versa. Thus, the data that must be re-processed is confined to two stages of processing: the input data to and output data from differential correction. Re-processing simply consists of removing all orbital data. This is accomplished by queueing the change-of-phase edit prefix, MPLED2, with the data both in the TMSTMS table and in the queue for D0DIFC. These entries, beginning with TMSTMS must be queued in such an order that entry for the last radar station crossed by the capsule is queued last or, in other words, chronologically. Suppressions are set which prohibit entry to the normal editing prefix, MPLED1, until processing is completed by MPLED2. When the queue for MPLED2 has been completely processed for re-entry, the processing of new data MPLED1 resumes.
and all new data is processed for the re-entry phase.

The Monitor program which controls the orbit-to-re-entry phase change, MYREST, and the programs which search the restart tape for the pre-retrofire vectors, MYRRRS and MTRRRS, are described in the following subsections. The orbit-to-re-entry edit prefix, MPLED2, is described in Subsection 6.3.
5.17 MONITOR ORBIT-TO-RE-ENTRY INTERPHASE PROCESSOR (MYREST)

MYREST has the primary purpose of controlling the phase change for orbit to re-entry, but also serves as an initialization processor when a restart is required during the re-entry phase.

The flow chart for the MYREST processor is shown in Figure 5-16.

5.17.1 Input Requirements

Input to MYREST consists of:

a) TMREST—the intermediate restart buffer, contains the Mercury Program System parameters required for entering the re-entry phase, or for any restart operation. This table is illustrated in Table 5-2.

b) TMRMXX—the location of the radar message block, where XX ranges from 01 to 19 corresponding to the internal station numbers of the various radar stations.

c) TMSTMS—a 15-word reference table which supplies pertinent information to the differential correction control program, DODIFC. TMSTMS supplies the reference locations for TMRMXX. The address field contains the location of a block of radar messages from a tracking station; the decrement field contains the time of minimum range (TMR) of the block of radar messages located by the address field.

<table>
<thead>
<tr>
<th>Sign</th>
<th>Decrement</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMSTMS</td>
<td>+</td>
<td>TMR from TMRMXX</td>
</tr>
</tbody>
</table>

The entries are arranged in descending order of satellite crossing, i.e., the entry for the last station crossed is first entry in the table. The sign of each entry except the last is positive; the sign of the last entry is set negative.

d) TDRANV—15-cell table (see Table 5-2) containing in the first seven cells the range and velocity vectors with associated time, the anchor point values for generating a curve by numerical integration. The last eight cells contain parameters which define the type integration required.

e) TMDTBO—one-cell table containing to the nearest second the delta time of burnout, i.e., the time which when added to the time of retrofire gives the time of burnout.

f) MCTOFS—contains the GMT of retrofire in fixed-point seconds.
MC 103

g) MCRERE—when non-zero, indicates MYREST has been entered for a restart in re-entry.

h) MCREEN—contains the number of retrorockets fired.

i) MC3RVT, MC4RVT—cells used to queue the on-line message processor to print the range and velocity vectors, respectively.

j) MCCPNI—control cell used by MYREST to queue the numerical integration program to generate a table.

k) MCORRE—contains a mask queued for the sense processor to turn the re-entry light on and the orbit light off on the Output Status Console.

l) MCRTRD—when greater than one, indicates the restart tape is being processed; when one, restart tape read unsuccessfully; when zero, restart tape read successfully.

5.17.2 Output Requirements

Output from MYREST consists of:

a) TMSTMS—reference table for the differential correction program (see 5.17.1). When MYREST has been entered for the orbit-to-re-entry interphase, each cell in TMSTMS is reset to negative zero.

b) TMCYCL, TMCYNO—the output cycle for O5ORMC, controlled by the fourth cell in each of these tables, is changed from once every six seconds to once every three seconds.

c) TDRANV—input table to numerical integration contains the last pre-retrofire range and velocity vectors.

d) TMPRNT—input table for the message processor to print on-line the range and velocity vectors given to numerical integration.

e) MCRERE—indicates, when non-zero, a re-entry restart condition. This cell is set by MFLORB and, when non-zero, is reset to zero by MYREST.

f) MCPHSE—a -1 is stored in the prefix of MCPHSE to indicate the re-entry phase for the logging programs.

g) MCDCCT—differential correction counter is reset to zero.

h) MCFRDC—initial differential correction indicator; set negative by MYREST. After the initial correction is performed, MCFRDC is set positive.
i) **MCBNOT**—contains the time of burnout: minutes in the address, seconds in the decrement.

j) **MCBJMN**—a 163 is stored in MCBJMN to reference the message for the high-speed output rate during re-entry.

k) **MCCHSC**—set non-zero, to indicate a change of scaling factor is required for the output driving plotboard 4.

l) **MCTTRV**—contains the time in fixed-point seconds of the range and velocity vectors to be used in the integration.

5.17.3 Method

**MYREST** receives control from M0PRIO, turns its own A indicator on and B indicator off, and suppresses MPDIFC, MPL0ED1, and MPDIFK. MPLED2 is suppressed until all of the required entries have been made in its queue and the phase change has been accomplished.

For an interphase entry, **MYREST** determines whether or not the last restart values (those still in core memory) are valid for orbit. If valid, they are moved from the restart table in core storage into the TDRANV table for numerical integration. If, however, the current restart values are post-retrofire, **MYREST** turns on the B indicator for MYRRRS, which must search the restart tape for the last valid orbit vectors. **MYREST** waits until MYRRRS and MTRRRS complete the search. If the tape search is unsuccessful, the phase change is not accomplished. The suppression indicators set earlier by **MYREST** are turned off: the C indicator for MPDIFC, MPDIFK, MPL0ED1 and, if there is one or more entry in the MPLED2 queue, for MPLED2. An on-line message is provided to state the re-entry phase has been entered and the re-entry light on the Output Status Console is turned on. Control returns to M0PRIO to await the manual insertion of the required vectors.

If the tape search is successful, the last valid orbit vectors have been stored in the assigned locations. The A and B indicators for MPDIFK and the A indicators for MPL0ED1 and MPDIFC are turned off, since a trap could have interrupted any of these programs before they had been able to set their suppressions of **MYREST**. If that trap was caused by the manually inserted retrofire information, control could be transferred to **MYREST** during an interruption of either edit or differential correction. When **MYREST** obtains the last valid orbit vectors, MPL0ED1, MPDIFC and MPDIFK must be re-entered at their initial locations since **MYREST**, as part of the phase change operation, must negate the current editing and differential correcting.

**MYREST** then searches the TMSTMS table for the first entry stored, i.e., the last entry in the table. If TMSTMS contains one or more entries, these are stored in the queue for MPLED2 in reverse order. A negative zero is then stored into each location of TMSTMS to reset the table to initial conditions.
The queue for MPDIFC is emptied, one word at a time, and the input to MPDIFC stored in the queue for MPLED2. The A indicators for MPCPNI, MYGEN1 and MYGEN3 are turned off. The queues for MPCPNI, MYGEN1 and MYGEN3 are cleared and all priority indicators for MYGEN1, MYGEN2 and MYGEN3 are turned off.

The GMT of burnout is computed from the sum of the GMT of retrofire plus the incremental time factor from retrofire to burnout. MCFRDC is set to indicate initial differential correction for re-entry data and the differential correction counter, MCDCT, is set zero. A 163 is stored in MCBJMN to reference the message which states the expected and actual high-speed output transmission rate for the re-entry phase. The high-speed output cycle is set for a three-second period. A -1 is stored in the prefix of MCPHSE, the phase indicator for logging. The retrofire indicator, MCNRRF, is set from MCREEN and the plot-board 4 scale factor is set for re-entry.

If MYREST has been entered for the normal interphase, controls are set for MFCPNI to queue input to R5RARF only one more time and MYGEN1 is queued to generate the last orbit table.

If MYREST has been entered for a restart in re-entry, controls are set to prevent MFCPNI from queueing R5RARF again. The re-entry restart indicator is reset, and MYGEN2 is queued to generate the re-entry table.

The message processor is queued to print on-line the time, range, and velocity vectors given to either MYGEN1 or MYGEN2 to integrate the required table.

The suppression indicators set earlier by MYREST are turned off: the C indicators for MPDIFC, MPDIFK, MPLED1 and, if there is one or more entry in the MPLED2 queue, for MPLED2. An on-line message is provided to state the re-entry phase has been entered and the re-entry light on the Output Status Console is turned on. The A indicator for MYREST is turned off and control transfers to M0PRIO.

5.17.4 Usage

MYREST is entered from, and exits to, M0PRIO.

a) Storage Required—215 locations

b) MYREST uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF, TRNON and UNQUE

2) Parameters—A, B, C, MNCPNI, MNDFC, MNDFK, MNGEN1, MNGEN2, MNGEN3, MNMESS, MNREST, MNRRRS and MNSENS

5-76
3) Communication cells—MCBJMN, MCBNOT, MCCHSC, MCCPNI, MCDCCT, MCFRDC, MCNRRF, MCORRE, MCPHSE, MCREEN, MCRERE, MCRRTRD, MC3RVT, MC4RVT, MCTOFS and MCTTRV

4) Tables—TDRANV, TMCYCL, TMCYNO, TMDTBO, TMPRNT, TMREST, TMSTMS and TMRMXX (where the XX varies from 01 to 19)

5) Constants—K00000, K00060, K00163, K00.A6 and K00218

c) Time Required:

1) Minimum—0.680 millisecond

2) Maximum—12.862* milliseconds

*Does not include the time required by MYRRRS and MTRRRS, if the restart tape must be used.
FIGURE 5-16. MYREST PROGRAM FLOW CHART (Sheet 1 of 4)
FIGURE 5-16. MYREST PROGRAM FLOW CHART (Sheet 2 of 4)
FIGURE 5-16. MYREST PROGRAM FLOW CHART (Sheet 3 of 4)
FIGURE 5-16. MYREST PROGRAM FLOW CHART (Sheet 4 of 4)
5.18 MONITOR RE-ENTRY RESTART TAPE PROCESSOR (MYRRRS)

MYRRRS searches the restart tape for the last set of values with a pre-retrofire time tag.

The flow chart for the MYRRRS processor is shown in Figure 5-17.

5.18.1 Input Requirements

Input to MYRRRS consists of:

a) MUREST—parameter designating the unit tape address (9) of the restart tapes on both channels B and C.

b) MNNWRB—parameter designating the number of words (31) in the TMREST table.

c) MNNWR1—parameter designating the number of data words (1) required by TMRST1 in addition to the number required by TMREST.

d) MNNWR2—parameter designating the number of additional words (10) required to incorporate error correction codes within TMRST1.

e) TMRSCD—eight-cell table containing the tape instructions which control the restart tape:

<table>
<thead>
<tr>
<th>TMRSCD</th>
<th>BSRB</th>
<th>MUREST</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1</td>
<td>RTBB</td>
<td>MUREST</td>
</tr>
<tr>
<td>+2</td>
<td>BSRC</td>
<td>MUREST</td>
</tr>
<tr>
<td>+3</td>
<td>RTBC</td>
<td>MUREST</td>
</tr>
<tr>
<td>+4</td>
<td>RCHB</td>
<td>MCRCMD</td>
</tr>
<tr>
<td>+5</td>
<td>RCHB</td>
<td>MCDQD1</td>
</tr>
<tr>
<td>+6</td>
<td>RCHC</td>
<td>MCRCMD</td>
</tr>
<tr>
<td>+7</td>
<td>RCHC</td>
<td>MCDQD1</td>
</tr>
</tbody>
</table>

MUREST EQU 9
MCRCMD IOCT TMRST1,, MNNWRB+MNNWR1+MNNWR2
MCDQD1 IOCTN 0,, ** 0

MYRRRS stores the appropriate number in the decrement of MCDQD1 to control skipping over records on the record tape.

f) TMRST1—restart tape buffer, whose length is defined: MNNWRB+MNNWR1+MNNWR2.

This table contains a record of data either to be written on or having been read from the restart tape. Before the error-correction codes have been included for writing or after the error correction codes
have been removed in reading, TMRST1 has the format: TMRST1— GMT in half-seconds the restart tape buffer was written on the restart tape.

\[
\begin{align*}
+1 & \\
\vdots & \\
\vdots & \\
+31 & \\
\end{align*}
\]

contents of TMREST (see Table 5-2).

g) MCCHIN—contains in the address a code which designates the channel to be used in searching the restart tape: a zero indicates channel C; a 2, channel B. Normally, channel C is used only when the channel B restart tape cannot be successfully read.

h) MCRSTP—contains the number plus one of the record at the read head for the restart tape currently being processed, i.e., the number of the next record to be written or read.

i) MCTOFS—contains the GMT of retrofire in fixed-point seconds.

j) MCRTRD—when greater than one, indicates the restart tape is being processed; when one, restart tape read unsuccessfully; when zero, restart tape read successfully.

k) MCRCMD—contains the input/output command for reading or writing the restart tape: IOCT TMRST1,, MNNWRB+MNNWRI+MNNWR2.

l) MCRRRS—indicates, when non-zero, that the restart tape search is currently in process. MCRRRS initially contains zero, is set non-zero during the search of either channel’s restart tape, and reset zero when the search is complete.

m) MCWWWV—contains the current GMT in 8-1/3 milliseconds (updated every minute) during an actual mission. During a simulated mission, MCWWWV is not used as a time cell. Consequently, MCWWWV may be used to determine whether or not the program is running in an actual or simulated mission. In a simulated mission there is no channel C restart tape, channel C being reserved to handle simulation control functions.

5.18.2 Output Requirements

Output from MYRRRS consists of:

a) TMRST1—the contents of TMRST1 as output from MYRRRS consists of a restart tape record with the error correction codes removed.
b) TDRANV—when MYRRRS obtains the valid restart tape values, the words in TMRST1+1 through TMRST1+16 are stored in TDRANV for the numerical integration program.

c) MCRRRS—indicates, when non-zero, that the restart tape search is currently in process. MCRRRS initially contains zero, is set non-zero during the search of either channel’s restart tape, and reset zero when the search is complete.

d) MCCHIN—contains in the address a code which designates the channel to be used in searching the restart tape: a zero indicates channel C; a 2, channel B. Normally, channel C is used only when the channel B restart tape cannot be successfully read.

e) MCDQD1—contains the command for spacing the restart tape. When the restart tape must be spaced, MYRRRS stores the computed value in the decrement of MCDQD1.

f) MCRTRD—when greater than one, indicates the restart tape is being processed; when one, restart tape read unsuccessfully; when zero, restart tape read successfully.

g) Location 00015—the trap control location for channel B contains a trap transfer (to MTRRRS) instruction.

h) Location 00017—the trap control location for channel C contains a trap transfer (to MTRRRS) instruction.

5.18.3 Method

MYRRRS receives control from M0PRI0 and turns its own B indicator on and A indicator off. If the channel B restart tape is to be searched (the channel C restart tape is normally used only if the channel B tape cannot be read successfully), the E indicator for MYSTLT, which also uses channel B, is turned on. A trap transfer (to MTRRRS) instruction is stored in the trap control location corresponding to the selected data channel: 00015 for channel B, 00017 for channel C.

On the initial entry, MYRRRS resets the counter for the number of attempts to read a given record on one restart tape and then sets suppression indicators for the other programs which use the MSRECC subroutine: MYWRRS, MYSCRD, MYRSYS and MYSRST. These suppressions remain until MYRRRS has completed searching the channel B restart tape, or both restart tapes, if necessary. MYRRRS then examines the tape position indicator to determine whether anything has been written on the restart tape. If the restart tape does not contain one record, MYRRRS queues an on-line message to state that no good vectors had been written on the restart tape. An indication is set to inform MYREST that the tape search was unsuccessful and the programs suppressed by MYRRRS on the initial
entry are unsuppressed. MYRRRS resets the control cells used for the restart tape search and exits to M0PRIO. In this situation the integration parameters cannot be obtained from the restart tape.

If the restart tape contains at least one record, MYRRRS backspaces one record on the selected restart tape and sets the internal tape position indicator for the proper location after the record has been read. MYRRRS then initiates transmission to read one record from the restart tape into the intermediate restart buffer, TMRST1. MYRRRS turns off its A indicator and exits to M0PRIO. On the trap following transmission, MTRRRS receives control and, if the tape search is not complete, turns on the B indicator for MYRRRS.

For all subsequent entries, MYRRRS executes the MSRECC subroutine to remove the error-correction codes from the record read by transmission initiated on the previous entry. Three attempts may be made to read and error-correct a given record on the same channel. After three failures the restart tape is restored to its original position (prior to entry to MYRRRS) for the next writing, and an indication is set to initiate a search for the same record on the channel C restart tape. (A channel C restart tape is not available during simulated runs.) If the record still cannot be read, a message is queued to state that neither tape can be error corrected. An indicator is set to inform MYREST that the tape search was unsuccessful and the tape is now repositioned for writing.

When a record has been successfully error-corrected, MYRRRS determines whether or not integration parameters have been written on tape. If these values cannot be found, an on-line message is queued to state that no good vectors have been written on the restart tape, the tape is repositioned for writing, and a cell set to inform MYREST that the search was unsuccessful.

When integration parameters are found, MYRRRS compares time tag of the last data used in preparing the integration parameters with the time of retrofire. If the vectors are not contaminated with post-retrofire data, MYREST is informed that the search was successful, the vectors are moved to the TDRANV table for input to numerical integration and the tape is repositioned for writing. If the data time tag is not pre-retrofire, further searching of the restart tape is necessary and MYRRRS proceeds to read the next oldest record. If the last record read was the first record on the tape, the entire tape has been searched without success. A message stating that no valid vectors are available is queued, the appropriate indication is set for MYREST, and the tape is repositioned for writing.

5.18.4 Usage

MYRRRS is entered from, and exits to, M0PRIO.

a) Storage Required—121 locations

5–86
b) MYRRRS uses:

1) Subroutine—MSRECC

2) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

3) Parameters—A, B, C, D, E, G, MNRRRS, MNSTLT, MNWRRS, MNSCRD, MNSRST, MNRSYS, MNNWRB, MNNWR1, MNNWR2, and MUREST

4) Communication cells—MCCHIN, MCDQD1, MCRCMD, MCRRRS, MCRSTP, MCRTRD, MCTOFS and MCWWWV

5) Tables—TDRANV, TMRSCD and TMRST1

6) Constant—K00001

7) Absolute Locations—00015 and 00017

c) Time Required:

1) Minimum—0.207* millisecond

2) Maximum—0.421* millisecond

* Does not include time required by MSRECC.
FIGURE 5-17. MYRRRS PROGRAM FLOW CHART (Sheet 1 of 3)
FIGURE 5-17. MYRRRS PROGRAM FLOW CHART (Sheet 2 of 3)
FIGURE 5-17. MYRRRS PROGRAM FLOW CHART (Sheet 3 of 3)
5.19 MONITOR RE-ENTRY RESTART TAPE TRAP PROCESSOR (MTRRRS)

MTRRRS is the trap processor which receives control after MYRRRS has initiated an input/output command either to read the restart tapes or to position them for writing.

The flow chart for the MTRRRS trap processor is shown in Figure 5-18.

5.19.1 Input Requirements

Input to MTRRRS consists of:

a) MCCHIN—communication cell controlled by the programs which use the restart tape. A 2 in the address indicates that the channel B restart tape is being used; a zero in the address indicates that the channel C restart tape is currently being used. A 1 in the decrement is an indicator the channel B restart tape search is complete, but was unsuccessful and that the channel C tape should now be used.

b) MCRRRS—indicates, when non-zero, that the restart tape search is currently in process. MCRRRS initially contains zero, is set non-zero during the search of either channel’s restart tape, and reset zero when the search is complete.

5.19.2 Output Requirements

If the tape search on either channel is complete, MCCHIN is reset; if the decrement of MCCHIN indicates a need to use the channel C restart tape, MCCHIN is cleared (zero is stored in the address to indicate channel C, the decrement is cleared to show the switch has been effected); if no channel C switch is required, a 2 is stored in the address of MCCHIN to reset restart operations for channel B usage.

5.19.3 Method

Prior to initiating a data channel operation, MYRRRS stores in the low core trap control location for either channel B or channel C a trap transfer instruction to MTRRRS. When MTRRRS receives control and determines the data channel responsible for the trap. The SAVE macro is executed and, if the trap occurred on channel B, the E indicator for MYSTLT is turned off to allow writing on the log tape (another channel B operation).

If MTRRRS has received control after a completed tape search, the decrement of MCCHIN is examined to determine whether or not the channel C restart tape must be used. If channel C is not required, the E indicator for MYWRRS, the D indicator for MYSCRD, the G indicator for MYRSYS and the C indicator for MYSRST are turned off and a 2 is stored in the address of MCCHIN to reset operations for channel B. Control then returns to MOPRIO. If channel C is
required, zero is stored in the address of MCCHIN and the decrement of MCCHIN is cleared. The B indicator for MYRRRS is turned on to continue the restart tape operation and control returns to M0PRIO.

If MTRRRS has received control and the tape search is not yet completed, the B indicator for MYRRRS is turned on and control returns to M0PRIO.

5.19.4 Usage

MTRRRS is entered from a trap transfer instruction in either the channel B or channel C trap control locations (00015 and 00017, respectively); MTRRRS exits to M0PRIO.

a) Storage Required—35 locations

b) MTRRRS uses:

1) Macros—SAVE, TRNOF and TRNON
2) Parameters—B, C, D, E, G, MNRRRS, MNRSYS, MNSCRD, MNSRST, MnSTLT and MNWRRS
3) Communication cells—MCCHIN and MCRRRS
4) Absolute locations—00014 and 00016

c) Time Required:

1) Minimum—0.068 millisecond
2) Maximum—0.294 millisecond
TRAP ON CHANNEL B OR C

TRAP LOC

(00015) = TTR MTRRRS
(00017) = TTR MTRRRS

MTRRRS

MTRRRS Occur On Channel C?

MCCHIN = 0

NO, CHANNEL B

DR1 YES

SAVE 12

TURN OFF CHANNEL C REDUNDANCY INDICATOR

DR2

TAPE SEARCH COMPLETE?

MCRRRS = 0

YES

INDICATION SET TO SWITCH TO CHANNEL C?

D(MCCHIN) = 1

NO

DR4

TRNON B MYRRRS

NO

MOPRIO

FINISHED, UNSUPPRESS OTHER CHANNEL B & C PROCESSORS

TRNON E MNWRRS

TRNON D MNSCRD

TRNON G MNRSSY

TRNON C MNSRST

SET INDICATOR FOR CHANNEL B 2 = A(MCCHIN)

FIGURE 5-18. MTRRRS PROGRAM FLOW CHART
5.20 RESTART

The Mercury Program System provides for two types of restarts, namely, a restart in the event of computer malfunction or complete program failure and a restart in the event of a bad differential correction. The latter case is simply a matter of computational reversion: suitable range and velocity vectors are entered three times each into the computer via DCC subchannel 30 (paper tape input). The Monitor suffix to IOMANI, MFMAN5, receives control after the vectors have been accepted and provides input to numerical integration via MYGEN2 to generate a new orbit or re-entry table, depending upon the current mission phase. After the table has been generated, normal orbit or re-entry processing conditions continue.

The restart in the event of computer malfunction or complete program failure requires that an end-of-file be written on the restart tapes (B9 and C9). A dump of core storage should be taken and the log tapes (B6 and B7) should be unloaded, labeled, and replaced with blanks. The Mercury System tapes A1 and A4 should be rewound. The Clear and Load Tape buttons are depressed and the Mercury Program System is reloaded for the launch phase. When the program reaches the stop at which the GMT time base is entered into the system, the orbit number is placed in the entry keys 2-5 and the time of restart, i.e., the historical time from which computations are to resume, is entered in the keys 18-35. The real time is entered in the keys 6-17. (The time settings are in a binary-coded hours, minutes, and seconds and are illustrated in the write-up for MTWWVL)

When the real time and the restart time have been entered, MYINIT receives control, observes the restart time (a restart time of zero is illegal), and queues input which requests MYQSYS to initiate the loading of the Monitor Orbit Restart Tape Processor and associated trap processor, MYSRST and MTSRST. MYINIT suppresses MPLCCM, but queues input to MPLCCM which indicates entry for restart. Finally, MYINIT activates the low-speed input subchannel for paper tape messages.

MYQSYS gives control to MYRSYS, which with MTRSYS loads the programs which search the restart tape. When MYSRST and MTSRST have been loaded, the suppression for MPLCCM is removed.

MPLCCM receives control, determines that a restart operation is taking place and transfers control immediately to MFLORB, the launch-to-orbit inter-phase suffix to MFLHLD. MFLORB informs MOPRIO that MYSRST should be given control for the restart tape search and MFLORB waits while the search is conducted.

MYSRST reads one or both, if necessary, of the restart tapes, searching for the data record corresponding to the given restart time. (Whenever a differential correction is accepted or rejected, the time as well as the acceptance or rejection, is given by an on-line message. When the final correction is made.
for a given station, the computed values are written on the restart tape, and also indicated in an on-line message. Therefore, to restart the Mercury Program System and restore it to the mission status at the time of a certain differential correction, the time of the associated differential correction on-line message should be used as the restart time.)

If MYSRST finds a valid restart data record with a time equal to, or less than, the given restart time, the search is complete and control returns to MFLORB at the interrupt point, where initialization of the orbit phase continues unless the data in the restart record has indicated a restart in re-entry. For a restart in re-entry MFLORB queues input requesting MYQSYS to load the edit and differential correction programs from the Mercury System tape. MFLORB then informs MOPRIO that the orbit-to-restart interphase processor, MYREST, should be given control.

If the restart is for the orbit phase, MFLORB completes the initialization for orbital computations and provides input to numerical integration via MYGEN1 to generate an orbit table from the restart vectors. Normal orbital processing continues.

If neither restart tape has been properly written, an on-line message states that neither restart tape can be error-corrected; the only recourse is to restart from insertion by entering via paper tape the GMT of lift-off and the orbit parameters at insertion. (Sense switch 3 must be down, GMT of lift-off must be entered once, the range vector must be entered three times followed by the velocity vector three times).

If neither restart tape has been written, an on-line message states that neither restart tape can be read. In this event either another restart must be tried by using a later restart time or manual input may be utilized to initialize the system at insertion. In fact, for a malfunction during launch, the above procedure would have to be employed, since the restart tape is not written during the launch phase, the system cannot be restarted in launch. However, given the time of lift-off and the insertion range and velocity vectors, the system can be restarted from insertion.

The restart time, and not the real time at restart, is the limiting factor in the computer's knowledge of paper tape input data. Any information entered into the computer via paper tape after the restart time cannot be retrieved from the restart tape. These messages, if any, must be re-inserted.

All of the programs used in restarts have been described in this and other sections of the volume, excepting MYSRST and MTSRST. These two programs are detailed in the two following subsections.
5.21 MONITOR ORBIT RESTART TAPE PROCESSOR (MYSRST)

MYSRST searches the restart tape for a record of data whose time tag is equal to, or the latest time tag less than, a restart time placed in the console keys. When obtained, this data record is stored in preassigned core locations.

The flow chart for the MYSRST processor is shown in Figure 5-19.

5.21.1 Input Requirements

Input to MYSRST consists of:

a) MUREST—parameter designating the unit tape address (9) of the restart tapes on both channels B and C.

b) MNNWNB—parameter designating the number of words (31) in the TMREST table.

c) MNNWRL—parameter designating the number of data words (1) required by TMRST1 in addition to the number required by TMREST.

d) MNNWRR—parameter designating the number of additional words (10) required to incorporate error correction codes within TMRST1.

e) TMRSTC—eight-cell table containing the tape instructions which control the restart tape:

| TMRSTC | BSRB | MUREST |
| +1     | RTBB | MUREST |
| +2     | BSRM | MUREST |
| +3     | RTBM | MUREST |
| +4     | RCHB | MCRCMD |
| +5     | RCHB | MCDQD1 |
| +6     | RCHC | MCRCMD |
| +7     | RCHC | MCDQD1 |

TMRSTC BSRB MUREST
+1 RTBB MUREST
+2 BSRM MUREST
+3 RTBM MUREST
+4 RCHB MCRCMD
+5 RCHB MCDQD1
+6 RCHC MCRCMD
+7 RCHC MCDQD1

MUREST EQU 9
MCRCMD IOCT TMRSTC,, MNNWBR+MNNWRL+MNNWR2
MCDQD1 IOCTN 0,, * * 0

MYSRST stores the appropriate number in the decrement of MCDQD1 to control skipping over records on the record tape.

f) TMRST1—restart tape buffer, whose length is defined: MNNWBR+MNNWRL+MNNWR2. This table contains a record of data either to be written on or having been read from the restart tape. Before the error correction codes have been included for writing or after the error correction codes have been removed in reading. TMRST1 has the format:
TMRST1—GMT half-seconds restart tape buffer was written on the restart tape.

\[
\begin{align*}
+1 \quad & \text{contents of TMREST (see Table 5-2).}
\end{align*}
\]

\[
+31
\]

**g)** MCCHIN—contains in the address a code which designates the channel to be used in searching the restart tape: a zero indicates channel C; a 2, channel B. Normally, channel C is used only when the channel B restart tape cannot be successfully read.

**h)** MCRSTP—contains the number plus one of the record at the read head for the restart tape currently being processed, i.e., the number of the next record to be written or read.

**i)** MCWWV contains the current GMT in 8-1/3 milliseconds (updated every minute) during an actual mission. During a simulated mission, MCWWV is not used as a time cell. Consequently, MCWWV may be used to determine whether or not the program is running in an actual or simulated mission. In a simulated mission there is no channel C restart tape, channel C being reserved to handle simulation control functions.

**j)** MCREST—contains the restart time, i.e., the time tag used by MYSRST to obtain the appropriate data record from the restart tape. This time enters the Mercury Program System with the GMT time initialization (see MTWV).

### 5.21.2 Output Requirements

MYSRST takes the restart record read into TMRST1 on a previous pass, executes the MSRECC subroutine to remove the error correction codes, and compares the time tag of the restart record to the input restart time. When the acceptable restart record is found, MYSRST moves the record into TMREST and from this table stores the restart values in the preassigned locations. The values and the preassigned locations are shown in Table 5-2.

When MYSRST initiates data transmission, a trap transfer instruction to MTSRST must be stored in the appropriate low-core location to control the data channel trap: location 00015 for channel B and location 00017 for channel C.

### 5.21.3 Method

Two restart tapes are written during an actual Mercury Program System run: one on channel B and one on channel C. During a simulated run there is no channel C restart tape.
If the orbit phase is never entered in the mission, the restart tapes are not written and an end-of-file must be written as the first record on both restart tapes. An end-of-file as the first record on the restart tape is interpreted by the restart program as an attempt to restart during the launch phase: an indication of this is provided via an on-line message requesting a paper tape input to accomplish the restart.

For a normal restart the channel B restart tape is searched for the restart record with the latest time tag less than or equal to the given restart time. Each record must be read into core and have the error correction codes removed before the time tags may be compared. If the record of data is found on the channel B restart tape, the data is moved from the restart buffer into the appropriate core locations. If the data record cannot be obtained from the channel B tape, i.e., the record cannot be error corrected, an identical search is made using the channel C restart tape. If the data record is obtained from the channel C tape, the procedure is the same as that for the record read from channel B. If the data record cannot be obtained from channel C, an on-line message is provided which states that neither restart tape could be error corrected.

Prior to returning control to M0PRIO, both restart tapes are positioned identically.

5.21.4 Usage

MYSRST is entered from, and exits to, M0PRIO.

a) Storage Required—253 locations

b) MYSRST uses:

1) Subroutine—MSRECC

2) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

3) Parameters—A, B, G, J, MNNWR1, MNNWR2, MNNWRB, MNRRRS, MNSRST, MNRSYS, MNSTLT, MNWRRS and MUREST

4) Communication cells—MCCHIN, MCDQD1, MCGTIN, MCGTLO, MCLFTM, MCRCMD, MCREEN, MCREST, MCRRRS, MCRSTP, MCSRST, MCTLST, MCTOFS and MCWWWV

5) Tables—DTCLS, TDCLLT, TDRANV, TMAGMT, TMEC1, TMEC2, TMETRP, TMETRS, TMGMT1, TMGMT2, TMREST, TMRSCD and TMRST1

7) Absolute locations—00015 and 00017

c) Time Required:

1) Minimum—0.25 millisecond

2) Maximum—5.90 milliseconds
FIGURE 5-19. MYSRST PROGRAM FLOW CHART (Sheet 1 of 4)
FIGURE 5-19. MYSRST PROGRAM FLOW CHART (Sheet 2 of 4)
FIGURE 5-19. MYSRST PROGRAM FLOW CHART (Sheet 3 of 4)
FIGURE 5-19. MYSRST PROGRAM FLOW CHART (Sheet 4 of 4)
5.22 MONITOR ORBIT RESTART TAPE TRAP PROCESSOR (MTSRST)

MTSRST receives control on the data channel (B or C) trap following a tape search operation by MYSRST. MTSRST determines the cause of the data channel trap and sets indicators for MYSRST to continue searching the restart tape or if the search has been successfully completed, MTSRST resets the parameters to their initial conditions to prepare for the next tape search request.

The flow chart for the MTSRST trap processor is shown in Figure 5-20.

5.22.1 Input Requirements

Input to MTSRST consists of:

a) MCCHIN—contains in the address a code which denotes the data channel of the restart tape currently being searched; a zero in the address denotes channel C; a 2, channel B. MCCHIN is set by MYSRST and is used in switching from channel B to channel C if the former tape cannot be successfully read. MTSRST determines which low-core location set by the computer when the trap occurs—00014 for channel B, 00016 for channel C—to examine from the code in MCCHIN.

b) MCRRRS—indicates the status of the trap search. MCRRRS initially contains zero, is set non-zero while the restart tape search is in progress, reset to zero when the search is complete. MCRRRS is controlled by MYSRST.

5.22.2 Output Requirements

Output from MTSRST consists of the following indicators set non-zero for MYSRST: DTEOF, if the trap was caused by an end-of-file other than at the beginning of the restart tape (on either channel); DTBTT, if the trap was caused by an end-of-file at the beginning of the channel B restart tape; DTCTT, if the trap was caused by an end-of-file at the beginning of the channel C restart tape (an end-of-file at the beginning of the restart tape is an indication that nothing has been written on the tape).

If the tape search has been completed, MTSRST must reset the parameters for the next usage of the restart tape: a 2 is stored in the address of MCCHIN to reference the channel B restart tape and MCSRST is cleared to indicate the restart tape has been read.

5.22.3 Method

MTSRST receives control on either a channel B or channel C trap following a restart tape I/O operation initiated by MYSRST. MTSRST determines the responsible channel by examining the MCCHIN communication cell and executes the SAVE macro for the appropriate low-core location. The G indicator for
MYSTLT is turned off to unsuppress logging, a channel B operation. If the trap was caused by an end-of-file, MTSRST determines where on the tape the end-of-file occurred and sets indicators for MYSRST based on this information.

If the restart tape search is not yet completed, MTSRST turns on the B indicator for MYSRST to continue the process and exits to MOPRIO.

If the restart tape search is completed (MCRRRS contains zero), the selected-tape indicator, MCCHIN, is reset for channel B, the G indicators for MYRRRS and MYWRRS are turned off to allow reading and writing of the restart tape, the J indicator for MYRSYS is turned off to allow further system tape loading, if required, and the restart tape-read indicator, MCSRST, is set to zero. MTSRST then exits to MOPRIO.

5.22.4 Usage

MTSRST is entered by a trap transfer instruction (TTR MTSRST) in either the channel B (00015) or the channel C (00017) trap control location; MTSRST exits to MOPRIO.

a) Storage Required—39 locations

b) MTSRST uses:

1) Macros—SAVE, TRNOF and TRNON

2) Parameters—B, G, J, MNRRRS, MNRSYS, MNSRST, MNSTLT, and MNWRRS

3) Communication cells—MCCHIN, MCRRRS and MCSRST

4) Absolute locations—00014 and 00016

c) Time Required:

1) Minimum—0.221 millisecond

2) Maximum—0.279 millisecond
FIGURE 5-20. MTSRST PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 5-20. MTSRST PROGRAM FLOW CHART (Sheet 2 of 2)
Section 6
CONTROL DURING ORBIT/RE-ENTRY

During the orbit and re-entry phases of the mission the Mercury Program System must provide output display information for the Mercury Control Center acquisition data for transmission to the remote sites of the Mercury tracking network. The prerequisite for this information is an orbit and/or a re-entry table, i.e., a tabular prediction of the capsule's trajectory expressed as range and velocity vectors at an associated time and given at regular intervals of a specified period. In addition, an orbit table is an essential requirement for the basic orbit cycle computations.

The Monitor programs which control the generation and correction of the orbit table to provide the required output values are described in this section.

6.1 BASIC COMPUTING CYCLE

The orbit table is provided by a general integration program which, given a range and a velocity vector with their associated time, uses Cowles' method to integrate numerically the three Newtonian equations of motion both backward and forward over any time interval, storing in any designated block of core memory predictions of the capsule's trajectory at specified time steps.

6.1.1 Initiating the Basic Cycle

Since the parameters which define the length of time to integrate forward or backward, the time interval, the storage location and frequency, and whether or not a correction must be applied for atmospheric drag, can be predetermined, the only variables necessary to generate an orbit table are the range and velocity vectors with the associated time: the anchor point for numerical integration. This anchor point is derived from one of the following four sources, each of which may trigger the basic computing cycle. (Figure 6-1).

a) Computed by Launch: When the abort/orbit decision is positive, the launch programs compute the anchor point vectors for the first even minute after insertion into orbit. The launch-to-orbit transition begins when control is given to MFLORB. This program prepares the computer for orbit processing and yields control to MYGEN1. This is the normal method of generating the initial orbit table on Mercury orbital missions.
b) Radar Input: The arrival of a complete radar message from one of Mercury tracking stations initiates a series of events which can be considered the heart of the orbit computations. The low-speed input processor, IOTTIN, places the data in the message block for the reporting station and prevents the data from being destroyed before it is at least 72 minutes old. IOTTIN converts the input data into the format required for processing. When an end-of-transmission is detected, an indication is given to the Monitor suffix to IOTTIN, MFTTIN.

If the reporting station has a co-located radar, i.e., both AN/FPS-16 and Verlort radars, only data from the radar first ending transmission is processed beyond the input level.

MFTTIN passes control to the edit program, E0LED1, which subjects the data to a time sequence check and certain smoothness tests and may eliminate portions of the message. The remaining radar points are corrected for refraction and local conditions, and the time of the capsule's closest approach is determined.

The differential correction program, D0DIFC, combines these new observations with the results of all previous calculations and produces a corrected range and velocity vector at an associated time: these are the basic values for the new orbit prediction.

D0DIFC may, however, reject the correction because the data appears erroneous or because the correction would be negligible. In this case the basic computing cycle is not entered. If a correction is acceptable, D0DIFC may request that another correction be attempted with the same data further to refine these vectors. If this option is exercised, D0DIFC does not receive control until the complete basic cycle has been terminated. D0DIFC can repeat the basic cycle in this manner until the desired degree of precision has been attained.

c) Restart: Each time new orbit parameters are computed, crucial information, including the integration parameters, is written on magnetic tape to maintain a history of critical changes in mission status throughout the flight. This feature allows the restoration of a previous mission condition at any time. When this modus operandi is utilized the computer is cleared, the Mercury Program System reloaded and the requested data is read from tape by MYSRST. MFLORB is entered to prepare the Mercury Program System for orbit processing and MYGEN1 is then given control.

For a mission of three or less orbits a restart would be used only in the event of a mechanical malfunction. However, a series of restarts could provide support for a mission of more than three orbits.

d) Manually inserted vectors: To alter the current orbit table under manual control, the vector and time components are punched on paper
FIGURE 6-1. BASIC ORBIT COMPUTING CYCLE (Sheet 1 of 3)
FIGURE 6-1. BASIC ORBIT COMPUTING CYCLE (Sheet 2 of 3)
FIGURE 6-1. BASIC ORBIT COMPUTING CYCLE (Sheet 3 of 3).
tape and fed into the IBM 7090 computer's core storage via the paper tape reader (subchannel 30 of the Data Communication Channel). Each time a new table is generated the anchor point vectors are provided by the on-line printer. Therefore, the Mercury Program System may revert to a previous orbit table under manual intervention without using the restart procedure. The insertion components computed at Bermuda are transmitted to Goddard via teletype and could be manually inserted to override the launch results.

The insertion vectors from paper tape are converted into the proper format and checked by the manual input processor, IOMANI. If no errors are detected, IOMANI gives control to its Monitor suffix, MFMAN5, which in turn yields control to MYGEN2.

Due to the many diversified requirements of the integration program and its output, a complex control scheme is required to allow the system to function in the proper real time sequence. Three control processors, MYGEN1, MYGEN2, and MYGEN3, have been designed to ensure proper usage of NOCPNI. These three processors control entrance to the basic computing cycle. A cycle initiated by one of these processors must be completed before either of the remaining two processors may generate another basic cycle entry.

6.1.2 Basic Computing Cycle During Orbit

At this point the integration parameters have been established and NOCPNI integrates to produce the orbit table as defined by the given vectors and as directed by the other parameters. This single prediction is, however, not completely adequate in that it does not take retrofire into account. Therefore, the capsule's predicted descent trajectory requires the re-entry and retrofiring program, R5RARF. The latest capsule clock time-to-fire setting is provided R5RARF, which, using the Lagrangian interpolation, determines from the orbit table the predicted range and velocity vectors for this time. R5RARF then adds the effect of a nominal three-rocket retrofire and produces the burnout time and range and velocity vectors. These are given to NOCPNI along with the standard re-entry integration parameters to produce the re-entry table—starting at burnout and ending at impact (60,000 feet).

The next sequential operation is to compute the times-to-fire for end of present orbit, end of third orbit, and for the next emergency area. A nominal time-to-fire and the longitude of the recovery area are presented to R5RARF, which interpolates for the range and velocity vectors at the given time. The effect of a nominal retrofire is added, and control given to NOCPNI. The integration is performed for this descent path with one difference; that is, the points along the trajectory are not stored and the only integration output is an impact point. Control returns to R5RARF which compares this computed impact point to the required impact location. If these do not agree within ten miles, the nominal time is adjusted appropriately and the procedure is repeated until the computed impact point is within the required tolerance. The nominal time as finally adjusted
now becomes the Greenwich Mean Time of retrofire (GMTRC) for the particular recovery area.

The process is repeated with different times and recovery areas for each of the remaining times-to-fire calculations.

6.1.3 Orbit-to-Re-entry Phase Change

When retrofire occurs, the Mercury Control Center informs Goddard of the time-of-firing and the number of rockets fired. This data is punched on paper tape and fed into the IBM 7090 computer's core storage via subchannel 30 of the DCC. The paper tape processor, I0MANI, informs its Monitor suffix, MFMAN2, of this fact and control is given to MYREST.

Prior to the arrival at Goddard of retrofire information data from post-retrofire tracking may have been processed with the system in the orbit mode. Consequently, the initial re-entry table could be in error if the existing orbit table had been used to determine the range and velocity vectors at burnout. To prevent this, MYREST searches the restart tape for the latest integration parameters with a time prior to retrofire. N0CPNI then generates the last valid orbit table. R5RARF takes the actual time-of-firing and derives the burnout range, velocity and time using the number of rockets fired. N0CPNI then generates the first actual re-entry table.

At the time phase change takes place, re-entry observations (those time-tagged after burnout) may have arrived in the computer and may be intermingled with orbital observations. MYREST directs control so that all radar observations currently in the computer plus those to arrive will be time-checked and those with pre-burnout time tags discarded. Data which may have been previously corrected, is presented to D0DIFC again with only re-entry data available and with indication of re-entry phase. (Figure 6-2.)

6.1.4 Basic Computing Cycle During Re-entry

In re-entry only the re-entry table must be generated. Thus, when a complete radar message is available, it is edited (E0LED1) and corrected (D0DIFC) to result in a corrected anchor point for a new re-entry table. The generation of a corrected re-entry table by N0CPNI terminates the cycle. As in orbit, D0DIFC may reject the correction or request that a successive correction to develop greater precision be attempted prior to processing new data. (Figure 6-3.)

6.1.5 Output Computations

Every six seconds throughout the orbit phase the output calculations program, O5ORMC, is entered. This program, using the latest orbit table, determines the critical orbital elements such as apogee, perigee, height, velocity, retrofire times and impact points. This data is given to O0ORRE, which converts, scales, and packs the data into the proper format for transmission over the high-speed lines to Cape Canaveral.
FIGURE 6-2. ORBIT TO RE-ENTRY PHASE CHANGE
MTTTIN, IOTTIN AND E0LED1 SAME AS IN ORBIT

FIGURE 6-3. BASIC RE-ENTRY COMPUTING CYCLE
The process is essentially the same in re-entry except the frequency is every three seconds, only the re-entry table is used, and some of the computed values are different.

To assist the radar sites in locating the capsule, acquisition data is computed and transmitted over the teletype network so that each site receives three messages per orbit, providing the capsule will pass within range, i.e., within 1° of the horizon. The sites receive this information at approximately 45 minutes, 25 minutes, and five minutes before the capsule appears over the horizon. Acquisition data consists of range, azimuth, elevation, and time for elevations of 1°, 10° and 30° above the horizon, as well as for the point of closest approach. The acquisition computations program, AOSTAD, checks the present capsule clock setting. If the time of the acquisition message is later than the most recent time-to-fire, or time-of-firing, the re-entry table will be used to generate the data, otherwise the orbit table provides the necessary input.
6.2 MONITOR PREFIX TO EOLED1 (MPLED1)

MPLED1 prepares the editing parameters for EOLED1 by providing the location of input radar messages. Special consideration is given to Bermuda and downrange stations i.e., Cape Canaveral, San Salvador and Grand Bahama. For first orbit Bermuda data, an indicator is set so MFLED1 will screen out powered flight data. Any first orbit downrange data is not further processed. On subsequent orbits the only downrange radar data processed is that from the first station completing transmission.

The flow chart for the MPLED1 prefix is shown in Figure 6-4.

6.2.1 Input Requirements

Input to MPLED1 consists of:

a) An entry in the input queue table for EOLED1. This entry contains in the address the internal station number of the radar site which provides the input for editing.

b) TMLSDB—contains in order by internal station number an entry for each Mercury radar tracking station. The address field of each entry contains the location of the radar's input table, TMRMXX.

c) MCHFSC—contains the current GMT in fixed-point half seconds.

d) MCGTLO—contains the GMT of lift-off in fixed-point seconds.

e) MCMINS—contains the current GMT in fixed-point minutes.

f) MCCAPE—initially zero, this cell contains the time of low-speed radar data input from the Cape Canaveral downrange tracking stations. This cell is used to control editing in the following manner: when the first complete downrange transmission has been received on orbits other than the first and is ready for editing, the current time in minutes is stored by MPLED1 in MCCAPE. No other low-speed input from the downrange stations is edited until the next pass over the downrange stations, which MPLED1 defines as a minimum of 72 minutes since the last downrange low-speed data.

6.2.2 Output Requirements

Output from MPLED1 consists of:

a) MCLED1—contains in the address the internal station number corresponding to the data to be edited.

b) TMRMXX—table of input data for editing (where XX corresponds to the internal station number, i.e., the address field of MCLED1). If the
input radar data does not qualify for editing, the sign of the first location in TMRMXX is set negative and zero is stored in the second location of the TMRMXX table.

c) MCLED—contains in the address the location of the TMRMXX input table.

d) MCCAPE—If thirty minutes has elapsed since lift-off and the input radar data is the first received from one of the downrange stations, the current time in minutes is stored in MCCAPE.

e) MCCAP1—set non-zero to indicate the first pass Bermuda data is to be screened for powered flight data by MFLED1.

6.2.3 Method

MPLED1 receives control after the low-speed input processor has determined the need to edit the input data from a radar tracking station (the end-of-transmission has been detected or the eight minutes may have elapsed since transmission began for this radar station). The A indicator for E0LED1 is turned on and MYREST is suppressed until this editing entry has been completed.

MPLED1 unqueues the oldest entry from the edit input queue table and from this entry provides the editing parameters for E0LED1.

If the input data has been received from any station other than the three Canaveral downrange stations, MPLED1 gives control directly to E0LED1 to edit the data. If thirty minutes have not elapsed since lift-off and if the data is from the Bermuda AN/FPS-16 radar, MCCAP1 is set non-zero to indicate initial, or first pass, Bermuda data. For the downrange stations two possibilities exist. The data is edited if thirty minutes have passed since lift-off and if no other downrange radar data has been edited on this orbital pass. If these two requirements are not met, the sign of TMRMXX is set negative, zero is stored in the second location of the TMRMXX table to indicate that no input data is available for editing, and MPLED1 gives control to MFLED1, bypassing editing for this entry.

6.2.4 Usage

MPLED1 is entered from M0PRIO; MPLED1 exits to E0LED1 or to MFLED1.

a) Storage Required—41 locations

b) MPLED1 uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, D, MNLED1 and MNREST
3) Communication cells—MCCAP1, MCCAPE, MCGTLO, MCHFSC, MCLED1, MCLEDD and MCMINS

4) Tables—TMLSDB and TMRMXX

5) Constants—K00072 and K01800

c) Time Required:
   1) Minimum—0.191 millisecond
   2) Maximum—0.248 millisecond
FIGURE 6-4. MPLED1 PROGRAM FLOW CHART
6.3 MONITOR CHANGE-OF-PHASE PREFIX TO E0LED1 (MPLED2)

MPLED2 is used when changing phase from orbit to re-entry, to serve as a queue for certain radar message blocks which may be acceptable re-entry input but which either have been queued as orbit input for differential correction or which already have been processed by differential correction as orbital input. This allows MFLED1 to re-queue differential correction in the proper order with these message blocks after making them valid for re-entry input.

The flow chart for the MPLED2 prefix is shown in Figure 6-5.

6.3.1 Input Requirements

Input to MPLED2 consists of: TMRMXX—the base address of the radar message block TMRMXX (where the XX ranges from 01 to 19 corresponding to the internal station number of the various radar stations) is entered in the queue for MPLED2.

6.3.2 Output Requirements

Output from MPLED2 consists of:

a) MCHECK—if the queue for MPLED2 has been emptied, MCHECK is set non-zero.

b) MCLEDD—contains in the address the base location of the radar message block, TMRMXX, to be processed by MFLED1.

6.3.3 Method

MPLED2 suppresses MYREST, which is not unsuppressed until MFLED1 receives the indication that the queue for MPLED2 has been emptied. The suppression is necessary to ensure the radar message blocks are queued for differential correction in the proper order.

MPLED2 then unqueues an entry from its queue and stores the entry into MCLEDD. If the queue is empty, the appropriate indication is set in MCHECK, and in either case control is transferred to MFLED1.

6.3.4 Usage

MPLED2 is entered from M0PRIO; MPLED2 exits to MFLED1.

a) Storage Required—15 locations
b) MPLED2 uses:

1) Macros—QENBA, QENBZ, TRNON and UNQUE
2) Parameters—MNLED2 and MNREST
3) Communication cells—MCHEK and MCLEDD
4) Tables—TMRMXX (where the XX ranges from 01 to 19) and the queue table for MPLED2

c) Time Required:

1) Minimum—0.124 millisecond
2) Maximum—0.456 millisecond
FIGURE 6-5. MPLLED2 PROGRAM FLOW CHART
6.4 MONITOR SUFFIX TO E0LED1 (MFLED1)

MFLED1 handles all exit control functions associated with the low-speed edit program, E0LED1. MFLED1 processes the edited radar message block containing first pass Bermuda data to eliminate all powered flight data and, after retrofire has occurred, processes the edited radar message block for re-entry input. All messages in the radar message block are thrown out which have a time tag earlier than the end of powered flight (for example, in the first pass Bermuda data) or which, in re-entry, have a time tag earlier than burnout. The number-of-messages indicator for the message block is updated, if necessary, as is the time of minimum range. Furthermore, during the change of phase from orbit to re-entry, MFLED1, together with MPLED2, has the added function of re-queueing differential correction (DC) in the proper order with certain message blocks which are valid re-entry input but which either have been queued as orbital input to differential correction or which have been processed by differential correction as orbital input; before re-queueing, the radar message block is processed as described above to be made valid for re-entry input.

The flow chart for MFLED1 suffix is shown in Figure 6-6.

6.4.1 Input Requirements

Input to MFLED1 consists of:

a) The radar message block TMRMXX specified in the address of MCLEDD, where XX varies from 01 to 19 corresponding to the internal station number of the various radar stations. The radar blocks have the following format:

<table>
<thead>
<tr>
<th>Word</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Station identification number in the address field.</td>
</tr>
<tr>
<td>2</td>
<td>Number of radar messages in this block.</td>
</tr>
<tr>
<td>3</td>
<td>Address field contains location of time of minimum range in this block relative to the first word. For example: if the first time (the time in word 4) is the time of minimum range, the address of word 3 contains a 3 (word 1 + 3). If the second time is the time of minimum range, the address of word 3 contains a 7.</td>
</tr>
<tr>
<td>4</td>
<td>Time (T_1) in fixed-point; minutes in address field, seconds in decrement field.</td>
</tr>
<tr>
<td>5</td>
<td>Range (R_1) in floating-point Mercury units.</td>
</tr>
</tbody>
</table>
Word | Contents
--- | ---
6 | Azimuth ($A_1$) in floating-point radians.
7 | Elevation ($E_1$) in floating-point radians.
8 | $T_2$; 2nd Radar Message
9 | $R_2$; 2nd Radar Message
10 | $A_2$; 2nd Radar Message
11 | $E_2$; 2nd Radar Message
| | (up to 50 T, R, A, E, messages)

$T_n$ is always greater than $T_{n-1}$.

b) MCLEDD—contains in the address the starting location of the radar message block for editing, TMRMXX (where the XX varies from 01 to 19).

c) MCNRRF—contains zero during orbit, set to non-zero during re-entry.

d) MCBNOT—contains in the re-entry phase GMT of burnout (seconds in address, minutes in decrement), set either by MYREST or MYSEEK.

e) MCPFLD—contains GMT of the termination of powered flight (seconds in address, minutes in decrement), set in launch.

f) MCCAP1—location initially zero, but set non-zero by MPLED1 to indicate to MFLED1 that the block being edited contains first pass Bermuda data. MCCAP1 is reset to zero by MFLED1.

g) MCCHEK—location initially zero, but set non-zero by MPLED2 to indicate to MFLED1 that the queue for MPLED2 has been emptied; it is then reset to zero by MFLED1.

### 6.4.2 Output Requirements

Output from MFLED1 consists of:

a) TMRMXX;
Station identification in the address field.

If the message block contains first pass Bermuda data or if retrofire has occurred, word 2 contains the number of messages in the block having a time greater than or equal to MCBNOT.

If the message block contains first pass Bermuda data or if retrofire has occurred, word 3 contains the location of the time of minimum range relative to the first word.

Time \( T_1 \) in fixed-point; minutes in address field, seconds in the decrement field.

Range \( R_1 \) in floating-point Mercury units.

Azimuth \( A_1 \) in floating-point radians.

Elevation \( E_1 \) in floating-point radians.

1st message in original block having a time greater than MCBNOT

2nd message in original block having a time greater than MCBNOT

(up to 50 messages)

b) MCCHEK—if set non-zero by MPLED2 (to indicate to MFLED1 that the queue for MPLED2 has been emptied), reset to zero by MFLED2.

c) MCCAP1—set to zero by MFLED1.

d) MCBNOT—if the radar block being edited contains first pass Bermuda data, MFLED1 stores in MCBNOT the GMT of the end of powered flight (minutes in decrement, seconds in address).
6.4.3 Method

When MFLED1 is entered, the second word of the radar message block, TMRMXX, which contains the number of radar messages accepted by the edit program, is tested. If this word is zero, differential correction is by-passed, and a message to this effect is queued. Otherwise, a test is made to determine whether or not the input is first pass Bermuda data, for which the time for screening the radar messages is set equal to the time of the end of powered flight. The screening process then proceeds as described below.

If the input is not first pass Bermuda data, a test is made to determine whether or not re-entry is in process. For the orbit phase, all messages in the block are valid, and thus DC is queued, as is an on-line message which states the number of observations presented to DC. For the re-entry phase, the time for screening the radar messages has been preset equal to the time of burnout by MYREST or MYSEEK.

The time of the first message in the radar block is compared to the screening time. If it is greater than or equal to the screening time, all the messages in the block are valid, since $T_n$ is always greater than $T_{n-1}$ in the edited radar message block. If the time of the first message in the radar block is less than the screening time, the block is searched from the last message received for the latest message having a time less than the screening time. When this time is found, the corresponding message, as well as those preceding, is rejected. The number of messages in the radar block is updated to indicate only the number of messages having an associated time greater than or equal to the time used for screening. If all messages are rejected, the same procedure is followed as when there are no input messages. However, if there are some valid messages in the block, the valid messages are moved forward so that the first message in the block is the first valid message.

A test is made to determine whether or not the message with the time of minimum range was accepted. If this message was accepted, word 3 in the radar message block is updated with the new relative location of the minimum range time. If, however, the message was rejected, word 3 in the radar block is set to reference the location of the time of the first message in the block. Differential correction is queued, as is a message stating "THE NUMBER OF OBSERVATIONS PRESENTED TO DC IS _________." Before exit is made to M0PRIO (by MPLED1 when its queue has been emptied), if MCCHEK is non-zero, MCCHEK is reset to zero, MYREST is unsuppressed after having been suppressed in MPLED2, and MPLEDI unsuppressed after having been suppressed.
in MYREST. These suppressions ensure that the queues to differential correction are accepted in the proper order. Whether MCCHEK is or is not equal to zero, MCCAP1 is re-initialized to zero, the suppression of MYREST set in MPLED1 is unsuppressed, and the A indicator turned off for both MPLED1 and MPLED2. Control is transferred to M0PRIO. (Note: MPLED1 and MPLED2 are never in process at the same time; the B indicator for MPLED2 is turned on only in MYREST, which cannot be entered when MPLED1 is in process, and which suppresses MPLED1; this suppression remains until the queue for MPLED2 is emptied.)

6.4.4 Usage

MFLED1 is entered from either MPLED1, MPLED2, or EOLED1; MFLED1 exits to M0PRIO.

a) Storage Required—57 locations

b) MFLED1 uses:

1) Macros—QENBA, QENBZ, QUEUE and TRNOF

2) Parameters—A, MNLED1 and MNLED2

3) Communication cells—MCBNOT, MCCAP1, MCCHEK, MCLEDD, MCNRRF and MCPFLD

4) Tables—TMRM01 . . . . . . . . TMRM19

5) Constants—K00001, K00003 and K00020

c) Time Required:

1) Minimum—0.153 millisecond

2) Maximum—3.372 milliseconds
FIGURE 6-6. MFLED1 PROGRAM FLOW CHART (Sheet 1 of 2)
Figure 6-6. MFLED1 Program Flow Chart (Sheet 2 of 2)
6.5 MONITOR PREFIX TO D0DIFC (MPDIFC)

MPDIFC is one of two prefixes to the Differential Correction Processing Program, D0DIFC. Entry is made to D0DIFC via the MPDIFC prefix only when there is new radar data which has not previously been used by the differential correction program. MPDIFC incorporates the new input into TMSTMS and eliminates from this table data which is 72 or more minutes older than the latest entry. If instructed by sense switch 2 and the entry keys, MPDIFC bypasses the new data.

The flow chart for the MPDIFC prefix is shown in Figure 6-7.

6.5.1 Input Requirements

Input for MPDIFC consists of:

a) An input queue entry word which contains in the address the location of the new radar message block.

b) TMSTMS—a table of up to 15 entries, containing in the address of each entry the location of the radar message block and in the decrement the time of minimum range (TMR) on that pass for that station. The entries are ordered according to TMR, with the entry for the most recent time first. No block with a TMR 72 or more minutes older than the most recent TMR is included. The last entry in the table is set negative; all preceding entries are positive. The contents of each location in the table initially must be set to negative zero.

6.5.2 Output Requirements

Output from MPDIFC consists of:

a) MCLENT—contains the location of the new data in the TMSTMS table relative to the first location in the table.

b) MCDCRJ—set non-zero when MPDIFC bypasses differential correction and exits to MFDIFC.

The accumulator contains a positive 1 when MPDIFC exits to MFDIFC; the accumulator is positive and contains the contents of MCLENT when MPDIFC exits to D0DIFC.

The TMSTMS table is updated.

6.5.3 Method

The method of MPDIFC is shown in Figure 6-7.
6.5.4 Usage

MPDIFC is entered from MOPRIO; MPDIFC exits to either DODIFC or MFDIFC.

a) Storage Required—136 locations

b) MPDIFC uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNON and UNQUE

2) Parameters—A, C, MNREST, MNDIFC, MNMESS

3) Communication cells—MCDCRJ and MCLENT

4) Table—TMSTMS

5) Constants—K00001, K00002 and K00072

c) Time Required:

Approximately 7-8 milliseconds
FIGURE 6-7. MPDIFC PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 6.7. MPDIFC PROGRAM FLOW CHART (Sheet 2 of 2).
6.6 MONITOR PREFIX TO D0DIFC (MPDIFK)

MPDIFK receives control after D0DIFC has requested a successive differential correction using the same radar data. MPDIFK is given control for as many times as another differential correction is requested for a given radar station’s data.

MPDIFK provides D0DIFC with the location of the last entry in the TMSTMS table by placing the contents of MCLENT in the accumulator. The accumulator sign is set negative to indicate that this is a successive entry and that no new observations are to be used in the differential correction.

The flow chart for the MPDIFK prefix is shown in Figure 6-8.

6.6.1 Input Requirements

Input to MPDIFK consists of the communication cell, MCLENT, which contains the location, relative to TMSTMS, of the latest entry in the TMSTMS table.

6.6.2 Output Requirements

The contents of MCLENT are stored in the accumulator and the sign is set negative.

6.6.3 Method

The method of MPDIFK is given in Figure 6-8.

6.6.4 Usage

MPDIFK is entered from M0PRT; MPDIFK exits to D0DIFC.

a) Storage Required—nine locations

b) MPDIFK uses:

1) Macros—TRNOF and TRNON

2) Parameters—A, B, C, MNDIFK and MNREST

3) Communication cell—MCLENT

c) Time Required—0.039 millisecond
FIGURE 6-8. MPDIFK PROGRAM FLOW CHART

6-32
6.7 MONITOR SUFFIX TO DODIFC (MFDIFC)

MFDIFC may be entered for one of the following reasons: (1) an acceptable differential correction has been made and DODIFC requests control to correct again using the same data, after a numerical integration table based on the present correction has been generated; (2) an acceptable correction has been made, but DODIFC does not wish to correct again using the same data; (3) DODIFC has rejected the correction, in which case a new table is not generated; (4) DODIFC has been bypassed due to manual intervention, i.e., sense switch setting on the computer console (see MPDIFC, Subsection 6.5).

MFDIFC controls the program flow by placing appropriate entries in the input queue for numerical integration. On-line messages are queued to provide an external indication of the program flow.

The flow chart for the MFDIFC suffix is shown in Figure 6-9.

6.7.1 Input Requirements

a) TDRANV—table containing the R and V vectors obtained from differential correction together with numerical integration criteria (see Table 6-1).

b) TDCLLT—table containing an entry indicating weights assigned to a radar station for the differential correction.

c) TMSTMS—indicates which station supplied new data for this differential correction.

d) TNNDCI—contains the standard integration format when numerical differential correction is being used.

e) MCTLST—contains the time of the last observation included in the differential correction. This time is written on the restart tape.

f) MCHFSC—contains the current GMT in fixed-point half seconds.

g) MCTABT—when non-zero, indicates the high-abort re-entry case.

h) MCLENT—contains the location, relative to TMSTMS, of the latest entry in the TMSTMS table. For example, if MCLENT contains zero, a station entry has been placed in the table at the TMSTMS location. If MCLENT contains 3, a station entry has been placed in the TMSTMS table at location TMSTMS + 3.

i) MCDCRJ—when non-zero, indicates differential correction was bypassed due to manual intervention.
If the accumulator is non-zero, differential correction rejected the input and integration is not desirable. If the accumulator is positive zero, differential correction was accepted, numerical integration is requested but further differential correction with the input data is not requested. If the accumulator is negative zero, differential correction was accepted, numerical integration is requested, and another differential correction using the same data is requested. If the accumulator is negative zero, and if the P bit contains 1, numerical differential correction is being used, one of the six tables is to be generated by N0CPNI and control returned to DODIFC.

6.7.2 Output Requirements

Output from MFDIFC consists of:

a) TMREST—data to be written on the restart tape is stored in the restart table.

b) MCDCCT—set non-zero when differential correction successful. This communication cell is used by N0CPNI to determine whether or not the previous table can be generated if an error occurs.

c) MCDCRJ—reset to zero, if non-zero upon entry to MFDIFC.

d) When appropriate, entries are stored in the queue tables for N0CPNI and MYMESS.

6.7.3 Method

The method of MFDIFC is shown in Figure 6-9.

6.7.4 Usage

MFDIFC is entered from D0DIFC or MPDIFC; MFDIFC exits to M0PRI0.

a) Storage Required—149 locations

b) MFDIFC uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, C, D, MNCPNI, MNDIFC, MNDIFK, MNGEN1, MNGEN2, MNGEN3, MNMESS, MNREST and MNWRRS

3) Communication cells—MCDCRJ, MCHFSC, MCLENT, MCTABT and MCTLST

4) Tables—TDCLLT, TDRANV, TMREST, TMSTMS and TNNDCI
5) Constants—K00178 and K00179

c) Time Required:

1) Minimum—0.191 millisecond

2) Maximum—0.664 millisecond
FIGURE 6-9. MFDIFC PROGRAM FLOW CHART (Sheet 1 of 3)

6-36
FIGURE 6-9. MFDIFC PROGRAM FLOW CHART (Sheet 2 of 3)
FIGURE 6-9. MFDIFC PROGRAM FLOW CHART (Sheet 3 of 3)
6.8 MONITOR NUMERICAL INTEGRATION GENERATOR (MYGEN1)

MYGEN1, together with MYGEN2 and MYGEN3, controls the use of the Numerical Integration Program, NOCPNI, by ensuring that the many demands made upon NOCPNI are handled without conflicting entries into the processing program.

The flow chart for the MYGEN1 processor is shown in Figure 6-10.

6.8.1 Input Requirements

Input to MYGEN1 consists of an entry in the MYGEN1 queue. The entry in the MYGEN1 queue is identical to an entry in the NOCPNI queue.

6.8.2 Output Requirements

The control word is taken from the MYGEN1 queue and stored in the NOCPNI queue.

6.8.3 Method

MYGEN1 is entered when the normal basic orbit cycle (as opposed to a situation forced by manually inserted vectors) requires an orbit table, a re-entry table and time-to-retrofire calculations or when the normal re-entry cycle requires a re-entry table. An entry to MYGEN1 follows a phase change from launch to orbit, a successful differential correction and a restart from tape.

MYGEN1 turns on suppression indicators for MYGEN2 and MYGEN3, since these programs may also provide input to the NOCPNI queue, and these suppression indicators remain on until the NOCPNI processing initiated by MYGEN1 is complete. (MYGEN1, MYGEN2 and MYGEN3 are all mutually exclusive in their usage of NOCPNI).

After MYGEN1 suppresses MYGEN2 and MYGEN3, the input queue entry for MYGEN1 is stored in the NOCPNI queue table and control returns to M0PRIO.

6.8.4 Usage

MYGEN1 is entered from, and exits to, M0PRIO.

a) Storage Required—19 locations

b) MYGEN1 uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF, TRNON and UNQUE

2) Parameters—A, C, MNCPNI, MNGEN1, MNGEN2 and MNGEN3

c) Time Required—0.290 millisecond
FIGURE 6-10. MYGEN1 PROGRAM FLOW CHART
6.9 MONITOR NUMERICAL INTEGRATION GENERATOR (MYGEN2)

MYGEN2 controls the use of the Numerical Integration Processing Program, NOCPNI, whenever R and V vectors are inserted manually.

The flow chart for the MYGEN2 processor is shown in Figure 6-11.

6.9.1 Input Requirements

Input to MYGEN2 consists of the communication cell, MCNRRF, which, when non-zero, indicates the re-entry phase.

6.9.2 Output Requirements

Output from MYGEN2 consists of:

a) MCRVPT—set non-zero to indicate that numerical integration based on manually inserted R and V vectors is in process.

b) An entry is placed in the queue table for NOCPNL. This entry locates the R and V vectors and specifies the integration parameters. The decrement of the queue entry contains a 2 to indicate that a re-entry table is desired or zero to indicate an orbit table.

6.9.3 Method

MYGEN2 is entered whenever R and V vectors are inserted manually. MYGEN1 and MYGEN3 are suppressed and remain suppressed until processing based on the inserted R and V vectors is complete. MCRVPT is set non-zero to indicate that operations in process are based on a manual insertion.

MYGEN2 sets up the proper queue control word with the table (orbit or re-entry) indication for MNCPNI.

6.9.4 Usage

MYGEN2 is entered from M0PRIO; MYGEN2 exits to M0PRIO.

a) Storage Required—24 locations

b) MYGEN2 uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, D, MNCPNI, MNGEN1, MNGEN2 and MNGEN3

3) Communication cells—MCNRRF and MCRVPT
MC 103

c) Time Required:

1) Minimum—0.187 millisecond
2) Maximum—0.196 millisecond
FIGURE 6-11. MYGEN2 PROGRAM FLOW CHART
6.10 MONITOR NUMERICAL INTEGRATION GENERATOR (MYGEN3)

MYGEN3, although not at present incorporated into the Mercury Program System, will be used when capsule impact points based on immediate retrofiring are displayed at Cape Canaveral. MYGEN3 will control the usage of numerical integration for the impact points, as MYGEN1 and MYGEN2 control numerical integration for other computations. Since these three generator processors are mutually exclusive, MYGEN3 must suppress MYGEN1 and MYGEN2 for the duration of MYGEN3's usage of numerical integration.

The present inclusion of the appropriate priority entries for MYGEN3 in the system will allow the incorporation of MYGEN3 without modification to MYGEN1 and MYGEN2.
6.11 MONITOR PREFIX TO N0CPNI (MPCPNI)

MPCPNI determines the reason for entering numerical integration, i.e., to generate an orbit table, a re-entry table, an impact point, or one of six tables requested by numerical differential correction. MPCPNI provides N0CPNI with the input parameters which define and direct the integration procedure.

MPCPNI must also suppress any program which uses the output from numerical integration.

The flow chart for the MPCPNI prefix is shown in Figure 6-12.

6.11.1 Input Requirements

Input to MPCPNI consists of one of the four following 15-word tables. The format conforms to that for the standard integration parameters and is illustrated in Table 6-1.

a) TDRANV is used by differential correction for the orbit table, the re-entry table, the abort table in the high-abort phase, the initial orbit table after the launch phase, i.e., the insertion parameters, and the initial tables for a restart.

b) TMRARF is used by R5RARF when a re-entry table or impact point is required and by the launch programs when a re-entry table is required for the low-abort or medium-abort phases.

c) TNNDCI is used by numerical differential correction when the capsule is below 450,000 feet in re-entry.

d) TIOTRV is used when R and V vectors and their associated time tag are inserted manually via paper tape.

The specific table required is determined from the entry in the N0CPNI queue table.

6.11.2 Output Requirements

Output from MPCPNI consists of:

a) TMBBNI—15-word table containing the integration input parameters moved from the appropriate table (one of the four listed in input).

b) MCNIIP—the numerical-integration-in-process indicator cell is set non-zero.

c) MCZRWX—contains the input control word for entry. This word was removed from N0CPNI input queue.
6.11.3 Method

MPCPNI turns on the A indicator for NOCPNI and suppresses the following programs for duration of integration process: OOORMC, MYSEEK, MYACQD, and MPCCIP. MPCPNI sets MCNIIP non-zero to indicate that integration is in process.

The oldest entry is taken from queue for NOCPNI and stored in MCZRWX. The address of MCZRWX contains the location +15 of the table to be used as input to numerical integration. The decrement of MCZRWX is zero if an orbit table, TNINT1, is required. The decrement of MCZRWX contains a 1 if numerical differential correction requires one of the six tables with a perturbed element: TNINT3, TNINT4, TNINT5, TNINT6, TNINT7 and TNINT8. These tables are used in the re-entry phase for heights below 450,000 feet. The decrement of MCZRWX contains a 2 if the re-entry table, TNINT2 or the impact point, TNINT9, is required.

MPCPNI then moves the table specified (in address of MCZRWX) into TMBBNI.

6.11.4 Usage

MPCPNI is entered from M0PRIO; MPCPNI exits to NOCPNI.

a) Storage Required—25 locations

b) MPCPNI uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, C, E, MNACQD, MNCCIP, MNCPNI, MNORMC and MNSEEK

3) Communication cells—MCNIIP and MCZRWX

4) Tables—TDRANV, TI0TRV, TMBBNI, TMRARF and TNNDCI

c) Time Required—0.405 millisecond
<table>
<thead>
<tr>
<th>Location</th>
<th>Contents</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table</td>
<td>X component, R vector</td>
<td>(X) floating point, Mercury units</td>
</tr>
<tr>
<td>+1</td>
<td>Y component, R vector</td>
<td>(Y) floating point, Mercury units</td>
</tr>
<tr>
<td>+2</td>
<td>Z component, R vector</td>
<td>(Z) floating point, Mercury units</td>
</tr>
<tr>
<td>+3</td>
<td>X component, V vector</td>
<td>(X) floating point, Mercury units</td>
</tr>
<tr>
<td>+4</td>
<td>Y component, V vector</td>
<td>(Y) floating point, Mercury units</td>
</tr>
<tr>
<td>+5</td>
<td>Z component, V vector</td>
<td>(Z) floating point, Mercury units</td>
</tr>
<tr>
<td>+6</td>
<td>Anchor time of above vectors</td>
<td>fixed point; units refer to +9</td>
</tr>
<tr>
<td>+7</td>
<td>Address contains desired integ. output</td>
<td>Symbolic</td>
</tr>
<tr>
<td>+8</td>
<td>integration interval</td>
<td>integer; units refer to +9</td>
</tr>
<tr>
<td>+9</td>
<td>time interval</td>
<td>if 0, interval is minutes if 1, interval is seconds</td>
</tr>
<tr>
<td>+10</td>
<td>desired time to integrate backwards</td>
<td>integer, units refer to +9</td>
</tr>
<tr>
<td>+11</td>
<td>desired time to integrate forward</td>
<td>integer, units refer to +9</td>
</tr>
<tr>
<td>+12</td>
<td>indication to apply effect of &quot;Drag&quot;</td>
<td>= 0, use Drag routine ≠ 0, do not use Drag routine</td>
</tr>
<tr>
<td>+13</td>
<td>indication whether R's only or R's and V's desired.</td>
<td>0: R's only 1: R's and V's</td>
</tr>
<tr>
<td>+14</td>
<td>Number of integration intervals per output</td>
<td>integer, fixed pt.</td>
</tr>
</tbody>
</table>
FIGURE 6-12. MCPFNI PROGRAM FLOW CHART
6.12 MONITOR SUFFIX TO NOCPNI (MFCPNI)

MFCPNI handles all control functions associated with exit from the Numerical Integration Processing Program, NOCPNI.

The flow chart for the MFCPNI suffix is shown in Figure 6-13.

6.12.1 Input Requirements

Input to MFCPNI consists of:

a) TMORMC—14th word contains computed latitude at 60,000 feet; 15th word contains computed longitude at 60,000 feet—used to print the impact point in the re-entry phase.

b) TFESAB—contains time of first even second after burnout, computed by R5RARF in fixed-point seconds.

c) TMSSEC—contains the time to retrofire during orbit and the time of retrofire during re-entry. This time is in fixed-point seconds and is used to print the anchor time of the abort/re-entry tables for the message: "REENTRY TABLES GENERATED BASED ON ___ HRS ___ MINS ___ SECS."

d) TNINT1—fourth location contains in fixed-point seconds the ending time of the orbit table.

e) MCTABT—indicates, when non-zero, the high-abort phase.

f) MCZRWX—queue control word for MNCPNI

g) MCSKPM—indicates, when zero, re-entry table generated; when non-zero, impact point generated.

h) MCNRRRF—when zero, indicates orbit phase; when non-zero, re-entry phase.

i) MCRVPT—set non-zero if input to integration was manually inserted (paper tape).

j) MCLMBT—when non-zero, indicates medium-abort phase.

k) MCHFSC—contains the current GMT in fixed-point half seconds.

l) Accumulator—when non-zero, indicates error by NOCPNI; when negative zero, indicates integration table reached 60,000 feet; when positive zero, indicates integration table did not reach 60,000 feet.
6.12.2 Output Requirements

Output from MFCPNI consists of:

a) MCSKPM—set non-zero when re-entry table generated.

b) MCRVPT—reset to zero, if non-zero on entry to MFCPNI.

c) MCESAB—contains the GMT of the first even second after burnout; set whenever new re-entry table generated and used by MYACQD and A0STAD.

d) McAPPE—set non-zero whenever an orbit table is generated by N0CPNI. This cell is used by MFORMC.

e) MCNIIP—reset zero, if non-zero on entry to MFCPNI. This cell is used by the medium-abort program.

f) MCDCCT—set to zero. This cell is used by N0CPNI to determine whether or not the previous integration table may be generated if an error occurs. Set non-zero by MFDIFC.

g) MCDOWN—set non-zero if the abort table reaches 60,000 feet. This cell is used by high-abort program, MYSEEK.

h) Queue entries are placed in the input tables for R5RARF and MYMESS.

6.12.3 Method

If an error occurred in the integration process, MFCPNI queues an on-line message which indicates the error.

If the high-abort phase has been entered, MFCPNI queues on-line messages with statements regarding the phase status, i.e., abort table, re-entry table, impact point. MFCPNI also must maintain priority controls as the situation requires.

If the orbit table has been generated, MFCPNI queues an on-line message to indicate the orbit table, and if the orbit table reaches 60,000 feet, the last entry in the table is also printed. R5RARF is queued to determine R and V vectors and their associated time tag for the re-entry table. If the orbit table has been generated in the re-entry phase, controls are set to bypass the queueing for R5RARF. If the orbit table has been generated in the orbit phase, controls are set for MFORMC to print on-line the computed perigee and apogee.

If a re-entry table has been generated, an on-line message stating this is queued, and, if in the re-entry phase, the latitude and longitude of the impact point are also printed. If the mission is in the orbit phase, MFCPNI queues R5RARF to calculate the retrofire time. When the initial re-entry table is
If an impact point has been generated in the time-to-fire cycle, no messages are printed and control is given to R5RARF.

6.12.4 Usage

MFCPNI is entered from N0CPNI; MFCPNI exits to M0PRI0.

a) Storage Required—233 locations

b) MFCPNI uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, C, D, E, H, MNACQD, MNCCIP, MNCNPNI, MNGEN1, MNGEN2, MNGEN3, MNMESS, MNORMC and MNRARF

3) Communication cells—MCAPPE, MCDCCT, MCESAB, MCLMBT, MCNIIP, MCNRRF, MCRVPT, MCSKPM, MCTABT and MCZRWX

4) Tables—TFESAB, TNINT1, TMORMC and TMSSEC

5) Constants—K.IRAD, K00001, K00027, K00037, K00038, K00060, K00081, K00085, K00154 and K00360

c) Time Required:

1) Minimum—0.061 millisecond

2) Maximum—0.642 millisecond
FIGURE 6-13. MFCPNI PROGRAM FLOW CHART (Sheet 1 of 6)
BE12 IS A NOP DURING ORBIT AND A TRANSFER TO BE11 DURING RE-ENTRY

HAS BE12 BEEN CHANGED FOR RE-ENTRY PHASE?

QENBZ (ENABLE)

QUEUE MNRARF BE1

IN RE-ENTRY? MCNRRF ≠ 0

BE11

QENBA (ENABLE)

INITIALIZE QUEUE CONTROL WORD FOR MPRARF (BE1).

BE12

BE11 IS A NOP DURING ORBIT AND A TRANSFER TO BE11 DURING RE-ENTRY

QENBA (ENABLE)

TABLE GENERATED FROM MANUAL INSERTED R AND V VECTOR MCRYPT ≠ 0

0 → MCRYPT

TRNOF D MNGEN1

TRNOF D MNGEN3

GMT OF FIRST EVEN SECOND AFTER BURNOUT → MCESAB (USED BY MYACQD)

QENBA (ENABLE)

QENBZ (ENABLE)

QUEUE MNRARF BE1

IN RE-ENTRY? MCNRRF ≠ 0

BE11

QENBA (ENABLE)

INITIALIZE QUEUE CONTROL WORD FOR MPRARF (BE1).

FIGURE 6-13. MFCPNI PROGRAM FLOW CHART (Sheet 2 of 6)
FIGURE 6-13. MFCPNI PROGRAM FLOW CHART (Sheet 3 of 6)
IS ORBIT TABLE IN ERROR? (GOES TO 60,000 FEET) NO
YES

SET UP QUEUE CONTROL WORD (BE60K) TO PRINT TIME OF LAST ENTRY IN TABLE

QENBZ (DISABLE)

QUEUE MNMESS, BE60K

IS RE-ENTRY TABLE IN ERROR? (DOES NOT REACH 60,000 FEET) YES NO

SET UP QUEUE CONTROL WORD (BE60K) TO PRINT RE-ENTRY TABLE DID NOT REACH 60,000 FEET

85 (MESSAGE NO) -> QUEUE CONTROL WORD (BE8) FOR MNMESS

SET INDICATION TO PRINT APOGEE AND PERIGEE (MCAPPE ≠ 0)

QENBZ (DISABLE)

TO PRINT R IN OCTAL

TO PRINT V IN OCTAL

2B

4B

2D

4C

FIGURE 6-13. MFCPNI PROGRAM FLOW CHART (Sheet 4 of 6)

QUEUE MNMESS, MCTRVT

QUEUE MNMESS, BEVEE

QENBA (ENABLE)
**FIGURE 6-13. MFCPNI PROGRAM FLOW CHART** (Sheet 5 of 6)
6A

BELL'S

HAS PREVIOUS TABLE BEEN GENERATED?

YES

BEXX

QENBZ
DISABLE)

NO

QENBZ
DISABLE)

MESSAGE:
"ERROR IN INTEGRATION PROCESS"

QENBA
DISABLE)

QUEUE
MNMESS,
K00081

QUEUE
MNMESS,
K00027

QENBA
DISABLE)

"ERROR IN INTEGRATION,
PREVIOUS TABLE GENERATED"

DID ERROR OCCUR IN ORBIT TABLE?

YES

BELCH

SET SIGN OF AC POSITIVE

NO

SET SIGN OF AC NEGATIVE

1A

2F

BE13

CHANGE INSTRUCTION IN BE12 FOR RE-ENTRY PHASE

FIGURE 6-13. MFCPNI PROGRAM FLOW CHART (Sheet 6 of 6)
6.13 MONITOR PREFIX TO R5RARF (MPRARF)

MPRARF determines if R5RARF is being entered to compute nominal R and V vectors and their associated time tag at burn-out for a re-entry table or impact point, or if data should be supplied to compute a time-to-fire for a specific recovery area. For the latter, the locations of the time-to-fire and the recovery area are placed in the MQ, and the location of the ten-mile increment of longitude and the type of recovery area are placed in the AC.

The flow chart for the MPRARF prefix is shown in Figure 6-14.

6.13.1 Input Requirements

Input to MPRARF consists of:

a) TMNTRF—a three-cell table containing the nominal retrofire times in fixed-point seconds for the termination of the first, second and third orbit. When R5RARF computes a new retrofire time, the computed value replaces the appropriate nominal value in this table.

b) TMLMPT—a three-cell table containing the longitude of the recovery areas for the first, second, and third orbits. The longitudes are expressed in floating-point radians, from 0 to 6.283185307 (2π).

c) TMLDLA—contains increments in longitudes corresponding to ten miles for the recovery areas specified in TMLMPT.

d) MCTABT—when non-zero, indicates the high-abort phase.

e) MCTOFS—contains the retrofire time to end the mission, or in the re-entry phase, the actual retrofire time.

f) MCSKPM—contains zero, if a re-entry table was generated on the previous entry to R5RARF; contains non-zero, if an impact point was generated on the previous entry to R5RARF.

g) MCPASN—contains the number of the present orbit: 1, 2, or 3.

h) MC3ORT—when non-zero, indicates the present orbit is the third.

i) MCCNTR—control cell which locates the current entry in the time and longitude tables. The contents of MCCNTR are one less than the orbit number: MCCNTR plus TMNTRF (TMLMPT or TMDLA) locates the proper entry in the table.

6.13.2 Output Requirements

Output from MPRARF consists of:
a) **TMSSEC**—in the orbit phase this cell contains the present capsule retrofire setting, or the actual time of firing in the re-entry phase.

b) **MCSKPM**—reset non-zero, if zero on entry to MPRARF.

c) **MC3ORT**—set non-zero, if the present orbit is the third orbit.

d) **MCCNTR**—contains one less than the present orbit number.

The MQ contains positive zero, if integration parameters for a re-entry table are required from R5RARF. The MQ contains negative zero, if integration parameters for an impact point are required from R5RARF. The MQ, when non-zero, contains in the address the location of the nominal time-to-fire for a particular recovery area and in the decrement the longitude of this recovery area. In addition, when the MQ is non-zero, the AC contains in the address the location of the incremental longitude for the recovery area and in the decrement the orbit number of the orbit for which the time-to-fire calculation is being made. The sign of the AC is negative, if the present orbit is the third. If the time-to-fire is to be computed for an emergency area, the decrement of the AC is zero.

6.13.3 Method

MPRARF removes the input control word from the R5RARF input queue table and stores this word in BL1. If BL1 is non-zero, a re-entry table is required and R5RARF is to determine the integration parameters based on either the present capsule setting or the retrofire time. A positive zero is stored in the MQ to indicate these requirements to R5RARF.

If the re-entry table has just been generated in the orbit phase, BL1 and MCSKPM contain zero. MPRARF informs R5RARF that the time-to-fire is required for the termination of the present orbit, by storing the location of the nominal time-to-fire for the present orbit in the address of the MQ. The location of the longitude for the associated recovery area is stored in the decrement of the MQ. The location of the incremental longitude (which defines the bounds of the recovery area) is placed in the address of the accumulator. A 1 or a 2 is placed in the decrement of the AC for the first and second orbits, respectively, and the AC sign is set positive. For the third orbit a 3 is placed in the decrement of the AC and the AC sign is set negative. If an impact point has been computed by N0CPNI, the MQ is set zero and the sign set negative. For this entry R5RARF compares the computed to the desired impact point.

When indication is made by R5RARF to MPRARF that the time-to-fire iterations are complete for the present orbit, MPRARF re-enters the prefix at MPRAR2. When control enters at this location, MPRARF sets controls for R5RARF to iterate for the time-to-fire to end the mission.

If the high-abort phase has been entered, MPRARF gives control to R5RARF to provide the re-entry table.
6.13.4 Usage

MPRARF is entered at its initial location from MOPRIO and at the MPRAR2 location from MFRARF; MPRARF exits to R5RARF.

a) Storage Required—84 locations

b) MPRARF uses:

1) Macros—QENBA, QENBZ, TRNOF, TRNON and UNIQUE

2) Parameters—A, B, D, MNRARF and MNSEEK

3) Communication cells—MCCNTR, MCPASN, MCSKPM, MCTABT, MCTOFS and MC3ORT

4) Tables—TMLDLA, TMLMPT, TMNTRF and TMSSEC

5) Constants—K00000, K00001, K00002, K00003, K00005 and KM0000

c) Time Required:

1) Minimum—0.090 millisecond

2) Maximum—0.237 millisecond
FIGURE 6-14. MPRARF PROGRAM FLOW CHART (Sheet 1 of 2)
MC 103

**Figure 6-14. MPRARF Program Flow Chart (Sheet 2 of 2)**

1. **Determine Present Orbit Number**
2. **Is Present Orbit No. 3?**
   - **Yes**: Set indication of this: MC3ORT = 3
   - **No**: Set MCCNTR to 1 less than orbit number: to be used in determination of desired time and area
3. **Location of Nominal Time to Fire**:
   - Add (MQ)
   - Loc. of Longitude Recovery Area: Dec (MQ)
   - Loc. of Increment of Longitude: Add (AC)
   - Area Indication: Decr (AC)
4. **Present Orbit 3rd Orbit**
   - **Yes**: Set AC sign negative
   - **No**: Set AC sign positive
5. **R5RARF**
6. **TRNON D MNSEEK**
7. **TRNOF B MNRARF**
8. **Set MQ = +0 R5RARF to set parameters for re-entry**
9. **No Need to Compute Retro-Fire Times If Mission in High Abort Phase**
6.14 MONITOR SUFFIX TO R5RARF (MFRARF)

MFRARF, together with MPRARF, controls computations in the orbit phase such that when a new re-entry table has been generated, the retrofire times are computed for end of present orbit, for the end of the mission and for next emergency areas.

The flow chart for the MFRARF suffix is shown in Figure 6-15.

6.14.1 Input Requirements

The contents of the accumulator are set by R5RARF to provide the following information to MFRARF: positive zero, numerical integration is to be entered to compute a re-entry table or impact point; negative zero, R5RARF detected an error condition; non-zero, the iterations through R5RARF and N0CPNI and time-of-retrofire calculations are completed for the desired area.

Other input to MFRARF consists of:

a) TMNTRF—table of nominal times-to-fire for ends of orbits, updated by R5RARF when new times are computed.

b) TMTFEA—table of nominal times-to-fire for the 14 emergency recovery areas. These times are updated by R5RARF when new ones are computed.

c) TMAREA—table of longitudes of emergency recovery areas.

d) TMDARE—table of longitude increments corresponding to ten miles.

e) MCTABT—when non-zero, indicates the high-abort phase.

f) MCCNTR—contains one less than the orbit pass number.

g) MCRVPT—when non-zero, indicates that R and V vectors have been manually inserted.

h) MCHFSC—contains the present GMT in fixed-point half seconds.

i) MCPASN—contains the present orbit pass number.

6.14.2 Output Requirements

Output from MFRARF consists of:

a) TMORMC—the 30th location in this table contains the next emergency recovery area for display at Canaveral.
b) MCCNTR—set to control determination of orbit number in time-to-fire calculations.

c) MCSKPM—set to zero, when all of the time-to-fire calculations have been completed.

d) MCRVPT—set non-zero if the R and V vectors were inserted manually. This cell is set to zero when all calculations are complete.

6.14.3 Method

If R5RARF has encountered an error in using the Lagrangian interpolation procedures, MFRARF controls are adjusted to attempt the remainder of the calculations and the message routine is queued to print on-line an indication of the error.

When the cycle is complete, i.e., times-to-fire are computed for all three cases, MFRARF queues two entries for on-line messages. The first message states that the times-to-fire calculations are complete and gives the next selected recovery area; the second message states the computed time-to-fire (GMTRC) for end of present orbit. When a new emergency recovery area is selected, MFRARF stores this in the output table for transmission to the Cape Canaveral displays.

6.14.4 Usage

MFRARF is entered from R5RARF; MFRARF exits to MPRAR2, R5RARF or M0PRIO.

a) Storage Required—58 locations

b) MFRARF uses:

1) Macros—QENBA, QENBZ, QUEUE and TRNOF

2) Parameters—A, C, D, MNCPNI, MNGEN1, MNGEN2, MNGEN3, MNMESS, MNRARF and MNSEEK

3) Communication cells—MCCNTR, MCHFSC, MCPASN, MCRVPT, MCSKPM and MCTABT

4) Tables—TMAREA, TMDARE, TMNTRF, TMORMC and TMTFEA

5) Constants—K00001 and K00003

c) Time Required:

1) Minimum—0.148 millisecond

2) Maximum—0.464 millisecond
FIGURE 6-15. MFRARF PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 6-15. MFRARF PROGRAM FLOW CHART (Sheet 2 of 2)
6.15 MONITOR PREFIX TO O5ORMC (MPORMC)

MPORMC handles all entry control functions for the high-speed output calculations program, O5ORMC.

The flow chart for the MPORMC prefix is shown in Figure 6-16.

6.15.1 Input Requirements

Input to MPORMC consists of:

a) MCHFSC—contains the current GMT in fixed-point half seconds.

b) MCNRRF—when zero, indicates the orbit phase; when non-zero, indicates the re-entry phase.

6.15.2 Output Requirements

Output from MPORMC consists of:

a) MCRTMS—contains present GMT, with minutes in the address and seconds in the decrement.

b) MCORIP—set non-zero to indicate O5ORMC is in progress.

c) The accumulator contains positive zero, for the orbit phase output computations, or negative zero, for re-entry phase output computations.

6.15.3 Method

MPORMC suppresses the output scaling and packing program, O0ORRE, which uses the output from O5ORMC. The coordinate conversion program for input on subchannel 2 is suppressed since, during the medium-abort phase, subchannel 2 provides input data for the output computations program.

MCORIP is set non-zero to indicate to the abort programs that the output calculations and conversions are in process. The present GMT is stored in MCRTMS and the accumulator sign is set to indicate the phase.

6.15.4 Usage

MPORMC is entered from M0PRI0; MPORMC exits to O5ORMC.

a) Storage Required—20 locations

b) MPORMC uses:

1) TRNOF and TRNON
2) Parameters—A, B, C, J, MNCCIP, MNORMC and MNORRE
3) Constants—K00000 and K00060
c) Time Required—0.087 millisecond
FIGURE 6-16. MPORMC PROGRAM FLOW CHART
6.16 MONITOR SUFFIX TO O5ORMC (MFORMC)

MFORMC handles all exit control functions for the high-speed output calculations program, O5ORMC.

The flow chart for the MFORMC suffix is shown in Figure 6-17.

6.16.1 Input Requirements

Input to MFORMC consists of:

a) TMORMC—the 17th location in this table contains the computed apogee distance in floating-point nautical miles.

b) TMLLHP—the 3rd location in this table contains the computed perigee distance in floating-point nautical miles.

c) MCAPPE—when non-zero, indicates new orbit generated.

d) MCNRRF—when zero, indicates the orbit phase; when non-zero, indicates the re-entry phase.

6.16.2 Output Requirements

The on-line message processor is queued with input to print the computed apogee and perigee distances, whenever a new orbit table is generated. The MCAPPE communication cell is reset to zero after these messages have been queued.

6.16.3 Method

MFORMC unsuppresses the output scaling and packing program, O0ORRE, if a new orbit table has not been generated, and exits to M0PRI0.

If a new orbit table has been generated and if the mission is in the orbit phase, MFORMC queues the on-line message processor with input to print the computed distance to apogee and perigee. If the mission is in the re-entry phase, MFORMC exits directly to M0PRI0.

6.16.4 Usage

MFORMC is entered from O5ORMC; MFORMC exits to M0PRI0.

a) Storage Required—27 locations

b) MFORMC uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON
2) Parameters—A, B, C, MNMESS, MNORMC, and MNORRE
3) Communication cells—MCAPPE and MCNRRF
4) Tables—TMORMC and TMLLHP
c) Time Required:
   1) Minimum—0.035 millisecond
   2) Maximum—0.141 millisecond
FIGURE 6-17. MFORMC PROGRAM FLOW CHART
Section 7
DATA COMMUNICATIONS CHANNEL
OUTPUT CONTROL

The Data Communications Channel (DCC) provides for the direct output of mission-control data to the Mercury Control Center at Cape Canaveral and to the Goddard plotboards and acquisition data to the tracking and telemetry stations around the world. All output utilizes the internal trapping feature of the IBM 7090, i.e., a program interrupt occurs on the completion of the data transmission. All interrupts produced by the DCC are interpreted by the Real Time Channel Main Controller Program, MORTCC. This controller executes the SAVE macro, which uses the Main Controller Save Program, M0SAVE, to preserve the condition of the interrupted program. MORTCC then transfers control to the Monitor trap processor appropriate for the subchannel on which the interrupt occurred.

The Monitor programs which control DCC output may be divided into three groups.

a) The high-speed output programs, described in Subsections 7.1 through 7.9.

b) The low-speed output programs which send acquisition data to the tracking sites, described in Subsections 7.10 through 7.18.

c) The sense output programs which control the sense output lights at Goddard, described in Subsections 7.19 through 7.21.

7.1 HIGH-SPEED OUTPUT

Throughout the Mercury mission—from lift-off through launch, orbit and until the impact point is reached in re-entry—the high-speed output controls drive visual displays at Goddard and Cape Canaveral. The information displayed enables trained observers to evaluate the mission in operation and make decisions as to which launch input source—Burroughs-GE or IP 7090—is to be used, whether to abort and when to fire retrorockets. The output data is sent over subchannels 3 and 4 of the Data Communications Channel at a rate of 1000 bits per second. Data transmitted to Cape Canaveral over subchannel 3 maintains the wall map, the digital displays, the plotboards and the strip charts, providing such data as emergency abort time, height of capsule, flight path angle and capsule velocity. Subchannel 4 is used for output to the Goddard plotboards. Various settings in the computer's console entry keys allow any of the four
<table>
<thead>
<tr>
<th>Location</th>
<th>Quantity</th>
<th>Phase Needed</th>
<th>Where Displayed</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMLANA</td>
<td>$y - y_{nom}$ (B-GE)</td>
<td>Launch</td>
<td>Strip Chart</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+1</td>
<td>$y - y_{nom}$ (IP7090)</td>
<td>Launch</td>
<td>Strip Chart</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+2</td>
<td>$V_{/Vr} - V_{/Vr_{nom}}$ (B-GE)</td>
<td>Launch</td>
<td>Strip Chart</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+3</td>
<td>$V_{/Vr} - V_{/Vr_{nom}}$ (IP7090)</td>
<td>Launch</td>
<td>Strip Chart</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+4</td>
<td>Data Source Indicator (1 = GE-GOD, 2 = RAW, 3 = IP7090)</td>
<td>Launch/Abort</td>
<td>-</td>
<td>Fx.Pt.-B15</td>
</tr>
<tr>
<td>+5</td>
<td>$\phi_{pp}$</td>
<td>Launch/Abort</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+6</td>
<td>$\lambda_{pp}$</td>
<td>Launch/Abort</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+7</td>
<td>$\phi$ Tower Impact Point – Before tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td></td>
<td>$\phi_{30\text{ sec}}$ – After tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+8</td>
<td>$\lambda$ Tower Impact Point – Before tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td></td>
<td>$\lambda_{30\text{ sec}}$ – After tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+9</td>
<td>GTRS – Time Remaining Until Retrofire</td>
<td>Abort</td>
<td>Wall digital display</td>
<td>Time</td>
</tr>
<tr>
<td>+10</td>
<td>GMTLC – GMT of Landing Computed</td>
<td>Abort</td>
<td>Recovery Status Monitor</td>
<td>Time</td>
</tr>
<tr>
<td>+11</td>
<td>Zero – Before tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$\phi$ Max – After tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td></td>
<td>$\phi$ Refined Impact Point</td>
<td>Abort</td>
<td>Recovery Status Monitor, Wall Map &amp; Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+12</td>
<td>$(3\pi/2)$ – Before tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ Max – After tower separation</td>
<td>Launch</td>
<td>Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ Refined Impact Point</td>
<td>Abort</td>
<td>Recovery Status Monitor, Wall Map &amp; Plotboard 4</td>
<td>Fl.Pt.-Radians</td>
</tr>
<tr>
<td>+13</td>
<td>Emergency Abort GMTRC</td>
<td>Launch/Abort</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+14</td>
<td>Zero – Before Separation</td>
<td>Launch</td>
<td>Retrofire Console</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$\Delta T$ – After separation</td>
<td>Launch</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+15</td>
<td>Emergency Abort ECTRC</td>
<td>Abort</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>Location</td>
<td>Phase Needed</td>
<td>Format</td>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>--------------------</td>
<td>-----------------------------</td>
<td>-------------------</td>
<td></td>
</tr>
<tr>
<td>+16</td>
<td>Zero - Before Seco + 5 sec.</td>
<td>Flight Dynamics Officer</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>+17</td>
<td>Negative of Orbit Capability - After Seco + 5 sec.</td>
<td>Flight Dynamics Officer</td>
<td>Launch</td>
<td></td>
</tr>
<tr>
<td>+18</td>
<td>Recovery Area</td>
<td>Launch / Abort</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+19</td>
<td>Abort Recommendation (1 = GO, 2 = NO GO)</td>
<td>Flight Dynamics Officer &amp; Plotboard 2</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+20</td>
<td>i = Flight Path Angle</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+21</td>
<td>h = Height of Capsule</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+22</td>
<td>Y/Y' = Velocity Ratio</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+23</td>
<td>V = Inertial Velocity</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+24</td>
<td>(Y - Y nom) = Cross Range Deviation</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+25</td>
<td>d = Down Range Distance</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+26</td>
<td>± Hrs = ICTRC ± Mins</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+27</td>
<td>± Secs = r - R</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+28</td>
<td>Data Source (1 = AN / FPS 16, 0 = AZUSA)</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
<tr>
<td>+29</td>
<td></td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Launch / Abort</td>
<td></td>
</tr>
</tbody>
</table>
The B indicator for MPLANA is turned on every half second during launch by MTHFSC. The B indicator is turned on in high abort before retrofire every second by MFABRT.

**Figure 7-1. Data Flow: High Speed Output During Launch**
Cape plotboards to be duplicated on the local plotboards (described in the OOPLOT write-up, MC 105, Goddard Processing Programs); hence, personnel at Goddard may monitor the output to the Cape Canaveral plotboards.

The high-speed output cycle is controlled by the half-second trap processor, MTHFSC. During launch, data is transmitted over the high-speed lines once every half second; during high abort before retrofire, data is sent once every second. In the orbit phase, the output cycle is every six seconds; in re-entry, low abort, medium abort and high abort after retrofire, data is sent every three seconds. The Monitor control of high-speed output is described in general in the following paragraphs.

7.1.1 High-Speed Output During Launch

In the launch phase and for the pre-retrofire part of high abort, the O0LANA processor scales and packs output data for Cape Canaveral and the local plotboards. MTHFSC, the half-second trap processor, controls the output cycle for high-speed transmission. In launch, MTHFSC sets priority indicators so that the Monitor prefix to O0LANA, MPLANA, receives control every half second. In high abort before retrofire, MTHFSC provides control to CCABRT every second. When CCABRT completes processing, it sets bits in the priority table so that MPLANA receives control.

When the launch programs or CCABRT have finished their calculations, their output is transferred to TMLANA, a 30-word table which serves as input to O0LANA, MPLANA, the first program in the high-speed output cycle, receives control and sets entry indicators for O0LANA, where the data in TMLANA is scaled, converted to the proper format, packed and stored for output in TMOLAB and TMMRLP. TMOLAB is a 13-word table which serves as input to MYHSOD, the Monitor processor for transmitting high-speed data to Cape Canaveral; TMMRLP is a two-word table which serves as input to MYHSOP, the Monitor processor for transmitting high-speed data to the Goddard plotboards.

MFLANA, the Monitor suffix to O0LANA, sets priority bits so that MYHSOD and MYHSOP receive control. MYHSOD and its trap processor, MTHSOD, unpack the data in TMOLAB into a table in core storage associated with subchannel 3 of the DCC, activate the subchannel and thus transmit high-speed output to Cape Canaveral. MYHSOP unpacks the data in TMMRLP into a table in core storage associated with subchannel 4 and then activates the subchannel which begins transmission of the data from core to the local plotboards. MTHSOD terminates the transmission of data to the Goddard plotboards and MTHSOD ends the transmission of high-speed data to Cape Canaveral.

The high-speed output cycle during launch is illustrated in Figure 7-1. MPLANA, MFLANA, MYHSOD, MTHSOD, MYHSOP and MTHSOP are described in detail in Subsections 7.2 through 7.9 O0LANA and CCABRT described in MC 105, Goddard Processing Programs.
<table>
<thead>
<tr>
<th>Location</th>
<th>Quantity</th>
<th>Phase Needed</th>
<th>Where Displayed</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMORRE</td>
<td>( \phi_{pp} )</td>
<td>Orbit/Re-entry</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+1</td>
<td>( \lambda_{pp} )</td>
<td>Orbit/Re-entry</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+2</td>
<td>( \phi ) 30 sec</td>
<td>Orbit</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+2</td>
<td>( \phi ) Refined Impact Point</td>
<td>Re-entry</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+3</td>
<td>( \lambda ) 30 sec</td>
<td>Orbit</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+3</td>
<td>( \lambda ) Refined Impact Point</td>
<td>Re-entry</td>
<td>Wall Map &amp; Plotboard 4</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+4</td>
<td>GTRS – Ground Time Remaining Until Retrofire</td>
<td>Orbit</td>
<td>Wall digital display</td>
<td>Time</td>
</tr>
<tr>
<td>+4</td>
<td>Ground Time Remaining Until Landing</td>
<td>Re-entry</td>
<td>Wall digital display</td>
<td>Time</td>
</tr>
<tr>
<td>+5</td>
<td>Emergency Abort GMTRC</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+6</td>
<td>Emergency Abort ECTR</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+7</td>
<td>End of Present Orbit GMTRC</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+8</td>
<td>End of Present Orbit ECTR</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+9</td>
<td>End of Mission GMTRC</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+10</td>
<td>End of Mission ECTR</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
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<tr>
<td>+11</td>
<td>Orbit Number</td>
<td>Orbit/Re-entry</td>
<td>Wall digital display</td>
<td>Fx. Pt. – B35</td>
</tr>
<tr>
<td>+12</td>
<td>GMTLC – GMT of Landing Computed</td>
<td>Orbit/Re-entry</td>
<td>Recovery Status Monitor</td>
<td>Time</td>
</tr>
<tr>
<td>+13</td>
<td>( \phi ) L.P. – Latitude of Mission End Landing Point</td>
<td>Orbit/Re-entry</td>
<td>Recovery Status Monitor</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+14</td>
<td>( \lambda ) L.P. – Longitude of Mission End Landing Point</td>
<td>Orbit/Re-entry</td>
<td>Recovery Status Monitor</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+15</td>
<td>h – Height of Capsule</td>
<td>Orbit/Re-entry</td>
<td>Plotboard 2</td>
<td>Fl. Pt. – Nautical Miles</td>
</tr>
<tr>
<td>+16</td>
<td>( h_a ) – Apogee height</td>
<td>Orbit</td>
<td>Flight Dynamics Officer</td>
<td>Fl. Pt. – Nautical Miles</td>
</tr>
<tr>
<td>+16</td>
<td>( y ) – Flight Path Angle</td>
<td>Re-entry</td>
<td>Flight Dynamics Officer</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>+17</td>
<td>GMTRS – GMT of Retrofire</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>+17</td>
<td>Elapsed Ground Time since Retrofire</td>
<td>Re-entry</td>
<td>Retrofire Console</td>
<td>Time</td>
</tr>
<tr>
<td>Location</td>
<td>Quantity</td>
<td>Phase Needed</td>
<td>Where Displayed</td>
<td>Format</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>--------------</td>
<td>-----------------</td>
<td>------------</td>
</tr>
<tr>
<td>18</td>
<td>± Hours</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Fx. Pt. – B35</td>
</tr>
<tr>
<td>19</td>
<td>ITRC ±Minutes</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Fx. Pt. – B35</td>
</tr>
<tr>
<td>20</td>
<td>± Seconds</td>
<td>Orbit</td>
<td>Retrofire Console</td>
<td>Fx. Pt. – B35</td>
</tr>
<tr>
<td>21</td>
<td>i – Inclination Angle</td>
<td>Orbit</td>
<td>Flight Dynamics Officer</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>22</td>
<td>Orbit Capability</td>
<td>Orbit</td>
<td>Flight Dynamics Officer</td>
<td>Fx. Pt. – B35</td>
</tr>
<tr>
<td>23</td>
<td>V – Inertial Velocity</td>
<td>Orbit/Re-entry</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Fl. Pt. – Ft/Sec</td>
</tr>
<tr>
<td>24</td>
<td>λp – Longitude of Perigee</td>
<td>Orbit</td>
<td>Plotboard 3</td>
<td>Fl. Pt. – Radians</td>
</tr>
<tr>
<td>25</td>
<td>te – Elapsed Time since Launch (seconds)</td>
<td>Orbit/Re-entry</td>
<td>Plotboard 2 &amp; Plotboard 3</td>
<td>Fx. Pt. – B35</td>
</tr>
<tr>
<td>27</td>
<td>a – R – Predicted Insertion Height</td>
<td>Orbit</td>
<td>Plotboard 2</td>
<td>Fl. Pt. – Nautical Miles</td>
</tr>
<tr>
<td>28</td>
<td>r – R</td>
<td>Orbit/Re-entry</td>
<td>Flight Dynamics Officer &amp; Plotboard 1</td>
<td>Fl. Pt. – Nautical Miles</td>
</tr>
<tr>
<td>29</td>
<td>Recovery Area</td>
<td>Orbit/Re-entry</td>
<td>Retrofire Console</td>
<td>Special Code</td>
</tr>
</tbody>
</table>
THE B INDICATOR FOR MPORRE IS TURNED ON BY MFORMC EVERY SIX SECONDS IN ORBIT AND EVERY THREE SECONDS IN RE-ENTRY AND RE-ENTRY FROM ABORT. IN LOW ABORT THE B INDICATOR FOR MPORRE IS TURNED ON EVERY THREE SECONDS BY MTHFSC.

FIGURE 7-2. DATA FLOW: HIGH SPEED OUTPUT DURING ORBIT, RE-ENTRY AND ABORT

7-8
7.1.2 High-Speed Output During Abort, Orbit and Re-entry

High-speed output data for the Cape Canaveral displays and the Goddard plotboards is scaled and packed by the O0ORRE processor during the orbit, re-entry and abort phases except for the high-abort phase before retrofire (see Subsection 7.1.1). The high-speed output cycle is controlled by MTHFSC, the half-second trap processor, which gives control to O5ORMC every six seconds in orbit and every three seconds in re-entry, medium abort and high abort after retrofire. When O5ORMC is completed, its Monitor suffix, MFORMC, sets priority indicators so that MPORRE, the prefix to O0ORRE, receives control. In low abort, MTHFSC sets in the priority table so that MPORRE receives control directly every three seconds.

The orbit, re-entry and abort processors store the high-speed output data in TMORMC. When given control, MPORRE transfers the data in TMORMC to another 30-word table, TMORRE, then passes control to O0ORRE, the processor which scales, converts and packs the output data into two tables: TMOLAB and TMMRLP. As in the launch phase, TMOLAB and TMMRLP serve as input to the monitor output processors, MYHSOD and MYHSOP. The suffix to O0ORRE, MFORRE, sets priority bits so that MYHSOD and MYHSOP receive control. These two output processors operate in the same way as during the launch phase (see Subsection 7.1.1) and, as in the launch phase, their trap processors MTHSOD and MTHSOP end the high-speed output cycle.

The high-speed output cycle during orbit, re-entry and abort is illustrated in Figure 7-2. MPORRE, MFORRE, MYHSOD, MTHSOD, MYHSOP and MTHSOP are described in detail in subsections 7.4 through 7.9. O0ORRE and O5ORMC are described in MC 105, Goddard Processing Programs.
7.2 MONITOR PREFIX TO OOLANA (MPLANA)

MPLANA supplies the necessary initial conditions for entry into OOLANA, the program which scales and packs the high-speed output data during launch and abort.

The flow chart for the MPLANA prefix is shown in Figure 7-3.

7.2.1 Input Requirements

Input to MPLANA consists of:

a) MCHFSC—contains the present GMT in fixed-point half seconds.

b) MCTABT—when non-zero, indicates high-abort phase.

7.2.2 Output Requirements

Output from MPLANA consists of:

a) MCPGMT—contains the present GMT in fixed-point seconds.

b) Before exiting to OOLANA, MPORRE sets the sign of the accumulator positive for the launch phase, negative for abort phase.

7.2.3 Method

The A indicator for OOLANA is turned on and the B indicator is turned off. While OOLANA scales and packs the high-speed output data, the high-abort program, CCABRT, is suppressed to prevent the abort program from storing over launch data in the OOLANA input table. If this happens, abort data would be transmitted in the launch-data format. The present GMT in fixed-point seconds is stored in MCPGMT, the accumulator is set positive for the launch phase or negative for the abort phase. MPLANA then gives control to OOLANA.

7.2.4 Usage

MPLANA is entered from M0PRI0; MPLANA exits to OOLANA.

a) Storage Required—16 locations

b) MPLANA uses:

1) Macros—TRNOF and TRNON
2) Parameters—A, B, E, MNLANA and MNABRT
3) Communication cells—MCHFSC, MCPGMT and MCTABT

c) Time Required—0.065 millisecond
MC-103

FIGURE 7-3. MPLANA PROGRAM FLOW CHART
7.3 MONITOR SUFFIX TO O0LANA (MFLANA)

MFLANA sets the necessary priority indicators for the transmission of O0LANA's output over the high-speed subchannels to Cape Canaveral and the local Goddard plotboards.

The flow chart for the MFLANA suffix is shown in Figure 7-4.

7.3.1 Input Requirements

MFLANA directs the program control, but has no input.

7.3.2 Output Requirements

MFLANA informs M0PRI0 that the high-speed output data is ready for transmission.

7.3.3 Method

MFLANA turns on the B indicators for MYHSOD and MYHSOP, the processors which respectively, handle the transmission of the high-speed output to Cape Canaveral and to the local Goddard plotboards. The high-abort program, CCABRT, suppressed by MPLANA, is unsuppressed. The A indicator for O0LANA is turned off and exit is to M0PRI0.

7.3.4 Usage

MFLANA is entered from O0LANA; MFLANA exits to M0PRI0.

a) Storage Required—9 locations

b) MFLANA uses:

1) Macros—TRNOF and TRNON

2) Parameters—A, B, E, MNHSOD, MNHSOP, MNABRT and MNLANA

c) Time Required—0.054 millisecond
FIGURE 7-4. MFLANA PROGRAM FLOW CHART
7.4 MONITOR PREFIX TO O0ORRE (MPORRE)

MPORRE sets up the input table and control indicators for O0ORRE, the program which scales and packs high-speed output data during orbit and re-entry.

The flow chart for the MPORRE prefix is shown in Figure 7-5.

7.4.1 Input Requirements

Input to MPORRE consists of:

a) TMORMC—30-cell table containing computed data for transmission to Cape Canaveral and to the local plotboards at Goddard. During orbit and re-entry, this table is the output from MSPASN, R5RARF, N0CPNI and O5ORMC.

b) MCNRRF—contains the number of retrorockets fired. This cell is zero in orbit, non-zero in re-entry.

7.4.2 Output Requirements

Output from MPORRE consists of:

a) TMORRE—30-cell table into which MPORRE stores the contents of TMORMC. TMORRE serves as input to O0ORRE.

b) Accumulator—set positive in orbit phase, negative in re-entry phase.

7.4.3 Method

The high-speed output cycle is controlled by the half second trap processor, MTHFSC, which periodically turns on the B indicator for MPORRE (described in Subsection 7.1.2).

MPORRE moves computed data from the TMORMC table into TMORRE. During this table transfer, O5ORMC and R5RARF, which output into TMORMC, are suppressed. In the orbit phase the accumulator is set positive and control transferred directly to O0ORRE.

In re-entry, the latitude and longitude of impact point are taken from TMORRE +13,+14 and are stored in TMORRE +2,+3 so that these quantities can be displayed on plotboard 4 and the wall map at Cape Canaveral. MPORRE sets the accumulator negative to indicate the re-entry phase and exits to O0ORRE.

7.4.4 Usage

MPORRE is entered from M0PRIO; MPORRE exits to O0ORRE.
MC 103

a) Storage Required—24 locations

b) MPORRE uses:
   1) Macros—TRNOF and TRNON
   2) Parameters—A, B, C, MNORRE, MNRARF and MNORMC
   3) Communication cell—MCNRRF
   4) Tables—TMORMC and TMORRE

c) Time Required:
   1) Minimum—0.457 millisecond
   2) Maximum—0.483 millisecond
FIGURE 7-5. MPORRE PROGRAM FLOW CHART
7.5 MONITOR SUFFIX TO 00ORRE (MFORRE)

After 00ORRE has filled its output table, TMOLAB, control passes to MFORRE. This suffix sets priority indicators for the high-speed output transmission processors and resets an indicator used by the medium-abort program.

The flow chart for the MFORRE suffix is shown in Figure 7-6.

7.5.1 Input Requirements

MFORRE directs the program control flow, but has no input.

7.5.2 Output Requirements

Output from MFORRE consists of the communication cell, MCORIP. This cell is set to zero, which indicates to the medium-abort program that all of the output data has been processed and packed.

7.5.3 Method

MFORRE turns on the B indicators for MYHSOD and MYHSOP, the high-speed output transmission processors for Cape Canaveral and the local plotters, respectively. The coordinate conversion program's prefix, MPCCIP, suppressed by O5ORMC, is unsuppressed. MCORIP is cleared, indicating to the medium-abort program that the output data has been processed. MPORRE turns off the A indicator for 00ORRE and exits to M0PRIO.

7.5.4 Usage

MFORRE is entered from 00ORRE; MFORRE exits to M0PRIO.

a) Storage Required—10 locations

b) MFORRE uses:

1) Macros—TRNOF and TRNON

2) Communication cell—MCORIP

3) Parameters—A, B, C, MNHSOD, MNHSOP, MNCCIP and MNORRE

c) Time Required—0.043 millisecond
CLEAR INDICATION THAT RE-ENTRY OUTPUT IN-PROCESS FOR MEDIUM ABORT PROGRAM (MCORIP)

FIGURE 7-6. MFORRE PROGRAM FLOW CHART
7.6 MONITOR HIGH-SPEED OUTPUT TO CAPE CANAVERAL PROCESSOR (MYHSOD)

MYHSOD and its trap processor, MTHSOD, move the packed high-speed output data, generated by OOLANA or OOORRE, for transmission by the DCC over subchannel 3. MYHSOD also logs the output data.

The flow chart for the MYHSOD processor is shown in Figure 7-7.

7.6.1 Input Requirements

Input to MYHSOD consists of:

a) TMOLAB—13-word table, each word containing 32 data bits, right justified, stored from right to left in the order of transmission. This table, referred to as a data frame, is the output of OOLANA in the launch/abort phase and of OOORRE in the orbit/re-entry phase.

b) TM8.3M—contains the number of 8-1/3 milliseconds elapsed since the last exact half second.

c) MCHFSC—contains the current GMT in fixed-point half seconds.

d) MCOLAB—contains the number of words (13) in the TMOLAB table.

e) MCHSOD—contains the number of eight-bit groups (51) contained in the TMOLAB table.

f) MCBETA—when positive, indicates this computer is transmitting. When negative, the other of the duplexed computers is transmitting.

g) MCACTV—mask used to activate and deactivate subchannels on the DCC.

h) MCLIDT—contains in floating-point seconds the time tag associated with the input vectors used to compute the current output. This time is used in logging.

7.6.2 Output Requirements

Output from MYHSOD consists of TMHSOD: a 32-word table in the core storage area associated with the DCC subchannel 3. For output transmission one 8-bit group is stored right justified in each of the 32 words.

7.6.3 Method

MYHSOD receives control after OOLANA or OOORRE has completed processing (described in Subsections 7.1.1 and 7.1.2).
If the computer is transmitting (the sign of MCBETA is positive), MYHSOD suppresses the two programs that give TMOLAB input: O0LANA and O0ORRE. MYHSOD then moves from 1 to N 8-bit groups from TMOLAB to TMHSOD (in order to stay within a half-second time period N is less than 63). One word from the input block, TMOLAB, is unpacked into four 8-bit groups and these are placed right justified into four words in the output block associated with subchannel 3, TMHSOD. When the 32 cells of TMHSOD are filled, subchannel 3 is activated. If an output frame is greater than 32 eight-bit groups (the present data frame consists of 51 eight-bit groups), MYHSOD and its trap processor, MTHSOD, refill TMHSOD with the remaining eight-bit groups after the first table of data has been transmitted. The sign of the word containing the last 8-bit group in a message is set negative which causes the DCC to deactivate the subchannel after the last word has been transmitted.

When the first 32 characters of a data frame have been transmitted, MTHSOD receives control. If more packed words in this data frame are waiting to be transmitted, MTHSOD unpacks one word and places the four 8-bit groups into the first four words of TMHSOD. This allows 32 milliseconds for the processing of other traps before completion of the unpacking must take place in MYHSOD. After unpacking the first 32 characters of the 51-character data frame, MYHSOD suppresses itself and remains suppressed until MTHSOD receives control. This prevents MYHSOD from receiving control until all of the data in TMHSOD has been transmitted. When the complete data frame has been unpacked, the input programs, O0ORRE and O0LANA, are unsuppressed, the logging is completed and control passes to M0PRIO.

The output message is logged from the packed message table, TMOLAB. After TMHSOD is filled, the first eight words of TMOLAB are logged. When the remaining five words are unpacked into TMHSOD, they are then logged. The logging time tag for MSLOGG is the time of the input vector used in calculating the output table and is in floating-point seconds. If this time (MCLIDT) is zero, the present GMT is used in logging.

If MYHSOD finds that the computer is not transmitting (the sign of MCBETA is negative), only logging takes place. The input programs, O0ORRE and O0LANA, are not suppressed and logging is accomplished in one entry into MYHSOD, with the current GMT used as the logging time tag.

7.6.4 Usage

MYHSOD is entered from, and exits to, M0PRIO.

a) Storage Required—149 locations

b) MYHSOD uses:

1) Subroutine—MSLOGG
2) Macros—QENBA, QENBZ, QPSLF, TRNOF and TRNON

3) Parameters—A, B, C, D, F, MNHSOD, MNLANA and MNORRE

4) Communication cells—MCACTV, MCBETA, MCHFSC, MCHSOD, MCLIDT and MCOLAB

5) Tables—TM8.3M and TMHSOD

6) Constants—K00001 and K00032

c) Time Required:

1) First pass—1.528 milliseconds

2) Second pass—1.388 milliseconds

3) Total time to unpack and log 51 characters—2.916 milliseconds
FIGURE 7.7. MYHSOD PROGRAM FLOW CHART (Sheet 1 of 3)
FIGURE 7-7. MYHSOD PROGRAM FLOW CHART (Sheet 2 of 3)
FIGURE 7-7. MYHSOD PROGRAM FLOW CHART (Sheet 3 of 3)
7.7 MONITOR TRAP PROCESSOR FOR HIGH-SPEED OUTPUT TO CAPE CANAVERAL (MTHSOD)

MTHSOD terminates the high-speed transmission of every data frame—51 eight-bit characters—to Cape Canaveral. If MTHSOD receives control with more characters in the present data frame to be transmitted, controls are set to transmit the remainder of the frame.

The flow chart for the MTHSOD trap processor is shown in Figure 7-8.

7.7.1 Input Requirements

Input to MTHSOD consists of:

a) TMOLAB—packed output table for high-speed data transmission to Cape Canaveral, described in Subsection 7.6.1.

b) MCACTV—mask used to activate and deactivate subchannels of the DCC.

7.7.2 Output Requirements

Output from MTHSOD consists of:

a) MCHOMS—cell containing the number of data frames sent since the last on-line message, stating the number of data frames (messages) sent, was printed. MTHSOD updates this cell and MTWWWV uses the cell in queueing the on-line message.

b) TMHSOD—unpacked output table for high-speed data transmission to Cape Canaveral, described in Subsection 7.6.2.

7.7.3 Method

MTHSOD receives control from M0RTCC after a trap on DCC subchannel 3. If MTHSOD finds that 51 eight-bit characters have been transmitted to Cape Canaveral, controls are reset for the next data frame and control passes to M0Prio. If MTHSOD finds four or less characters of the present data frame remain, these characters are unpacked from TMOLAB and placed, right justified, in TMHSOD for transmission. The sign of the last word is set negative, which causes the DCC to trap and deactivate subchannel 3 after this word is transmitted. If more than four characters remain (the normal condition with the present 51-character data frame), the next four characters are unpacked and stored in the first four cells of TMHSOD. Controls are then set for MYHSOD to receive control and unpack the remaining characters. Since subchannel 3 remains activated until a complete frame has been transmitted, the unpacking of four characters by MTHSOD allows 32 milliseconds (one millisecond for each bit in the four characters) for the processing of other traps before the unpacking must be by MYHSOD.
MTHSOD removes the suppression MYHSOD set for itself, turns off the A indicator for MYHSOD and transfers to M0PRIO.

7.7.4 Usage

MTHSOD is entered from M0RTCC following a trap on DCC subchannel 3; MTHSOD exits to M0PRIO.

a) Storage Required—28 locations

b) MYHSOD uses:

1) Macros—TRNOF and TRNON
2) Parameters—A, B, F and MNHSOD
3) Communication cells—MCACTV and MCHOMS
4) Tables—TMOLAB and TMHSOD

c) Time Required:

1) Minimum—0.065 millisecond
2) Maximum—0.179 millisecond
FIGURE 7-8. MTHSOD PROGRAM FLOW CHART
7.8 MONITOR HIGH-SPEED OUTPUT TO GODDARD PROCESSOR (MYHSOP)

MYHSOP unpacks the two word output block, TMMRLP, generated by O0LANA or O0ORRE, for transmission to the local plotboards over DCC subchannel 4.

The flow chart for the MYHSOP processor is shown in Figure 7-9.

7.8.1 Input Requirements

Input to MYHSOP consists of TMMRLP. This table consists of two words: the first word contains 32 data bits; the second word contains 16 data bits—both right justified and from right to left in the order of transmission. TMMRLP is the output of O0LANA in the launch/abort phase and of O0ORRE in the orbit/re-entry phase. Twenty bits are assigned to each plotboard arm (ten per coordinate) and the remaining eight bits form a control word.

7.8.2 Output Requirements

Output from MYHSOP consists of:

a) TMHSOP—six-cell table for high-speed output via DCC subchannel 4. For transmission one eight-bit group is stored right justified in each of the six words. The DCC ignores all bit positions other than the last eight and the sign position.

b) MCACTV—mask used to activate and deactivate subchannels on the DCC.

7.8.3 Method

MYHSOP receives control after O0LANA or O0ORRE has completed processing (described in Subsections 7.1.1 and 7.1.2).

MYHSOP first unpacks the 48 data bits from the TMMRLP table. The data is taken in eight-bit groups from right to left and placed in the TMHSOP output table right justified, one 8-bit group per word (see Figure 7-9). The sign of the last word is set negative which causes the DCC to deactivate the subchannel after the six words have been transmitted. When TMHSOP is filled, subchannel 4 is activated and the DCC begins transmission to the local plotboards.

MYHSOP suppresses itself and remains suppressed until all of the high-speed data has been transmitted and MTHSOP receives control.

7.8.4 Usage

MYHSOP is entered from, and exits to, M0PRI0.
a) Storage Required—31 locations

b) MYHSOP uses:
   1) Macros—QENBZ, QPSLF, TRNOF and TRNON
   2) Communication cell—MCACTV
   3) Tables—TMHSOP and TMMRLP

c) Time Required—0.120 millisecond
FIGURE 7-9. MYHSOP PROGRAM FLOW CHART
7.9 MONITOR TRAP PROCESSOR FOR HIGH-SPEED OUTPUT TO GODDARD (MTHSOP)

MTHSOP terminates transmission of the data output to the local Goddard plotboards.

The flow chart for the MTHSOP trap processor is shown in Figure 7-10.

7.9.1 Input Requirements

There is no external input to MTHSOD.

7.9.2 Output Requirements

Output from MTHSOP consists of the communication cell, MCACTV. This cell is the mask used to activate and deactivate subchannels on the DCC and is set to deactivate subchannel 4.

7.9.3 Method

MTHSOP receives control from M0RTCC following a trap on DCC subchannel 4. MTHSOP removes the appropriate bit in MCACTV (bit position 4) so that subchannel 4 is not activated by the QPSLF macro (the subchannel is deactivated when the last word is transmitted). The A and C indicators for MYHSOP are turned off (MYHSOP suppressed itself with the C indicator) and exit is to M0PRIO.

7.9.4 Usage

MTHSOP is entered from M0RTCC following a trap on DCC subchannel 4; MTHSOP exits to M0PRIO.

a) Storage Required—8 locations

b) MTHSOP uses:

1) Macro—TRNOF

2) Parameters—A, C, and MNHSOP

3) Communication cell—MCACTV

c) Time Required—0.050 millisecond
FIGURE 7-10. MTHSOP PROGRAM FLOW CHART
7.10 TELETYPE OUTPUT: ACQUISITION DATA

Acquisition data is transmitted via teletype to the Mercury radar and telemetry stations to aid them in tracking the capsule. When possible, this data is sent to a station 45, 25 and five minutes before the capsule is due to appear above the horizon and consists of a time, range, azimuth and elevation for the capsule at one degree, ten degrees and thirty degrees above the horizon. In addition, a range, azimuth and elevation are given for the time of closest approach plus ten seconds. This data is transmitted via the Data Communications Channel at a rate of ten teletype characters (50 bits) per second over subchannels 10 and 11. Each subchannel may select one of eight external terminals for transmission. The subchannel and terminal number for a station are determined from the Station Characteristics table, TMCHAR.

For the purpose of sending acquisition data, eighteen sectors have been established, each sector consisting of 20 degrees of longitude. The first sector begins with the longitude of Cape Canaveral (299.44 degrees East) and the next sector boundary is 20 degrees east. During orbit, when the capsule enters a new sector, the stations in the 2nd, 6th and 10th sectors east of the sector entered are sent acquisition data. In re-entry, the stations in the present sector and in the next two sectors receive acquisition data, providing the capsule will pass within their range.

The acquisition data output cycle is composed of three parts: determination of the need for acquisition data; preparation of the data and initiation of transmission; transmission and logging of the acquisition data.

The Monitor processor, MYACQD, determines the need for preparing acquisition data by comparing the present longitude with the boundary of the next sector, adjusted by MYACQD after a new sector has been entered. If the present longitude is greater or equal to the test longitude, a new sector has been entered, and a need for acquisition data has been established. A list of the stations to receive data is compiled with the stations arranged in an east to west order and entries are made in the queue tables for MYTTOX and MYTTOY, the Monitor processors which gather acquisition data and initiate transmission.

For a system restart or the re-entry phase, MYACQD recognizes the need for sending acquisition data. During the launch phase, acquisition data is sent to Bermuda after the MLUPDT subroutine turns on the B indicator for MYTTOX. This acquisition data is computed by the main launch processors independently of MYACQD (which is suppressed during the launch phase). MYTTOX handles subchannel 10 acquisition data; MYTTOY handles acquisition data on subchannel 11. Since MYTTOY, MYTTYO and MYTTOY function in the same way as MYTTOX, MYTTXO and MTTTOX, only the later group is described here.

MYTTOX receives control from M0PRI0 after the B indicator for MYTTOX has been turned on (either by an entry in the MYTTOX queue or by a direct input.
THE B INDICATOR FOR MYACQD IS TURNED ONCE EVERY MINUTE BY MYMINS. MYACQD IS SUPPRESSED IN LAUNCH.

A0STAD, Q0LSTY AJACQ, QTYYA

MYTTOY GATHER, CONVERT, PACK DATA OUTPUT ONE WORD

INPUT QTTYB INPUT

MYTTOX (31 PACKED WORDS)

MTTTOX UNPACKS ONE MORE WORD UNTIL ALL UNPACKED

MTTTOY UNPACKS ONE MORE WORD UNTIL ALL UNPACKED

TMXBOX (6 WORDS) CORE ASSOS. WITH SUB. CH. 10.

MYTTOX LOG DATA

MYTTOY LOG DATA

TMYBOX (6 WORDS) CORE ASSOS. WITH SUB. CH. 11

ALL OUTPUT TRANSMITTED

TO ONE OF EIGHT TERMINALS

FIGURE 7-11. DATA FLOW: TELETYPewriter OUTPUT
from MLUPDT). The queue word contains an internal station number and an estimated horizon crossing time for the station's sector. The AJACQ macro uses this information to prepare input for two subroutines: A0STAD, which determines whether or not the capsule is to pass within the station's range and gathers acquisition data for the station if the capsule will be in range, and O01STY, which converts the data to teletype format and packs it for transmission by MYTTOX. (In launch, only Bermuda receives acquisition data and A0STAD is not used).

MYTTOX then employs the QTYYA macro to unpack the first word, after which transmission is initiated by MYTTOX. MTTTOX receives control on the trap following the transmission and using the QTYYB macro continues to unpack the remaining data until all the acquisition data (31 packed words) has been sent. When the transmission is complete, MYTTOX receives control and logs the transmitted information. MYTTOX ends the teletype output cycle.

The teletype output cycle is illustrated in Figure 7-11. MYACQD, MYTTOX, MYTTOY, AJACQ, QTYYA, MTTTOX, MTTTOY, QTYYB, MYTTOX and MYTTOY are described in detail in Subsections 7.11 through 7.18. A0STAD and O01STY are described in MC 105, Goddard Processing Programs.
7.11 MONITOR ACQUISITION DATA PROCESSOR (MYACQD)

MYACQD determines the need for acquisition data. When the need is established, MYACQD lists the stations to receive acquisition data and the horizon crossing times for the sectors in which the stations are located. MYACQD provides this information for MYTTOX or MYTTOY, the processors which prepare and initiate transmission of the acquisition data.

A general flow diagram for the MYACQD processor is shown in Figure 7-12; a detailed flow chart is given in Figure 7-13.

7.11.1 Input Requirements

Input to MYACQD consists of:

a) MNSCNO—parameter designating the number of stations in the Station Characteristics table.

b) MCESAB—when non-zero, indicates re-entry phase.

c) MCMINS—contains the current GMT in fixed-point minutes.

d) MCHFSC—contains the current GMT in fixed-point half seconds.

e) MCGTLO—contains the GMT of lift-off in fixed-point seconds.

f) MCREST—when non-zero, indicates a system restart.

g) MCNRRF—when non-zero, indicates the re-entry phase.

h) TMORMC—30-cell table containing output data for Cape Canaveral. The second cell in TMORMC contains the present longitude of the capsule.

i) TMSTCH—25-cell table which provides reference for the Station Characteristics table, TMCHAR.

j) TMCHAR—the Station Characteristics table. Each tracking and telemetry station in the Mercury network is represented by a 34-cell Station Characteristics block in TMCHAR.

7.11.2 Output Requirements

MYACQD provides input data for the MYTTOX and MYTTOY queue tables.

7.11.3 Method

The B indicator for MYACQD is turned on every minute by the Monitor Minute Processor, MYMINS, although during the launch, low-abort, and medium-abort phases, MYACQD is suppressed.
After receiving control, MYACQD determines whether or not a re-entry table is available. Without this table acquisition data cannot be transmitted—the AOSTAD subroutine requires an integration table—and MYACQD exits to M0PRI0.

When a re-entry table is available, MYACQD determines whether or not the capsule has entered a new sector by comparing the capsule's longitude with the longitude of the next sector's western boundary. Unless a new sector has been entered, MYACQD exits to M0PRI0. When a new sector (N) has been entered, acquisition data must be generated and sent to all qualifying stations in sectors N +2, N +6, and N +10.

From the Station Characteristics table, MYACQD determines which stations are in the selected sectors. For each station found, the internal station number and the estimated horizon crossing time for the sector are stored in the decrement and address, respectively, of an entry in the queue for MYTTOX for subchannel 10 or MYTTOY for subchannel 11. The estimated horizon crossing time for sector N +2 is generated by incrementing by five the current time in minutes; for sector N +6, the current time is increased by 25 minutes; for sector N +10, the current time is increased by 45 minutes.

Three situations require MYACQD to deviate from the nominal flow (described above):

a) When MYACQD first receives control, except in the re-entry phase or after a restart, the time since lift-off is computed. If less than 230 seconds have elapsed, MYACQD recognizes that the mission has entered a high abort—MYACQD is suppressed and cannot be entered during the launch, low-abort or medium-abort phases. For less than 230 seconds after lift-off, MYACQD sets controls to send acquisition data to the Bermuda and Canary Island tracking stations. For an entry 230 or more seconds after lift-off, acquisition data is sent to the Canary Island tracking station, if it has not already received acquisition data. On the next entry, MYACQD sets controls to send acquisition data to the Mid-Atlantic Ship. After the initial acquisition data has been sent to any of the above stations, that station receives data again only when it appears in the normal acquisition data list (exclusive of the two exceptions given below).

b) On the first entry after a system restart, MYACQD must calculate the present sector from the capsule's longitude so that on the next entry a valid check can be made as to whether or not the capsule has entered a new sector. When the capsule's current sector (N) has been established, controls are set to send acquisition data to the qualifying stations in sectors N +2, N +6 and N +10. After the present sector has been computed, the restart portion of MYACQD is not used again.
c) When the re-entry phase is entered, MYACQD immediately sets controls to transmit re-entry acquisition data to the stations in the current sector and the following two sectors.

Thereafter, in the re-entry phase, when MYACQD finds the capsule has entered a new sector (N), controls are set to send acquisition data to stations in sectors N, N+1 and N+2. The current time is used as the horizon crossing time for the current sector, N. The time for the next sector, N+1, is the current time plus three minutes; the time for sector N+2 is the current time plus six minutes.

7.11.4 Usage

MYACQD is entered from, and exits to, M0PRIO.

a) Storage Required—257 locations

b) MYACQD uses:

1) Macros—QENBA, QENBZ, QUEUE, TRNOF and TRNON

2) Parameters—A, B, MNACQD, MNTTOX and MNTTOY

3) Communication cells—MCESAB, MCGTLO, MCHFSC, MCMINS, MCNRRF and MCREST

4) Tables—TMCHAR, TMORMC and TMSTCH

5) Constants—K00001, K00004, K00005, K00010, K00018, K00020, K000210 and KKK2PI

c) Time Required:

1) With no re-entry table and mission not in re-entry phase—0.078 millisecond

2) If a new sector has been entered and less than 230 seconds have passed since lift-off—3.174 milliseconds

3) If acquisition data is to be sent to stations in sectors N+2, N+6 and N+10—2.825 milliseconds
MC-IO3
AKRST
CALCULATE PRESENT SECTOR AND LONG. OF NEXT SECTOR
SET $a \neq 0, \beta \neq 0$

AKAA
FIND STATIONS IN SECTORS $N + 2, N + 6, N + 10$ WHERE $N =$ PRESENT SECTOR

1
QUEUE MYTTOX, MYTTOY WITH STATION NUMBERS AND HORIZEN CROSSING TIMES

MOPRIO

MYACQD
IS THERE A RE-ENTRY TABLE
YES
NO

MOPRIO

NEW SECTOR?
YES
NO

MOPRIO

RE-ENTRY PHASE? $MCNRRF \neq 0$

$\gamma = 0$?
YES
NO

RE-ENTRY PHASE? $MCNRRF \neq 0$
YES
NO

AKREN
SET $\gamma \neq 0$

FIND HORIZEN CROSSING TIMES FOR SECTORS $N, N + 1, N + 2$ WHERE $N =$ PRESENT SECTOR

FIND STATIONS IN ABOVE SECTORS

1

MOPRIO

RE-ENTRY PHASE? $MCNRRF \neq 0$

$\beta = 0$?
YES
NO

$\delta = 0?$
YES
NO

AKZ2
QUEUE MYTTOX TO SEND ACQ. DATA TO BERMUDA

AK23
OVER 230 SECS SINCE LIFTOFF?
YES
NO

AKXY
QUEUE MYTTOX TO SEND ACQ. DATA TO CANARY ISLANDS

SET $\delta \neq 0, \epsilon \neq 0$

$\epsilon = 0$?
YES
NO

SET $\beta \neq 0$

$\alpha, \beta, \gamma, \delta$ AND $\epsilon$ ARE ORIGINALLY ZERO

AKXY
QUEUE MYTTOX TO SEND ACQ. DATA TO MID ATLANTIC SHIP

FIGURE 7-12. GENERAL FLOW DIAGRAM, MYACQD
FIGURE 7-13. MYACQD PROGRAM FLOW CHART (Sheet 1 of 5)

7-45
FIGURE 7-13. MYACQD PROGRAM FLOW CHART (Sheet 2 of 5)
THE STATION CHARACTERISTICS BLOCK, TMCHAR, IS USED TO DETERMINE WHICH STATIONS ARE IN A SECTOR.

\[ P = 1, 2 \text{ OR } 3 \] FOR 1ST, 2ND OR 3RD OUTPUT SECTOR.
\[ N = \text{INTERNAL STATION NUMBER} \]

\[ Q = C(AKNSC + P - 1) \]

PLACE INTERNAL STA. NUMBER IN DECREMENT OF AKNUM

SEND ACQ. DATA TO BERMUDA

SEND ACQUISITION DATA TO CANARY ISLANDS

FIGURE 7-13. MYACQD PROGRAM FLOW CHART (Sheet 3 of 5)
PLACE HORIZON CROSSING TIME FOR THIS STATION'S SECTOR IN ADDRESS OF AKNUM. C(AKTIM), C(AKTIM + 1) OR C(AKTIM + 2)

THIS IS DETERMINED BY EXAMINING THE DCC OUTPUT MASK FOR THIS STATION WHICH WAS TAKEN FROM THE STATION CHARACTERISTICS TABLE

IS THE OUTPUT LINE FOR THIS STATION 10 OR 11? USE AFSTA

DCC SUBCHAN. 11

AKAY

AKAY

QENBZ

(QENABLE)

QUEUE MNTTOX, AKNUM

QENBA

(QENABLE)

TO SEND ACQ DATA TO THE MID ATLANTIC SHIP

FIGURE 7-13. MYACQD PROGRAM FLOW CHART (Sheet 4 of 5)
FIGURE 7-13. MYACQD PROGRAM FLOW CHART (Sheet 5 of 5)
7.12 MONITOR SUBCHANNEL 10 TELETYPING OUTPUT PROCESSOR (MYTTOX)

MYTTOX transmits acquisition data via subchannel 10 of the DCC.

The flow chart for the MYTTOX processor is shown in Figure 7-14.

7.12.1 Input Requirements

Input to MYTTOX consists of:

a) MNOLSY—parameter designating the number of packed words in an acquisition message, 31. MNOLSY serves as the E parameter for the QTYYA macro.

b) TMX01—four-cell table providing input to A0STAD and O0LSTY, the two MYTTOX subroutines that gather, convert and pack acquisition data. TMX01 is updated by AJACQ and is represented by the parameter, D, for the AJACQ macro.

c) TMLSIX—31-cell table, containing the packed output data generated by O0LSTY. TMLSIX is represented by the parameter, B, for the QTYYA macro. The length of TMLSIX is defined by MNOLSY.

d) TMXBOX—six-cell table for output on DCC subchannel 10. This table is represented by the parameter, D, for QTYYA.

e) TM8.3M—contains the number of 8-1/3 milliseconds elapsed since the last exact half second.

f) MCHFSC—contains the current GMT in fixed-point half seconds.

g) MCBETA—indicates which of the duplexed IBM 7090 computers is transmitting externally. Although both computers receive and process input, only one computer is on-line for external output transmission. The sign of MCBETA is positive when the computer is transmitting.

h) MCPHSE—communication cell whose prefix specifies the mission phase:

P(MCPHSE) - 0, launch phase
P(MCPHSE) - 1, high-abort phase
P(MCPHSE) - 2, low-abort phase
P(MCPHSE) - 3, medium-abort phase
P(MCPHSE) - -0, orbit phase
P(MCPHSE) - -1, re-entry from orbit phase
P(MCPHSE) - -2, re-entry from high-abort phase
7.12.2 Output Requirements

Output from MYTTOX consists of:

a) TMOX01—four-cell table for input to A0STAD and O0LSTY. In the launch phase, the logging time tag is stored in TMOX01 + 2, otherwise the AJACQ macro updates TMOX01 (see Subsection 7.13).

b) MCTLAD—used when MYTTOX is entered in the launch phase, MCTLAD is set zero to indicate acquisition data is being sent; MCTLAD is set non-zero, when transmission is completed.

c) MCACTV—mask used to activate and deactivate subchannels on the DCC. MYTTOX uses MCACTV to activate subchannel 10.

7.12.3 Method

MYACQD queues input to MYTTOX when acquisition data must be transmitted via DCC subchannel 10, except during launch, when the B indicator for MYTTOX is turned on directly by the launch output-updating subroutine, MLUPDT. During launch, the main launch processors supply the acquisition data for Bermuda and MYTTOX is given control to convert and pack (via O0LSTY) and transmit the message.

In the non-launch phases, MYTTOX receives control as a result of an entry in its queue table. This entry is stored in TMOX01, where it serves as input to the AJACQ macro. The input word contains in the decrement the internal station number of the station to receive data and in the address the estimated capsule horizon crossing time for the station's sector. AJACQ updates control words for A0STAD and O0LSTY. If the capsule will pass within range, A0STAD gathers acquisition data for that station and O0LSTY converts, packs and stores this data in the TMLSOX table. If, however, A0STAD finds that the capsule will be out of range for the given station, no acquisition data is gathered and the subroutine makes a special return, whereupon MYTTOX queues an on-line message stating that no acquisition data was sent to this particular station.

Following a normal return from A0STAD, MYTTOX determines whether or not this computer is transmitting. If it is, QT TYA unpacks the first word of the acquisition message and transmission is initiated. If the computer is not transmitting, an on-line message is queued to state that acquisition data was sent (although this computer did not do the transmitting).

The B indicator is turned on for MYTTXO, the subchannel 10 logging processor. MYTTOX then suppresses itself and remains suppressed until transmission and logging have been completed.

Since A0STAD and O0LSTY are shared by MYTTOX and MYTTOY, either processor must suppress the other before using A0STAD or O0LSTY.
7.12.4 Usage

MYTTOX is entered from, and exits to, M0PRIO.

a) Storage Required—101 locations

b) MYTTOX uses:

1) Subroutines—A0STAD and O0LSTY

2) Macros—AJACQ, QENBA, QENBZ, QPSLF, QTYYA, QUEUE, TRNOF, TRNON and UNQUE

3) Parameters—A, B, C, D, MNMESS, MNOLSY, MNTTOX, MNTTOY and MNTTXO

4) Communication cells—MCACTV, MCBETA, MCHFSC and MCPPHE

5) Tables—TM8.3M, TMLSOX, TMOX01 and TMXBOX

c) Time Required:

1) If MYTTOX is entered during the launch phase—73.465 milliseconds (maximum), 73.230 milliseconds of which are for the subroutine O0LSTY.

2) If the capsule will not pass within range of the station—36.768 milliseconds (maximum), 36.363 milliseconds of which are for A0STAD.

3) If the capsule will be within range of the station—109.945 milliseconds (maximum), 109.593 milliseconds of which are for O0LSTY and A0STAD.
FIGURE 7-14. MYTTOX PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 7-14. MYTTOX PROGRAM FLOW CHART (Sheet 2 of 2)
7.13 MONITOR SUBCHANNEL 11 TELETYPE OUTPUT PROCESSOR (MYTTOY)

MYTTOY transmits acquisition data via subchannel 11 of the DCC.

The flow chart for the MYTTOY processor is shown in Figure 7-15.

7.13.1 Input Requirements

Input to MYTTOY consists of:

a) MNOLS Y—parameter designating the number of packed words in an acquisition message, 31. MNOLS Y serves as the E parameter for the QTTYA macro.

b) TMOY01—four-cell table providing input to A0STAD and O0LSTY, the two MYTTOY subroutines that gather, convert and pack acquisition data. TMOY01 is updated by AJACQ and is represented by the parameter, D, for the AJACQ macro.

c) TMLSOY—31-cell table, containing the packed output data generated by O0LSTY. TMLSOY is represented by the parameter, B, for the QTTYA macro. The length of TMLSOY is defined by MNOLS Y.

d) TMYBOX—six-cell table for output on DCC subchannel 11. This table is represented by the parameter, D, for QTTYA.

e) TM8.3M—contains the number of 8-1/3 milliseconds elapsed since the last exact half second.

f) MCHFSC—contains the current GMT in fixed-point half seconds.

g) MCBETA—indicates which of the duplexed IBM 7090 computers is transmitting externally. Although both computers receive and process input, only one computer is on-line for external output transmission. The sign of MCBETA is positive when the computer is transmitting.

7.13.2 Output Requirements

Output from MYTTOY consists of MCACTV, the mask used to activate and deactivate subchannels on the DCC. MYTTOY uses MCACTV to activate subchannel 11.

7.13.3 Method

MYTTOY receives control as a result of an entry in its queue table. This entry is stored in TMOY01, where it serves as input to the AJACQ macro. The input word contains in the decrement the internal station number of the station to receive data and in the address the estimated capsule horizon crossing time.
for the station's sector. AJACQ updates control words for A0STAD and O0LSTY. If the capsule will pass within range, A0STAD gathers acquisition data for that station and O0LSTY converts, packs and stores this data in the TMLSOY table. If, however, A0STAD finds that the capsule will be out of range for the given station, no acquisition data is gathered and the subroutine makes a special return, whereupon MYTT0Y queues an on-line message stating that no acquisition data was sent to this particular station.

Following a normal return from A0STAD, MYTT0Y determines whether or not this computer is transmitting. If it is, QTYYA unpacks the first word of the acquisition message and transmission is initiated. If the computer is not transmitting, an on-line message is queued to state that acquisition data was sent (although this computer did not do the transmitting).

The B indicator is turned on for MYTT0Y, the subchannel 11 logging processor. MYTT0Y then suppresses itself and remains suppressed until transmission and logging have been completed.

Since A0STAD and O0LSTY are shared by MYTT0Y and MYTT0X, either processor must suppress the other before using A0STAD or O0LSTY.

7.13.4 Usage

MYTT0Y is entered from, and exits to, M0PRIO.

a) Storage Required—88 locations

b) MYTT0Y uses:

1) Subroutines—A0STAD and O0LSTY
2) Macros—AJACQ, QENBA, QENBZ, QPSLF, QTYYA, QUEUE, TRN0F, TRNON and UNQUE
3) Parameters—A, B, C, D, MNMESS, MNOLSY, MNST0X, MNST0Y and MNST0Y
4) Communication cells—MCAC0V, MCBETA and MCHFSC
5) Tables—TM8.3M, TMLSOY, TM0Y01 and TM0YBOX

c) Time Required:

1) If the capsule will not pass within range of the station—36.757 milliseconds (maximum)
2) If the capsule will be within range of the station—109.933 milliseconds (maximum)
FIGURE 7-15. MYTTOY PROGRAM FLOW CHART
7.14 ACQUISITION DATA MACRO (AJACQ)

The AJACQ macro sets control words for AOSTAD and OOLSTY, the programs which compute, convert and pack the acquisition data. This macro is used by two programs: MYTTOX and MYTTOY.

The flow chart for AJACQ is shown in Figure 7-16.

7.14.1 Input Requirements

The AJACQ macro is defined:

<table>
<thead>
<tr>
<th>AJACQ</th>
<th>MACRO</th>
<th>D, F</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLA</td>
<td>D +3</td>
<td></td>
</tr>
<tr>
<td>STO</td>
<td>MCACQ1</td>
<td></td>
</tr>
<tr>
<td>CLA</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>STA</td>
<td>MCACQ2</td>
<td></td>
</tr>
<tr>
<td>STD</td>
<td>MCACQ1</td>
<td></td>
</tr>
<tr>
<td>STD</td>
<td>* + 4</td>
<td></td>
</tr>
<tr>
<td>AXT</td>
<td>F, 2</td>
<td></td>
</tr>
<tr>
<td>SXD</td>
<td>D + 3, 2</td>
<td></td>
</tr>
<tr>
<td>AXT</td>
<td>TMSTCH, 2</td>
<td></td>
</tr>
<tr>
<td>TXI</td>
<td>* +1, 2,**</td>
<td></td>
</tr>
<tr>
<td>SXA</td>
<td>* +1, 2</td>
<td></td>
</tr>
<tr>
<td>CLA</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>PAC</td>
<td>0, 2</td>
<td></td>
</tr>
<tr>
<td>CLA</td>
<td>3, 2</td>
<td></td>
</tr>
<tr>
<td>STA</td>
<td>D + 1</td>
<td></td>
</tr>
<tr>
<td>CLA</td>
<td>MCHFSC</td>
<td></td>
</tr>
<tr>
<td>ALS</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>ORA</td>
<td>TM8.3M</td>
<td></td>
</tr>
<tr>
<td>STO</td>
<td>D + 2</td>
<td></td>
</tr>
<tr>
<td>END</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Output for OOLSTY in address

Estimated horizon crossing time in address

Internal station number in decrement

Number of packed words

Station Characteristics Reference Table

Get control word from TMSTCH for 1th station

Get control word for output subchannel and terminal

Half-second time cell

8-1/3 millisecond counter

Time for logging

where the parameters, D and F, are defined:

a) D—four-word table which serves as both input and output for AJACQ. As input, D contains in the decrement the internal station number of the station to receive acquisition data and in the address the horizon crossing time for the station's sector. D + 3 contains in the address the location of the block for output from OOLSTY. D + 1, D + 2 and the decrement of D + 3 contain output from AJACQ. The correct terminal number for the sense output mask is taken from the Station Characteristics table and is stored in the address of D + 1. The number of
packed words of acquisition data for a station is stored in the decrement of \( D+3 \) and the logging time is stored in \( D+2 \). When \( \text{AJACQ} \) is used in \( \text{MYTTOX} \), \( D \) is \( \text{TMOX01} \); for \( \text{MYTTOY} \), \( D \) is \( \text{TMOY01} \).

b) \( F \)—parameter designating the number of packed output words in the acquisition message. In \( \text{MYTTOX} \) and \( \text{MYTTOY} \), \( F \) has the same value: \( \text{MNOLSYY} \) (equal to 31).

c) \( \text{TMSTCH} \)—25-cell table for referencing the Station Characteristics table, \( \text{TMCHAR} \).

d) \( \text{TMCHAR} \)—the Station Characteristics table. Each tracking station in the Mercury network is represented by a 34-cell Station Characteristics block in \( \text{TMCHAR} \).

e) \( \text{TM8.3M} \)—the number of 8-1/3 milliseconds elapsed since the last exact half second. \( \text{TM8.3M} \) and \( \text{MCHFSC} \) are combined to determine the logging time tag.

f) \( \text{MCHFSC} \)—contains the current GMT in fixed-point half-seconds.

7.14.2 Output Requirements

a) \( D \)—the \( D \) table, as defined by the macro parameter, is prepared for output. This table is described above under a).

b) \( \text{MCACQ1} \)—contains in the address the location of the output block that is to be used by the packing routine, \( \text{O0LSTY} \), and in the decrement the internal number of the station to receive acquisition data.

c) \( \text{MCACQ2} \)—contains the estimated horizon crossing time in fixed-point minutes.

7.14.3 Method

The location of the output block for \( \text{O0LSTY} \) is taken from the address of \( D+3 \) and stored in the address of \( \text{MCACQ1} \). Using word \( D \) as input, the horizon crossing time is stored in the address of \( \text{MCACQ2} \) and the internal station number is stored in the decrement of \( \text{MCACQ2} \). The number of packed words in the acquisition message is stored in the decrement of \( D+3 \). The appropriate sense output mask for the subchannel and terminal corresponding to the station is stored in \( D+1 \); the terminal number is obtained from the Station Characteristics table, \( \text{TMCHAR} \), via \( \text{TMSTCH} \), and the subchannel-activation bit is assumed already in the decrement of \( D+1 \). The standard logging time tag is generated and stored in \( D+2 \).
7.14.4 **Usage**

Entry to AJACQ has no restrictions; AJACQ exits to the 19th location following entry.

a) Storage Required—19 locations

b) AJACQ uses:
   1) Communication cells—MCACQ1, MCACQ2 and MCHFSC
   2) Tables—TM8.3M, TMSTCH and TMCHAR
   3) The macro parameters—D and F

c) Time Required—0.080 millisecond
FIGURE 7-16. AJACQ MACRO FLOW CHART
7.15 TELETYPE OUTPUT MACRO (QTTRYA)

The QTTRYA macro unpacks a packed teletype output word into the proper format for transmission by the DCC. This macro is used by two programs: MYTTOX and MYTTOY.

The flow chart for QTTRYA is shown in Figure 7-17.

7.15.1 Input Requirements

The QTTRYA macro is defined:

```
QTTRYA MACRO B, D, E, F
LXD E + 3, 2
AXT 6, 1
LDQ B + F, 2
LGL 6
STA D, 1
TIX * -2, 1, 1
TXI * +1, 2, -1
SXD E + 3, 2
END
```

where the parameters are:

a) B—the location of the input table. From the B table QTTRYA obtains the word to be unpacked. The input word is composed of six 6-bit bytes, each byte composed of a teletype character preceded by a leading zero. (See Figure 7-17 for the unpacking method.) The location of the input word is given under d).

b) D—the location of the output table plus six. The output is stored one byte right justified into each of the six locations: D-6, D-5, D-4, D-3, D-2 and D-1.

c) E—the decrement of location E+3 contains the number of words in the input table, B, to be unpacked.

d) F—the original number of packed words in the B input table. The location of the input word is: B + F - decrement of (E + 3).

7.15.2 Output Requirements

QTTRYA stores one teletype character into the six sequential locations beginning with D-6.
7.15.3 Method

The input word to be unpacked is taken from the location B + F - decrement of (E + 3) (where B, F and E are described above). The word is unpacked from left to right, and one 6-bit byte is stored right justified into each of the six words of the output table, D-6. The number of words remaining is reduced by one and the new count is stored back into the decrement of E + 3.

7.15.4 Usage

Entry into QTYYA has no restrictions; QTYYA exits to the eighth location following entry.

a) Storage Required—8 locations

b) QTYYA uses the macro parameters B, D, E, and F.

c) Time Required—0.100 millisecond
FIGURE 7-17 QTYYA MACRO FLOW CHART
7.16 MONITOR TELETYPe OUTPUT TRAP PROCESSORS (MTTTOX, MTTTOY)

MTTTOX receives control when a trap occurs on DCC subchannel 10; MTTTOY receives control when a trap occurs on DCC subchannel 11. These two processors unpack one word of acquisition data each time they are entered and continue to do so until the complete message has been transmitted.

The flow chart for MTTTOX is shown in Figure 7-18. The flow chart for MTTTOY is shown in Figure 7-19.

7.16.1 Input Requirements

Input to MTTTOX consists of:

a) MNOLSY—parameter designating the number of words in the TMLSOX table, 31.

b) TMOX01—four-cell table which is the output of the AJACQ macro as used by MTTTOX. TMOX01+1 contains the sense output mask for the particular station to which acquisition data is being sent and the decrement of TMOX01 contains this station's internal station number. TMOX01 serves as the E parameter for the QTTYB macro.

c) TMXBOX—six-cell table for output on DCC subchannel 10.

d) TMLSOX—31-cell table containing the packed-word output of O0LSTY, when O0LSTY is used by MTTTOX.

Input to MTTTOY consists of: TMOY01, TMYBOX, TMLSOY and MNOLSY. The tables are the subchannel 11 counterparts to the input tables for MTTTOX.

7.16.2 Output Requirements

Output from both MTTTOX and MTTTOY consists of MCACTV, the communication cell used to activate and deactivate subchannels of the DCC.

7.16.3 Method

Since MTTTOX and MTTTOY function in exactly the same way (differing only in the subchannels they service), only the method of MTTTOX is described here.

MTTTOX continues the unpacking and transmitting of acquisition data, which was initiated by MTTTOX. The QTYYB macro determines whether or not a complete message has been sent and, if not, QTYYB unpacks the next word of the message for transmission. As soon as the unpacked teletype characters have been sent, MTTTOX again receives control via the trap, and again QTYYB makes its decision.
When all of the packed teletype words have been unpacked and transmitted, MTTTOX deactivates subchannel 10, queues an on-line message stating that acquisition data has been sent to the specified station. MTTTOX then turns on the B indicator for MYTTXO, which logs the transmitted data.

7.16.4 Usage

MTTTOX is entered from M0RTCC following a trap on DCC subchannel 10; MTTTOX exits to M0PRIO.

MTTTOY is entered from M0RTCC following a trap on DCC subchannel 11; MTTTOY exits to M0PRIO.

a) Storage Required (each)—22 locations

b) MTTTOX uses:
   1) Macros—QPSLF, QTYYB, QUEUE and TRNON
   2) Parameters—B, MNMESS, MNOLSY and MNTTXO
   3) Communication cell—MCACTV
   4) Tables—TMLSOX, TMOX01 and TMXBOX

MTTTOY uses:
   1) Macros—QPSLF, QTYYB, QUEUE and TRNON
   2) Parameters—B, MNMESS, MNOLSY and MNTTYO
   3) Communication cell—MCACTV
   4) Tables—TMLSOY, TMOY01 and TMYBOX

c) Time Required (each):
   1) If not all words have been transmitted—0.107 millisecond
   2) If all words have been transmitted—0.143 millisecond
FIGURE 7-18. MTTTOX PROGRAM FLOW CHART
FIGURE 7-19. MTTTOY PROGRAM FLOW CHART
7.17 TELETYPe OUTPUT TEST MACRO (QTTYB)

If teletype output remains to be transmitted, QTTYB unpacks one word of six teletype characters and stores these into the core storage areas assigned for transmission via the DCC. If the complete message has been transmitted, QTTYB transfers control via a designated exit.

QTTYB is used by the two programs which control teletype output transmission: MTTTOY and MTTTOX.

The flow chart for the QTTYB macro is shown in Figure 7-20.

7.17.1 Input Requirements

The QTTYB macro is defined:

```
QTTYB MACRO B, C, D, E, F
LXD E+3, 2
TXL C, 2, 0
AXT 6, 1
LDQ B+F, 2
LGL 6
STA D, 1
TIX *+1, 2, -1
SXD E+3, 2
END
```

where the parameters are defined:

a) B—the location of the table from which QTTYB obtains a word to be unpacked. The input word is composed of six 6-bit bytes, each byte composed of a teletype character preceded by a leading zero (see Figure 7-20).

b) C—the location to which QTTYB exits if there is no input, i.e., if all of the words in the B table have already been unpacked.

c) D—the location of the output table plus six. If QTTYB has no input, there is no output. Otherwise the output is stored one byte right justified into each of the six locations: D-6, D-5, D-4, D-3, D-2 and D-1.

d) E—the decrement of location E+3 contains the number of words in the input table, D-6, remaining to be unpacked.
e) F—the original number of packed words in the B table. An input word for QTTYB exists as long as the decrement of E + 3 is not zero. At any time the location of the input word is: B + F - decrement of (E + 3).

7.17.2 Output Requirements

If the decrement of (E + 3) is zero, there is no output. If the decrement is non-zero, QTTYB stores data into the six word table, D-6.

7.17.3 Method

The decrement of (E + 3) is examined and, if zero, QTTYB exits to C. If the decrement of (E + 3) is non-zero, the next word is taken from location B + F - decrement (E + 3), unpacked from left to right, with one 6-bit byte stored right justified into each of the six words of the output table, D-6. The word count, i.e., the number of words remaining to be unpacked, is reduced by one and the new count is stored in the decrement of (E + 3).

7.17.4 Usage

Entry into QTTYB has no restrictions; QTTYB exits to the location specified by C if no words remain to be unpacked. QTTYB exits to the 9th location following entry if a word is unpacked.

a) Storage Required—9 locations

b) QTTYB uses the macro parameters B, C, D, E, and F

c) Time Required:

1) QTTYB has no words to unpack—0.008 millisecond

2) If QTTYB unpacks a word—0.105 millisecond
GET ONE WORD FROM TABLE B
TAKE WORD FROM LOCATION
[B + F - DECR(E + 3)]

UNPACK WORD AND STORE ONE 6 BIT
BYTE INTO EACH OF THE 6 CELLS IN THE
TABLE (D-6)

REDUCE PACKED WORD COUNT
DECR (E + 3) - 1
→ DECR (E + 3)

INPUT:
WORD FROM TABLE B (SIX 6-BIT BYTES)

A B C D E F

OUTPUT (IF THERE IS OUTPUT):
6 WORD TABLE D-6

D-6  D-5  D-4  D-3  D-2  D-1

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MTTTOX</th>
<th>MTTTOY</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>TMLSOX</td>
<td>TMLSOY</td>
</tr>
<tr>
<td>C</td>
<td>CP1</td>
<td>CQ1</td>
</tr>
<tr>
<td>D</td>
<td>TMXBOX + 6</td>
<td>TMYBOX + 6</td>
</tr>
<tr>
<td>E</td>
<td>TMOX01</td>
<td>TMOY01</td>
</tr>
<tr>
<td>F</td>
<td>MNOLSY</td>
<td>MNOLSY</td>
</tr>
</tbody>
</table>

FIGURE 7-20. QTLYB MACRO FLOW CHART
7.18 MONITOR TELETYPE OUTPUT LOGGING PROCESSORS (MYTTXO AND MYTTYO)

MYTTXO and MYTTYO log all acquisition data transmitted over the low-speed teletype output subchannels. MYTTXO logs the messages transmitted over subchannel 10; MYTTYO logs the messages transmitted over subchannel 11.

The flow charts for the MYTTXO and MYTTYO processors are shown in Figures 7-21 and 7-22, respectively.

7.18.1 Input Requirements

Input to MYTTXO (MYTTYO) consists of:

a) MNOLSY—parameter designating the number of packed words, 31, in the TMLSOX (TMLSOY) table.

b) TMOX01 (TMOY01)—four-cell table, which, as output from AJACQ, provides input to MYTTYX (MYTTYO). The second word in the table contains the mask to activate the DCC subchannel and select the proper terminal. The sign of the second word, if negative, indicates the computer was transmitting. The third word in the table contains the logging time tag. The decrement of the fourth word contains the number of packed words to be logged, 31.

c) TMLSOX (TMLSOY)—31-cell table containing the packed teletype data.

7.18.2 Output Requirements

MYTTXO (MYTTYO) sets up the calling sequence for MSLOGG, the subroutine which logs the data TMLSOX in (TMLSOY).

MYTTXO clears MCTLAD, a communication cell used by the launch programs. From MCTLAD, the launch programs determine whether or not the last acquisition message has been completely transmitted and logged. (MYTTYO is not used during launch).

7.18.3 Method

The B indicator for MYTTXO (MYTTYO) is turned on by MTITTOX (MTITTOY). TMLSOX (TMLSOY), the table to be logged, contains 31 words, requiring three entries to the logging subroutine: 12 words are logged on each of the first two passes and seven are logged on the last pass. The calling sequence to MSLOGG is set up as follows: the logging time tag is taken from TMOX01 + 2 (TMOY01 + 2) and is loaded into the MQ; the word containing the subchannel number, the terminal number and the indication as to whether or not the computer was transmitting, is taken from TMOX01 + 1 (TMOY01 + 1) and stored in the second word of the calling sequence. The location of the data to be logged
and the data word count are stored in the address and decrement, respectively, of the third word of the calling sequence.

Following logging, MYTTOX (MYTTOY) is unsuppressed (it suppressed itself) and, in MYTTXO, MCTLAB is set to zero. Control transfers to M0PRIO.

The usage of MCTLAB is the only difference between the logic of MYTTOX and that of MYTTOY. MCTLAB is set non-zero in MYTTOX, if launch phase acquisition data is to be sent to Bermuda.

7.18.4 Usage

MYTTXO (MYTTYO) enters from, and exits to, M0PRIO.

a) Storage Required:
   1) MYTTXO—39 locations
   2) MYTTYO—38 locations

b) MYTTXO uses:
   1) Subroutine—MSLOGG
   2) Macros—QENBA, QENBZ, TRNOF and TRNON
   3) Parameters—A, B, D, MNOLSY, MNTTOX and MNTTXO
   4) Communication cell—MCTLAB
   5) Tables—TMOX01 and TMLSOX

c) MYTTYO uses:
   1) Subroutine—MSLOGG
   2) Macros—QENBA, QENBZ, TRNOF and TRNON
   3) Parameters—A, B, D, MNOLSY, MNTTOY and MNTTYO
   4) Tables—TMOY01 and TMLSOY

d) Time Required (including MSLOGG):
   1) MYTTXO—1.701 milliseconds
   2) MYTTYO—1.697 milliseconds
FIGURE 7-21. MYTTXO PROGRAM FLOW CHART
FIGURE 7-22. MYTTYO PROGRAM FLOW CHART
7.19 SENSE OUTPUT TO OUTPUT STATUS CONSOLE

The Output Status Console provides eight indicator lights; these are used to provide external indications of mission flight phases, quality of input radar data and the selected source of high-speed input data during launch. These lights are controlled by a fixed location (symbolically, TMSENS) in computer core storage whenever DCC subchannel 31 is activated. Bit positions 28 through 35 of TMSENS drive the eight indicators: a 1 in the bit position is required to turn on, or keep on, the corresponding indicator.

The Output Status Console's indicator lights are illustrated below:

<table>
<thead>
<tr>
<th>LAUNCH</th>
<th>ABORT</th>
<th>ORBIT</th>
<th>RE-ENTRY</th>
<th>GE/B SELECT</th>
<th>IP FPS-16 SELECT</th>
<th>IP AZUSA SELECT</th>
<th>BAD OR MISSING DATA</th>
</tr>
</thead>
</table>

Each of the Goddard duplexed computers drives a separate panel of lights on the Output Status Console. The Bad or Missing Data indicator has an associated audible tone; this tone is distinct for each computer.

Whenever any program recognizes the need for change in the sense indicator lights of the Output Status Console, a mask is stored in the queue table for the sense output processor, MYSENS, and its B indicator is turned on. The mask must have the following format: a 1 in bit positions 10-17 indicates that the corresponding light is to be turned off; a 1 in bit positions 28-35 indicates the corresponding light is to be turned on. The left-most bit of each group corresponds to the left-most light on the Output Status Console. When bits specify that a given light is to be turned off and on, off takes precedence.

The control cycle for sense output to the Output Status Console is illustrated in Figure 7-23. The Monitor programs which change the Output Status Console are given in Table 7-3.
<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>LAUNCH</th>
<th>ABORT</th>
<th>ORBIT</th>
<th>RE-ENTRY</th>
<th>GE/B SELECT</th>
<th>IP FPS-16 SELECT</th>
<th>IP AZUZA SELECT</th>
<th>BAD OR MISSING DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFMAN1</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MYREST</td>
<td></td>
<td></td>
<td>OFF</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MYSEEK</td>
<td>OFF</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFLABT</td>
<td>ON</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFML6A</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFHSGB</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFHS08</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFLRT2</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFLRT1</td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFLHLD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OFF</td>
</tr>
<tr>
<td>MFLORB</td>
<td>OFF</td>
<td></td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPLCCM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ON</td>
</tr>
<tr>
<td>MPLCCM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>OFF</td>
</tr>
<tr>
<td>MPLCCM</td>
<td>OFF</td>
<td></td>
<td>ON</td>
<td></td>
<td>OFF</td>
<td>ON</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPLCCM</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPLCCM</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPLCCM</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MONITOR PROGRAMS
(SEE TABLE 7-3)

OUTPUT

Q27 (10 WORDS)
QUEUE TABLE
FOR MYSENS

INPUT

CONTROL
TRANSFER

MYSENS
GENERATE
OUTPUT WORD,
ACTIVATE
SUB, CH. 31

OUTPUT

MTSENS:
BITS 26-35

TRAP

DCC SUBCHANNEL

LAUNCH | ABORT | ORBIT | RE-ENTRY | GE/B SELECT | IP FPS-16 SELECT | IP AZUZA SELECT | BAD OR MISSING DATA

OUTPUT STATUS CONSOLE
AT GODDARD

FIGURE 7-23. DATA FLOW: TRANSMISSION TO OUTPUT STATUS CONSOLE
7.20 MONITOR SENSE OUTPUT PROCESSOR (MYSENS)

MYSENS and its trap processor, MTSENS, control the eight lights on the Output Status Console.

The flow chart for the MYSENS processor is shown in Figure 7-24.

7.20.1 Input Requirements

Input to MYSENS consists of:

a) TMSSENS—one-word table used by MYSENS to determine the current setting of the Output Status Console. MYSENS uses TMSSENS to determine what changes are necessary for the Output Status Console's indicator lights.

b) TM8.3M—contains the number of 8-1/3 milliseconds elapsed since the last exact half second.

c) MCHFSC—contains the current GMT in fixed-point half seconds.

d) MCSEN2—mask, 777 777 777 757, which with MCACTV is used to activate the sense output subchannel of the DCC, subchannel 31. This mask is also used by MTSENS to deactivate subchannel 31.

7.20.2 Output Requirements

Output from MYSENS consists of:

a) MCSEN1—contains the logging time tag.

b) MCACTV—set to activate DCC subchannel 31.

c) TMSSENS—bit positions 28-35 of TMSSENS are set with 1's and zeros, respectively, to turn on or turn off the appropriate lights.

7.20.3 Method

MYSENS receives input from a queue table and hence its B indicator is controlled by MOQUEU. As long as there are entries in its queue, MYSEN's B indicator remains on.

The MYSENS input consists of the word from its queue table: each 1 in positions 10-17 indicates the corresponding light is to be turned off; each 1 in positions 28-35 indicates which lights are to be turned on. The left-most bit position of each group indicates the left-most light on the Output Status Console. If bits are present in the input word to both turn off and turn on the same light, off takes precedence. MYSENS combines the input word with the current
setting in TMSSENS to generate a new mask (assuming a change is required) which is stored in TMSSENS. The logging time tag for MTSENS is generated and stored in MCSEN1. Subchannel 31 is activated to begin transmission, MYSENS suppresses itself (it is unsuppressed by MTSENS), and exit is made to M0PRIO.

7.20.4 Usage

MYSENS is entered from, and exits to, M0PRIO.

a) Storage Required—37 locations

b) MYSENS uses:

1) Macros—QPSLF, TRNOF, TRNON and UNIQUE

2) Parameters—MNSENS, A, and C

3) Communication cells—MCACTV, MCHFSC, MCSEN1 and MCSEN2

4) Tables—TMSSENS and TM8.3M

c) Time Required (average)—0.209 millisecond
FIGURE 7-24. MYSENS PROGRAM FLOW CHART
7.21 MONITOR SENSE OUTPUT TRAP PROCESSOR (MTSENS)

MTSENS terminates transmission of an output word to the Output Status Console via DCC subchannel 31 and then logs the sense output.

The flow chart for the MTSENS trap processor is shown in Figure 7-25.

7.21.1 Input Requirements

Input to MTSENS consists of:

a) TMSENS—A one-word table that is used for output over subchannel 31 of the DCC. This word is the output of MYSENS and is logged by MTSENS.

b) MCSEN1—contains the logging time tag generated by MYSENS.

c) MCSEN2—mask, 777 777 777 757, which with MCACTV is used to deactivate subchannel 31 of the DCC.

7.21.2 Output Requirements

Output from MTSENS consists of MCACTV, the mask used to activate and deactivate subchannels of the DCC.

7.21.3 Method

MTSENS receives control when a trap occurs on subchannel 31 of the DCC. MTSENS removes the bit from position 31 of the DCC subchannel mask, MCACTV, so that subchannel 31 will be deactivated when the macro PSLF is executed. Subchannel 31 is then deactivated. TMSENS, the output word to the sense console is logged, MYSENS is unsuppressed and control is returned to M0PRIO.

7.21.4 Usage

MTSENS is entered from M0RTCC following a trap on DCC subchannel 31; MTSENS exits to M0PRIO.

a) Storage Required—9 locations

b) MTSENS uses:

1) Subroutine—MSLOGG

2) Macros—QPSLF and TRNOF

3) Parameters—C and MNSENS
4) Communication cells—MCACTV, MCSEN1 and MCSEN2

5) Table—TMSENS

c) Time Required—0.499 millisecond
MC-103

FIGURE 7-25. MTSENS PROGRAM FLOW CHART
Section 8
ON-LINE MESSAGES AND LOGGING

Throughout the Mercury mission, on-line messages are generated by the tracking program to provide immediately accessible information to the personnel at the IBM 7090 console. In addition, a permanent log tape records for post-flight and other analyses all on-line messages and all input/output data transmitted via the Data Communications Channel. Unlike the operations of data channels A, B, and C described in Section 5, the printing of on-line messages on channel A and logging on channel B are not related to a flight phase or other conditions in the Mercury mission. However, the restrictions specified in Section 1 for usage of the data channels apply equally to the on-line message and logging programs.

8.1 THE ON-LINE MESSAGE SYSTEM

8.1.1 The On-Line Message Cycle

In a normal situation the on-line message cycle requires the execution in the stated order of the following four processors: MYMESS, MTMSCK, MYMSCK, and MTENPR. A brief description of the on-line message cycle is given below.

The general function and integration of the processors for on-line messages are illustrated in Figure 8-1.

MYMESS, the Monitor On-Line Message Processor, must initiate every on-line message. MYMESS receives control from M0Prio whenever priority restrictions permit, after an entry has been placed in the MYMESS input queue. MYMESS suppresses all other processors which initiate transmission on data channel A (except MYMSCK which is never given control until after the transmission initiated by MYMESS is completed). The one-word input (see Subsection 8.1.2) from the queue specifies the message which must be read from the message tape. MYMESS checks the number for possible error.

a) If the number of the requested message is zero or greater than the highest message number, MYMESS sets the channel A trap control location to give control to MTENPR, generates the information necessary for logging, and gives the commands and instructions to print a standard error message directly from core storage. When MYMESS finds an error in the message number, neither MTMSCK nor MYMSCK is used, nor is the message tape.
FIGURE 8-1. ON-LINE MESSAGE CYCLE
b) If the message number is valid, MYMESS sets the channel A trap control location to give control to MTMSCK, and generates the commands and instructions necessary to position the message tape at the requested message and read the message into core storage. MYMESS suppresses itself and exits to M0PRIO.

MTMSCK, the Monitor Message Check Trap Processor, checks for a redundancy error in the reading of the message from the message tape. If redundancy had occurred MTMSCK attempts to reread the message without redundancy and may resort to the auxiliary message tape. If redundancy had not occurred, the processor saves the control word set by the channel A trap, updates the tape position cell and turns on the B indicator for MYMSCK, MTMSCK exits to M0PRIO.

MYMSCK, the Monitor Message Check Processor, receives control from M0PRI0 and sets channel A trap location to give control to MTENPR.

a) If MYMSCK is in the process of printing out a block of data for a differential correction message, control is immediately passed to the MYMSCK routine that will print the next line of data.

b) If the trap from the message tape input was caused by an end-of-file or if the number of the message requested and of the message read from tape are not identical, MYMSCK generates the information for logging and gives the commands and instructions necessary to print from core storage the applicable error message.

If the requested message was properly read from tape into core, MYMSCK generates the information for logging, and if the message requires the addition of variable field data, MYMSCK converts the specified data into card image and adds this to the message. If the variable field data consists of a whole block of data (as after a differential correction), controls are set for MYMSCK to receive control from M0PRI0 once for every printed line of data. During the printing of this block of data, MYMESS is suppressed.

The current time is also added to every message from tape before the commands are given to print the message. MYMSCK exits to M0PRI0.

MTENPR, the Monitor End-of-Printing Trap Processor, receives control every time a line is printed and always completes the message cycle.

a) If the line printed is a message requiring no data following it, MTENPR logs the message and unsuppresses the channel A transmission processors.

b) If the line printed is a differential correction message which requires a block of data, the message is logged, the B indicator for MYMSCK is turned on and MTENPR exits to M0PRI0.
c) If the line printed is part of a block of data printed after a differential correction message, the B indicator for MYMSCK is turned on and MTENPR exits to M0PRIO.

8.1.2 On-Line Messages

The time of printing is added to every non-error message printed. (When a block of data is printed following differential correction, the time appears only in the first and last lines of print.) This time is GMT and appears as hours, minutes and seconds, left justified, on the printed message. A period separates the hours from the minutes and the minutes from the seconds. An example of a complete message is:

11.06.22 THE TIME OF LIFTOFF IS 11 HRS 06 MINS 21 SECS

The on-line message cycle can currently process messages with or without variable fields. The messages without variable fields are read from tape, given a time tag and printed. The variable fields may consist of floating-point numbers, octal integers, a time in hours, minutes and seconds (as in the example above), a fixed-point number, or a block of data following a message. The procedures for queueing these types of messages are given below. The messages used in the Mercury Program System are given in Table 8-1. The computer must be disabled during the queueing procedure.

Message without a variable field:

```
Message without a variable field: QUEUE MNMESS, K
```

where location K contains the message number.

Message on tape:

```
ORBIT PHASE HAS BEEN ENTERED
```

Message printed:

```
11.06.22 ORBIT PHASE HAS BEEN ENTERED
```

Floating-point number variable field:

```
Floating-point number variable field: QUEUE MNMESS, K
```

where location K contains a 6 in the prefix, the message number in the decrement, the number of the floating-point numbers to be printed (1, 2 or 3) in the tag, and the location of the block containing the floating-point numbers in the address. Floating-point numbers are printed in the format: \( \pm X,XXXXXXX, \pm XX \) where the latter two digits represent the exponent of ten.

Message on tape:

```
APOGEE N.M. PERIGEE N.M.
```

Message printed:

```
11.06.22 APOGEE N.M. +1.3888065, +02, +8.6774363, +01 PERIGEE N.M.
```
If only one floating-point number is to be printed, columns 23 through 36 of the card image are cleared and the number is placed there. If two floating-point numbers are to be printed, the first is placed in columns 23 through 36 of the card image and the second in columns 41 through 54. These columns are cleared before the floating-point numbers are placed in the card image. If three floating-point numbers are to be printed, the first is placed in columns 23 through 36, the second in columns 41 through 54, and the last in columns 59 through 72. These columns are cleared before the floating-point numbers are stored in the card image.

Octal integer variable field: \texttt{QUEUE \ MNMES, K} where location \texttt{K} contains a 5 in the prefix, the message number in the decrement, the number of integers to be printed (1, 2 or 3) in the tag, and the location of the block of integers to be printed in the address. Octal integers are printed as 12 octal digits.

Message on tape:

\begin{verbatim}
LAUNCH VX = VY = VZ =
\end{verbatim}

Message printed:

\begin{verbatim}
11.06.22 LAUNCH VX=600760204031 VY=575654307563 VZ=176566507306
\end{verbatim}

If only one integer is to be printed, columns 25 through 36 of the card image are cleared and the integer is placed there. If two integers are to be printed, the first is placed in columns 43 through 54 of the card image and the second in columns 61 through 72. These columns are cleared first. If three integers are to be printed, the first is placed in columns 25 through 36, the second in columns 43 through 54 and the third in columns 61 through 72 of the card image.

Time variable field: \texttt{QUEUE \ MNMES, K} where location \texttt{K} contains a 4 in the prefix, the message number in the decrement, and the time in fixed-point seconds in the tag and address, right justified. The time in fixed-point seconds cannot exceed 18 bit positions.

Message on tape:

\begin{verbatim}
THE TIME OF LIFTOFF IS HRS MINS SECS
\end{verbatim}

Message printed:

\begin{verbatim}
11.06.22 THE TIME OF LIFTOFF IS 11 HRS 06 MINS 21 SECS
\end{verbatim}

Fixed-point integer variable field: \texttt{QUEUE \ MNMES, K} where location \texttt{K} contains a 7 in the prefix, the message number in the decrement, and the fixed-point integer in the tag and address, right justified. The integer cannot exceed 18 bit positions.
**Message on tape:**

VELOCITY USED IN FINAL GO-NOGO IS (FT./SEC.)

**Message printed:**

11.06.22 VELOCITY USED IN FINAL GO-NOGO IS (FT./SEC.) 25612

**Block of differential correction data:**

```
QUEUE MNMESS, K
```

where location K contains a 3 in the prefix, the message number in the decrement and in the address, the location of the first word of the table containing the differential correction data to be printed. This table (shown below) contains 96 words of information. If the first word of the table contains zero, no data is printed.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE</td>
<td>000 000 000 0XX (where XX is the number of stations giving data)</td>
</tr>
<tr>
<td>+1</td>
<td>+3</td>
</tr>
<tr>
<td>+4</td>
<td>+6</td>
</tr>
<tr>
<td>+7</td>
<td></td>
</tr>
<tr>
<td>+8</td>
<td></td>
</tr>
<tr>
<td>+9</td>
<td></td>
</tr>
<tr>
<td>+10</td>
<td>+11</td>
</tr>
<tr>
<td>+12</td>
<td>+26</td>
</tr>
<tr>
<td>+27</td>
<td>+41</td>
</tr>
<tr>
<td>+42</td>
<td>+56</td>
</tr>
<tr>
<td>+57</td>
<td>+71</td>
</tr>
<tr>
<td>+72</td>
<td>+86</td>
</tr>
<tr>
<td>+87</td>
<td>+89</td>
</tr>
<tr>
<td>+90</td>
<td>+92</td>
</tr>
<tr>
<td>+93</td>
<td>+95</td>
</tr>
<tr>
<td>+96</td>
<td></td>
</tr>
</tbody>
</table>

8-6
Message on tape:

DIFFERENTIAL CORRECTION SUCCESSFUL (BERMUDA 709 VERLORT)

Message printed:

11.06.22  DIFFERENTIAL CORRECTION SUCCESSFUL (BERMUDA 709 VERLORT)

<p>| DELTA R  | +2.000 000 0, +01 | +1.000 000 0, +00 | +2.000 000 0, +00 |
| DELTA V  | +3.000 000 0, +00 | +4.000 000 0, +00 | +5.000 000 0, +00 |
| SIG, K-1, K0 | +6.000 000 0, +00 | +7.000 000 0, +00 | +8.000 000 0, +00 |
| SUM OF SQS | +9.000 000 0, +00 | +1.000 000 0, +01 |
| STA. NUMBER | 21        | 22        |
| EQS/STATION | 99        | 97        |
| 2ND EDIT   | 91        | 32        |
| 3RD EDIT   | 11        | 15        |
| RESIDUAL/M | +2.199 999 9, -01 | +3.300 000 0, +01 |
| A, E, I    | +6.143 217 8, -01 | +2.498 999 9, -07 | -1.111 000 0, -01 |
| R FL PT/OCT | 123 456 712 345 | 111 411 111 111 | 204 500 000 000 |
| V FL PT/OCT | 210 600 000 000 | 003 010 000 000 | 001 400 000 000 |
| 11.06.23   | TIME OF R IN HRS., MINS., SECS. (GMT) | 10 55 15 |</p>
<table>
<thead>
<tr>
<th>Message No.</th>
<th>Message</th>
<th>Used By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-17</td>
<td>(Station/Radar Type) Has Begun Transmission</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>18-24</td>
<td>Station Number (x) Has Begun Transmission</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>25</td>
<td>Time To Fire Re-entry Table Not Reach 60,000 Feet</td>
<td>MFRARF</td>
</tr>
<tr>
<td>26</td>
<td>Sense Switch 2 Down, ______ In Keys</td>
<td>MPDIFC</td>
</tr>
<tr>
<td>27</td>
<td>Station Number 27 Has Begun Transmission</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>28</td>
<td>Inserted R ________</td>
<td>MFMAN5</td>
</tr>
<tr>
<td>29</td>
<td>Inserted V ________</td>
<td>MFMAN5</td>
</tr>
<tr>
<td>30</td>
<td>Inserted Time _______ Hrs. ______ Mins. ______ Secs.</td>
<td>MFMAN5</td>
</tr>
<tr>
<td>31</td>
<td>GMTRC For End Of Present Orbit Is ______ Hrs. ______ Mins. ______ Secs.</td>
<td>MFRARF</td>
</tr>
<tr>
<td>32</td>
<td>Manual Insertion Lift-Off _______ Hrs. ______ Mins. ______ Secs.</td>
<td>MFMAN1</td>
</tr>
<tr>
<td>33</td>
<td>Manual Insertion Accepted, Number Of Retros Fired Is ______</td>
<td>MFMAN2</td>
</tr>
<tr>
<td>34</td>
<td>Manual Insertion Accepted, Clock Reading Read ______</td>
<td>MFMAN3</td>
</tr>
<tr>
<td>35</td>
<td>Manual Insertion Rejected, Enter The Message Again</td>
<td>MFMAN1</td>
</tr>
<tr>
<td>36</td>
<td>Abort Table Has Been Generated</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>37</td>
<td>Abort Table Reached 60,000 Feet</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>38</td>
<td>Re-entry Table Did Not Reach 60,000 Feet</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>39</td>
<td>Number Of Observations Presented To DC By Edit Is ______</td>
<td>MFLEDI</td>
</tr>
<tr>
<td>42</td>
<td>Normal Operation Begun</td>
<td>MTWWVI</td>
</tr>
<tr>
<td>43</td>
<td>File Protect Tape On B6 And Set Up New Reel</td>
<td>MYSTLT</td>
</tr>
<tr>
<td>44</td>
<td>File Protect Tape On B7 And Set Up New Reel</td>
<td>MYSTLT</td>
</tr>
<tr>
<td>Message No.</td>
<td>Message</td>
<td>Used By</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>45</td>
<td>Differential Correction Rejected</td>
<td>MFDIFC</td>
</tr>
<tr>
<td>46</td>
<td>Differential Correction Successful</td>
<td>MFDIFC</td>
</tr>
<tr>
<td>47</td>
<td>Following Number Of Minutes Has Passed</td>
<td>MYMINS</td>
</tr>
<tr>
<td>48-64</td>
<td>(Station/Radar Type) Has Ended Transmission</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>65-75</td>
<td>Station Number (x) Has Ended Transmission</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>76</td>
<td>Following Station Has Been Deleted From D.C.</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>77</td>
<td>Following Station Has Been Restored To D.C.</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>78</td>
<td>Message Block For Following Station Is Negative</td>
<td>MFTTIN</td>
</tr>
<tr>
<td>79</td>
<td>Abort Phase Above TOWS Has Been Entered</td>
<td>MFLABT</td>
</tr>
<tr>
<td>80</td>
<td>Orbit Phase Has Been Entered</td>
<td>MFLORB</td>
</tr>
<tr>
<td>81</td>
<td>Error In Integration Process</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>82</td>
<td>R And V For Requested Time Not Within Limits Of Orbit Table</td>
<td>MFRARF</td>
</tr>
<tr>
<td>83</td>
<td>Redundancy Occurred On Message Tape, Auxilliary Tape Being Used</td>
<td>MTMSCK</td>
</tr>
<tr>
<td>84</td>
<td>Station Characteristics Tape Read Successfully</td>
<td>MYSCRD</td>
</tr>
<tr>
<td>85</td>
<td>Numerical Integration Successfully Completed</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>86-109</td>
<td>(Station/Radar Type) Acquisition Data Sent</td>
<td>MYTTOX, MYTTOY, MTTTOX, MTTTOY</td>
</tr>
<tr>
<td>110</td>
<td>A Record Has Been Written On The Restart Tape</td>
<td>MTWRRS, MYWRRS, MTWRSI</td>
</tr>
<tr>
<td>Message No.</td>
<td>Message</td>
<td>Used By</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>111</td>
<td>Floating Point/Octal Rx = ___ Ry = ___ Rz = ___</td>
<td>MFCPNI MYREST MFLORB MFLABT</td>
</tr>
<tr>
<td>112</td>
<td>Anchor Time For Above R, V Values = ___ Hrs. ___ Mins. ___ Secs.</td>
<td>MYREST MFLORB MFLABT MFCPNI</td>
</tr>
<tr>
<td>113</td>
<td>R Vector Accepted, Enter Velocity</td>
<td>MFMAN5</td>
</tr>
<tr>
<td>114</td>
<td>Velocity Vector Accepted</td>
<td>MFMAN5</td>
</tr>
<tr>
<td>115</td>
<td>Floating Point/Octal Vx = ___ Vy = ___ Vz = ___</td>
<td>MYREST MFLORB MFLABT MFCPNI</td>
</tr>
<tr>
<td>118</td>
<td>Apogee, Nautical Miles ___ ___ Perigee, Nautical Miles</td>
<td>MFORMC</td>
</tr>
<tr>
<td>119</td>
<td>Latitude ___ ___ Longitude of Impact, (Longitude is Degrees West)</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>120-143</td>
<td>(Station/Radar Type) Acquisition Data Not Sent</td>
<td>MYTTOX MYTTOY MTTTOX MTTTOY</td>
</tr>
<tr>
<td>146</td>
<td>Launch Rx = ___ Ry = ___ Rz = ___</td>
<td>MFLHLD</td>
</tr>
<tr>
<td>147</td>
<td>Launch Vx = ___ Vy = ___ Vz = ___</td>
<td>MFLHLD</td>
</tr>
<tr>
<td>148</td>
<td>Time (Lift-Off) Floating Point/Octal Seconds ____</td>
<td>MFLHLD</td>
</tr>
<tr>
<td>152</td>
<td>Restart Program Loaded</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>153</td>
<td>Restart Program Requested</td>
<td>MYQSYS</td>
</tr>
<tr>
<td>154</td>
<td>New Re-entry Table Generated</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>Message No.</td>
<td>Message</td>
<td>Used By</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>156</td>
<td>Time-to-fire Calculations Complete, Next Recovery Area Is _______</td>
<td>MFRARF</td>
</tr>
<tr>
<td>158</td>
<td>Line Two, Low Buffer Check Sum Error</td>
<td>IOHS09</td>
</tr>
<tr>
<td>159</td>
<td>Line Two, High Buffer Check Sum Error</td>
<td>IOHS09</td>
</tr>
<tr>
<td>160</td>
<td>Line Two, High Buffer Telemetry Rejected</td>
<td>IOHS09</td>
</tr>
<tr>
<td>161</td>
<td>Line Two, Low Buffer Telemetry Rejected</td>
<td>IOHS09</td>
</tr>
<tr>
<td>162</td>
<td>HS Output Transmission Rate To Cape Expected 240, Actual _______</td>
<td>MTWWWV</td>
</tr>
<tr>
<td>163</td>
<td>HS Output Transmission Rate To Cape Expected 40, Actual _______</td>
<td>MTWWWV</td>
</tr>
<tr>
<td>164</td>
<td>HS Output Transmission Rate To Cape Expected 20, Actual _______</td>
<td>MTWWWV</td>
</tr>
<tr>
<td>165</td>
<td>HS Output Transmission Rate To Cape Expected 120, Actual _______</td>
<td>MTWWWV</td>
</tr>
<tr>
<td>166</td>
<td>Line One, Low Buffer Check Sum Error</td>
<td>IOHSGB</td>
</tr>
<tr>
<td>167</td>
<td>Line One, High Buffer Check Sum Error</td>
<td>IOHSGB</td>
</tr>
<tr>
<td>168</td>
<td>Line One, High Buffer Telemetry Rejected</td>
<td>IOHSGB</td>
</tr>
<tr>
<td>169</td>
<td>Line One, Low Buffer Telemetry Rejected</td>
<td>IOHSGB</td>
</tr>
<tr>
<td>170</td>
<td>RSYSERR1 No Control Or EOF Record After EOF (ETRT2)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>171</td>
<td>RSYSERR2, EOF Is First Record Read After Rewind, Spacing Files, (ETRT3)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>172</td>
<td>RSYSERR3, Data Record Is First Record Read After Rewind, Spacing (ETRT3)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>173</td>
<td>RSYSERR4, MSRECC Error Return—Decode File Control Record (ETCWD)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>Message No.</td>
<td>Message</td>
<td>Used By</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>174</td>
<td>RSYSERR6, MSRECC Error Return—Decode Control Record After Rewind, Spacing</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>175</td>
<td>RSYSERR7, File Number Requested Not File Read (ETTS1)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>176</td>
<td>RSYSERR8, MSRECC Error Return—Decode Data Record (ETECC)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>177</td>
<td>RSYSERR9, Data Record Read Too Small (ETECC)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>178</td>
<td>Low Abort Phase Has Been Entered</td>
<td>MFLRT1</td>
</tr>
<tr>
<td>179</td>
<td>Medium Abort Phase Has Been Entered</td>
<td>MFLRT2</td>
</tr>
<tr>
<td>180-198</td>
<td>Differential Correction Rejected</td>
<td>MFDIFC</td>
</tr>
<tr>
<td>199-217</td>
<td>Differential Correction Successful</td>
<td>MFDIFC</td>
</tr>
<tr>
<td>218</td>
<td>Orbit-Re-entry Phase Change Accomplished</td>
<td>MYREST</td>
</tr>
<tr>
<td>219</td>
<td>Time Of Lift-off Is (GMT) ____Hrs. ____Mins. ____Secs.</td>
<td>MFMAN1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MFH508</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MFH5GB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MFML6A</td>
</tr>
<tr>
<td>220</td>
<td>N = 0, Edit Program Rejected, Differential Correction Bypassed</td>
<td>MFLED1</td>
</tr>
<tr>
<td>221</td>
<td>The WWV Time Entered Is (GMT) ____Hrs. ____Mins. ____Secs.</td>
<td>MTWWVI</td>
</tr>
<tr>
<td>222</td>
<td>Escape Rockets Fired</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>223</td>
<td>Tower Separation Signal Has Been Received</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>224</td>
<td>Abort Initiate Signal Has Been Received</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>225</td>
<td>SECO Signal Received</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>226</td>
<td>Capsule Separation Signal Received</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>Message No.</td>
<td>Message</td>
<td>Used By</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>227</td>
<td>Capsule Separation Assumed</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>228</td>
<td>(Number) Good Vectors Written On The Restart Tape</td>
<td>MYRRRS</td>
</tr>
<tr>
<td>229-232</td>
<td>(Number) Posigrade Rockets Fired</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>233-243</td>
<td>Points Used To Calculate Final GO–NOGO</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>244</td>
<td>GO Is Recommended</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>245</td>
<td>NOGO Is Recommended</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>246</td>
<td>Insufficient Data To Recommend GO–NOGO</td>
<td>MLUPDT</td>
</tr>
<tr>
<td>247</td>
<td>Time Of Retro–fire Is (GMT) ____Hrs. ____Mins. ____Secs.</td>
<td>MFLHLD</td>
</tr>
<tr>
<td>248</td>
<td>Velocity Used In Final GO–NOGO Is (Feet Per Second)</td>
<td>MFLHLD</td>
</tr>
<tr>
<td>249</td>
<td>Gamma Used In Final GO–NOGO (Degrees) Is ____</td>
<td>MFLHLD</td>
</tr>
<tr>
<td>250</td>
<td>Neither Restart Tape Can Be Error Corrected</td>
<td>MYRRRS</td>
</tr>
<tr>
<td>251</td>
<td>An Erroneous Trap Occurred On The DCC, Subchannel Number ______</td>
<td>MYSRST</td>
</tr>
<tr>
<td>252</td>
<td>Orbit Table Reached 60,000 Feet At ____Hrs. ____Mins. ____Secs.</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>253</td>
<td>Splash* GMT Exceeds Last Time Entry In Re–entry Table</td>
<td>MFABRT</td>
</tr>
<tr>
<td>254</td>
<td>Re–entry Table Generated Based On ____Hrs. ____Mins. ____Secs.</td>
<td>MFCPNI</td>
</tr>
<tr>
<td>255</td>
<td>Time Restarted From Is ____Hrs. ____Mins. ____Secs.</td>
<td>MTWWVI</td>
</tr>
<tr>
<td>256</td>
<td>Neither Restart Tape Can Be Read, Insert Restart Values</td>
<td>MYSRST</td>
</tr>
<tr>
<td>Message No.</td>
<td>Message</td>
<td>Used By</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>257</td>
<td>Manual Insertion Accepted Orbit Switch</td>
<td>MFMAOS</td>
</tr>
<tr>
<td>258</td>
<td>Manual Insertion Accepted Abort Switch</td>
<td>MFMAOS</td>
</tr>
<tr>
<td>259</td>
<td>Manual Insertion Retro-fire Time Is ____ Hrs. ____ Mins. ___. Secs.</td>
<td>MFMAN2</td>
</tr>
<tr>
<td>260</td>
<td>RSYSERA, Data Record Read Too Large (ETECC)</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>261</td>
<td>Edit, Differential Correction Programs Loaded</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>262</td>
<td>Edit, Differential Correction Programs Requested</td>
<td>MYQSYS</td>
</tr>
<tr>
<td>263</td>
<td>RSYSMSG, File Number 3 Successfully Loaded</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>264</td>
<td>RSYSMSG, File Number 3 Requested</td>
<td>MYRSYS</td>
</tr>
<tr>
<td>267</td>
<td>RSYSERR, Tape Check Trap. Machine Error If System Not Enabled</td>
<td>MTRSYS</td>
</tr>
<tr>
<td>268</td>
<td>Signal To Enter Orbit Phase Has Been Received</td>
<td></td>
</tr>
<tr>
<td>269</td>
<td>RSYSERR, Location 10, Bits 13-17, Illegal Configuration Probable Machine Error</td>
<td>MTRSYS</td>
</tr>
<tr>
<td>270</td>
<td>Station Characteristics Auxiliary Tape Cannot Be Read</td>
<td>MYSCRD</td>
</tr>
<tr>
<td>271</td>
<td>Signal To Enter Abort Phase Has Been Received</td>
<td></td>
</tr>
</tbody>
</table>
8.2 MONITOR ON-LINE MESSAGE PROCESSOR (MYMESS)

MYMESS is the initial program in the cycle which prints on-line a prepared message from tape. A one-word input identifies the requested message by number and type. If the message number refers to a non-existent message, MYMESS initiates directly the printing of an error indication; otherwise, MYMESS locates the message on the message tape and initiates transmission of the message into core storage.

If MTMSCK finds that the message cannot be read without redundancy errors, MYMESS initiates transmission to read the same message from the auxiliary message tape.

MYMESS also sets bits in the Monitor priority table and establishes other controls for channel A operation.

The flow chart for the MYMESS processor is shown in Figure 8-2.

8.2.1 Input Requirements

Input to MYMESS consists of:

a) MUTAPA—parameter designating the unit tape address of the message tape, A6.

b) MUTAPB—parameter designating the unit tape address of the auxiliary message tape, A5.

c) MNAENO—parameter designating the number of messages on the message tape. Since each message consists of one record, MNAENO also defines the number of records on the message tape. Each message contains 25 words: A one-word message (record) number followed by the message itself in the remaining 24 words.

d) MCMTPR—contains the instruction TTR MTENPR.

e) MCTPOS—indicates the position of the message tape. Since the tape is initially set to the first message, MCTPOS initially contains the number 1. For each message read from the message tape, MYMSCK updates MCTPOS to correspond to the current tape position. MYMESS calculates from MCTPOS the required direction the message tape must be spaced to be positioned at the requested message.

f) MCCHTP—indicates whether or not the auxiliary message tape should be used. This indicator is set by MTMSCK.

g) MCRTBI—contains the instruction RTBA 6. This instruction selects the message tape for the reading mode of operation. If the auxiliary
tape is to be used, the contents of MCRTB1 are exchanged with the contents of MCRTB2.

h) MCRTB2—contains the instruction RTBA 5.

i) MCREW1—contains the instruction REWA 6. This instruction rewinds the message tape. If the auxiliary tape is to be used, the contents of MCREW1 are exchanged with the contents of MCREW2.

j) MCREW2—contains the instruction REWA 5.

k) MCBSR1—contains the instruction BSRA 6. This instruction backspaces one record on the message tape and is used by MTMSCK in an attempt to read a record without redundancy. If the auxiliary message tape is to be used, MYMESS exchanges the contents of MCBSR1 with MCBSR2.

l) MCBSR2—contains the instruction BSRA 5.

m) TMCMDA—Monitor table of input/output commands used by MYMESS and MTMSCK to control the on-line message printing.

n) TMMES2—24-word table containing, in card image format, the message BINARY NUMBER PRINTED BELOW WAS REQUESTED BUT DOES NOT EXIST.

o) Queue table for MYMESS—MYMESS is entered only when there is at least one entry in its queue table.

8.2.2 Output Requirements

Output from MYMESS depends upon the number of the requested message. If the message number is non-existent, i.e., equal to zero or greater than the number of messages on the message tape, MYMESS initiates printing of the illegal number with the error message contained in TMMES2 (BINARY NUMBER PRINTED BELOW WAS REQUESTED BUT DOES NOT EXIST). MYMESS also provides the following output requirements:

a) TMPRLG—a five-cell table used by MSLOGG as input for the logging of on-line message printouts. MYMESS stores a 2 in the address of TMPRLG + 4 to indicate that the error message was printed; the illegal message number is stored in TMPRLG + 2.

b) Location 00013—contains the instruction TTR MTENPR if an error message is to be printed and contains the instruction TTR MTMSCK in the case of a legal message request.

c) MCMSNO—contains in the address the number of the requested message.
d) MCMVIP—contains the one-word requested message as obtained from the input queue for MYMESS.

e) TMMESS—a 25-word table into which the message from tape is to be read.

8.2.3 Method

MYMESS receives control from M0PRIO when one or more message requests are stored in the input queue to MYMESS. The program first turns on its own A indicator and suppresses all other programs initiating transmission on A.

If the indicator (MCCHTP) that the auxiliary tape is to be used is on (it is turned on by MTMSCK if the last message requested could not be read from the message tape), MYMESS switches to the auxiliary message tape and initiates transmission to read in the message that could not be read from the other tape. If the indicator (MCCHTP) is not on, the computer is disabled and the input data word is taken from the input queue for MYMESS. If the queue contains only one word the B indicator is turned off. The computer is enabled.

The input data word is contained in MCMSNO and is also stored into MCMVIP for later reference, if the message requires variable field data.

The prefix of the input data word specifies the type of message requested. If the prefix is zero, the message does not require a variable field addition and the message number is in the address of the input data word. If the prefix is non-zero (octal 7, 6, 5, 4, and 3 are the five legal alternatives), a variable field is required, and the message number is contained in the decrement of the input data word, with the address containing information as to the input data for the variable field. For the non-zero prefix, MCMSNO is cleared and the message number stored in the address.

The requested message number is examined for legality:

a) If the message number is valid, MYMESS stores in the channel A trap control location (00013) the instruction TTR MTMSCK, MYMESS then determines the position of the message on the tape relative to the tape position. If the requested message is past the read head, the message tape is rewound. The computer is disabled and tape commands are generated to space up to and then read the requested message into core storage, storing the 25-word message record in the TMMESS table.

b) If the requested message number is invalid, i.e., equal to zero or greater than the largest message number on the message tape, the illegal number is converted into a card image format by the BINNO
The five-word input table, TMPRLG, for logging is used with a 2 stored in the address of TMPRLG + 4 and the illegal number in TMPRLG + 2. MYMESS stores in the channel A trap control location (00013) a trap transfer to MTENPR instruction. The computer is disabled and the commands are given to print on-line the error message (BINARY NUMBER PRINTED BELOW WAS REQUESTED BUT DOES NOT EXIST) from TMMES2 and the binary number from TMMES3.

Finally, the prefix of MCMVIP is checked to see if the illegal message number was a message queued by differential correction in calling for a block of data. If this is the case, differential correction is unsuppressed (since it suppresses itself until the block of data is printed on-line).

MYMESS suppresses itself to prevent entry until the current message has been completely processed. The computer is enabled, the A indicator for MYMESS is turned off, and control returns to M0PRIO.

8.2.4 Usage

MYMESS is entered from, and exits to, M0PRIO.

a) Storage Required—129 locations

b) MYMESS uses:

1) Macros—BINNO, QENBA, QENBZ, TRNON, TRNOF and UNQUE

2) Parameters—MUTAPA, MUTAPB, MNAENO, MNCDRD, MNMESS, MNSCRD, MNDIFC, MNDIFK, A, C, D, and G

3) Communication cells—MCMSNO, MCMTPR, MCMVIP, MCTPOS, MCCHTP, MCRTB1, MCRTB2, MCREW1, MCREW2, MCBSR1 and MCBSR2

4) Tables—TMCMDA, TMMESS, TMMES2 and TMPRLG

5) Constants—K00000, K00001, K00002 and K00025

6) Absolute location—00013

c) Time Required:

1) Minimum—0.196 millisecond

2) Most Probable—0.330 millisecond

3) Maximum—0.545 millisecond
FIGURE 8-2. MYMESS PROGRAM FLOW CHART (Sheet 1 of 2)
FIGURE 8-2. MYMES$ PROGRAM FLOW CHART (Sheet 2 of 2)
8.3 BINARY NUMBER CARD IMAGE MACRO (BINNO)

BINNO converts the number in location MCMSNO into a Hollerith-coded card image so an on-line print in the decimal mode may reproduce the number in 36-bit binary format.

The flow chart for the BINNO macro is shown in Figure 8-3.

8.3.1 Input Requirements

The BINNO macro is defined:

```
BINNO MACRO
  AXT 24,1
  STZ TMMES3 + 24,1
  TIX *-1, 1, 1
  CAL MCMSNO
  STO TMMES3 + 16
  COM
  SLW TMMES3 + 18
END
```

The location, MCMSNO, contains the message number of the requested message.

8.3.2 Output Requirements

TMMES3 is a 24-cell table in which is placed the card image of the number from MCMSNO. Every location is cleared except TMMES3 + 16 and TMMES3 + 18, 1-row left and 0-row left, respectively, of the card image. TMMES3 + 16 contains the number in MCMSNO; TMMES3 + 18 contains the complement of this number.

8.3.3 Method

The 24 cells of the TMMES3 table are cleared. The contents of location MCMSNO are stored in the 17th word of the table; the complement of the contents of location MCMSNO is stored in the 19th word of this table. Consequently, for every 1 in location MCMSNO, the corresponding bit in TMMES3 + 16 becomes a 1. For every zero in location MCMSNO, the corresponding
bit in TMMES3 + 18 becomes a 1. An on-line printout (in the decimal mode) of the TMMES3 table produces the number in binary format.

8.3.4 Usage

Entry into BINNO has no restrictions, except that the location MCMSNO must contain the number to be converted (BINNO is used only by MYMESS and MYMSCK). BINNO exits to the seventh location following entry.

a) Storage Required—seven locations

b) BINNO uses:
   1) Communication cell—MCMSNO
   2) Table—TMMES3

c) Time Required—0.240 millisecond
CLEAR THE 24 CELLS OF TABLE TMME53

STORE MCMSNO INTO TMME53 + 16

STORE COMPLEMENT OF MCMSNO INTO TMME53 + 18

FIGURE 8-3. BINNO MACRO FLOW CHART
8.4 MONITOR MESSAGE CHECK TRAP PROCESSOR (MTMSCK)

MTMSCK receives control from the channel A trap following the reading of a tape message into core by MYMESS. If redundancy errors occurred during the reading, MTMSCK attempts to reread the message from the tape without redundancy. If the redundancy persists, MTMSCK sets an indicator for MYMESS to read the message from the auxiliary tape.

If the message was read without redundancy errors, MTMSCK updates the tape position communication cell, saves the control word set by the trap and establishes controls for the message check processor, MYMSCK.

The flow chart for the MTMSCK trap processor is shown in Figure 8–4.

8.4.1 Input Requirements

Input to MTMSCK consists of:

a) MCMSNO—communication cell, set by MYMESS, which contains the number of the requested message in the address.

b) MNRDMS—parameter containing the number of attempts that MTMSCK will make to read a record without redundancy before switching to the auxiliary message tape.

c) MCBSR1—contains the instruction BSRA 6, which backspaces one record on the primary message tape.

d) MCRTB1—contains the instruction RTBA 6, which read-selects the primary message tape. When the auxiliary message tape is being used, MCBSR1 contains BSRA 5 and MCRTB1 contains RTBA 5.

e) Location 00012—the location of the cell set by the computer at the channel A trap. The address of this location contains the location counter value when the trap occurred. The three low order bits in the decrement are coded to indicate the reason for the trap.

8.4.2 Output Requirements

Output from MTMSCK consists of:

a) MCEFTS—contains the contents of location 00012.

b) MCTPOS—contains the current position of the message tape, i.e., the number of the message now positioned at the tape read head.

c) MCCHTP—location used as an indicator for MYMESS to switch to the auxiliary message tape.
d) MCTCFR—location used to indicate that the message tape has already been changed for the particular message being processed. It is set by MYMESS and reset by MTMSCK.

e) MYMSCK turns off the D indicator for MYMESS if the message tapes are to be changed in an attempt to read the message without redundancy. MYMSCK turns on the B indicator for MYMSCK if the message was read without redundancy.

8.4.3 Method

MTMSCK receives control on a TTR MTMSCK in location 00013 following a trap on channel A. The SAVE macro is executed to preserve the condition of the interrupted program for a later return. If no redundancy occurred during the reading of the message tape, the cell which indicates the position of the message tape is updated and the B indicator for MYMSCK is turned on. The contents of location 00012 are stored in the MCEFTS communication cell for interpretation by MYMSCK, the next step in the one-line message program cycle, and control is returned to MOPRIO.

If redundancy occurred during the reading of the message tape, MTMSCK backspaces the message tape one record and initiates transmission with an IOCT command to read the same message again. When the message has been read into core, control returns to MTMSCK by way of a channel A trap.

If redundancy occurs on the reread, MTMSCK continues to reread the message until either no redundancy occurs (in which case MTMSCK proceeds normally) or until the number of times the reread has taken place reaches the count specified by MNRDMA. In the latter case the program sets an indicator (MCCHTP) to inform MYMESS that the auxiliary tape must be used. Then MTMSCK queues the on-line message: REDUNDANCY OCCURRED ON MESSAGE TAPE, AUXILIARY TAPE BEING USED. MTMSCK unsuppresses MYMESS and transfers control to MOPRIO, MYMESS then switches to the auxiliary message tape and initiates transmission to read in the same message.

If the message cannot be read from the auxiliary tape (after MNRDMS attempts), the program continues on in the normal flow, turning on the B indicator for MYMSCK, as described above.

8.4.4 Usage

MTMSCK is entered by a trap transfer instruction (TTR MTMSCK) in the channel A trap location (00013); MTMSCK exits to MOPRIO.

a) Storage Required—39 locations

b) MYMSCK uses:

1) Macros—QUEUE, SAVE, TRNON and TRNOF
2) Parameters—B, D, MNMESS, MNMSCK and MNRDMS

3) Communication Cells—MCEFTS, MCMSNO, MCTPOS, MCBSR1, MCRTB1, MCCHTP and MCTCFR

4) Constants—K00001 and K00083

5) Location—00012

c) Time Required:

1) Maximum—0.316 millisecond

2) Most probable—0.215 millisecond

3) Minimum—0.206 millisecond
Figure 8-4. MTMSCK Program Flow Chart

- CHANNEL A TRAP
- TTR MTMSCK SET IN LOCATION 00013 BY MYMESS
- MTMSCK
  - FFUN1: INCREMENT "MESSAGE READING COUNTER" BY 1, (FFCTT+1) → FFCTT
  - MESSAGE READ MAXIMUM NO. OF TIMES ALREADY? FFCTT = MNRDMS
- FFUN3: REDUNDANCY CHECK OCCURRED ON CHANNEL A IN READING MESSAGE?
  - TRNON B MNMSCK
    - UPDATE TAPE POSITION CELL. (MCMSNO) + 1 → MCTPOS
    - STORE LOCATION SET BY TRAP (00012) INTO MCEFTS
    - RESET "TAPE CHANGED" INDICATOR FOR MTMSCK. 0 → MCTCFR
    - RESET "MESSAGE READING COUNTER" TO ZERO. 0 → FFCTT
- FFUN4: BACKSPACE 1 RECORD TO POSITION MESSAGE TAPE AT START OF MESSAGE
  - READ MESSAGE INTO CORE STORAGE AGAIN
    - TRNOF D MNMNESS
    - FFUN4: "REUNDANCY OCCURRED ON MESSAGE TAPE, AUXILIARY TAPE BEING USED"
8.5 MONITOR MESSAGE CHECK PROCESSOR (MYMSCK)

If MYMSCK has received control following the reading of a message from tape, this program compares the number of the message read from tape with the number of the message requested and prints an error indication if these do not agree. If the requested message has been properly read into core storage, MYMSCK supplies the current time and any necessary variable fields for each message. If the message requires a block of data, controls are set for this. For every message read from tape, MYMSCK provides the logging input.

If MYMSCK has received control to continue printing the block of differential correction data, the next line of information is prepared for printing.

The general and the detailed flow charts for the MYMSCK processor are shown in Figures 8-5 and 8-6.

8.5.1 Input Requirements

Input to MYMSCK consists of:

a) MUTAPA—parameter designating the unit tape address of the message tape, A6.

b) TMCMDA—Monitor table of input/output commands used by MYMESS and MYMSCK to control on-line message printing.

c) TMMESS—25-cell table containing the message read into core storage by MYMESS. The first cell contains the number of the message; the remaining 24 cells contain the card image of the message.

d) TMMES1—24-cell table containing in card image format the error message: MESSAGE NUMBER REQUESTED DISAGREES WITH ONE FOUND—BOTH PRINTED BELOW.

e) TMMES5—two-cell table of conversion factors used in computing hours, minutes and seconds from a value given in seconds.

f) TMMES6—three-cell table of bit masks used in adding the card image of a time to the card image of the message.

g) TMMES7—three-cell table of bit masks used in adding a card image of the current time to the card image of the message.

h) MCHFSC—contains the current GMT in fixed-point half seconds.

i) MCEFTS—contains the contents of location 00012 when the trap occurred. The cell is saved by MTMSCK and contains the reason code for the channel A trap in bits 15, 16 and 17 of the decrement. A 1 in
bit position 17 is the result of a trap following the completion of an
IOCT, IORT, or IOST command with no load channel instruction wait-
ing. This is the expected condition. A 1 in bit position 16 is the result
of a redundancy check during the I/O operation. This is an error con-
dition. Channel A is never enabled for this type of trap. A 1 in bit
position 15 is the result of an end-of-file indicator being turned on in
reading the tape. This is an error condition.

j) MCMSNO—communication cell containing in the address the number
of the requested message.

k) MCMTPR—communication cell containing the instruction TTR
MTENPR.

l) MCNRRF—cell indicating the number of retrorockets fired. This cell,
when non-zero, indicates the re-entry phase for which MYMSCK does
not print A, E, I in differential correction message data block.

m) MCMVIP—communication cell containing the original requested mes-
sage input to MYMESS. If the requested message does not require a
variable field, MCMVIP and MCMSNO are identical. If a variable field
is necessary to complete the message, the decrement of MCMVIP
contains the message number (corresponding to the address of
MCMSNO) and the address contains information as to the data to be
used in the variable field.

8.5.2 Output Requirements

Output from MYMSCK is a function of the success in reading the requested
message from tape into core storage:

a) If the message has been read successfully, the present time is con-
verted and added to the card image of the message in core. If a vari-
able field must be supplied to the message, MYMSCK constructs a
card image of the field and adds this to the card image for on-line
printing. If the variable field consists of a block of data following the
message, controls are set for this type of printout. The logging input
table is generated as follows: the decrement of TMPRLG + 3 contains
the message number. The prefix, tag and address of TMPRLG + 3 are
identical to the prefix, tag and address of the word brought from the
message queue by MYMESS. TMPRLG through TMPRLG + 2 contain
the data in the variable field, if there is a variable field. None of the
variables in the block of data from a differential correction is logged.
(See Subsection 8.8 on MSLOGG for a complete description of the log-
ging format of on-line messages.)

b) If an end-of-file was read on the message tape, the tape is rewound, a
1 is stored in MCTPOS to update the position, and the logging input is
set as follows: a 1 is stored in the address of TMPRLG + 4. The
following message is printed on-line: BINARY NUMBER REQUESTED DISAGREES WITH ONE FOUND—BOTH PRINTED BELOW. (There is, however, no additional printout for this error. This distinguishes an end-of-file error from the error from the error condition described in the following paragraph.)

c) If the number of the message read into core storage does not agree with the number of the requested message (TMMESS ≠ MCMSNO), the message tape is rewound, a 1 is stored in MCTPOS to update the tape position cell, and the logging input is set as follows: a 1 is stored in the address of TMPRLG + 4 and the requested message number (MCMSNO) is stored in TMPRLG +1. The requested message number is also stored in the TMMESS table in card image format and the following messages are printed on-line: MESSAGE NUMBER REQUESTED DISAGREES WITH ONE FOUND—BOTH PRINTED BELOW. The requested message number in 36-bit binary format follows.

d) If MYMSCK received control for another line of data following a differential correction, this line of data is converted and printed. No logging takes place since the message read from tape, which preceded the block of data, was logged with the indication that a data block would follow.

e) MCDCPR—location set by MYMSCK indicating to its trap processor, MTENPR, that a block of data is being printed for a differential correction. If this indicator is non-zero, MTENPR turns on the B indicator for MYMSCK so that control will again pass to MYMSCK without having to first pass through MYMESS, the first processor in the on-line message cycle.

f) MCDC01—location set by MYMSCK, to control the logging of the on-line messages. MTENPR logs the on-line message only when MCDC01 is zero. Since the variables in the block of data after a differential correction are not logged, MCDC01 is non-zero when these lines are being printed.

Each time that MYMSCK is entered, the instruction TTR MTENPR is stored in the channel A trap control location, 00013.

8.6.3 Method

MYMSCK receives control from M0PRIO and turns its own A indicator on and B indicator off. MYMSCK turns on the C indicator for MYMESS to suppress that processor until MYMSCK has updated the tape position cell, MCTPOS. The instruction TTR MTENPR is stored in the channel A trap control location, 00013 (an on-line print always follows the entry into MYMSCK).

MCDCPR is checked to see if a block of data is being printed for a differential correction. If MCDCPR is non-zero, at least one line of print remains.
MYMSCK determines which line is to be printed next, converts the data into card image format and adds a heading to the message from BCI information in core storage. The heading is converted, rather than read from tape, to conserve time, since the differential correction program is printing the differential correction output block. If MYMSCK determines the line it is processing for the block of data is the last line in the block, the C indicator for MYMESS is turned off and MCDCPR is reset to zero so that MTENPR can unsuppress MYMESS and the on-line message system may then process the next entry in the message queue. MYMSCK then turns off its own A indicator and exits to M0PRIO.

If the data being processed is not for the last line in the block of data for differential correction, MYMSCK turns off its A indicator and exits to M0PRIO. In this case MYMSCK again receives control from M0PRIO after MTENPR is executed.

If MCDCPR indicates that MYMSCK is not in the process of printing a block of differential correction data, the Message Check Processor examines MCEFTS to determine the cause of the trap that occurred from reading the message tape. If the trap was the result of an end-of-file, an error condition has occurred and the conditions described in Subsection 8.5.2, b) are established. Otherwise, MYMSCK assumes a complete message has been read into the TMMESS block and examines the number to see if the message was the one requested. If the message numbers are not identical, an error has occurred and the conditions described in Subsection 8.5.2, c) are established. After either of the above error conditions, the prefix of MCMVIP is checked to see if the message was queued by the Differential Correction Program. If so, differential correction is unsuppressed by turning off the G indicators for its two prefixes, MPDIFC and MPDIFK. (The Differential Correction Program suppresses itself when it queues a message requiring the printing of a block of data, and expects the message routing to unsuppress it when the block of data has been printed.) After the above test is made, MYMSCK turns off the C indicator for MYMESS, turns off its own A indicator and exits to M0PRIO.

If the proper message has been read into core storage, MYMSCK establishes the logging input table and examines the original (to MYMESS) input word, MCMVIP, to determine whether the message requires additional variable field information. Every correct message requires the addition of the current GMT.

If the message requires an integer, the integer is contained in the tag and address of MCMVIP. This number is converted to BCD with the AFOBS subroutine (Figure 8-6, Sheet 12) and then added to the message with the AFCAP subroutine (Figure 8-6, Sheet 11).

If the message requires the addition of one to three floating-point numbers, these numbers are obtained from a block, the location of which is contained in the address of MCMVIP. The numbers are added to the message with the AFFLT subroutine (Figure 8-6, Sheet 14).
If the message requires the addition of one to three octal integers, these numbers are obtained from a block, the location of which is contained in the address of MCMVIP. The numbers are added to the message with the AFTCO subroutine (Figure 8-6, Sheet 13).

If the message requires a time (other than current GMT), MYMSCK obtains the time in fixed-point seconds from the tag and address of MCMVIP. The time is converted into hours, minutes and seconds. These values are converted into card image format and added to the message for printing.

If the message requires that a block of data follow it (for the format of the block, see Subsection 8.1.2) controls are set for MYMSCK to obtain control once for every line that is to be printed. The message cycle cannot begin processing a new message until all of the data in the block has been printed. When all of the block has been printed, the Differential Correction Program is unsuppressed by turning off the G indicators for MPDIFC and MPDIFK.

After the variable field has been added to the message, or, in the case of a block of differential correction data, after controls have been set to print the block, MYMSCK adds the present time (obtained from MCHFSC) to the message and initiates transmission to print the message. MYMSCK turns off the C indicator for MYMESS (MYMESS is still suppressed by its D indicator and this is turned off only by MTENPR), MYMSCK turns off its own A indicator and exits to M0PRIO.

8.6.4 Usage

MYMSCK is entered from, and exits to, M0PRIO.

   a) Storage Required—644 locations

   b) MYMSCK uses:

   1) Macros—BINNO, TRNOF and TRNON

   2) Parameters—A, B, C, G, MNMSCK, MNMESS, MUTAPA, MNDIFC and MNDIFK

   3) Communication cells—MCEFTS, MCHFSC, MCMSNO, MCMTPR, MCMVIP, MCDCPR, MCDC01 and MCNRRF

   4) Tables—TMCMDA, TMMESS, TMMES1, TMMES3, TMMES5, TMMES6, TMMES7 and TMRPG

   5) Constants—K00000, K00001, K00003, K00009, K00010, K00030, K00033, K00036, K00039, K002.0, K010.0, KCH200, KCH233, K0MANT, KMNMSK, KMSKFT, KMSRES, KPEROD and KTGMSK
6) Location—00013

c) Time Required (all times are maximum):

1) EOF read on Message tape—.123 millisecond
2) Error in reading message—.391 millisecond
3) No variable field—.682 millisecond
4) Integer variable field—2.388 milliseconds
5) Floating point variable field, one number—3.823 milliseconds
6) Floating point variable field, two numbers—5.895 milliseconds
7) Floating point variable field, three numbers—8.007 milliseconds
8) Octal integer variable field, one number—1.372 milliseconds
9) Octal integer variable field, two numbers—1.936 milliseconds
10) Octal integer variable field, three numbers—2.499 milliseconds
11) Time variable field—1.214 milliseconds
12) Block of data after a differential correction, one station, (MYMSCK is entered 14 times)—48.216 milliseconds
13) Block of data after a differential correction, two stations, (MYMSCK is entered 14 times)—50.419 milliseconds
14) Block of data after a differential correction, 15 stations, (MYMSCK is entered 22 times)—88.938 milliseconds
FIGURE 8-5. GENERAL FLOW DIAGRAM, MYMSCK PROCESSOR
FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 1 of 14)
FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 2 of 14)
FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 3 of 14)
**Figure 8-6. MYSCK Program Flow Chart (Sheet 4 of 14)**
FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 5 of 14)
FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 6 of 14)
SUBROUTINE ONVERTS BCI TO CARD IMAGE (TMNESS +1 -> +24)

CALLING SEQUENCE

TSX AFCAP,4
PZE INPUT,, N
WHERE 0 < N < 12 AND
N IS THE NUMBER OF BCI WORDS TO BE CONVERTED
RETURN IS TO 2,4

FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 7 of 14)
AFOBS SUBROUTINE CONVERTS BINARY TO BCI, OUTPUT STARTING AT LOCATION AFFOT + 3

CALLING SEQUENCE

TSX AFOBS,4 WITH NUMBER OF NUMBERS TO BE CONVERTED IN XR2 (1 TO 9) AND THE ADDRESS OF THE INPUT BLOCK IN THE AC ADDRESS. RETURN IS TO 1, 4

FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 8 of 14)
SUBROUTINE TSX AFTCO 4
LOCATION IN AC AND NUMBER OF NUMBERS TO BE CONVERTED IN XR2 (1-3). RETURN 1,4.

SUBROUTINE TSX AFOCT, 4
LOCATION OF THE 3 OCTAL INTEGERS IN THE AC. RETURN IS TO 1,4.

FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 9 of 14)
SUBROUTINE AFFLT

CALLING SEQUENCE

TSX AFFLT, 4
WITH INPUT LOCATION
IN AC AND NUMBER
OF NUMBERS TO BE
CONVERTED IN XR2 (1-3)
RETURN IS TO 1, 4.

ENTER

AFFLT

SAVE XR4
AND XR2

INITIALIZE:
CLEAR BCI
OUTPUT BLOCK

GET FLOATING
POINT NUMBER

CHARACTERISTIC
GREATER THAN
(>) 200?

MULTIPLY THE
FLOATING POINT
NUMBER BY 10

ADD ONE TO
EXPONENT
COUNT

PLACE COMMA
AND MINUS SIGN
FOR EXPONENT IN
OUTPUT BLOCK

CONVERT EXPONENT
TO BCI AND STORE
IN OUTPUT

IS THE SIGN
OF THE FLOATING
POINT NUMBER
MINUS?

PLUS SIGN FOR
NUMBER IN
BCI OUTPUT

BCI MINUS SIGN
FOR NUMBER IN
OUTPUT

ARE ALL
FLOATING POINT
NUMBERS
CONVERTED

UPDATE INPUT
AND OUTPUT
ADDRESSES FOR
THE NEXT
NUMBER

FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 10 of 14)
FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 11 of 14)
MC 103

**Calling Sequence**

| TSX AFTDC,4 | WITH INPUT ADDRESS IN TMMES3 + 18 AND NUMBER OF NUMBERS TO BE CONVERTED IN XR2 (1-9). RETURN IS 1,4 |

**Figure 8-6. MYMSCK Program Flow Chart (Sheet 12 of 14)**

- **AFTDC**
  - SUBROUTINE CONVERTS FLOATING POINT AND ADDS A HEADING TO CARD IMAGE (TMMES3 + 1 ++ 24) FOR DIFF. COR.  

- **Calling Sequence**
  - TSX AFTDC,4
  - WITH INPUT ADDRESS IN TMMES3 + 18 AND NUMBER OF NUMBERS TO BE CONVERTED IN XR2 (1-9). RETURN IS 1,4

- **ENTER**

- **AFTDC**
  - UPDATE INPUT ADDRESS

- **AFFLT**
  - FLOATING POINT TO CARD IMAGE

- **AFBS3**
  - HEADING TO CARD IMAGE

- **RETURN**
AFBS3 subroutine reduces count of lines left to be printed by one and puts heading in the card image (TMMESS + 1 + 24) for the dif. cor. block.

CALLING SEQUENCE
TSX AFBS3,4 with line count in TMMESS + 17. Return is to 1, 4.

AFBSA subroutine puts heading in card image (TMMESS + 1 + 24) for the dif. cor. block.

CALLING SEQUENCE
TSX AFBSA,4 return 1, 4

ENTER
AFBS3
REDUCE BY 1 THE NUMBER OF LINES TO BE PRINTED

AFBSA
UPDATE HEADING ADDRESS FOR AFCAP

AFCAP (BCI TO CARD IMAGE)

RETURN

FIGURE 8-6. MYMSCK PROGRAM FLOW CHART (Sheet 13 of 14)
### Calling Sequence

**TSX AFSTA, 4**

With the number of binary numbers to be converted in XR2(1-9) and the address of the input block in the AC address return is to 1, 4

---

**Figure 8-6. MYMSCK Program Flow Chart (Sheet 14 of 14)**
8.6 MONITOR END-OF-PRINTING TRAP PROCESSOR (MTENPR)

MTENPR, the last program in the on-line message cycle, receives control after the message has been printed. This program logs the on-line print and/or controls the printing of the differential correction data block. If the differential correction data block has not been completely printed, MTENPR sets control to continue printing the data. If any given message is complete, MTENPR restores the on-line message cycle to its initial state in preparation for the next message request.

The flow chart for the MTENPR trap processor is shown in Figure 8-7.

8.6.1 Input Requirements

Input to MTENPR consists of:

a) TM8.3M—contains the number of 8-1/3 millisecond intervals elapsed since the last exact half second.

b) TMPRLG—a five-cell table containing input data for logging the on-line print. This table is established during the printing cycle by MYMSCK or MYMESS.

c) MCHFSC—contains the current GMT in fixed-point half seconds.

d) MCBETA—indicates, when positive, that this 7090 is in the transmission mode for external transmission.

e) MCDCPR—indicates, when non-zero, MYMSCK is in the process of printing the differential correction data block.

f) MCDC01—indicates, when zero, that logging is required by MTENPR. Since the variables in the differential correction data block are not logged, MCDC01 is non-zero when these lines are being printed.

8.6.2 Output Requirements

If the message printed requires no additional printed data, MTENPR logs the message and unsuppresses MYMESS, MYCDRD, MYSCRD and MYRSYS.

If, however, any data in the differential correction data block remains to be printed, the B indicator for MYMSCK is turned on.

8.6.3 Method

MTENPR receives control on a channel A trap following the on-line printing of a message. This trap processor executes the SAVE macro to preserve the condition of the program interrupted by the trap. If the line printed was a message
from tape or an error message from core, MTENPR constructs the standard logging time tag, stores it in the MQ, completes the log calling sequence and logs the printed message. If the line printed was part of the differential correction data block, the print is not logged.

MTENPR then examines MCDCPR to determine whether or not more data from the differential correction block remains to be printed. If the complete block has not yet been printed, MTENPR turns on the B indicator for MYMSCK and exits to MOPRIO. Otherwise, the other channel A transmission processors are unsuppressed and control returns to MOPRIO.

8.6.4 Usage

MTENPR is entered by a trap transfer instruction in the channel A trap location, 00013; MTENPR exits to MOPRIO.

a) Storage Required—35 locations

b) MTENPR uses:

1) Subroutine—MSLOGG

2) Macros—SAVE, TRNOF and TRNON

3) Parameters—B, C, D, MNCDRD, MNMESS, MNMSCK, MNSCRD and MNRSYS

4) Communication cells—MCBETA, MCHFSC, MCDCPR and MCDC01

5) Table—TM8.3M

c) Time Required:

1) On-line print does not require logging—0.208 millisecond

2) On-line print requires logging—0.757 millisecond
FIGURE 8-7. MTENPR PROGRAM FLOW CHART
8.7 THE LOGGING PROCESS

8.7.1 The Logging Cycle

Three programs are required to complete the logging cycle: MSLOGG, MYSTLT and MTENLG. The general function and interrelation of these programs are illustrated in Figure 8-8. A brief description of the logging cycle is presented below:

MSLOGG, the Monitor Logging Subroutine, stores the data for logging into a 17-cell block (illustrated in Figure 8-9) in a 170-cell logging buffer. There are two logging buffers, each having a capacity of ten blocks. When a buffer is filled, MSLOGG turns on the B indicator for the Monitor Logging Processor, MYSTLT. MSLOGG keeps a serial count of the logging blocks and, when the serial count reaches a specified increment, MSLOGG changes instructions so that the alternate log tape will now be used by MYSTLT. MSLOGG is used by the following programs:

1) MPHSGB, to log high-speed input data from the Burroughs-GE computer.
2) MPHS09, to log high-speed input data from the IP-7090 computer at Cape Canaveral.
3) MYHSOD, to log high-speed output data to Cape Canaveral (which includes the output used to drive the local plotboards).
4) MTTTIN, to log low-speed input data.
5) MTENPR, to log on-line messages.
6) MYTTXO and MYTTYO, to log low-speed output acquisition data.
7) MTSENS, to log sense output to the Output Status Console.

MYSTLT, the Monitor Logging Processor, generates the I/O commands to write the logging buffer on the log tape (the logging buffer and log tape addresses are controlled by MSLOGG). If a log tape has been filled, MYSTLT queues an on-line message which states that a log tape has been filled and should be replaced. A log tape that has been filled will be rewound and unloaded by the program. MYSTLT initiates the data transmission to the log tape and suppresses itself until after the writing is completed.

MTENLG, the Monitor End-Of-Logging Trap Processor, checks for redundancy in the writing of the logging buffer and unsuppresses MYSTLT for the next writing on the log tape.

8.7.2 Format of the Logging Blocks

The logging block consists of 17 cells. The first five cells comprise the heading and contain information relative to the logged data. The first word of the heading identifies the DCC subchannel transmitting or receiving the data. The second
LOGGING INPUT DATA

MSLOGG:
STORES LOGGING BLOCK IN LOGGING BUFFER

MOPRIO:
GIVES CONTROL BY PRIORITY

MSLOGG:
STORES LOGGING BLOCK IN LOGGING BUFFER

LOGGING BUFFER
170 WORDS

LOGGING BLOCK
10 WORDS

I/O
CORE STORAGE TO TAPE

LOG TAPE

IOCT TRAP

MTENLG:
SETS CONTROLS FOR NEXT LOGGING OPERATION

FIGURE 8-8. LOGGING CYCLE
word of the heading contains the time the data was transmitted or received and
the third word contains the time the data was placed in the logging block. Both
time tags have the same format: bits S, 1-26 contain the Greenwich Mean Time
in half seconds, bits 27-35 contain the count of 8-1/3 millisecond intervals since
the last half second. High-speed output (subchannel 3) has a special time tag in
the second word of the heading. This time tag is associated with the input vector
used in calculating the output and is in floating-point seconds. The fourth word
contains the logging block serial count. The fifth word contains a mission phase
indicator in the prefix and the logging block data word count in the address. The
last twelve cells contain the logged data which is stored forward from the last
word in the block. If less than twelve data words are to be placed in the logging
block, a non-data mask is stored in the unused cells following the heading but
preceding the logged data.

High-speed input data: DCC subchannels 1 and 2. Data logged—each high-
speed input subchannel receives input in two 24-word blocks. Each word consists
of eight bits right justified. Data word count—normally 12 words. The 48 words of
input are logged in four successive entries to MSLOGG.

High-speed output data: DCC subchannels 3 and 4. Data logged—high-speed
output is packed four 8-bit characters per word for logging. The characters are
packed from right to left. Output over subchannel 4 is not logged since all of this
data is contained in the output logged for subchannel 3. Data word count—a max-
imum of 32 characters, eight computer words, are logged in one block. There-
fore, each high-speed output log block contains at least four non-data words fol-
lowing the heading. Thirty-two characters are logged in successive entries to
MSLOGG until 32 or less characters remain in the output message. The last
pass completes the logging of the output message and the character count of the
last pass is placed in the address of the first word of the heading.

Low-speed input data: DCC subchannels 14 through 30. Data logged—low-
speed input messages are composed of 6-bit characters. These are packed six
characters to a logging word, left justified. Data word count—varies from one to
ten.

Low-speed output data: DCC subchannels 10 and 11. Data logged—low-speed
output messages are composed of 6-bit characters. These are packed six char-
acters to a logging word, left justified. Data word count—varies from one to 12.

Sense output for the Output Status Console: DCC subchannel 31. Data logged—
one word which controls the eight indicator lights on the Output Status Console.
Data word count—one.

On-line message: Uses channel A, logging identification number is 33. Data
logged—the on-line message is logged from a 5-cell table (TMPRLG) generated
during the on-line message cycle. For the structure of TMPRLG see the follow-
ing information. Data word count—five. The 5-cell data table, TMPRLG, used to
log the on-line message is stored in words 13 through 17 of the logging block.
** Figure 8-9. MSLOGG Logging Block and Calling Sequence**

<table>
<thead>
<tr>
<th>WORD</th>
<th>5</th>
<th>3</th>
<th>18</th>
<th>21</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IDENTIFICATION BY DCC SUBCHANNEL NO.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TIME TAG: DATA TRANSMITTED/RECEIVED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TIME TAG: DATA STORED IN THIS BLOCK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SERIAL COUNT OF LOGGING BLOCKS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>** DATA WORD COUNT IN THIS LOGGING BLOCK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NON-DATA MASK (777 777 777 777)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>NON-DATA MASK (777 777 777 777)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>FIRST DATA WORD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>SECOND DATA WORD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>(DATA STORED FROM BOTTOM OF BLOCK)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>LAST DATA WORD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** MISSION PHASE INDICATOR**

** MSLOGG CALLING SEQUENCE **

TSX MSLOGG, 4
PZE ,, IDENTIFICATION
PZE DATA LOCATION,, DATA WORD COUNT
RETURN
The format for this table (TMPRLG) is as follows:

<table>
<thead>
<tr>
<th>TMPRLG</th>
<th>variable field</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1</td>
<td>variable field</td>
</tr>
<tr>
<td>+2</td>
<td>variable field or illegal message number</td>
</tr>
<tr>
<td>+3</td>
<td>Prefix</td>
</tr>
<tr>
<td>+4</td>
<td>Redundancy indication</td>
</tr>
</tbody>
</table>

If a message was read from tape and printed, the number of the message printed appears in the decrement of TMPRLG + 3. Otherwise the decrement is zero (as in the case of a request for a non-existent message).

If the prefix of TMPRLG + 3 is zero, there was no variable field for the message. TMPRLG, TMPRLG + 1, TMPRLG + 2, and the tag and address of TMPRLG + 3 are zero.

If the prefix of TMPRLG + 3 is non-zero, TMPRLG + 3 contains the word brought from the message queue. If the prefix is a 7 (denoting an integer variable field) or a 5 (denoting a time variable field) the variable field will be contained in the tag and address of TMPRLG + 3. This variable field will be positive, right oriented and in fixed point (the time will be infixed-point seconds). TMPRLG, TMPRLG + 1, and TMPRLG + 2 are zero. If the prefix is a 6 (floating-point variable field) or a 5 (octal integer variable field) the number of variables can range from 1 to 3. If there was only one variable in the printed message it is contained in TMPRLG + 2. If there were two variables, the first is contained in TMPRLG + 1 and the second in TMPRLG + 2. If there were three variables the first is contained in TMPRLG, the second in TMPRLG + 1 and the last in TMPRLG + 2. The unused cells of the three locations used for the variable field are zero. The number of variables logged can be determined from the tag of TMPRLG + 3 which contains 1, 2, or 3. If the prefix is a 3 (a block of data after differential correction) none of the variables are logged. If the prefix is a 2 or a 1, no variable field was added to the message printed.

The decrement of TMPRLG + 3 indicates whether or not redundancy occurred on the message tape: if the decrement contains a 1, the auxiliary tape was used in an attempt to read the message from tape without redundancy; if the decrement contains a 2, redundancy occurred on both message tapes for this particular message; if the decrement is zero, no redundancy occurred.

The address of TMPRLG indicates which error message (if any) was printed. A 1 indicates that the message "MESSAGE NUMBER REQUESTED DISAGREES WITH ONE FOUND—BOTH PRINTED BELOW" was printed. TMPRLG, TMPRLG + 1, and TMPRLG + 2 are zero and the decrement of TMPRLG+3 contains the
number of the message printed. If the decrement of $\text{TMPRLG} + 3$ is zero, an end-of-file on the message tape caused the trap. In this case no other message was printed below the error message. A 2 indicates that the message "BINARY NUMBER PRINTED BELOW WAS REQUESTED BUT DOES NOT EXIST" was printed. The binary number requested is in $\text{TMPRLG} 2$. $\text{TMPRLG}$ and $\text{TMPRLG} + 1$ are zero. A zero indicates that neither error message was printed.
8.8 MONITOR LOGGING SUBROUTINE (MSLOGG)

MSLOGG, MYSTLT and MTENLG provide a system for reproducing all input to and output from the Mercury Program System for post-mission and other analyses. MSLOGG stores logging blocks into the logging buffer in core storage and sets controls to write the logging buffer, when filled, onto the log tape. MYSTLT and MTENLG are the ordinary and trap processors, respectively, which control the writing of the logging buffer on the log tape.

The flow chart for the MSLOGG subroutine is shown in Figure 8-10.

8.8.1 Input Requirements

The calling sequence for MSLOGG is defined:

\[
\begin{align*}
& a \quad \text{TSX} \quad \text{MSLOGG, 4} \\
& a + 1 \quad \text{PZE(MZE)} \quad \text{Address, Identification} \\
& a + 2 \quad \text{PZE} \quad \text{Data Location, Data Word Count} \\
& a + 3 \quad \text{Return}
\end{align*}
\]

The information which must be supplied in the calling sequence is described in a) through c) of the following list of input to MSLOGG:

a) Identification—the decrement of the second word of the calling sequence contains the number of the DCC subchannel sending or receiving the transmitted data. The number 33 identifies the logging of an on-line message printout.

b) Address—the address of the second word in the calling sequence is zero for all subchannels except 3, 4, 10 and 11. For subchannels 10 and 11 the address contains the number of the output teletype transmission terminal (0-7). For subchannels 3 and 4 the number of words logged is variable. The data is logged eight words at a time, four characters to a word, until an end-of-message is encountered, at which time the number of characters in the last block (varying from 1 to 32) is placed in the address of the second word of the calling sequence.

c) Prefix—the prefix of the second word of the calling sequence is used in the logging for subchannels 3, 10, and 11 and the logging of the on-line messages. For these subchannels and for the logging of on-line messages, the prefix of the second word of the calling sequence to MSLOGG is made identical with the prefix of MCBETA, i.e., if the 7090 is transmitting the sign of MCBETA is positive and if it is not transmitting the sign of MCBETA is negative. For the duplex 7090
computer operation at Goddard only one computer is transmitting externally at any given time.

d) Data Word Count—the decrement of the third word of the calling sequence contains the count of the data words to be logged. MSLOGG accepts a maximum word count of 12.

e) Data Location—the address of the third word of the calling sequence contains the location of the data to be stored in the logging block.

f) MQ—contains the time tag associated with the data to be logged. This time represents the time of reception for input data and the time of transmission for output data and on-line message printouts. The composition of the time tag is: 

MQ1-26 contain the contents of MCHFSC (GMT in half-seconds); MQ27-35 contain the contents of TM8.3M (number of 8-1/3 milliseconds since last half second). High-speed output (subchannel 3) requires a special time in the MQ. This time is the time tag associated with the input vector that was used in calculating the high-speed output. This time is logged in floating-point seconds.

g) MCHFSC, TM8.3M—communication cell and table, respectively, used by MSLOGG to construct a time tag of the format as described in f) above.

h) MCPHSE—communication cell whose prefix specifies the mission phase:

P(MCPHSE) = 0, launch phase
P(MCPHSE) = 1, high-abort phase
P(MCPHSE) = 2, low-abort phase
P(MCPHSE) = 3, medium-abort phase
P(MCPHSE) = -0, orbit phase
P(MCPHSE) = -1, re-entry from orbit phase
P(MCPHSE) = -2, re-entry from high-abort phase

i) MCALBL, MCALBT—communication cells containing in their addresses the locations of the logging buffer being filled and the logging buffer being written on tape, respectively. MCALBL and MCALBT contain the locations of TMALB1 and TMALB2 in opposition with each other as these two buffers are alternately filled and written on the log tape.
j) MCLTP1, MCLTP2—communication cells containing the write-select instructions WTBB MULTP1 and WTBB MULTP2. The instruction in MCLTP1 addresses the log tape being written. The instruction in MCLTP2 addresses the log tape in reserve. Normally, one log tape is written until it is filled; then MSLOGG exchanges MCLTP1 and MCLTP2.

k) MCALM1, MCALM2—communication cells containing in their addresses the message numbers for the following two messages: FILE PROTECT TAPE ON B6 AND SET UP NEW TAPE and FILE PROTECT TAPE ON B7 AND SET UP NEW TAPE. At any time the message number in MCALM1 corresponds to the tape being written, i.e., the tape unit addressed by instruction in MCLTP1 is the tape unit referred to by the message whose number is in MCALM1. MCALM1 is maintained by MSLOGG and the on-line message, to which this number refers, is queued by MYSTLT.

l) MULTP1, MULTP2—parameters designating the primary and secondary logging tapes, B6 and B7, respectively.

m) ALNOW—internal cell whose contents designate the total number of words (heading and data) per logging block, 17.

n) ALNOB—internal cell whose contents designate the maximum number of logging blocks per logging buffer, 10.

o) ALBGL—internal cell whose contents upon entry to MSLOGG designate the number of blocks stored in the logging buffer.

p) ALTFL—internal cell whose contents designate the serial count (ALSCT) at which the current log tape is filled and must be replaced. Since each filled log tape contains 41,020 blocks, ALTFL contains N x 41,020 where N represents the number of the log tape currently being written.

q) ALSCT—internal cell containing the serial count of logging blocks stored in logging buffers. The contents of ALSCT are incremented by one for each logging block stored in a logging buffer.

r) ALONE—mask, 777 777 777 777. This mask is stored in each unused location of the logging block and indicates a non-data word. The total number of non-data words and data words must equal 12 for each logging block.

s) ALTFN — constant, 41020 (decimal)

The computer must be disabled during the execution of the MSLOGG subroutine.
8.8.2 Output Requirements

MSLOGG fills a 17-word logging block in the logging buffer, either TMALB1 or TMALB2, as designated by MCALBL. The first five words of the block compose the heading and provide descriptive information relative to the logged data. The last 12 words of the block contain the logged data, with the last data word stored in the 17th word of the block, the second last data word in the 16th word of the block, etc. If less than 12 words are available for logging, the words following the heading but preceding the logged data contain the non-data octal mask, 777 777 777 777.

For every entry MSLOGG increments both the serial block count in ALSCT and the block per buffer count in ALBFL by one. The following output is conditional:

a) If the 17-word logging block fills the logging buffer (the contents of ALBFL and ALNOB are equal), the contents of MCALBL and MCALBT are exchanged so that the location of the alternate logging buffer will be contained in MCALBL. The B indicator is turned on for MYSTLT, the processor which writes the filled logging buffer on the log tape.

b) If MSLOGG finds that the log tape has been filled (contents of ALSCT and ALTFL are equal), MSLOGG also exchanges the contents of MCLTP1 and MCLTP2 so that the alternate tape will be used by MYSTLT. MCALM1 and MCALM2 are exchanged so that the on-line message whose number is in MCALM1 refers to the tape now being written.

8.8.3 Method

Upon entry MSLOGG saves index registers 1 and 2. The logging block per buffer counter is incremented by one and the location of the block within the buffer is computed. MSLOGG begins setting up the five word heading in the logging block (see Figure 8-9). The second word of the calling sequence, the data identification, is stored in the first word of the heading. The data time tag from the MQ is stored as the second word of the heading. MSLOGG constructs a logging time tag of the same format and stores this as the third word of the heading. The logging block serial count is incremented by one and stored in the fourth word of the heading.

The third word of the calling sequence, the data word count, is stored in the fifth word of the heading. MSLOGG sets the prefix of the fifth word of the heading to indicate mission phase: +0 for launch, +1 for high abort, +2 for low abort, +3 for medium abort, -0 for orbit phase, -1 for re-entry from orbit or -2 for re-entry from high abort.

Every non-data location following the five-word head is filled with a non-data mask and MSLOGG completes the logging block by storing the data words.
forward from the last location in the logging block. The last data word is stored in the last location.

If the logging buffer is not filled, MSLOGG restores index registers and program control returns to the fourth word in the calling sequence.

If the logging buffer now contains the maximum number of logging blocks, the alternate buffer is set for the next logging. If the log tape is full, the primary and the alternate log tapes are effectively switched by exchanging the contents of cells containing the tape data-select instructions. An on-line message queued by MYSTLT states that one log tape has been filled and should be replaced with a blank. Whether or not the tape was full, MSLOGG turns on the B indicator for MYSTLT, the processor which writes the buffer on the log tape. Index registers are restored and program control returns to the fourth word in the calling sequence.

8.8.4 Usage

MSLOGG is entered from the following calling sequence:

<table>
<thead>
<tr>
<th>Location</th>
<th>Operation</th>
<th>Address, Tag, Decrement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>TSX</td>
<td>MSLOGG, 4</td>
</tr>
<tr>
<td>a + 1</td>
<td>PZE(MZE)</td>
<td>Address,, Identification</td>
</tr>
<tr>
<td>a + 2</td>
<td>PZE</td>
<td>Data Location,, Data Word Count</td>
</tr>
<tr>
<td>a + 3</td>
<td>Return</td>
<td></td>
</tr>
</tbody>
</table>

a) Storage Required—70 locations

b) MSLOGG uses:

1) Macro—TRNON

2) Parameters—B, MNSTLT, MULTP1 and MULTP2

3) Communication cells—MCPHSE, MCALBL, MCALBT, MCALM1, MCALM2, MCHFSC, MCLTP1, MCLTP2, ALBFL, ALSCT and ALTFL

4) Tables—TMALB1, TMALB2 and TM8.3M

5) Constants—K00001, ALNOB, ALNOW and ALTFN

6) Mask—ALONE
c) Time Required (maximum):

1) If buffer not full—0.394 millisecond

2) If buffer full, but tape not full—0.438 millisecond

3) If tape full—0.473 millisecond
ENTRY

MSLOGG

SAVE INDEX REGISTERS

INCREMENT BLOCK COUNT
SET BUFFER BLOCK LOCATION

STORE 2ND WORD OF CALLING SEQUENCE IN 1ST WORD OF HEADING

STORE DATA TIME FROM MQ IN 2ND WORD OF HEADING

STORE LOG TIME IN 3RD WORD OF HEADING

INCREMENT SERIAL COUNT BY 1 AND STORE IN 4TH WORD OF HEADING

STORE DATA WORD COUNT IN ADDRESS OF 5TH WORD OF HEADING

STORE PHASE INDICATOR IN PREFIX OF 5TH WORD OF HEADING

FILL EACH NON-DATA LOG BLOCK LOCATION WITH NON-DATA MASK (777 777 777 777)

MOVE DATA INTO LOW LOCATIONS OF LOGGING BLOCK

IS THE LOGGING BUFFER NOW FULL?

YES

SWITCH TAPES. SET NEW COUNT FOR "TAPE FULL" TEST

IS THE LOG TAPE FULL?

NO

ALTR1

ALTR2

TRNON B MNSTLT

RESTORE INDEX REGISTERS

EXIT

FIGURE 8-10. MSLOGG SUBROUTINE FLOW CHART

8-67
8.9 MONITOR LOGGING PROCESSOR (MYSTLT)

MYSTLT receives control from MOPRIO after the Monitor Logging Subroutine, MSLOGG, has completely filled a logging buffer. The Logging Processor initiates transmission to write the logging buffer on the log tape and, if necessary, queues an on-line message stating that one of the log tapes is full.

The flow chart for the MYSTLT processor is shown in Figure 8-11.

8.9.1 Input Requirements

Input to MYSTLT consists of:

a) MCALBT—communication cell containing in the address the location of the logging buffer, either TMALB1 or TMALB2, to be written on the log tape. This cell is set by MSLOGG.

b) MCLPT1—communication cell containing the write-select instruction, either WTBB MULTP1 or WTBB MULTP2, for writing the log tape. MULTP1 and MULTP2 are parameters designating the primary and secondary, or alternate, logging tapes, B6 and B7, respectively. MCALBT is set by MSLOGG.

8.9.2 Output Requirements

MYSTLT provides the address for the data channel command and initiates transmission to write a 170-word logging buffer on the log tape. MYSTLT stores a trap transfer instruction (TTR MTENLG) in the channel B trap location 00015.

8.9.3 Method

MYSTLT receives control from MOPRIO after the Logging Subroutine, MSLOGG, has completely filled one of the two logging buffers and has turned on the B indicator for MYSTLT. When MSLOGG has filled a logging buffer, the subroutine provides all necessary input data for MYSTLT. MYSTLT turns on its own A indicator and suppresses the other routines using channel B. Then the address of the buffer to be written on tape is obtained from MCALBT and stored in the address of the data channel command. The computer is disabled and MYSTLT executes MCLTP1 to select the tape unit, and resets and loads the channel. If the contents of MCLTP1, the cell containing a write-select instruction for the log tape, have changed since the last time MYSTLT was executed, one log tape has been filled. In this case MYSTLT writes an end-of-file on the log tape that is full. MYSTLT rewinds and unloads the filled tape, and queues an on-line message which states that a log tape has been filled and should be replaced.

MYSTLT then turns on its own C indicator to suppress itself until after the transmission is completed (the C indicator is turned off by MTENLG) MYSTLT turns off its A indicator and exits to MOPRIO.
8.9.4 Usage

MYSTLT is entered from, and exits to, M0PRIO.

a) Storage Required—45 locations

b) MYSTLT uses:

1) Macros—QENBZ, TRNOF, TRNON and QUEUE

2) Parameters—A, B, C, E, F, MNSTLT, MULTP1, MULTP2, MNWRRS, MNRRRS, MNSRST and MNMESS

3) Communication cells—MCALBT, MCLTP1 and MCALM2

4) Tables—TMALB1 and TMALB2

5) Location—00015

c) Time Required:

1) If no message is printed on-line—0.113 millisecond

2) If a message is printed on-line—0.204 millisecond
FIGURE 8-11. MYSTLT PROGRAM FLOW CHART
8.10 MONITOR END-OF-LOGGING TRAP PROCESSOR (MTENLGLG)

MTENLGLG receives control from the channel B trap following the writing of a logging buffer on the log tape. MTENLGLG checks for redundancy during the tape writing and removes the suppression condition from MYSTLTL and the other channel B routines suppressed by MYSTLTL.

The flow chart for the MTENLGLG trap processor is shown in Figure 8-12.

8.10.1 Input Requirements

Input to MTENLGLG consists of the tape check indicator.

8.10.2 Output Requirements

If a redundancy had occurred in writing the logging buffer, MTENLGLG stores a 1 in the tag of the next logging buffer, TMALB1 or TMALB2, to be written on the log tape.

MTENLGLG also unsuppresses MYSTLTL so that the current logging buffer, when filled, may be written on the log tape. All other routines utilizing channel B, that were suppressed by MYSTLTL, are unsuppressed by MTENLGLG.

8.10.3 Method

MTENLGLG receives control from a trap transfer instruction (TTR MTENLGLG) in the channel B trap control location. The trap processor executes the SAVE macro to preserve the condition of the interrupted program.

The tape check indicator is examined for a redundancy in writing the log tape. If a redundancy had occurred, a 1 is stored in the tag of the first word of the next buffer to be written on the log tape. (When interpreting the log tape, the tag of record n 1 is checked to determine if redundancy had occurred in writing record n.)

MTENLGLG turns off the C indicator for MYSTLTL which allows MYSTLTL to write the next logging buffer as soon as it becomes filled. All other channel B routines, suppressed by MYSTLTL are unsuppressed by MTENLGLG. Program control returns to MOPRIO.

8.10.4 Usage

MTENLGLG is entered from a trap transfer in the channel B trap control location (00015); MTENLGLG exits to MOPRIO.

a) Storage Required—16 locations

b) MTENLGLG uses:

1) Macros—SAVE and TRNOF
2) Parameters—C, E, F, MNSTLT, MNWRRS, MNRRRS, and MNSRST
3) Communication cell—MCALBL
4) Tables—TMALB1 and TMALB2
5) Constant—KT0001
c) Time Required—0.209 millisecond
CHANNEL B TRAP

00015

TTR MTENST (SET BY MYMESS OR MYMSCK)

MTENST

SAVE 12

REDUNDANCY IN WRITING LOG TAPE?

NO

ANTR1

STORE 1 IN TAG OF NEXT LOGGING BUFFER TO BE_WRITTEN ON LOG TAPE

YES

ANTR2

TRNOF C MNSTLT

FIGURE 8-12. MTENLG PROGRAM FLOW CHART

TRN OF C MNWRRS

TRNOF E MNRRRS

TRNOF F MNSRST

MOPRIQ

8-75
Section 9
MONITOR SYMBOL REFERENCE LISTS

The symbolic notations which identify the Monitor programs, communication cells, tables and parameters follow the conventions outlined below. Each symbol consists of six characters. The first two characters conform to a standard code and specify a general function. The remaining four characters are generally mnemonic and indicate a specific function.

**M0XXXX**—Monitor controlling program. Any program with M0 as the first two characters of its symbolic name performs some basic controlling function.

**MTXXXX**—Monitor trap processor. Any program with MT as the first two characters of its symbolic name performs some function associated either with the termination of input or output transmission or with timing control interrupts.

**MYXXXX**—Monitor processor. Any program with MY as the first two characters of its symbolic name performs some Monitor control function, i.e., initiation of output transmission, maintenance of timing control, generation of a numerical integration cycle.

**MPXXXX**—Monitor prefix to a processing program. A Monitor prefix is the method whereby Monitor communicates directly with the processing programs.

**MPXXXX**—Monitor suffix to a processing program. A Monitor suffix is the method whereby the processing programs communicate directly with Monitor.

**MSXXXX**—Monitor subroutine.

**MLXXXX**—Monitor subroutine used during the launch phase.

**MNXXXX**—The Monitor name for a Monitor processor or a non-Monitor processing program. This name is equivalent to a number which represents the location of the processor or processing program in the Monitor Reference Table, TMREFR. The MNXXXX number is generally called the routine number of the program to which it refers. In addition, MNXXXX numbers are also used to define system parameters.

**MUXXXX**—parameter designating a tape unit addressed by a Monitor processor or trap processor.
MCXXXX—Monitor communication cell, i.e., one word which contains some controlling information.

TMXXXX—Monitor table.

MXXXXX—Monitor external program, i.e., a support program, which does not have a functional role in the operative tracking program.
9.1 PROGRAMS

The listings of the various programs including Monitor controllers, trap and non-trap processors, processing programs, subroutines, prefixes and suffixes are given below. The number following the definition refers to the subsection of the manual in which the program is described in detail.

9.1.1 Main Controllers

MODIAG—Main Controller Diagnostic Program, receives control when the Mercury Program System must wait for a trap to continue processing (2.5).

MOINIT—Main Controller Initialization Program, initiates the process of preparing the operational program for processing (5.6).

MOPRIO—Main Controller Priority Program, gives program control to Monitor processors and, via their prefixes, to the processing programs on the basis of a priority table (2.1).

MOQUEUE—Main Controller Queue Program, places entries in the input queue tables (2.6).

MORTCC—Real Time Channel Main Controller Program, interprets all programs interrupts produced by the Data Communications Channel (2.2).

MORTRN—Main Controller Return Program, restores the machine condition prior to returning control to a previously interrupted processor or processing program (2.4).

MOSAVE—Main Controller Save Program, saves the machine condition when a processor or processing program is interrupted by a trap (2.3).

MOUNQUE—Main Controller Unqueue Program, supplies the processors or processing programs with input from their queue tables (2.7).

9.1.2 Monitor Processors (with associate Monitor name)

MYACQD—Monitor Acquisition Data Processor, determines when the capsule has entered a new sector and checks for sending acquisition data; MNACQD (7.11).

MYCDRD—Monitor On-Line Card Processor, provisional for on-line card input; MNCDRD (not used in present Mercury Program System).

MYENBO—Monitor Disable Program, disables the computer from all data channel traps; no routine number (2.13).
MYGEN1—Monitor Numerical Integration Generator, provides controls for integration following the launch-to-orbit interphase, an acceptable differential correction or a tape restart; MNGEN1 (6.8).

MYGEN2—Monitor Numerical Integration Generator, provides controls for integration following the manual insertion of range and velocity vectors; MNGEN2 (6.9).

MYGEN3—Monitor Numerical Integration Generator, when incorporated into the Mercury Program System, will provide controls for integration to obtain impact points based on immediate retrofire; MNGEN3 (6.10).

MYHSOD—Monitor High-Speed Output to Cape Canaveral Processor, initiates transmission of high-speed output data to the Mercury Control Center displays; MNHSOD (7.6).

MYHSOP—Monitor High-Speed Output to Goddard Processor, initiates transmission of high-speed output data to the local digital-to-analog converters to drive to Goddard plotboards; MNHSOP (7.8).

MYINIT—Monitor Initialization Processor, prepares the Mercury Programs System for data processing and transmission; MNINIT (5.7).

MYMESS—Monitor On-Line Message Processor, reads prepared message into core storage from the message tape; MNMESS (8.2).

MYMINS—Monitor Minute Processor, receives control at one-minute intervals, updates a time cell, executes subroutines which determine orbital pass number and excessive transmission times for low-speed radar input; MNMINS (3.24).

MYMSCK—Monitor Message Check Processor, initiates on-line printing of message read from tape; MNMSCK (8.5).

MYPSSLF—Monitor Present Sense Line Program, executes PSLF instruction to activate/deactivate subchannels of the Data Communications Channel; no routine number (2.14).

MYQSYS—Monitor System Tape Queueing Processor, sets controls to begin cycle which loads programs into core from the Mercury System tape; MNQSYS (5.11).

MYREST—Monitor Orbit-to-Re-entry Interphase Processor, sets controls for the Mercury Program System to enter the re-entry phase or to restart in re-entry; MNREST (5.17).

MYRRRS—Monitor Re-entry Restart Tape Processor, reads the restart tape on request to obtain last valid orbit data for orbit-to-re-entry interphase; MNRRRS (5.18).
**MYRSYS**—Monitor System Tape Processor, loads programs into core storage from the Mercury System tape during real time processing; MNRSYS (5.12).

**MYSRST**—Monitor Orbit Restart Tape Processor, reads the restart tape on request to obtain orbit-integration parameters with a time tag equal or prior to a given restart time; MNSRST (5.21).

**MYESK**—Monitor High-Abort Control Processor, controls the Mercury Program System during the launch-to-high-abort-to-re-entry interphase operations; MNSEEK (4.17).

**MYSSENS**—Monitor Sense Output Processor, transmits to the sense lights of the Output Status Console; MNSENS (7.20).

**MYSRST**—Monitor Orbit Restart Tape Processor, reads the restart tape on request to obtain orbit-integration parameters with a time tag equal or prior to a given restart time; MNSRST (5.21).

**MYSTLT**—Monitor Logging Processor, writes the logging buffers on the log tape; MNSTLT (8.9).

**MYTTOX**—Monitor Subchannel 10 Teletype Output Processor, transmits acquisition data to Mercury tracking stations via DCC subchannel 10; MNTTOX (7.12).

**MYTTXO**—Monitor Teletype Output Logging Processor, logs acquisition data transmitted on DCC subchannel 10; MNTTXO (7.18).

**MYWRRS**—Monitor Restart Tape Writer Processor, writes a record of data on the restart tape; MNWRRS (5.14).

### 9.1.3 Monitor Trap Processors

**MTENLG**—Monitor End-of-Logging Trap Processor, services the trap after a logging buffer is written on tape (8.10).

**MTENPR**—Monitor End-of-Printing Trap Processor, services the trap after message printed on-line (8.6).
MTENST—Monitor Station Characteristics Tape Trap Processor, services trap after Station Characteristics tape record read from tape (5.9).

MTERTC—Monitor Real Time Channel Error Trap Processor, services trap caused by an unassigned subchannel of the DCC (3.26).

MTHFSC—Monitor Half-Second Trap Processor, services half-second traps produced by DCC subchannel 7 (3.22).

MTHS09—Monitor IP 7090 High-Speed Input Trap Processor, services traps produced by input on DCC subchannel 2 (3.6).

MTHSGB—Monitor B-GE High-Speed Input Trap Processor, services traps produced by input on DCC subchannel 1 (3.2).

MTHSOD—Monitor Trap Processor for High-Speed Output to Cape Canaveral, services traps produced by output on DCC subchannel 3 (7.7).

MTHSOP—Monitor Trap Processor for High-Speed Output to Goddard, services traps produced by output on DCC subchannel 4 (7.9).

MTINTV—Monitor Interval Timer Trap Processor, services traps produced by DCC subchannel 9 (not currently used in the Mercury Program System).

MTMNSCK—Monitor Message Check Trap Processor, services trap after record read from message tape (8.4).

MTRRRRS—Monitor Re-entry Restart Tape Trap Processor, services traps after record read from restart tape by MYRRRS (5.19).

MTRSYS—Monitor System Tape Trap Processor, services traps after record read from Mercury System tape by MYRSYS (5.13).

MTSESN—Monitor Sense Output Trap Processor, services traps after sense output on DCC subchannel 31 (7.21).

MTSRST—Monitor Orbit Restart Tape Trap Processor, services traps after record read from restart tape by MYSRST (5.22).

MTTINN—Monitor Teletype Input Trap Processor, services traps produced by input on DCC subchannels 14 through 30 (3.11).

MTTTOX—Monitor Teletype Output Trap Processor, services traps produced by output on DCC subchannel 10 (7.16).

MTTTOY—Monitor Teletype Output Trap Processor, services traps produced by output on DCC subchannel 11 (7.16).
MTWRRS—Monitor Restart Tape Writer Trap Processor, services traps after record written on channel C restart tape (5.15).

MTWRS1—Monitor Restart Tape Writer Trap Processor, services traps after record written on channel B restart tape (5.15).

MTWWVI—Monitor Initial WWV Trap Processor, services the WWV one-minute pulse received on DCC subchannel 8, enters GMT into Mercury Program System (3.20).

MTWWVY—Monitor WWV Trap Processor, services WWV traps produced on DCC subchannel 8 after MTWWVI enters time into system (3.21).

9.1.4 Goddard Processing Programs (with associated Monitor prefix, routine number, and suffix)

AOSTAD—processing program for preparing acquisition data for the Mercury tracking stations. AOSTAD, used as a subroutine by MYTTOX and MYTTOY, has no prefix nor suffix.

CC7091—coordinate conversion processing program for subchannel 2 IP 7090 data during launch/abort. Prefix and routine number: MPCCIP, MNCCIP (4.5). Suffix: MFCCIP (4.6).

CCABRT—processing program for main calculations during the high-abort phase. Prefix and routine number: MPABRT, MNABRT (4.18). Suffix: MFABRT (4.19).

CCGEB1—coordinate conversion processing program for subchannel 1 input during launch/abort. Prefix and routine number: MPCCGB, MNCCGB (4.2). Suffixes: MFCCGB (4.3) and MFCCGE (4.4).

CCHOLD—processing program for main calculations during the hold phase. Prefix and routine number: MPLCCM, MNLCCM (4.10). Suffix: MFLHLD (4.15). Suffixes to MFLHLD: MFLABT (4.16) and MFLORB (4.20).

CCHOMI—processing program for main calculations with input data missing during the hold phase. Prefix and routine number: MPLCCM, MNLCCM (4.10). Suffix: MFLHLD (4.15). Suffixes to MFLHLD: MFLABT (4.16) and MFLORB (4.20).

CCMAIN—main launch processing program. Prefix and routine number: MPLCCM, MNLCCM (4.10). Suffixes: MFLRT1 (4.11), MFLRT2 (4.12), MFLNML (4.13) and MFLHLD (4.15).

CCMISS—main launch processing program for bad or missing data. Prefix and routine number: MPLCCM, MNLCCM (4.10). Suffixes: MFLRT1 (4.11), MFLRT2 (4.12), MFLNML (4.13) and MFLHLD (4.15).

CCRAWR—coordinate conversion and editing processing program for sub-channel 2 raw radar data during launch/abort. Prefix and routine number: MPCCIP, MNCCIP (4.5). Suffix: MFCCRW (4.7).

CCRTMI—main processing program for bad or missing input data during the low-abort phase. Prefix and routine number: MPLCCM, MNLCCM (4.10). Suffix: MFLRT1 (4.11).


CCST16—strip chart processing program for raw AN/FPS-16 radar data during launch/abort. Prefix and routine number: MPSTRP, MNSTRP (4.8). Suffix: MFSTRP (4.9).

CCSTGE—strip chart processing program for B-GE data. Prefix and routine number: MPSTRP, MNSTRP (4.8). Suffix: MFSTRP (4.9).

CCSTIP—strip chart processing program for subchannel 2 IP 7090 data. Prefix and routine number: MPSTRP, MNSTRP (4.8). Suffix: MFSTRP (4.9).

DODIFC—differential correction control processing program. Prefixes and routine numbers: MPDIFC, MNDIFC (6.5) and MPDIFK, MNDIFK (6.6). Suffix: MF DIFC (6.7).

EOLED1—edit processing program for low-speed input radar data. Prefixes and routine numbers: MPLED1, MNLED1 (6.2) and MPLED2, MNLED2 (6.3). Suffix: MFLED1 (6.4).

HOS09—input processing program for data received over subchannel 2 during launch/abort. Prefix and routine number: MPHS09, MNHS09 (3.7). Suffixes: MFHS09 (3.8) and MFHS08 (3.9).

HOSGB—input processing program for data received over subchannel 1 during launch/abort. Prefix and routine number: MPHSGB, MNHSGB (3.3). Suffixes: MFHSGB (3.4) and MFML6A (3.5).

IMANI—input processing program for manually inserted messages over DCC subchannel 30. Prefix and routine number: MPTTIN, MNTTIN (3.12).
Suffixes: MFMAN1 (3.14), MFMAN1 (3.15), MFMAOS (3.16), MFMAN2 (3.17) and MFMAN5 (3.18).

**MFFTIN**—input processing program for low-speed radar data received from the Mercury tracking stations. Prefix and routine number: MPTTIN, MNTTIN (3.12). Suffix: MFFTIN (3.13).

**N0CPNI**—numerical integration control processing program. Prefix and routine number: MPCPNI, MNCPNI (6.11). Suffix: MFCPNI (6.12).

**O0LANA**—processing program for scaling and packing high-speed output data during launch/abort. Prefix and routine number: MPLANA, MNLANA (7.2). Suffix: MFLANA (7.3).

**O0LSTY**—processing program for converting acquisition data into teletype format for transmission to the tracking stations. O0LSTY, used as a subroutine by MYTTOX and MYTTOY, has no prefix nor suffix.

**O0ORRE**—processing program for scaling and packing high-speed output data during orbit and re-entry. Prefix and routine number: MPORRE, MNORRE (7.4). Suffix: MFORRE (7.5).

**O5ORMC**—processing program for output calculations during orbit and re-entry. Prefix and routine number: MPORMC, MNORMC (6.15). Suffix: MFORMC (6.16).


9.1.5 Monitor Subroutines

**MLUPDT**—Monitor Launch-Output Updating Subroutine, updates high-speed output block during the launch phase. MLUPDT (4.14) is used by MFLNML and MFLHLD.

**MSLOAD**—Mercury System Tape Loader Subroutine, initially loads the launch/abort phase of the Mercury Program System (5.4). MSLOAD is used by MXLOAD.

**MSLOGG**—Monitor Logging Subroutine, stores logging data into the logging buffers for writing on the log tape (8.8).

**MSPASN**—Monitor Pass Number Determination Subroutine, determines change in orbit number (3.24). MSPASN is a subroutine of MYMINS.

**MSRECC**—Monitor Error Correction Code Reader Subroutine, removes error codes from an encoded record read from the Mercury System tape, the Station Characteristics tape or the restart tape (5.5).
MSTICK—Monitor Teletype Input Check Subroutine, determines when an end-of-transmission must be forced for a station due to transmission duration exceeding specified time limits (3.25). MSTICK is a subroutine of MYMINS.

MSWECC—Monitor Error Correction Code Writer Subroutine, expands a record to include error-correction (hamming) codes prior to writing the record on tape (5.3).

9.1.6 Monitor Macros

AJACQ—Acquisition Data Macro, sets controls for entry to AOSTAD and O0LSTY to generate and prepare acquisition data for transmission (7.14).

BINNO—Binary Number Card Image Macro, converts binary number to card image for on-line printing (8.3).

QENBA—Enable Macro, enables data channels A, B, C and F (the DCC) for traps (2.12).

QENBZ—Disable Macro, disables all data channels from trapping (2.13).

QPSLF—Present Sense Line Macro, activates/deactivates subchannels of the Data Communications Channel (2.14).

QTYYA—Teletype Output Macro, unpacks teletype output for transmission by the DCC (7.15).

QTYYB—Teletype Output Test Macro, tests teletype output and continues transmission if data remains to be sent (7.17).

QUEUE—Queue Macro, sets calling sequence for transfer to Main Controller Queue Program (2.6).

REFER—Reference Macro, prepares the basic Monitor control tables during program assembly (2.16).

SAVE—Save Macro, sets calling sequence for transfer to Main Controller Save Program (2.15).

TRNOF—Turn Off Macro, turns off a specified indicator for an entry in the Monitor priority table (2.8).

TRNON—Turn On Macro, turns on a specified indicator for an entry in the Monitor priority table (2.9).

UNQUE—Unqueue Macro, sets calling sequence for transfer to Main Controller Unqueue Program (2.11).
9.2 COMMUNICATION CELLS

The communication cells used by the Monitor programs are listed below in alphabetical order:

**MC1RVT**—locates the three components of the range vector supplied to MFLABT or MFLORB by the launch processing programs. Used by MFLABT or MFLORB for input to MYMESS.

**MC2RVT**—locates the three components of the velocity vector supplied to MFLABT or MFLORB by the launch processing programs. Used by MFLABT or MFLORB for input to MYMESS.

**MC3RVT**—locates the three components of the range vector obtained from the restart tape by MYRRRS for MYREST. Used by MYREST for input to MYMESS.

**MC4RVT**—locates the three components of the velocity vector obtained from the restart tape by MYRRRS for MYREST. Used by MYREST for input to MYMESS.

**MCABRE**—preset mask for sense output to indicate on the Output Status Console the re-entry from high-abort (both abort and re-entry lights). Used by MYSEEK for input to MYSENS.

**MCACQ1**—contains in the address the location of the acquisition data output block for OOLSTY and in the decrement the internal station number of the station to receive acquisition data. Set by MLUPDT for launch acquisition data; set by AJACQ for orbit and re-entry acquisition data.

**MCACQ2**—contains the estimated horizon crossing time for AOSTAD to compute acquisition data. Set by AJACQ.

**MCACTV**—mask addressed by the PSLF instruction (in the QPSLF macro) to activate/deactivate subchannels of the DCC. Set by Monitor programs which control DCC transmission; used by QPSLF.

**MCALBL**—locates the current logging buffer. Set and used by MSLOGG; used by MYSTLT.

**MCALBT**—locates the reserve logging buffer. Set and used by MSLOGG; used by MYSTLT.

**MCALM1**—number for message stating log tape B6 filled. Set and used by MSLOGG for input to MYMESS.

**MCALM2**—number for message stating log tape B7 filled. Set and used by MSLOGG for input to MYMESS.
MCAPPE—set non-zero by MFCPNI whenever new orbit table generated. Used and reset by MFORMC when output completed.

MCAZSA—preset mask for sense output to indicate on the Output Status Console the IP 7090-processed Azusa data is selected for the main launch computations. Used by MPLCCM for input to MYSENS.

MCBETA—sign conforms to the sign of TM8.3M, updated every half second, indicating which of the duplexed computers is on-line for external transmission. Set and maintained by MTHFSC; used by MYHSOD, MYTTOX, MYTTOY and MTENPR.

MCBJMN—contains the number of the on-line message relating high-speed output transmission rate to flight phase. Set by MFLRT1, MFLRT2, MFLABT, MYSEEK, MYREST and MFLED1.

MCBNOT—contains the computed time of retrofire burnout. Set by MYSEEK, MYREST or MFLED1; used by MFLED1.

MCBSR1—contains backspace-record instruction addressing primary message tape. Used by MYMESS and MTMSCK.

MCBSR2—contains backspace-record instruction addressing auxiliary message tape. Used by MYMESS and MTMSCK.

MCCAP1—control cell used to limit complete processing to only one of the three downrange (Cape Canaveral, Grand Bahama, San Salvador) tracking stations. Set and used by MPLED1.

MCCHAN—cell addressed by a store channel A instruction. Set by MTRSYS for MYRSYS.

MCCHEK—set non-zero, when the queue for MPLED2 has been emptied (during the orbit-to-re-entry interphase). Set by MPLED2; used and reset by MFLED1.

MCCHIN—the address designates the channel used in the restart tape search: a 2 for channel B, zero for channel C. Set and used by MYRRRS, MTRRRS, MYSRST and MTSRST.

MCCHSC—when non-zero, indicates output scaling and packing program must change scale for plotboard 4 output. Set by MYREST and MFLHLD.

MCCHTP—when non-zero, indicates auxiliary message tape should be used. Set by MTMSCK for MYMESS.

MCCNTR—locates entries in the time and longitude tables for retrofire and re-entry area computations. Set and used by MPRARF; used and reset by MFRARF.
**MCCOM1**—when zero, indicates B-GE input data is acceptable. Initially set by M0INIT; set by H0HSGB; used by MFHSGB and MFCCGB.

**MCCOM2**—when zero, indicates subchannel 2 input is acceptable. Set by H0HS09; used by MFHSG09 and MFCCIP.

**MCCPNR**—queue control word used by MYREST to request numerical integration to produce last orbit table before re-entry table. Used by MYREST.

**MCDC01**—set non-zero to suppress logging of differential correction on-line printout. Set by MYMSCK; used by MTENPR.

**MCDCCT**—differential correction control cell. Set non-zero by MFDIFC when correction acceptable; reset by MYREST.

**MCDCPR**—when non-zero, MYMSCK is printing data from a differential correction. Set by MYMSCK; used by MTENPR.

**MCDCRJ**—set non-zero, when MFDIFC bypasses D0DIFC and exits to MFDIFC. Set by MFDIFC; used and reset by MFDIFC.

**MCDIAG**—count of entries to M0DIAG. Initially cleared by M0INIT. (MCDIAG not currently used by M0DIAG.)

**MCDOWN**—set non-zero, when integration abort table reaches 60,000 feet. Set by MFCPNI for MYSEEK.

**MCDQD1**—contains the input/output command for spacing over words on the restart tape. Set and used by MYRRRS and MYSRST.

**MCEFTS**—contains contents of low core location set by channel A trap. Set by MTMSCK for MYMSCK.

**MCESAB**—contains the GMT of the (predicted) first even second after burnout. Set by MFCPNI whenever new re-entry table generated; used by MYACQD and AOSTAD.

**MCETRT**—internal control switch for MYRSYS. Set and used by MYRSYS; set by MTRSYS.

**MCFILR**—contains number of file to be loaded from Mercury System tape. Set and used by MYRSYS; used by MTRSYS.

**MCHST2**—logging time tag for subchannel 2 input. Generated by MTHS09; used by MPHSG09.

**MCISTN**—contains the internal station number of any Mercury tracking station not ending transmission eight minutes after initiating transmission. Set by MPTTIN for I0TTIN.
**MCLEDI**—contains in the address the internal station number whose input data is to be edited. Set by MPLED1 for EOLED1.

**MCLEDI**—contains in the address the location of the TMRMXX input table (where XX is the internal station number) for editing. Set by MPLED1 for EOLED1; used by MFLED1.

**MCLENT**—locates new data in the TMSTMS table. Set by MPDIFC for D0DIFC; used by MPDIFK and MFDIFC.

**MCLFTM**—contains the GMT of lift-off in floating-point seconds. Set by MFMAN1; used by MFHSGB, MFML6A, MFHS09, MFHS08, MPCCGB, MPCCIP and MFLHLD.

**MCLGDT**—contains the time the last good data was processed by the main launch processing programs. Set and used by MPLCCM.

**MCLIDT**—contains the time tag of the launch input vectors used to supply output. This time tag is logged with the output data. Set by MLUPD1 and MFLHLD; used by MYHSOD.

**MCLLBT**—when non-zero, mission has entered the low-abort phase. Set by MFLRT1; used by MPLCCM.

**MCLLDT**—when non-zero, launch/abort phase requires low-speed radar input, i.e., activation of the low-speed input subchannels of the DCC. Used by MPLCCM, MFLRT1, MFLRT2, MFLNML and MFLHLD.

**MCFINI**—when non-zero, indicates low-abort phase has ended. Used by MPHSGG, MPHLS9, MFLHLD, MPLCCM, MFLRT1, MFLRT2 and MFLNML.

**MCFP16**—preset mask for sense output to indicate on Output Status Console IP 7090-processed AN/FPS-16 data is selected for main launch computations. Used by MPLCCM for input to MYSENS.

**MCFRDC**—when zero, indicates initial differential correction. Reset by MYREST.

**MCGE.B**—preset mask for sense output to indicate on Output Status Console B-GE data is selected for main launch computations. Used by MPLCCM for input to MYSENS.

**MCGTIN**—contains time of insertion into orbit in fixed-point minutes. Set by MFLOB; used by MFMAN5 and MSPASN.

**MCGTLO**—contains GMT of lift-off in fixed-point seconds. Set by 10HSGB, MFML6A, MFHS08 or MFMAN1; used by MFHSGB, MFLOB, MPLED1 and MYACQD.
MCHFS1—controls number of cycled routines to be readied by MTHFSC. Initially set by MYINIT; reset by MFLABT, MFLORB; used by MTHFSC.

MCHFSC—contains the current GMT in fixed-point half seconds. Originally set by MTWWV1; maintained by MTHFSC; used by any program that needs to know the current time.

MCHOMS—contains the number of high-speed output transmissions to Cape Canaveral since the last message stating same. Set by MTHSOD; reset by MFLORB; used and reset by MTWWV.

MCHSOD—contains the number of eight-bit groups in the TMOLAB table; used by MYHSOD.

MCHST1—logging time tag for subchannel 1 input. Generated by MTHSGB; used by MPHSGB.

MCLMBT—when non-zero, medium-abort phase has been entered. Set by MFLRT2; used by MFHS09, MPCCIP, MPLCCM, MFCPNI.

MCLMSG—coded designation of numbers of messages requested by the main launch processing programs. Used by MLUPDT.

MCLNAB—preset mask for sense output to indicate on the Output Status Console the high-abort phase (launch and abort lights) has been entered. Used by MFLABT for input to MYSENS.

MCLNCH—preset mask for sense output to indicate on Output Status Console the launch phase has been entered. Used by MFHSGB, MFML6A, MFHS08 or MFMAN1 for input to MYSENS.

MCLNOR—preset mask for sense output to indicate on the Output Status Console the orbit phase has been entered. Used by MFLORB for input to MYSENS.

MCLNRE—preset mask for sense output to indicate on the Output Status Console the low-abort or medium-abort phase has been entered (both launch and re-entry lights). Used by MFLRT1 or MFLRT2 for input to MYSENS.

MCLOCT—locates proper table, abort or re-entry, for calculations by CCABRT. Set by MPABRT for CCABRT.

MCLTMN—contains the time of entry to the main launch processing program in floating-point seconds. Set by MPLCCM.

MCLOTP1—contains write-select instruction addressing the primary log tape. Set by MSLOGG; used by MYSTLT.
MC 103

**MCLTP2**—contains write-select instruction addressing the auxiliary log tape. Contents exchanged with MCLTP1 when primary log tape filled. Used by MSLOGG.

**MCMAN5**—when non-zero, indicates manually-inserted vectors are required for MFLORB. Set and used by MFLORB.

**MCMAOS**—contains the abort/orbit decision entered into the system via paper tape; a 1 indicates orbit; a 2 indicates abort. Set by MFMAOS; used by MPLCCM.

**MCMARF**—contains the time of retrofire inserted for high-abort to re-entry phase change. Set by FMFAN2; used by MYSEEK.

**MCMINS**—contains the current GMT in fixed-point minutes. Initially set by MTWWVI; maintained by MYMINS; used by MPTTIN, FMFAN5, MSTICK, MPLED1 and MYACQD.

**MCMPTE**—contains a number specifying the maximum number of manually-inserted words processed by MTTTIN per entry to TTTTIN. Set by MPTTIN or FMFAN1; used by MPTTIN; reset by FMFAN1, FMFAOS, FMFAN2 and FMFAN5.

**MCMSNO**—contains the number of the requested message. Set by MYMESS for MYMSCK; used by BINNO and MYMSCK.

**MCMTPR**—contains a trap transfer instruction addressing MTENPR. Used by MYMESS and MYMSCK.

**MCMTRS**—contains a trap transfer instruction addressing MTRSYS. Used by MYRSYS.

**MCMPVD**—contains the original input word for MYMESS. Set by MYMESS for MYMSCK to check message for variable field information.

**MCNGEN**—when non-zero, indicates the hold, low-abort or medium-abort phase has been entered (and B-GE data is not needed). Set by MFLRT1, MFLRT2, MFLHLD or MFLNML; used by MPHSGB, MPHSGB, MFH09, MFH08, MPCCGB, MPCCIP, MFCCIP and MFCCRW.

**MCNIIP**—when non-zero, indicates numerical integration is in process. Set by MPCPNI; used by MPH09, MPCCIP and MPLCCM; reset by MFCPNI.

**MCNOCH**—when non-zero, indicates a bad or missing data entry to CCMEAB, the medium-abort processing program. Set by MPLCCM.

**MCNRF1**—contains the number of retros fired, as reported over subchannel 1. Set by MFML6A; used by MFH08.
MCNRF2—contains the number of retros fired, as reported over subchannel 2. Set by IOHS09; used by MFML6A and MFHS08.

MCNRRF—contains the number of retros fired. Set by IOMANI, MFLRT1, MFLRT2, or MYSEEK. Used by MFMAN5, MSPASN, MFLED1, MYGEN2, MFCPNI, MPORMC, MFORMC, MPORRE, MYMSCK and MYACQD (to test for re-entry phase).

MCNTRF—contains the total number of retros fired, as reported over subchannels 1 and 2. Set by MFML6A or MFHS08; used by MYSEEK.

MCO3RT—when non-zero, present orbit is the third. Set and used by MPRARF.

MCOLAB—contains the number of words in the TMOLAB table. Used by MYHSOD.

MCORIP—when non-zero, indicates re-entry output computations are in process. Set by MPORMC; used by MPHS09 and MPCCIP; reset by MFORRE.

MCORRE—preset mask for sense output to indicate on the Output Status Console the re-entry phase has been entered (orbit light off, re-entry light on). Used by MYREST for input to MYSENS.

MCPASN—contains the orbital pass number. Preset to 1; maintained by MSPASN; used by MPRARF and MFRARF.

MCPFLD—contains the time of insertion computed by the launch processing programs. Set by MFLHLD; used by MFLORB and MFLED1.

MCPGMT—contains the current time at entry to OOLANA. Set by MPLANA.

MCYPHSE—phase indicator for logging. Originally set for launch; updated by MFLRT1, MFLRT2, MFLABT, MYSEEK, MYREST; used by MFLRT2, MYTTOX and MSLOGG.

MCPNOL—indicates, when zero, a request to print on-line the launch flight parameters. Used by MFLHLD.

MCRAWR—preset mask for sense output to indicate on the Output Status Console that raw AN/FPS-16 radar data is selected for the main launch computations. Used by MPLCCM for input to MYSENS.

MCRCMD—contains an input/output command addressing the restart tape. Used by MYWRRS, MYRRRS, and MYSRST.

MCREC—contains a count of the number of errors corrected by MSRECC.
MCREEN—contains the number of retros fired, as reported by paper tape. Set by IOMANI; used by MFMAN2, MYSEEK and MYREST.

MCRERE—when non-zero, indicates restart in the re-entry phase. Set by MFLORB; used and reset by MYREST.

MCREST—contains the GMT for restart in fixed-point seconds. Set by MTWVV1; used by MSPASN, MFLORB, MYINIT, MYSRST and MYACQD.

MCREW1—contains a rewind instruction addressing the primary message tape. Used by MYMESS.

MCREW2—contains a rewind instruction addressing the auxiliary message tape. Used by MYMESS.

MCRRRS—when non-zero, indicates restart tape being searched; when zero, search completed. Set and used by MYRRRS and MYSRST; used by MTRRRRS and MTSRST.

MCRTSTP—contains the position (record number) or the restart tape, i.e., the number of the next record to be read or written. Set and used by MTWRRS, MTWRS1, MYRRRS and MYSRST.

MCRTB1—contains a read-select instruction addressing the primary message tape. Used by MYMESS and MTMSCK.

MCRTB2—contains a read-select instruction addressing the auxiliary message tape. Used by MYMESS.

MCRTMS—contains the current time at entry to O5ORMC. Set by MPORMC.

MCRTRD—when greater than one, restart tape being read; when one, restart tape read unsuccessfully; when zero, restart tape read successfully. Used by MYREST; set and used by MYRRRS.

MCRVPT—when non-zero, indicates integration from manually-inserted vectors is in process. Set by MYGEN2; used and reset by MFCPNI and MFRARF.

MCS709—when non-zero, indicates subchannel 2 data is selected for main launch computations. Set by I0HS09; used by MFHS09 and MFHS08.

MCSAVE—save location for program when interrupt occurs. Set by M0PRI0 before giving control to any program; used by M0SAVE and M0RTRN.

MCSCER—indicates which (primary or auxiliary) Station Characteristics tape is being processed. Set and used by MYSCRD; set by MTENST.
MC SCHG—sign corresponds to the sign of TM8.3M at the last half-second trap and, if positive, this computer was at that time transmitting externally. Set and maintained by MTHFSC.

MC SDHA—when non-zero, acceptable selected-source data has arrived and has been processed previously. Set by MPLCCM; used by MPLCCM, MFCCGE, MPCCGB, MPCCIP, MFCCRW and MFSTRP.

MC SELM—contains for the main launch processing programs the time interval for extrapolation when input data is bad or missing. Set by MPLCCM.

MC SELS—indicates the selected source for main launch computations: a 1 indicates B-GE data; a 2 indicates raw AN/FPS-16 radar data; a 3 indicates IP 7090-processed Azusa data; a 4 indicates IP 7090-processed AN/FPS-16 data. Set by MFHSGB, MFHSG09, MFHSG08, MPLCCM, MFLRT1, MFLRT2 and MFLHLD. Used by MPCCGB, MPCCIP, MPLCCM and MFLNML.

MC SEN1—contains the time tag for sense output. Generated by MYSENS for MTSENS to use in logging.

MC SEN2—mask used by MYSENS and MTSENS to control subchannel 31 of the DCC.

MC SGEB—when non-zero, B-GE data is selected for main launch computations. Set by MFHSGB; used by MFHSGB.

MC SKPM—when zero, indicates re-entry table generated; when non-zero, impact point generated. Used and set by MPRARF; used and reset by MFCPNL.

MC SRST—when non-zero, restart tape being searched for restart parameters. Reset by MTSRST; used by MFLORB.

MC SSI—when non-zero, selected-source data is being processed by the main launch processing programs. Reset by MFCCGE, MFCCRW, MFSTRP, MPLCCM, MFLRT1, MFLRT2, MFLNML and MFLHLD; used by MPCCGB and MPCCIP.

MC SYSF—when non-zero, indicates edit and differential correction programs have been loaded from the system tape into core storage. Used by MYRSYS.

MC TABT—when non-zero, indicates the high-abort phase has been entered. Set by MFLABT; used by MPHSGB, MPHSG09, MFHSG08, MFMAN2, MFDIFC, MFCPNL, MPRARF, MFRARF and MPLANA.

MC TADL—set non-zero when main launch processors have acquisition data to be sent. Used and reset by MLUPDT.
MC 103

**MCTAL1**—timer set to delay 30 seconds after retrofire before entering the abort phase. Set by MFML6A.

**MCTAL2**—timer set to delay 30 seconds after retrofire before entering the abort phase. Set by MFHS08.

**MCTCFR**—indicates the message tape has been changed to attempt to read a given record. Set by MYMESS; reset by MTMSCK.

**MCTDEL**—contains delta time to enter launch programs after lift-off reported. Preset; used by MFHSGB, MFML6A and MFHS08.

**MCTEL1**—when zero, indicates valid telemetry data received over subchannel 1. Set by IOHSGB; used by MFML6A.

**MCTEL2**—when zero, indicates valid telemetry data received over subchannel 2. Set by IOHS09; used by MFHS08.

**MCTGP1**—contains the time the last acceptable B-GE data was processed by IOHSGB. Set by MFHSGB; used by MPCCGB.

**MCTGP2**—contains the time the last acceptable subchannel 2 data was processed by IOHS09. Set by MFHS09; used by MPCCIP.

**MCTHLD**—when non-zero, the mission has entered the hold phase. Set by MFLHLD; used by MPLCCM; reset by MFLT1, MFLNML, MFLABT and MFLORB.

**MCTLAD**—during the launch phase, when zero, indicates acquisition data being set; when non-zero, acquisition data has been set. Set by MYTTOX; used by MLUPDT; reset by MYTTOX.

**MCTLST**—contains the time tag of manually-inserted vectors or the time tag of the vector produced by differential correction. Set by MFDIFC; used and set by MFLORB.

**MCTLTM**—time tag for entry to main launch computations. Set by MPLCCM.

**MCTMRF**—earlier of the retrofire times reported on subchannels 1 and 2. Set by MFML6A or MFHS08; used by MYSEEK.

**MCTMWT**—contains in fixed-point half seconds the GMT to enter the launch programs: MCHFSC at lift-off plus MCTDEL. Set by MFHSGB, MFML6A, MFHS08; used by MPCCGB or MPCCIP.

**MCTOFS**—manually inserted retrofire time. Set by MFLORB (predicted); set by IOMANI (actual); reset by MYRRRS; used by MFMAN2.
MCTORI—when non-zero, signals the need to check for retrofire information by the launch programs. Set by MFLHLD; used by MFML6A and MFHS08.

MCTPOS—position indicator for the message tape. Set by MTMSCK and MYMSCK; used by MYMESS.

MCTRAP—set non-zero by QENBZ before disable instruction; set to zero by QENBA before enable instruction. When M0SAVE finds MCTRAP non-zero, M0RTRN disables before returning control to the interrupted program.

MCTRFL—contains the time in floating-point seconds of the first retrofire indication received over subchannel 1. Set by I0HSGB; used by MFML6A and MFHS08.

MCTRFS—contains the time in floating-point seconds of the first retrofire indication received over subchannel 2. Set by I0HS09; used by MFML6A.

MCTRTV—contains the time tag for vectors to be printed on-line. Set by MFLABT or MFLORB for input to MYMESS.

MCTSET—contains in the address the number of the file to be loaded from the Mercury System tape; contains a 1 in the decrement if the primary system tape cannot be read and the auxiliary system tape must be used. Set by MYQSYS for MYRSYS; set and used by MYRSYS and MTRSYS.

MCTTVR—contains the time of the vectors used in the last valid orbit table before re-entry. Used by MYREST for input to MYMESS.

MCWCH2—indicates which subchannel 2 data has been processed by I0HS09 (subchannel 2 may provide three different types of data): a 2 specifies raw AN/FPS-16 radar data; a 3 specifies IP 7090-processed Azusa data; a 4 specifies IP 7090-processed AN/FPS-16 data. Set by I0HS09; used by MFHS09, MFHS08, MPCCIP, MFLRT1, MFLRT2 and MFLHLD.

MCWDCT—contains the number of words necessary to complete a manually-inserted message. Set by MFMANI; used by MPTTIN; reset by MFMAN1, MFMAOS, MFMAN2 and MFMAN5.

MCWDIR—when non-zero, re-entry table needed from numerical integration. Used by MFLRT1.

MCWWWV—contains the GMT in fixed-point 8-1/3 milliseconds. Originally set by MTWVI; maintained every minute by MTWWWV; used (to determine whether or not a mission is simulated or actual) by MTWRRS, MTWRS1, MYRRRS and MYRSSST.

MCX4RA—temporary storage of program condition (index register 4, return address) at program interrupt. Set by SAVE macro; used by M0SAVE.
MFZRWX—input control word for numerical integration. Set by MFCPNI for NONCPNI; used by MFCPNI.
9.3 TABLES

The Monitor controlled tables are listed below in alphabetical order:

**TM8MNS**—timing table used by MSTICK to determine when radar stations have exceeded the maximum transmission time.

**TM8.3M**—cell containing the 8-1/3 millisecond counter on subchannel 7.

**TMAGMT**—cell containing the capsule attitude at retrofire. Set by MFMAN2.

**TMALB1, TMALB2**—the two 17-cell logging buffers filled by MSLOGG. When TMALB1 is filled, it is written on the log tape by MYSTLT while MSLOGG fills TMALB2.

**TMAREA**—14-cell table containing the longitude of emergency recovery areas. Used by MFRARF.

**TMBBNI**—15-cell table of input to numerical integration (see Table 6-1). Used by MPCPNL.

**TMBFBK**—temporary storage for Station Characteristics blocks while error correction codes are being removed by MSRECC. Used by MYSCRD.

**TMCHAR**—permanent location of the Station Characteristics blocks for all Mercury stations (see Table 5-1).

**TMCMDA**—table of input/output commands used by the on-line message processors.

**TMCYCL**—five-cell table used as counter and reference table for routines which must be initiated at specified half-second periods (see Figure 3-24).

**TMCYNO**—table of cells for resetting TMCYCL.

**TMDARE**—table of increments of longitude corresponding to ten miles at the recovery areas. Used by MFRARF.

**TMDTBO**—preset cell containing the time increment for obtaining burnout time from time of retrofire. Used by MYSEEK and MYREST.

**TMECT1**—cell containing elapsed capsule time setting at time, T₁.

**TMECT2**—cell containing elapsed capsule time setting at time, T₂.

**TMETRS**—cell containing the setting of the capsule clock; minutes in the address, seconds in the decrement.
**TMFMSK**—12-cell table containing the masks used by TRNOF macro for control of the indicators in the Monitor priority table, TMPRIO.

**TMFRPR**—basic Monitor table (see Table 2-2), contains entries for the Mercury programs in priority order referencing their routine numbers.

**TMGEB1**—seven-cell table containing the time and position and velocity vector components for input to main launch computations. Set by MPLCCM from TMH1DB.

**TMGEDS**—four-cell table of B-GE discrete signals and time tags for input to the main launch computations. Set by MPLCCM from TMH1TM.

**TMGMT1**—cell containing GMT associated with TMECT1.

**TMGMT2**—cell containing GMT associated with TMECT2.

**TMH1DB**—seven-cell table of IOHSGB-processed output from B-GE computer.

**TMH2DB**—seven-cell table of IOHS09-processed output from IP 7090 computer.

**TMH1TM**—four-cell data buffer containing the discrete signals of lift-off, BECO and SECO and all telemetry indications plus the time tag associated with each of the two sets of signals.

**TMH2TM**—two-cell table containing capsule telemetry signal and time tag received on DCC subchannel 2.

**TMHEDP**—seven-cell table of editing parameters used by IOHS09 to edit raw AN/FPS-16 radar data received over subchannel 2 of the DCC.

**TMHRae**—361-cell table containing the AN/FPS-16 radar data received over subchannel 2.

**TMHS09**—input table for high-speed data received on DCC subchannel 2 from Cape Canaveral. Data contains capsule telemetry and either raw AN/FPS-16 radar data or IP 7090-processed AN/FPS-16 or Azusa data.

**TMHS1T**—three-cell table of B-GE telemetry times.

**TMHS2T**—three-cell table of IP 7090 telemetry times.

**TMHSGB**—input table for high-speed data received on DCC subchannel 1 from the Cape Canaveral B-GE computer. Data includes capsule telemetry and B-GE data.

**TMHSLL1**—processing buffer containing TMHSGB and TMXSGB for input to
TMHSL2—processing buffer containing TMHS09 and TMXS09 for input to 10HS09.

TMHSOD—output table for high-speed output on subchannel 3 to drive the Mercury Control Center displays.

TMHSOP—output table for high-speed output on subchannel 4 to drive the Goddard plotboards.

TMIMPP—ten-cell table of impact data used to derive retrofire times.

TMINRT—eight-cell table used to initialize TMRARF.

TMINTV—cell associated with interval timer on DCC subchannel 9.

TMLABF—16-cell table of computed launch acquisition data.

TMLANA—30-cell input table for OOLANA to convert, scale and pack output during launch/abort (see Table 7-1).

TMLDLA—four-cell table of delta longitudes for recovery areas.

TMLLHP—three-cell table containing the computed latitude, longitude and height of perigee.

TMLMPT—four-cell table containing the longitudes of recovery areas.

TMLOUT—four-cell reference table for entrance to the strip chart processors from MPSTRP.

TMLSDB—19-cell table referencing radar input blocks (TMRM01—TMRM19) by internal station number.

TMLSOX—31-cell table containing the packed acquisition data generated by OOLSTY for transmission on subchannel 10.

TMLSOY—31-cell table containing the packed acquisition data generated by OOLSTY for transmission on subchannel 11.

TMMANI—six-cell table of input for 10MANI.

TMMES1—24-cell table containing in card-image format the error message: Message Number Requested Disagrees With One Found—Both Printed Below.

TMMES2—24-cell table containing in card-image format the error message:
Binary Number Printed Below Was Requested But Does Not Exist.

**TMMES3**—24-cell table containing the binary number referred to by TMMES2.

**TMMES5, TMMES6, TMMES7**—tables of constants and conversion factors used by MYMSCK in adding variable fields to messages printed on-line.

**TMMESS**—25-cell table used as temporary storage of message read from tape while MYMSCK checks the message, adds variable fields, and then prints the message.

**TMMRLP**—two-cell table containing the packed data for transmission to Goddard plotboards.

**TMNMSK**—12-cell table containing the masks used by the TRNON macro to control indicator bits in the Monitor priority table, TMPRIO.

**TMNTRF**—three-cell table containing the nominal times for retrofire to terminate one, two or three orbits.

**TMOLAB**—13-cell table containing the packed data for transmission to the Mercury Control Center during the launch/abort phase. This table is the output of OOLANA and is used by MYHSOD.

**TMORMC**—30-cell output table containing the main output computations during orbit and re-entry. This table is output from O5ORMC and input to O0ORRE.

**TMORRE**—30-cell table containing the contents of TMORMC for input to O0ORRE (see Table 7-2).

**TMOX01, TMOY01**—four-cell tables containing input to AOSTAD and OOLSTY for the generation and conversion to teletype format of acquisition data on subchannels 10 and 11, respectively.

**TMPANL**—462-cell table (an 11-cell block for each referenced Mercury program) containing the blocks for saving the computer condition when program interrupted by trap.

**TMPRIO**—basic Monitor table containing priority indicators and entry locations for all Monitor processors and processing programs (see Table 2-1).

**TMPRLG**—five-cell table used by the on-line message programs as input to MSLOGG for logging on-line message prints (see Subsection 8.7.2).

**TMPRNT**—six-cell table used to print on-line the components of the range and the velocity vector used for numerical integration.
**TMQKEY**—basic Monitor table containing count of entries in the queue and the location of the queue for all Monitor processors and processing programs which have input queue tables (see Table 2-4).

**TMQKY2**—basic Monitor table containing the number of maximum entries in the queue table for each Monitor processor and processing program (see Table 2-4).

**TMRARF**—15-cell input table for numerical integration to generate re-entry table.

**TMRDLG**—two-cell table used in logging by on-line message programs when redundancy occurs in reading either or both of the message tapes.

**TMREFR**—basic Monitor table containing the Monitor processors and processing programs in routine number order referencing their locations in the priority table (see Table 2-3).

**TMREST**—31-cell table containing data to be written on or data read from the restart tape (see Table 5-2).

**TMRSCD**—eight-cell table containing the input/output commands used to read or write the restart table (see Subsection 5.21.1).

**TMRST1**—42-cell buffer containing restart data as written on or as read from the restart tape (with error correction codes included). The contents of TMREST are stored into the 2nd through 32nd locations of TMRST1 (see Table 5-2).

**TMRTCC**—reference table for determining the transfer of control by M0RTCC following interrupts produced by the Data Communications Channel (see Table 2-1).

**TMSAVE**—basic Monitor table containing the processing programs and Monitor processors listed in routine number order referencing their save blocks in TMPANL (see Table 2-3).

**TMSSENS**—output cell to drive Output Status Console indicator lights over DCC subchannel 31.

**TMSL0P**—cell containing the relation between the rate of the capsule clock and GMT.

**TMSSEC**—cell containing the computed GMT of retrofire.

**TMSTAD**—16-cell table containing the acquisition data values generated by A0STAD for O0LSTY to convert to teletype format.
TMSTCH—25-cell table containing for Mercury radar and telemetry stations entries which reference their Station Characteristics blocks in TMCHAR.

TMSTMS—15-cell table containing reference data for the differential correction processing program.

TMSYSF, TMSYSR—five-cell table containing message numbers for the messages stating the file requested and the file loaded by MYRSYS and MTRSYS.

TMTPEA—14-cell table containing the times-to-fire for the emergency recovery areas.

TMTI01..., TMTI17—input tables for teletype-format data received on DCC subchannels 14 through 30.

TMTML1, TMTML2—18-cell tables containing the capsule telemetry messages and time tags received over subchannels 1 and 2, respectively.


TMXBOX, TMYBOX—six-cell tables for acquisition data transmitted on DCC subchannels 10 and 11, respectively.

TMXS09—input table for data received on DCC subchannel 2. TMXS09 input is identical to that of TMHS09.

TMXSGB—input table for data received on DCC subchannel 1. TMXSGB input is identical to that of TMHSGB.