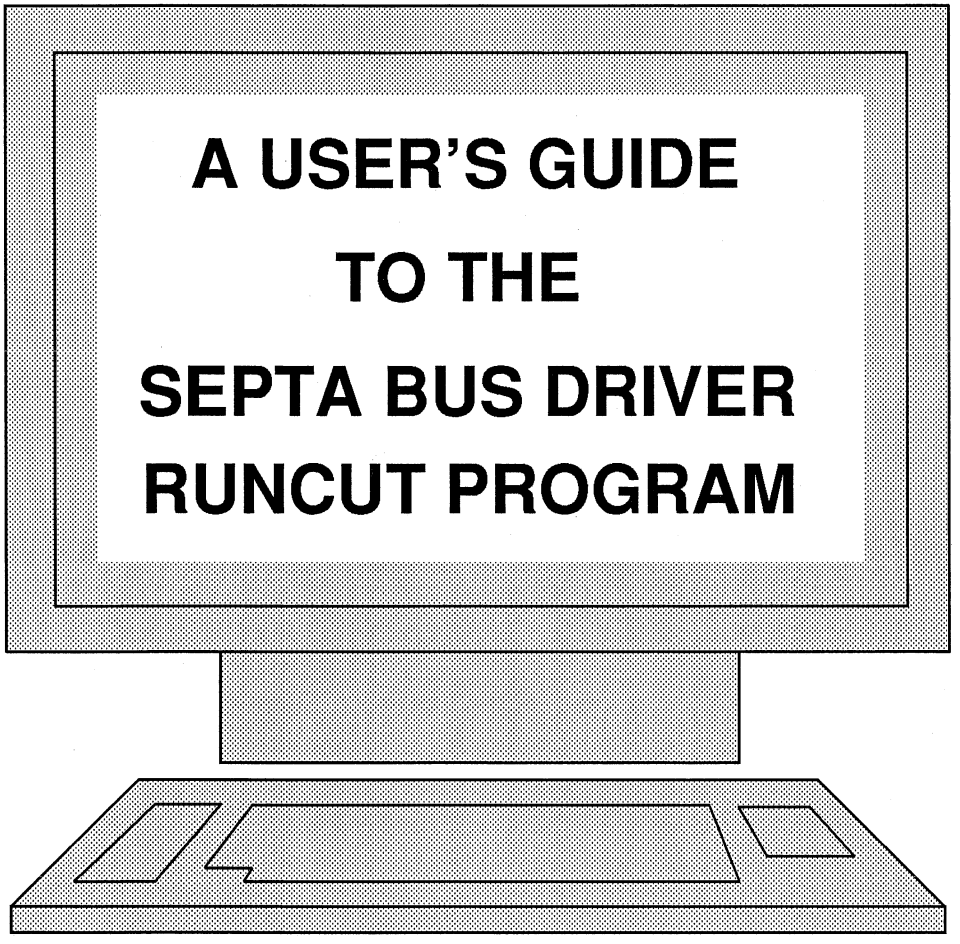
A USER'S GUIDE TO THE SEPTA BUS DRIVER RUNCUT PROGRAM



PREPARED FOR:

SOUTHEASTERN PENNSYLVANIA TRANSPORTATION AUTHORITY

BY

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Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency which provides continuing, comprehensive and coordinated planning for the orderly growth and development of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. The Commission is an advisory agency which divides its planning and service functions among the Office of the Executive Director, the Office of Public Affairs, and four line Divisions: Transportation Planning, Regional Information Services Center, Strategic Planning, and Finance and Administration. DVRPC's mission for the 1980s is to emphasize technical assistance and services and to conduct high priority studies for member state and local governments, while determining and meeting the needs of the private sector.

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DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Publication Abstract

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ABSTRACT

This user's guide was prepared by the Delaware Valley Regional Planning Commission (DVRPC), to assist SEPTA scheduling-making personnel in learning to effectively utilize the runcut computer program created by DVRPC staff under subcontract to SEPTA. The runcut program is quite flexible and can accommodate a wide variety of scheduling approaches through a system of interactive commands and options. This user's guide contains examples that illustrate the most promising of the approaches evaluated in the report "Testing and Evaluating the SEPTA Runcutter" published by DVRPC in October 1987. This report also contains an overview of the entire scheduling-making process and a glossary of schedule-making terms.

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EXECUTIVE SUMMARY

This user's guide was prepared by the Delaware Valley Regional Planning Commission (DVRPC), to assist the SEPTA schedule-making personnel in learning to effectively utilize the runcut computer program created by DVRPC staff under subcontract to SEPTA. The interaction of service requirements, contract provisions, and scheduling practices makes the driver runcutting phase of schedule-making, during which driver work assignments are developed, both complex and crucial to the overall efficiency of SEPTA's operations. The runcut program is quite flexible and can accommodate a wide variety of scheduling approaches through a system of interactive commands and options. The selection of the best way to apply the program for a given depot situation is a valuable skill that must be learned through experience. This user's guide contains three examples that illustrate the most promising of the runcutter usage scenarios evaluated in the report "Testing and Evaluating the SEPTA Runcutter" published by DVRPC in October 1987; manual decision-making, optimal swing run hooking, and schedule improvement. Once a schedule-maker has mastered the use of the runcutter in these three examples, he/she may want to experiment with some of the advanced techniques evaluated in that report. Ultimately, the precise methods used to operate the runcutter will be determined by the schedule-makers themselves, based on their experience and individualized techniques. This user's guide also contains an overview of the entire schedule-making process and a glossary of schedule-making terms in appendices I and II.

INTRODUCTION

The Delaware Valley Regional Planning Commission (DVRPC), as part of its regular Planning Work Program, was requested by the Southeastern Pennsylvania Transportation Authority (SEPTA) to prepare a user's guide to assist the schedule-making personnel in learning to effectively utilize the runcut computer program prepared by DVRPC staff under subcontract to SEPTA. In response to this request this document, which consists of a series of examples that illustrate the use of the runcut program, was prepared.

Schedule-making is a complex operation that involves three basic steps:

1. Determining the amount or frequency of service to be provided for each line, often by hour of the day. The new service level is determined by some combination of policy, ridership counts and/or complaints from the riding public.
2. Given the revised service levels, the bus itineraries or vehicle block must be revised to accommodate the adjusted service frequencies. In addition to service frequencies, this adjustment must take into account bus running times, SEPTA policies, and union contract provisions, particularly required lunch and other layovers.
3. Finally, drivers must be assigned to buses in such a way as to cover the schedule while avoiding penalties and time allowances specified in the union contract. Generally undesirable working conditions such as excessive run spreads and overtime are penalized in this agreement.

The interaction of service requirements, contract provisions, and scheduling practices makes this final driver runcutting phase of schedule-making both complex and crucial to the overall efficiency of the schedule. This final step is the focus of the runcutter computer program. A more detailed description of each step in the scheduling process, together with a glossary of schedule-making terms, is found in appendix II.

Because of its complexity, schedule-making is as much an art as a science. Schedule-makers often develop individualized approaches to runcutting in general, and even tailor techniques to specific garages. For this reason, the runcut program is quite flexible and can accommodate a wide variety of scheduling approaches through a system of interactive commands and options. There are two basic modes of operation within the runcut program, manual and automatic decision-making. Manual decision-making uses the computer to perform all cost calculations, both with regard to the final schedule as well as during manual analysis to improve the schedule and reduce its cost. The computer generates a series of reports which summarize the cost of the schedule and document it, ultimately for driver information, public schedule production, and archival purposes. All decisions about where to cut blocks and how to hook pieces into swing run are made manually.

Automatic decision-making selectively builds upon the manual approach, substituting the power of the computer for time consuming and difficult manual analysis. As of this writing, there are two useful modes of automatic decision-making within the runcut program -- automatic swing hooking and automatic schedule improvement or cost reduction.

Automatic swing run hooking produces swing runs entirely by computer from manually specified pieces. In the process, this almost always produces a hooking solution that is less costly than SEPTA's manual

solution methods. The automatic hooking algorithm does not change the straight runs that were manually input. Its ability to reduce costs, however, makes it an important component of the automatic schedule improvement routines.

Often in runcutting, a rough schedule will be initially produced to be incrementally improved and refined by the schedule-maker. The automatic schedule improvement routines assist in this process by shifting piece and straight run boundaries, creating new runs and rehooking pieces into swing runs. In the process, a significant reduction in total driver hours may occur, depending on the efficiency of the initial schedule. This routine may help to equalize the discrepancy in performance between an outstanding and an average schedule-maker.

There are many different ways to apply the runcutter; the selection of the best way for a given depot situation is a valuable skill that must be built up through experience. This user's guide contains three examples that illustrate the most promising of the methods evaluated in the report "Testing and Evaluating the SEPTA Runcutter" published by DVRPC in October 1987; manual decision-making, optimal swing run hooking, and schedule improvement. Once a schedule-maker has mastered the use of the runcutter in these three examples, he/she may want to experiment with some of the advanced techniques evaluated in that report. Ultimately, the precise methods used to operate the runcutter will be determined by the schedule-makers themselves, based on their experience and individual techniques.

The first command illustrated is the HELP command. The runcutter is self-documenting in that a synopsis of each command and its options is stored in the machine and can be accessed on demand to explore the system or refresh the schedule-maker's memory.

I. THE COMMAND SYNTAX

1.1 Introduction

For someone learning to use the runcut program, the HELP command is by far the most important command in RUCUS II. In many properties using similar versions of the runcutter, the scheduling staff learned to use the program almost entirely through this command.

1.2 Listing the Valid Steps

HELP has two modes of operation. The first, illustrated in Figure 1.1, simply lists the valid runcutter commands, or steps, together with a synopsis of the function of each. In this figure, and all that follow, the command typed by the schedule-maker is indicated by the ====>. The remainder of the figure displays the computer response on a facsimile of the computer screen. By simply typing in HELP and hitting the enter key, this list is generated.

Figure 1.1

```
====> HELP

VALID STEPS:-

   SET         SET UP PARAMETERS
   CONSTRAI    DISPLAY CURRENT VALUES OF CONSTRAINT PARAMETERS.
   FETCH       READ IN DATA FOR RUN CUT - BLOCK DATA AND RELIEF POINT FILE
   DISPLAY     DISPLAY SELECTED INFORMATION FROM BLOCKS.
   RESTORE     READ IN AN EXISTING SOLUTION
   CUT         CUT A STRAIGHT PIECE FROM A BLOCK AS SPECIFIED BY THE USER.
   SPLIT       SPLIT A RUN UP INTO PIECES AS SPECIFIED BY THE USER.
   SCUT        CUT A SPECIAL PIECE FROM A BLOCK AS SPECIFIED BY THE USER.
   UNHOOK      UNHOOK A RUN INTO SEPARATE PIECES
   HOOK        HOOK PIECES TOGETHER TO FORM A RUN.
   JOIN        JOIN SPECIAL PIECES TOGETHER TO FORM A RUN.
   SWITCH      SWITCH TWO RUNS.
   SHIFT       SHIFT AN END POINT OF A RUN.
   UNDO        UNDO A RUN OR RUNS
   RPLIST      LIST RELIEF POINT TRAVEL TIMES
   STRAIGHT    CUT ONE-PIECE STRAIGHTS
   SWINGS      CREATE SWING RUNS FROM REMAINING A.M. AND P.M. PIECES
   LEFTOVER    DISPLAY ANY BLOCK DATA WHICH HAS NOT BEEN ASSIGNED TO A RUN
   SPECIALS    DISPLAY ANY RUNS WHICH ARE INPUT AS SPECIALS
   SHOOK       HOOK SPECIALS DISPLAYED BY SPECIALS COMMAND INTO RUNS
   PROFILE     DISPLAY PROFILE OF BLOCK DATA
   PLOT        DISPLAY PLOT OF CURRENT STATUS OF BLOCKS.
   ETC.
   ETC.
```

1.3 Listing the Command Options

HELP, when followed or delineated by the name of a valid step or command, causes the options associated with that command to be displayed on the screen. Figure 1.2 shows the results when HELP DISPLAY is entered into the computer by the schedule-maker. The left-most entry is the correct spelling of each valid option. The entry following the "=" sign indicates the type of option; "T" or "F" for logical (true, false), numeric for a list of numbers, and a ":" for a time. If HELP is displayed after execution of a scheduling command, the values after the "=" give the current setting of these parameters. Figures 1.3 and 1.4 display two uses of the DISPLAY command's options. DISPLAY LINE 9 ALL causes all block data from line 9 to be displayed on the screen. This is equivalent to DISPLAY LINE 9 ALL T. Logical options are set to true by listing them. Setting to false requires an "F", however.

Figure 1.2

```
====> HELP DISPLAY

  DETAIL    =    F       PRINT IN DETAIL
  SUMMARY   =    F       PRINT A SUMMARY
  PRINTER   =    F       OUTPUT IS TO GO TO PRINTER
  SCREEN    =    F       OUTPUT IS TO GO TO SCREEN
  BLOCK     =        0   BLOCK OR BLOCKS SELECTED
  BLOCKS    =        0   BLOCK NUMBERS TO BE DISPLAYED. E.G. BLOCKS=1,3,5-10,15
  LINES     =        0   SPECIFY LINES TO BE DISPLAYED
  LINE      =        0   SPECIFY LINE TO BE DISPLAYED
  LEFT      =    F       DISPLAY UNASSIGNED WORK ONLY
  ALL       =    F       DISPLAY ASSIGNED AND UNASSIGNED WORK
  ASSIGNED  =    F       DISPLAY ASSIGNED WORK ONLY
  NEAR      =     : 0    DISPLAY NEAREST RELIEF POINTS TO TIME SPECIFIED
  BEFORE    =     : 0    DISPLAY ONLY BLOCKS WHICH BEGIN BEFORE SPECIFIED TIME
  AFTER     =     : 0    DISPLAY ONLY BLOCKS WHICH END AFTER SPECIFIED TIME
?
```

Figure 1.3

```
====> DISPLAY LINE 9 ALL

 BLK/LINE START OF PIECE  RELIEF TIME   RELIEF TIME   RELIEF TIME  END OF PIECE
   5/   9     6:19  AL  |  6:29  FJ  |  6:50  OB+ |  6:59  OB+ |
                        |  7:17  FJ  |  8:16  FJ  |  8:41  OB+ |
                        |  8:56  OB+ |  9:13  FJ  |            |  10:19  AL

   6/   9     6:34  AL  |  6:44  FJ  |  7:06  OB+ |  7:15  OB+ |
                        |  7:33  FJ  |  8:38  FJ  |  9:03  OB+ |
                        |  9:24  OB+ |  9:41  FJ  | 10:43  FJ  |  11:30  AL

   7/   9     6:43  AL* |  6:53  FJ* |  7:16  OB* |  7:21  OB* |
                        |  7:39  FJ* |            |            |   8:46  AL

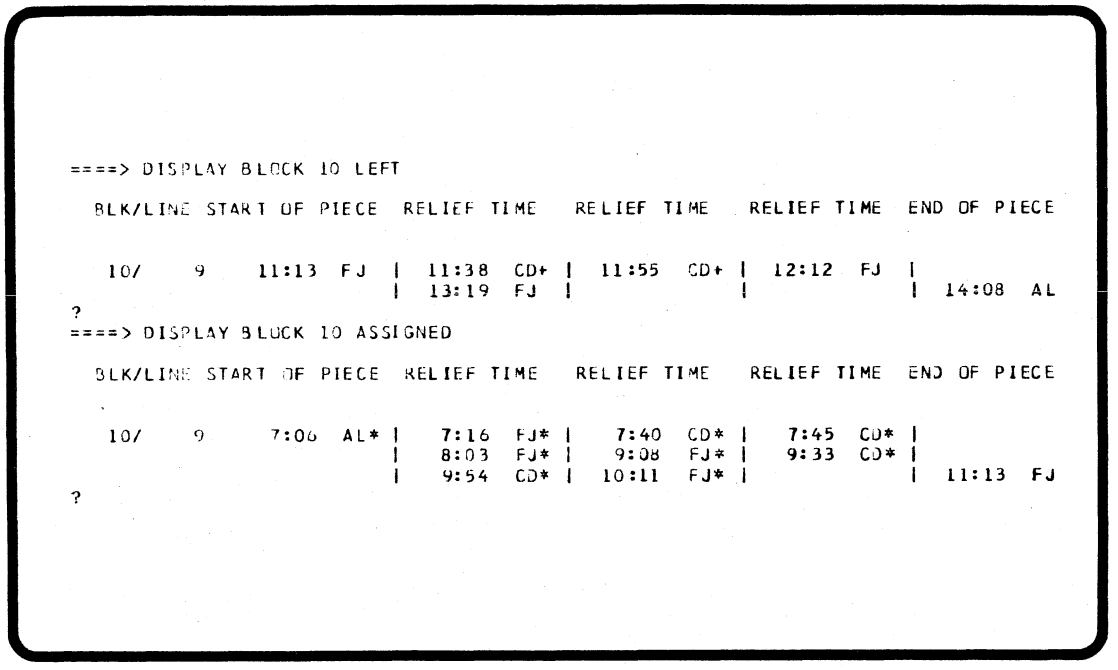
   8/   9     6:54  AL* |  7:04  FJ* |  7:28  OB* |  7:33  OB* |
                        |  7:51  FJ* |  8:58  FJ* |            |   9:45  AL

   9/   9     7:00  AL  |  7:10  FJ  |  7:34  OB+ |  7:39  OB+ |
                        |  7:57  FJ  |            |            |   9:04  AL

  10/   9     7:06  AL* |  7:16  FJ* |  7:40  OB* |  7:45  OB* |
                        |  8:03  FJ* |  9:08  FJ* |  9:33  OB* |
                        |  9:54  OB* | 10:11  FJ* | 11:13  FJ  |
                        | 11:38  OB+ | 11:55  OB+ | 12:12  FJ  |
                        | 13:19  FJ  |            |            |  14:08  AL
ETC.
ETC.
```

The summary that follows is largely self-explanatory. The two-letter code following the time refers to the node name specified in the nodes document of the vehicle scheduler. "AL" refers to Allegheny Depot; "OB" and "FJ" are presumably places along the line. The "+" following the place code delineates a relief layover. If no relief occurs and this layover is eligible, it may be considered a lunch layover. A lunch layover would be designated with an "L" indicating that no relief is possible. Unmarked nodes are simply relief points. If a given portion of a block has been cut, it will be indicated by "*." A list of lines may be substituted for the single number "9". Omitting all selections (DISPLAY ALL) will include all block data resident in the program at that time. Figure 1.4 displays other options available to the display command. One may select [on blocks] and print unassigned (left) or assigned work only.

Figure 1.4



```
====> DISPLAY BLOCK 10 LEFT

  BLK/LINE START OF PIECE  RELIEF TIME   RELIEF TIME   RELIEF TIME  END OF PIECE

   10/    9    11:13  FJ  |  11:38  CD+ |  11:55  CD+ |  12:12  FJ  |
                           |  13:19  FJ  |             |             |  14:08  AL
?
====> DISPLAY BLOCK 10 ASSIGNED

  BLK/LINE START OF PIECE  RELIEF TIME   RELIEF TIME   RELIEF TIME  END OF PIECE

   10/    9     7:06  AL* |   7:16  FJ* |   7:40  CD* |   7:45  CD* |
                           |   8:03  FJ* |   9:08  FJ* |   9:33  CD* |
                           |   9:54  CD* |  10:11  FJ* |             |  11:13  FJ
?
```

Another command generating useful summaries is the REPORT command which prints summaries of runs. Figure 1.5 displays the option list for this command. For instance, "REPORT DETAIL PRINTER" will display all runs in numerical order and send a hard copy of this report to the printer.

Sample summaries selecting a run type, block number, run number and illegal status are given in Figures 1.6, 1.7 and 1.8. These selection criteria are most useful in manually analyzing a developing runcut. This summary is also mostly self-explanatory. The three categories of "ON-OFF" refer to morning, midday and night. Terms such as platform time (PLTFM) are explained in the appendix. If illegal or undesirable, messages to this effect are included in the run listing. These messages may be omitted by setting the FINAL option to true (REPORT FINAL). The other options of these commands perform the functions described in the HELP listing. All other runcutter commands follow this system of commands and options.

Figure 1.5

```
====> HELP REPORT

  DETAIL    =    F       PRINT IN DETAIL
  PRINTER   =    F       OUTPUT IS TO GO TO PRINTER
  SCREEN    =    F       OUTPUT IS TO GO TO SCREEN
  DETAIL    =    F       PRINT IN DETAIL (WITH FLAGS)
  ALL       =    F       PRINT ALL RUNS
  BLOCKS    =        0   BLOCK NUMBERS TO BE DISPLAYED. E.G. BLOCKS=1,3,5-10,15
  BLOCK     =        0   BLOCK OR BLOCKS SELECTED
  RUN       =        0   RUN NUMBER OR NUMBERS SELECTED
  FINAL     =    F       PRINT REPORT WITHOUT WARNING MESSAGES
  AMS       =    F       REPORT ALL AM STRAIGHTS
  LONG      =    F       REPORT ALL LONG STRAIGHTS
  MATINEE   =    F       REPORT ALL MATINEE STRAIGHTS
  PMS       =    F       REPORT ALL PM STRAIGHTS
  OWL       =    T       REPORT ALL OWL STRAIGHTS
  EARLY     =    T       REPORT ALL EARLY SWINGS
  REGULAR   =    F       REPORT ALL REGULAR SWINGS
  LATES     =    F       REPORT ALL LATE SWINGS
  NIGHT     =    F       REPORT ALL NIGHT SWINGS
  AMTRIPP   =    F       REPORT ALL AM TRIPPERS
  MIDDAY    =    F       REPORT ALL MID-DAY TRIPPERS
  PMTRIPP   =    F       REPORT ALL PM TRIPPERS
  FOURDAY   =    F       REPORT ALL 4 DAY RUNS
  STRAIGHT  =    F       REPORT ALL STRAIGHTS
  SWINGS    =    F       REPORT ALL SWINGS
  TRIPPERS  =    F       REPORT ALL TRIPPERS
  ILLEGAL   =    F       REPORT ALL ILLEGAL RUNS
  BEFORE    =     : 0    LATEST TIME TO BE CONSIDERED
  AFTER     =     : 0    EARLIEST TIME TO BE CONSIDERED
```

Figure 1.6

```
====> REPORT TRIPPERS

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
494 *        173|              |               |AS1520  1742CL|   0 |  0 | 3:51
          - TRIPPER NOT GARAGE TO GARAGE

 >> RTES: 911**** PLTFM:  2:22   SPD ALW:   0:00  PAID TVL:  0:12   PAY:  3.9
 >> TIME ON: 15:08   TIME OFF: 17:42

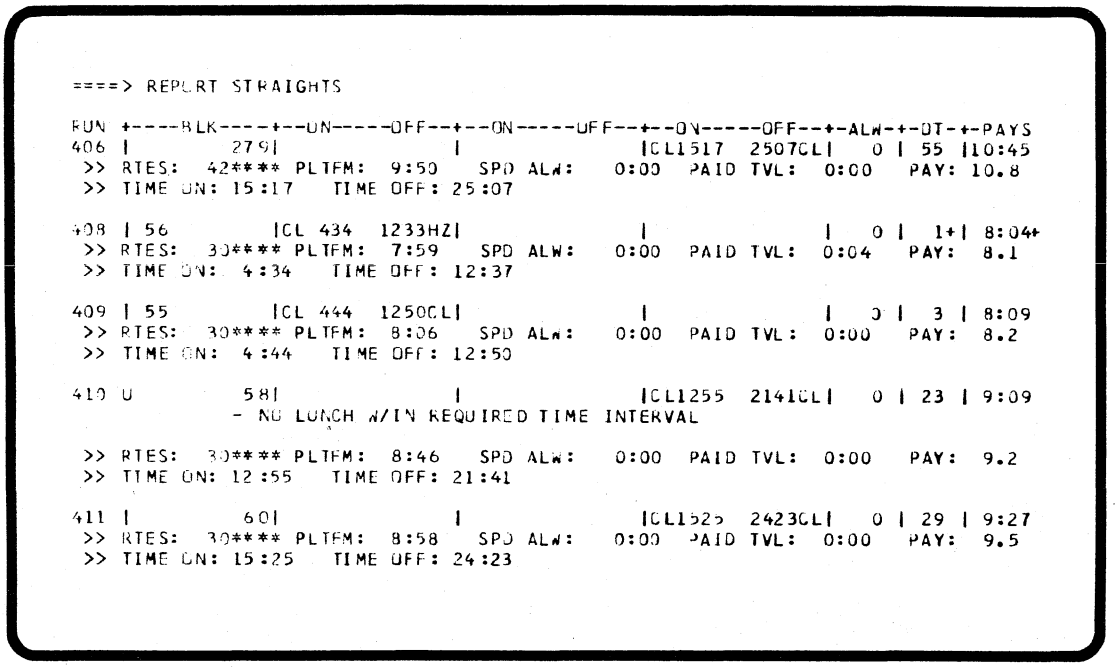
====> REPORT BLOCK 23

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
482 | 23-   - 36|CL 630  1027CL|               |GY1344  1731CL|   0 |  0 | 8:15
 >> RTES:  43  31 PLTFM:  7:44   SPD ALW:   0:31  PAID TVL:  0:00   PAY:  8.3
 >> TIME ON:  6:30   TIME OFF: 17:31

====> REPORT RUN 254

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
254 |149-   - 49|CL 703  1240BZ|               |CL1528  1743CL|   0 |  0 | 8:12
 >> RTES: 852  31 PLTFM:  7:52   SPD ALW:   0:20  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON:  7:03   TIME OFF: 17:43
```

Figure 1.7



```
====> REPORT STRAIGHTS

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
406 |        279|               |               |CL1517  2507CL|   0 | 55 |10:45
 >> RTES:  42**** PLTFM:  9:50   SPD ALW:   0:00  PAID TVL:  0:00   PAY: 10.8
 >> TIME ON: 15:17   TIME OFF: 25:07

408 | 56        |CL 434  1233HZ|               |              |   0 |  1+| 8:04+
 >> RTES:  30**** PLTFM:  7:59   SPD ALW:   0:00  PAID TVL:  0:04   PAY:  8.1
 >> TIME ON:  4:34   TIME OFF: 12:37

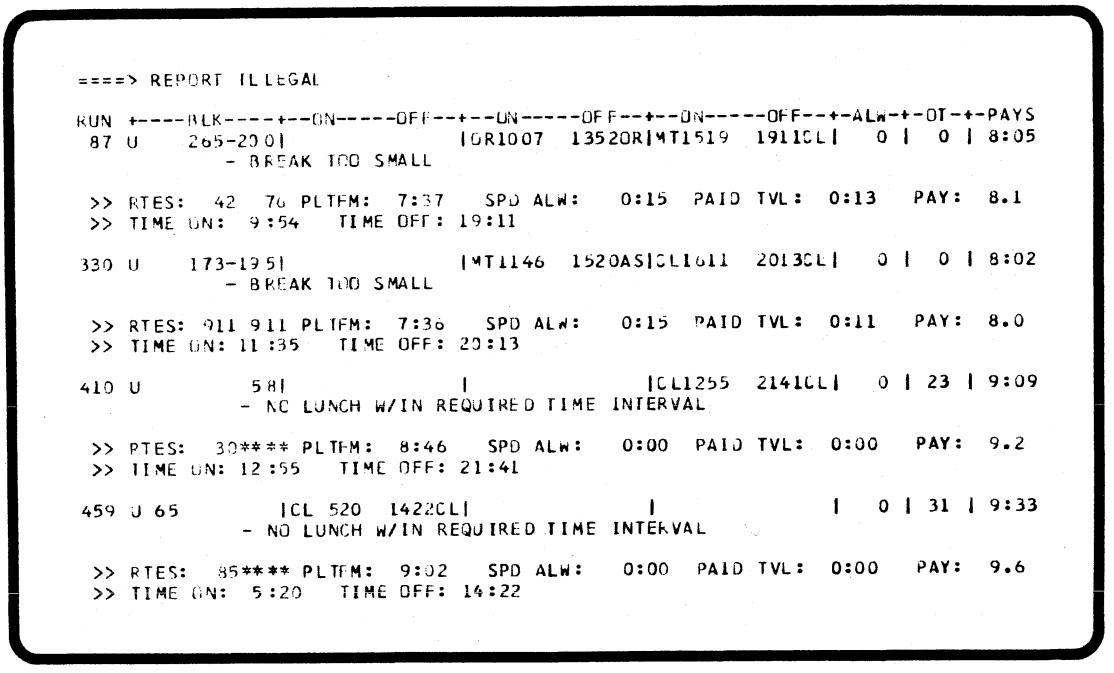
409 | 55        |CL 444  1250CL|               |              |   0 |  3 | 8:09
 >> RTES:  30**** PLTFM:  8:06   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON:  4:44   TIME OFF: 12:50

410 U         58|               |               |CL1255  2141CL|   0 | 23 | 9:09
            - NO LUNCH W/IN REQUIRED TIME INTERVAL

 >> RTES:  30**** PLTFM:  8:46   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  9.2
 >> TIME ON: 12:55   TIME OFF: 21:41

411 |         60|               |               |CL1525  2423CL|   0 | 29 | 9:27
 >> RTES:  30**** PLTFM:  8:58   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  9.5
 >> TIME ON: 15:25   TIME OFF: 24:23
```

Figure 1.8



```
====> REPORT ILLEGAL

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
 87 U    265-2001|               |OR1007  1352OR|MT1519  1911CL|   0 |  0 | 8:05
            - BREAK TOO SMALL

 >> RTES:  42  76 PLTFM:  7:37   SPD ALW:   0:15  PAID TVL:  0:13   PAY:  8.1
 >> TIME ON:  9:54   TIME OFF: 19:11

330 U    173-1951               |MT1146  1520AS|CL1611  2013CL|   0 |  0 | 8:02
            - BREAK TOO SMALL

 >> RTES: 911 911 PLTFM:  7:36   SPD ALW:   0:15  PAID TVL:  0:11   PAY:  8.0
 >> TIME ON: 11:35   TIME OFF: 20:13

410 U         58|               |               |CL1255  2141CL|   0 | 23 | 9:09
            - NO LUNCH W/IN REQUIRED TIME INTERVAL

 >> RTES:  30**** PLTFM:  8:46   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  9.2
 >> TIME ON: 12:55   TIME OFF: 21:41

459 U 65        |CL 520  1422CL|               |              |   0 | 31 | 9:33
            - NO LUNCH W/IN REQUIRED TIME INTERVAL

 >> RTES:  85**** PLTFM:  9:02   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  9.6
 >> TIME ON:  5:20   TIME OFF: 14:22
```

II. MANUAL DECISION-MAKING

2.1 Introduction

The example illustrates the use of the SEPTA runcutter to create a schedule, making all decisions about where to cut blocks and how to hook pieces manually. Runs are costed, documented, and summarized automatically by the computer, saving considerable manual effort. Commands are also included to fine-tune the runcut by switching swing run pieces, splitting and joining pieces and shifting the boundaries of pieces and straight runs. The cost implications of these adjustments are displayed automatically to assist in the fine-tuning process. This is the most common use of the runcut program in other properties.

2.2 Manually Inputting a Runcut

Figures 2.1 through 2.6 illustrate the steps needed to input, cost, document, and summarize a schedule with the runcut program. The first step is to fetch in the block data (2.1). These data must have been previously

Figure 2.1

```
====> FETCH LGRP 9 SER 1
READING DATA FOR LINE GROUP      9 DIVISION    0 SERVICE    1
    33 NEW BLOCKS READ IN FOR A TOTAL OF     33 BLOCKS
?
====> SET DETAIL ON
?
====> SCUT BLOCK 8 AT 654 945

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  1 T  8        |AL 654   945AL|               |               |   0 |  0 | 4:16
 >> RTES:   9**** PLTFM:  2:51   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  4.3
 >> TIME ON:  6:54   TIME OFF:  9:45
?
====> SCUT BLOCK 16 AT 1318 1814
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 T         16|               |               |AL1318  1814AL|   0 |  0 | 7:24
 >> RTES:   9**** PLTFM:  4:56   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  7.4
 >> TIME ON: 13:18   TIME OFF: 18:14
?
====> HOOK RUNS 1 2
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  1 |  8-   - 16|AL 654   945AL|               |AL1318  1814AL|   0 |  0 | 8:37
 >> RTES:   9   9 PLTFM:  7:47   SPD ALW:   0:50  PAID TVL:  0:00   PAY:  8.6
?
```

extracted from the vehicle scheduler program using the EXTBLO command with "LABE" set to "R" and "L". The FETCH command is programmed to automatically bring in both lunch and relief points (nodes), and those labels need not be specified in the runcutter fetch. "SER" refers to the service codes defined in the vehicle scheduler. In this case "1" refers to weekday service. The next step is to "SET DETAIL ON" which, as discussed under command syntax, is equivalent to "SET DETAIL T," and "SET DETAIL." SET is a command which sets the global parameters which apply to all commands, such as DETAIL which prints a detailed run description, or minimum and maximum piece size platform time, etc., for edit purposes. Current settings of these edit parameters may be displayed by typing "CONSTRAI."

Next we input swing run pieces with the SCUT command. This command is equivalent to CUT except that SCUT marks the piece as eligible to be hooked in the automatic hooking procedures. SCUT and CUT both require a block number to be specified. If the entire block is to be cut, or if all remaining work can be cut as a single piece, no time need be specified. A contiguous portion of the block may be specified with "AT" followed by the times at the beginning and ending relief points (see DISPLAY examples under HELP above). Alternately, "NEAR" could be used in place of "AT" if approximate times are known. If a given piece is out of conformance with the current setting of the edit parameters or lunch provisions, a warning message is issued but the work is still cut, unless the time points are incorrect or the block is already cut. The command "UNDO RUN 1" would have eliminated Run 1 in Figure 2.1 if a mistake had been made. The HOOK command then hooks the two runs together to form a swing run. As in the SCUT and CUT command, scheduling practice as defined in the edit parameters are overridden by the manual HOOK command, although appropriate warnings are issued. Similarly,

a second swing run is cut and hooked in Figure 2.2 and straight runs are cut in Figure 2.3. At this point we decide that we want to cross-route with Route 433. So we fetch in the block data (Figure 2.4) and create another swing run.

Figure 2.2

```
====> SCUT BLOCK 10 AT 706 1113
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  3 * 10        |AL 706  1113FJ|              |              |   0 |  0 | 6:51
 >> RTES:   9**** PLTFM:  4:07   SPD ALW:   0:00  PAID TVL:  0:27   PAY:  6.9
 >> TIME ON:  7:06   TIME OFF: 11:40

?
====> SCUT BLOCK 22 AT 1446 1844
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  4 T         22|              |             |AL1446  1844AL|   0 |  0 | 5:57
 >> RTES:   9**** PLTFM:  3:58   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  6.0
 >> TIME ON: 14:46   TIME OFF: 18:44
?
====> HOOK RUNS 3 4
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  3 | 10-   - 22|AL 706  1113FJ|              |AL1446  1844AL|   0 |  2+| 9:15+
 >> RTES:   9   9 PLTFM:  8:05   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  9.3
 >> TIME ON:  7:06   TIME OFF: 18:44
?
```

Figure 2.3

```
====> CUT BLOCK 31 AT 440 1247
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  3 | 31        |AL 440  1247AL|              |              |   0 |  3+| 8:10+
 >> RTES:   9**** PLTFM:  8:07   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON:  4:40   TIME OFF: 12:47
?
====> CUT BLOCK 17
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  5 |         17|              |             |AL1333  2209AL|   0 | 18 | 8:54
 >> RTES:   9**** PLTFM:  8:36   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.9
 >> TIME ON: 13:33   TIME OFF: 22:09
?
====> CUT BLOCK 21
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  6 |         21|              |             |AL1443  2303AL|   0 | 10 | 8:30
 >> RTES:   9**** PLTFM:  8:20   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.5
 >> TIME ON: 14:43   TIME OFF: 23:03
?
```

Figure 2.4

```
====> FETCH LGRP 433
READING DATA FOR LINE GROUP   433 DIVISION   0 SERVICE   1
    16 NEW BLOCKS READ IN FOR A TOTAL OF    49 BLOCKS
?
SCUT BLOCK 7 82
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  7 T  7        |AL 643   846AL|              |              |   0 |  0 | 3:04
 >> RTES:   9**** PLTFM:  2:03   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  3.1
 >> TIME ON:  6:43   TIME OFF:  8:46
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  8 T        82|              |              |AL1212  1741AL|   0 |  0 | 8:13
 >> RTES: 433**** PLTFM:  5:29   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON: 12:12   TIME OFF: 17:41
?
====> REPORT BLOCK 7 82
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  7 T  7        |AL 643   846AL|              |              |   0 |  0 | 3:04
 >> RTES:   9**** PLTFM:  2:03   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  3.1
 >> TIME ON:  6:43   TIME OFF:  8:46
  8 T        82|              |              |AL1212  1741AL|   0 |  0 | 8:13
 >> RTES: 433**** PLTFM:  5:29   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON: 12:12   TIME OFF: 17:41
?
====> HOOK RUNS 7 8
RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  7 |  7-   - 82|AL 643   846AL|              |AL1212  1741AL|   0 |  0 | 8:01
 >> RTES:   9 433 PLTFM:  7:32   SPD ALW:   0:29  PAID TVL:  0:00   PAY:  8.0
 >> TIME ON:  6:43   TIME OFF: 17:41
?
```

Thus far the run numbers have been arbitrary, having been set by the order in which the work was cut. The RENUMBER command (Figure 2.5) allows the schedule-maker to put the runs in the standard sequence for documentation purposes. "FINAL" causes the renumbering to follow the standard SEPTA order of early straights, swings, late straights, etc., by line. "FROM 100" causes the renumbering to start with 100, which is particularly useful if parts of a depot are cut separately.

Finally, we list the renumbered schedule with the REPORT command. If we wanted a hard copy printout of this report for archival purposes, we would type in "REPORT DETAIL PRINTER." Figure 2.6 displays the standard run tally that follows the run report. This is particularly useful for its summary of schedule cost. There are tentative plans to add another option to the REPORT command which would output the runcut in computer readable form to eliminate the key punching step currently in SEPTA scheduling procedures.

Figure 2.5

```
====> RENUMBER FINAL FROM 100
?
====> REPORT DETAIL

RUN +----BLK----+--ON----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
100 | 31         |AL 440  1247AL|             |             |   0 |  3+| 8:10+
 >> RTES:   9**** PLTFM:  8:07   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON:  4:40   TIME OFF: 12:47

101 |  7-   - 82|AL 643   846AL|             |ALL212  1741AL|   0 |  0 | 8:01
 >> RTES:   9 433 PLTFM:  7:32   SPD ALW:   0:29  PAID TVL:  0:00   PAY:  8.0
 >> TIME ON:  6:43   TIME OFF: 17:41

102 |  8-   - 16|AL 654   945AL|             |ALL318  1814AL|   0 |  0 | 8:37
 >> RTES:   9   9 PLTFM:  7:47   SPD ALW:   0:50  PAID TVL:  0:00   PAY:  8.6
 >> TIME ON:  6:54   TIME OFF: 18:14

103 | 10-   - 22|AL 706  1113FJ|             |ALL446  1844AL|   0 |  2+| 9:15+
 >> RTES:   9   9 PLTFM:  8:05   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  9.3
 >> TIME ON:  7:06   TIME OFF: 18:44

104 |         17|             |             |ALL333  2209AL|   0 | 18 | 8:54
 >> RTES:   9**** PLTFM:  8:36   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.9
 >> TIME ON: 13:33   TIME OFF: 22:09

105 |         21|             |             |ALL443  2303AL|   0 | 10 | 8:30
 >> RTES:   9**** PLTFM:  8:20   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.5
 >> TIME ON: 14:43   TIME OFF: 23:03
```

Figure 2.6

```
NO. OF AM STRAIGHTS                1  TOTAL PLATFORM      48:27
NO. OF LONG STRAIGHTS              0  TOTAL ALOW TIME      0:00
NO. OF MATINEE STRAIGHTS           0  TOTAL SPRD BONUS     2:27
NO. OF PM STRAIGHTS                2  TOTAL PAID TRAV.     0:00
NO. OF OWL STRAIGHTS               0  TOTAL OVERTIME       0:34
NO. OF EARLY SWINGS                0  TOTAL REPT/T-IN      1:30
NO. OF REGULAR SWINGS              3  TOTAL STRAIGHTS         3
NO. OF LATE SWINGS                 0  TOTAL SWINGS            3
NO. OF NIGHT SWINGS                0  TOTAL TRIPPERS          0
NO. OF AM TRIPPERS                 0  TOTAL RUNS              6
NO. OF MID-DAY TRIPPERS            0
NO. OF PM TRIPPERS                 0
NO. OF FOUR DAY RUNS               0  TOTAL COST          51:28
```

2.3 Editing a Runcut

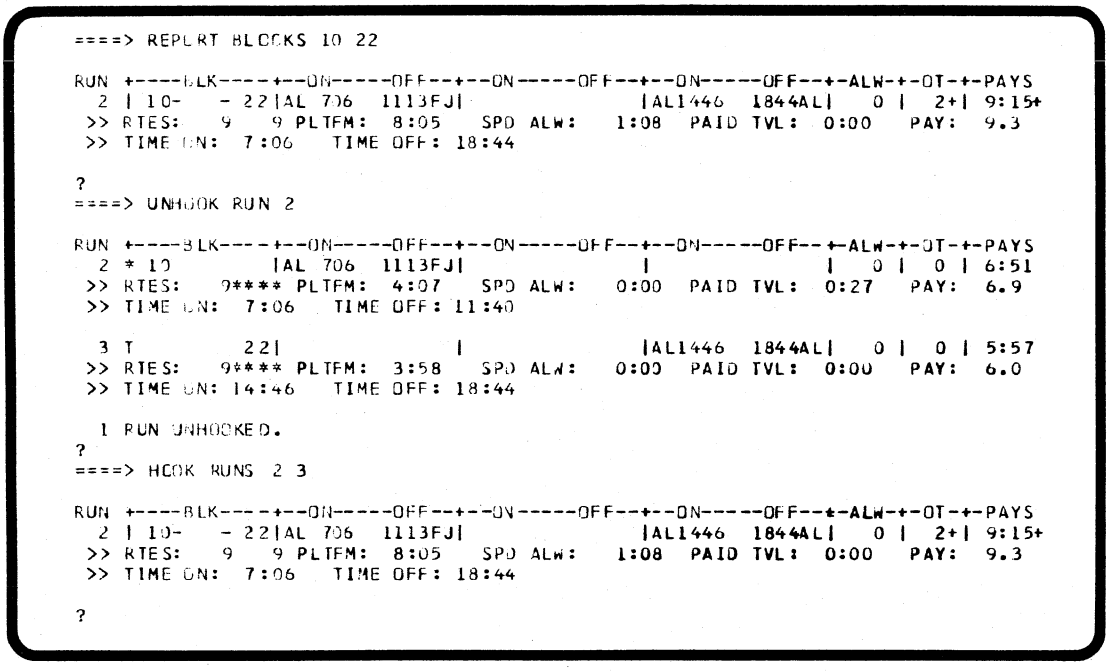
The manual commands of the runcut program also contain facilities to fine-tune a schedule. The use of these commands is illustrated in Figures 2.7 through 2.11. We can selectively report on runs, blocks, illegal status, etc., and UNHOOK (Figure 2.7), switch swing run pieces (Figure 2.8), shift end points of straight runs, pieces, or trippers (Figure 2.9). In this command, "A", "B", "C", and "D" refer to the end points of a swing run (e.g. A - B, C - D), straights, trippers, and unhooked pieces will have only an "A" and "B" point. "BY" refers to the number of relief points to be shifted to the left or right. We can also split a piece into multiple parts with the SPLIT command (Figure 2.10) and join together contiguous pieces in a block (Figure 2.11). In all cases, the cost consequences of an edit change are calculated for summary purposes. Some edit commands such as SHIFT or SWITCH display the change in hours on the terminal screen.

Several other commands are also illustrated in Figure 2.11. NOCHANGE prevents the automatic routines discussed in the next two sections from changing this run. For instance, if a certain swing run is needed, regardless of its cost, manually hooking it and executing the NOCHANGE command will preserve this run through the automatic hooking or schedule improvement routines. The CHANGE command turns off NOCHANGE. The SAVE command must be executed if the run data will be needed in the future for further editing, archival purposes, or combination with other routes. These data are saved under a file name that should be written down for future reference. The RESTORE command, also illustrated, cannot be used without this name.

If there is a possibility of conflicts between the runs being restored and work already in the runcutter, these runs should be undone

prior to the restoration step. It is not necessary to FETCH in block data prior to issuing the RESTORE command. These data are automatically FETCHED if not already in the computer. Finally, the "END" command terminates a runcut session, releasing all computer printouts created during the session.

Figure 2.7



```
====> REPORT BLOCKS 10 22

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 | 10-   - 22|AL 706  1113FJ|              |AL1446  1844AL|   0 |  2+| 9:15+
 >> RTES:   9   9 PLTFM:  8:05   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  9.3
 >> TIME ON:  7:06   TIME OFF: 18:44

?
====> UNHOOK RUN 2

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 * 10        |AL 706  1113FJ|              |              |   0 |  0 | 6:51
 >> RTES:   9**** PLTFM:  4:07   SPD ALW:   0:00  PAID TVL:  0:27   PAY:  6.9
 >> TIME ON:  7:06   TIME OFF: 11:40

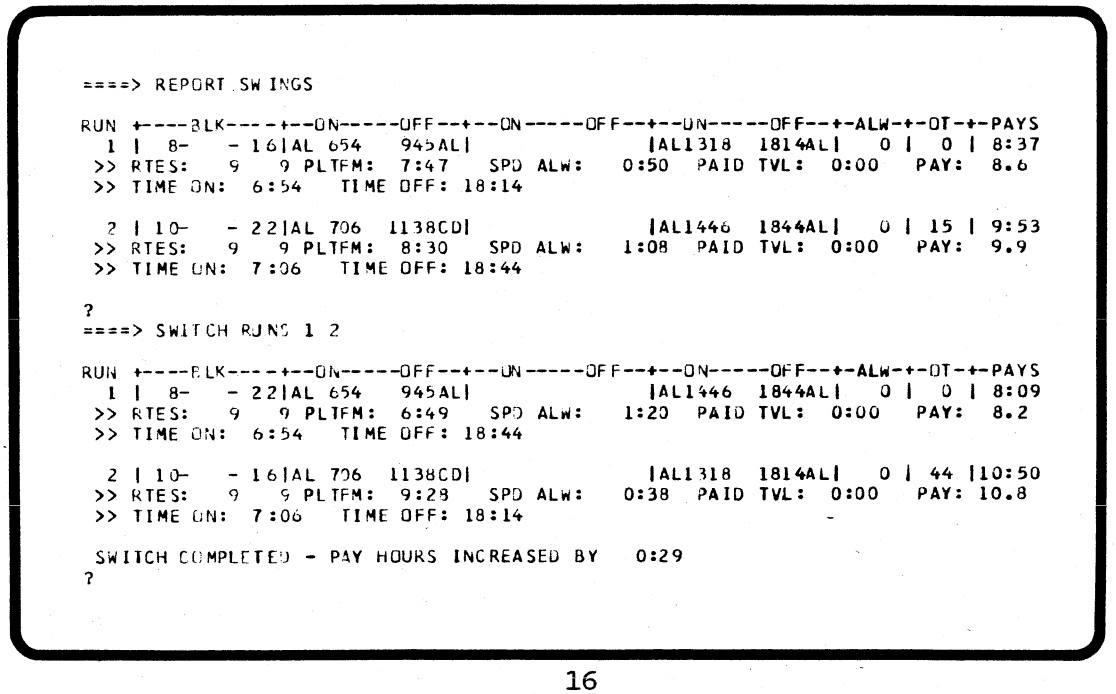
  3 T         22|              |              |AL1446  1844AL|   0 |  0 | 5:57
 >> RTES:   9**** PLTFM:  3:58   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  6.0
 >> TIME ON: 14:46   TIME OFF: 18:44

  1 RUN UNHOOKED.
?
====> HOOK RUNS 2 3

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 | 10-   - 22|AL 706  1113FJ|              |AL1446  1844AL|   0 |  2+| 9:15+
 >> RTES:   9   9 PLTFM:  8:05   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  9.3
 >> TIME ON:  7:06   TIME OFF: 18:44

?
```

Figure 2.8



```
====> REPORT SWINGS

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  1 |  8-   - 16|AL 654   945AL|              |AL1318  1814AL|   0 |  0 | 8:37
 >> RTES:   9   9 PLTFM:  7:47   SPD ALW:   0:50  PAID TVL:  0:00   PAY:  8.6
 >> TIME ON:  6:54   TIME OFF: 18:14

  2 | 10-   - 22|AL 706  1138CD|              |AL1446  1844AL|   0 | 15 | 9:53
 >> RTES:   9   9 PLTFM:  8:30   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  9.9
 >> TIME ON:  7:06   TIME OFF: 18:44

?
====> SWITCH RUNS 1 2

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  1 |  8-   - 22|AL 654   945AL|              |AL1446  1844AL|   0 |  0 | 8:09
 >> RTES:   9   9 PLTFM:  6:49   SPD ALW:   1:20  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON:  6:54   TIME OFF: 18:44

  2 | 10-   - 16|AL 706  1138CD|              |AL1318  1814AL|   0 | 44 |10:50
 >> RTES:   9   9 PLTFM:  9:28   SPD ALW:   0:38  PAID TVL:  0:00   PAY: 10.8
 >> TIME ON:  7:06   TIME OFF: 18:14

 SWITCH COMPLETED - PAY HOURS INCREASED BY   0:29
?
```

Figure 2.9

```
====> SHIFT RUN 2 B LEFT BY 1

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 | 10-    - 22|AL 706  1011FJ|              |AL1446  1844AL|   0 |  0 | 8:11
 >> RTES:    9    9 PLTFM:  7:03   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  8.2
 >> TIME ON:  7:06   TIME OFF: 18:44

 SHIFT COMPLETED - PAY HOURS REDUCED BY   1:04
?
====> SHIFT RUN 2 RIGHT BY 2

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 | 10-    - 22|AL 706  1138CD|              |AL1446  1844AL|   0 | 15 | 9:53
 >> RTES:    9    9 PLTFM:  8:30   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  9.9
 >> TIME ON:  7:06   TIME OFF: 18:44

 SHIFT COMPLETED - PAY HOURS INCREASED BY   1:42
?
====> SHIFT RUN 2 C RIGHT BY 1

 WARNING - SHIFT LEAVES AN UNASSIGNED PIECE
           AT THE END OF THE BLOCK.

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 | 10-    - 22|AL 706  1138CD|              |FJ1552  1844AL|   0 |  0 | 8:32
 >> RTES:    9    9 PLTFM:  7:24   SPD ALW:   1:08  PAID TVL:  0:00   PAY:  8.5
 >> TIME ON:  7:06   TIME OFF: 18:44

 SHIFT COMPLETED - PAY HOURS REDUCED BY   1:21
?
```

Figure 2.10

```
====> DISPLAY BLOCK 21 ALL

  BLK/LINE START OF PIECE  RELIEF TIME   RELIEF TIME   RELIEF TIME  END OF PIECE


   21/    9    14:43  AL* |  15:08  CD* |  15:25  FJ* |  16:42  FJ* |
                         |  17:10  CD* |  17:22  CD* |  17:35  FJ* |
                         |  18:38  FJ* |  18:59  CD* |  19:15  CD* |
                         |  19:27  FJ* |  20:26  FJ* |  20:46  CD* |
                         |  21:15  CD* |  21:27  FJ* |  22:22  FJ* |  23:03  AL
?
====> REPORT BLOCK 21

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  4 |         21|              |              |AL1443  2303AL|   0 | 10 | 8:30
 >> RTES:   9**** PLTFM:  8:20   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  8.5
 >> TIME ON: 14:43   TIME OFF: 23:03

?
====> SPLIT RUN 4 AT 1859

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  4 *         21|              |              |AL1443  1859CD|   0 |  0 | 6:24
 >> RTES:   9**** PLTFM:  4:16   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  6.4
 >> TIME ON: 14:43   TIME OFF: 18:59

  5 *         21|              |              |CD1859  2303AL|   0 |  0 | 6:06
 >> RTES:   9**** PLTFM:  4:04   SPD ALW:   0:00  PAID TVL:  0:00   PAY:  6.1
 >> TIME ON: 18:59   TIME OFF: 23:03

?
```

Figure 2.11

```
====> JOIN RUNS 4 5

RUN +----BLK-----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  4 |         21|              |               |AL1443  2303AL|   0 | 10 | 8:30
 >> RTES:   9**** PLTFM:  8:20   SPD ALW:   0:00   PAID TVL:  0:00   PAY:  8.5
 >> TIME ON: 14:43   TIME OFF: 23:03

?
====> NOCHANGE RUNS 4 5 6
?
====> CHANGE RUNS 4 5 6
?
====> UNDO RUN 1
  1 RUN UNDONE.
?
====> SAVE FILE ANYNAME
?
====> UNDO ALL
  23 RUNS UNDONE.
?
====> RESTORE FILE ANYNAME SER 1
READING DATA FOR LINE GROUP     9 DIVISION   0 SERVICE   1
THE BLOCKDATA FOR LINE GROUP    9 DIVISION   0 SERVICE   1
    HAS ALREADY BEEN READ
?
====> END
 END OF RUNCUT SESSION
 DO YOU WANT TO SAVE RUNS (Y FOR YES)?
====> N
```

III. AUTOMATIC SWING RUN HOOKING

3.1 Introduction

This example illustrates the use of the SEPTA runcutter to accomplish automatic swing run hooking. It takes as input manually derived straight runs and swing run pieces and uses the OPTHOOK command to accomplish all hooking analyses automatically.

3.2 Fetching in the Block Data

The first step in this process, to fetch in the vehicle block data, is illustrated in Figure 3.1. The command line (marked by the ====> symbol) uses the FETCH command to input the block data for Routes 9, 27, 32 (433), 38, 39, 48 and 61. These routes together make up Allegheny Depot. This process will ordinarily be executed for an entire depot. This block data

Figure 3.1

```
====> FETCH LGRP 9 27 32 433 38 39 48 61 SER 1 LABELS K L

READING DATA FOR LINE GROUP      9 DIVISION    0 SERVICE    1
    33 NEW BLOCKS READ IN FOR A TOTAL OF     33 BLOCKS

READING DATA FOR LINE GROUP     27 DIVISION    0 SERVICE    1
    27 NEW BLOCKS READ IN FOR A TOTAL OF     60 BLOCKS

READING DATA FOR LINE GROUP     32 DIVISION    0 SERVICE    1
    24 NEW BLOCKS READ IN FOR A TOTAL OF     84 BLOCKS

READING DATA FOR LINE GROUP     38 DIVISION    0 SERVICE    1
    23 NEW BLOCKS READ IN FOR A TOTAL OF    107 BLOCKS

READING DATA FOR LINE GROUP     39 DIVISION    0 SERVICE    1
     9 NEW BLOCKS READ IN FOR A TOTAL OF    116 BLOCKS

READING DATA FOR LINE GROUP     48 DIVISION    0 SERVICE    1
    38 NEW BLOCKS READ IN FOR A TOTAL OF    154 BLOCKS

READING DATA FOR LINE GROUP     61 DIVISION    0 SERVICE    1
    19 NEW BLOCKS READ IN FOR A TOTAL OF    173 BLOCKS

READING DATA FOR LINE GROUP    433 DIVISION    0 SERVICE    1
    16 NEW BLOCKS READ IN FOR A TOTAL OF    189 BLOCKS
```

must be produced by the vehicle scheduler program and made available through the EXTBLO command prior to executing the Runcut program. All block numbers must be unique within the depot.

Several subcommands or options are illustrated by this example. LGRP specifies the line groups to be fetched. SER specifies that Service 1 (weekday) is to be input and LABELS specifies that check points labeled as relief (R) or lunch (L) in the vehicle scheduler program are to be extracted from the block data. The computer output in Figure 3.1 indicates that the Runcut program has found all of the line groups requested and that a total of 189 blocks are loaded into the program for runcutting.

Figure 3.2 displays the check points and times for block 40 of Route (LGRP) 27. As specified in the FETCH Command, lunch and relief points are included. An "L" designates lunch/non-relief layover. The symbol AL refers to Allegheny Depot.

Figure 3.2

```
====> DISPLAY BLOCK 40 ALL
BLK/LINE START OF PIECE  RELIEF TIME   RELIEF TIME   RELIEF TIME  END OF PIECE

 40/   27     5:25  AL  |   6:15  AE  |   6:59  AE  |   7:56  AE  |
                        |   8:53  AAL |   9:19  AAL |   9:45  AE  |
                        |  10:31  AE  |  10:57  AAL |  11:34  AAL |
                        |  12:00  AE  |  12:53  AE  |  14:00  AE  |
                        |  15:03  AE  |  16:00  AE  |  16:56  AE  |  17:51  AL
```

The display command was used for this summary. "All" tells the program that both scheduled and unscheduled work is to be displayed. Two other useful options relating to work status are ASSIGNED and LEFT (unassigned). If "BLOCK 40" is left out, all blocks are listed. The PRINTER option which directs a copy to the hard copy printer is useful in this case since the number of blocks is large. Following this, the schedule maker will take the hard copy display to his desk and analyze the changes from the previous schedule and make a set of STRAIGHT runs and SWING run pieces. Appendix 2 of the Testing and Evaluation report presents a complete list of command options, or this list may be generated on the tube by typing HELP DISPLAY, (or any other command).

3.3 Manually Cutting Straight Runs and Swing Run Pieces

The next step in this runcutting example is to input the schedule maker's straight runs and swing run pieces. In order to implement noon-to-night, a clear distinction must be made inside the computer between straights and swing run pieces. For this reason two commands have been provided: CUT and SCUT. These commands are identical in their format and options; however, CUT tells the computer that a straight run is being cut and SCUT indicates that it is a swing run piece.

Figure 3.3 illustrates the use of these two commands. CUT BLOCK 40 tells the computer to cut all of block 40 into a run. As indicated in the response, the run created is illegal (run #1) since block 40 contains over 12 platform hours. So we UNDO run 1 and cut the first part (525 to 1253) as a straight run. The term "AT" specifies that the cut point times must exactly correspond to check point times. The afternoon part of BLOCK 40 is a swing run piece. Consequently, SCUT is used. "NEAR 1252 1751" tells the computer to take the relief point times nearest to the cut point times indicated. There-

fore, the computer cut the piece at 1253. An alternative to the NEAR option would be SCUT BLOCK 40 since all remaining work in block 40 is to be cut.

Figure 3.3

```
====> CUT BLOCK 40

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  1 U     40    |              |AL 525  1751AL|              |   0 |213 |14:39
 >> RTES:  27**** PLTFM: 12:26   SPD ALW:   0:00   PAID TVL:  0:00   PAY: 14.7
 >> TIME ON:  5:25   TIME OFF: 17:51

            - PAY TIME TOO LARGE
            - PLATFORM TIME TOO LARGE


====> UNDO RUN  1

   1 RUN UNDONE.


====> CUT BLOCK 40 AT 525 1253

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
  2 | 40        |AL 525  1253AE|              |              |   5 |   0 | 8:00
 >> RTES:  27**** PLTFM:  7:28   SPD ALW:   0:00   PAID TVL:  0:27   PAY:  8.0
 >> TIME ON:  5:25   TIME OFF: 13:20


====> SCUT BLOCK 40 NEAR 1252 1751

RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
236 *       40|              |              |AE1253  1751AL|   0 |   0 | 8:07
 >> RTES:  27**** PLTFM:  4:58   SPD ALW:   0:00   PAID TVL:  0:27   PAY: 8.1
 >> TIME ON: 12:26   TIME OFF: 17:51
```

3.4 Cutting Swing Run Pieces with Streamlined Data Entry Techniques

Since swing run pieces are more numerous than straight runs, considerable benefit in terms of schedule maker productivity is derived from reducing the number of computer commands that must be issued to input swing run pieces. The following two-step procedure, which is executed after the specification of all straight runs with the CUT command, greatly reduces the effort needed to enter swing run pieces into the computer.

The basic method is to make temporary swing runs out of all contiguous leftover pieces after the straights are cut and then subdivide these temporary pieces as needed into the final swing run pieces. Figures 3.4, 3.5 and 3.6 illustrate the use of these runcutter commands. The EXTRAS command, (Figure 3.4) automatically creates the temporary pieces with a single command. Most of these pieces will be in final form; however, some of the pieces created

by EXTRAS must be subdivided to correspond to the manually determined piece boundaries. But before this can be done, the schedule maker must know the temporary run number assigned to this composite piece. A convenient way to obtain this information is to specify the DETAIL and PRINTER options of the EXTRAS command. This produces a hard copy listing of the temporary pieces created. If this is hard copy listing not available, one can proceed block by block, using the block select option of the REPORT command. Figure 3.4 shows the summary for block 96 which at present consists of one temporary run, numbered 302.

Figure 3.4

```
====> EXTRAS DETAIL PRINTER

RUN +---BLK---+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS

302 U     96    |              |AL 610  1644AL|              |   0 |117 |11:51
 >> RTES:  32**** PLTFM: 10:34   SPD ALW:   0:00  PAID TVL:  0:00   PAY: 11.9
 >> TIME ON:  6:10   TIME OFF: 16:44

303 *       15E|              |              |TZ1254  1701AL|   0 |  0 | 6:37
 >> RTES:  39**** PLTFM:  4:07   SPD ALW:   0:00  PAID TVL:  0:18   PAY:  6.6
 >> TIME ON: 12:36   TIME OFF: 17:01

319 *       40|              |              |AE1253  1751AL|   0 |  0 | 8:07
 >> RTES:  27**** PLTFM:  4:58   SPD ALW:   0:00  PAID TVL:  0:27   PAY:  8.1
 >> TIME ON: 12:26   TIME OFF: 17:51

 ETC.


====> REPORT BLOCK 96

RUN +---BLK---+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
302 U     96    |              |AL 610  1644AL|              |   0 |117 |11:51
            - PAY TIME TOO LARGE
            - PLATFORM TIME TOO LARGE

 >> RTES:  32**** PLTFM: 10:34   SPD ALW:   0:00  PAID TVL:  0:00   PAY: 11.9
 >> TIME ON:  6:10   TIME OFF: 16:44
```

The subdivision of the temporary swing run pieces is carried out with the SPLIT command illustrated in Figure 3.5. In this example temporary run 302 is split into three pieces by dividing at 1037 and 1359 in the process, creating the three swing run pieces specified by the schedule maker. As in CUT and SCUT, one can specify cut point times with NEAR as well as AT.

The JOIN command undoes the SPLIT command if a mistake has been made. In Figure 3.6 run 303 has been erroneously split near 1600 creating pieces 303 and 385. JOIN RUNS 303 385 puts the work back into its original form.

Figure 3.5

```
====> SPLIT RUN 302 AT 1037 1359

 RUN +---BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
 302 * 96        |AL 61C  1037OD|              |              |   0 |  0 | 6:49
  >> RTES:  32**** PLTFM:  4:27   SPD ALW:   0:00  PAID TVL:  0:06   PAY:  6.8
  >> TIME ON:  6:10   TIME OFF: 10:43

 385 *     96    |              |CD1037  1359CI|              |   0 |  0 | 5:24
  >> RTES:  32**** PLTFM:  3:22   SPD ALW:   0:00  PAID TVL:  0:14   PAY:  5.4
  >> TIME ON: 10:31   TIME OFF: 14:07

 386 *         96|              |              |OI1359  1644AL|   0 |  0 | 4:19
  >> RTES:  32**** PLTFM:  2:45   SPD ALW:   0:00  PAID TVL:  0:08   PAY:  4.3
  >> TIME ON: 13:51   TIME OFF: 16:44
```

Figure 3.6

```
====> SPLIT RUN 303 NEAR 1600

 RUN +---BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
 303 *       158|              |              |TZ1254  1542TZ|   0 |  0 | 5:09
  >> RTES:  39**** PLTFM:  2:48   SPD ALW:   0:00  PAID TVL:  0:38   PAY:  5.2
  >> TIME ON: 12:36   TIME OFF: 16:02

 385 *       158|              |              |TZ1542  1701AL|   0 |  0 | 2:25
  >> RTES:  39**** PLTFM:  1:19   SPD ALW:   0:00  PAID TVL:  0:18   PAY:  2.4
  >> TIME ON: 15:24   TIME OFF: 17:01



====> JOIN RUNS 303 385

  THE NEW RUN IS ILLEGAL FOR THE FOLLOWING REASONS
            - TRIPPER NOT GARAGE TO GARAGE


 RUN +----BLK----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
 303 *       158|              |              |TZ1254  1701AL|   0 |  0 | 6:37
  >> RTES:  39**** PLTFM:  4:07   SPD ALW:   0:00  PAID TVL:  0:18   PAY:  6.6
  >> TIME ON: 12:36   TIME OFF: 17:01
```

3.5 Automatic Optimal Swing Run Hooking

This section illustrates automatic swing run hooking with the OPTHOOK command. This command replaces all manual swing run hooking analysis and in the process produces significant pay hour savings over manual analyses.

The first step is to determine a dividing time (the NOON parameter) that balances the AM and PM pieces for purpose of noon-to-night. This can be done manually by analyzing the results of detailed listing produced by the SPECIALS command (Figure 3.7). However, it is usually more convenient to run the SPECIALS command with detail off in a trial and error fashion. This is illustrated in Figure 3.8. In this example SPECIALS with NOON set at 1100 counts 86 AM and 92 PM pieces while NOON set at 1115 produces a balanced configuration with 89 AM and PM pieces.

Figure 3.7

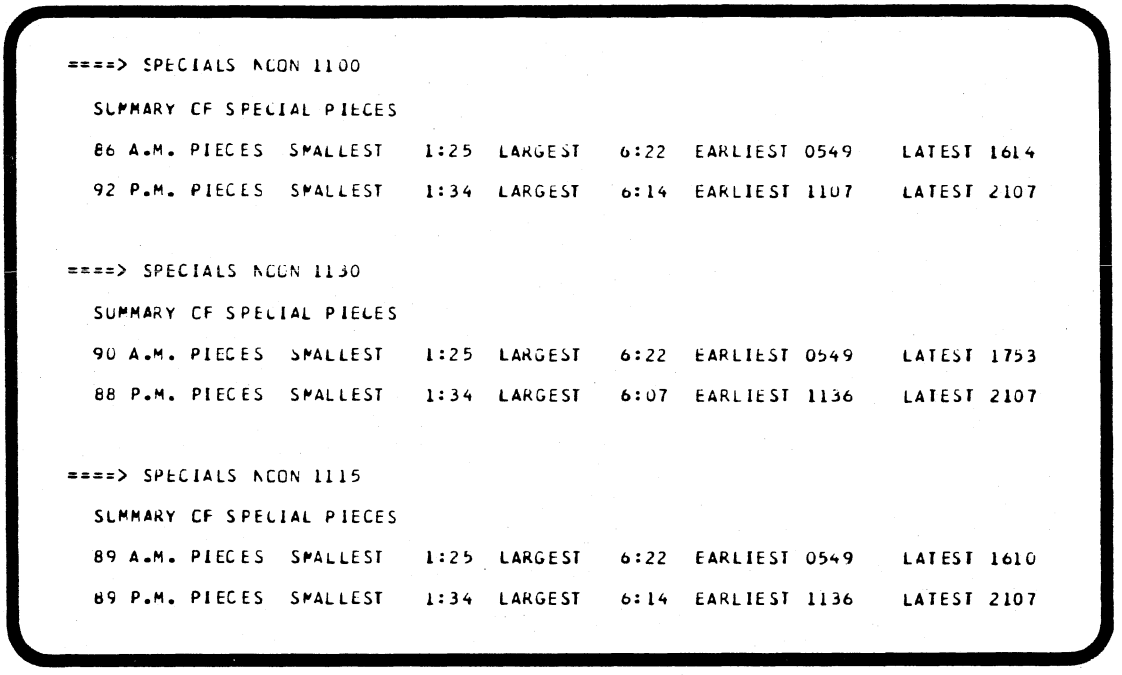
```
====> SPECIALS DETAIL PRINTER

                    LISTING OF SPECIAL PIECES
     ********** AM **********          ********** PM **********
      ON   BLOCK/RUN  OFF     PLAT          ON   BLOCK/RUN  OFF     PLAT
 ---------------------------------   ---------------------------------

    0557     42/270  1026      4:29    RP 1254    158/303  1701      4:07
    0610     96/302  1644     10:34       1212     82/315  1741      5:29
 HOOKING WOULD CAUSE AN OVERLAP OF PIECES IN
 THE NEW RUN.
    0621     98/299  1614      9:53    RP 1253     40/319  1751      4:58
 HOOKING WOULD CAUSE AN OVERLAP OF PIECES IN
 THE NEW RUN.
    0624    211/297  1504      8:40    RP 1439    138/320  1753      3:14
 HOOKING WOULD CAUSE AN OVERLAP OF PIECES IN
 THE NEW RUN.
    0626     48/253  0932      3:06       1508    227/379  1742  RP  2:34
 WARNING - CREATED RUN VIOLATES THE CONTRACT.
 THE NEW RUN IS ILLEGAL FOR THE FOLLOWING REASONS
           - PAY TIME TOO SMALL
           - PLATFORM TIME TOO SMALL

 ETC.
 ETC.
```

Figure 3.8



With the noon parameter SET, the OPTHOOK command matches AM and PM pieces in a minimum cost fashion. The use of this command is illustrated in Figures 3.9 through 3.11. The OPTHOOK command is conversational in format in that it asks the schedule maker to monitor the results and take appropriate action, given the number of trippers created. In this example, however, we match only AM with PM swing run pieces.

The OPTHOOK command is initiated by typing in OPTHOOK NOON 1115. If NOON is omitted it defaults to 1200. In this example the default value would force trippers because of the imbalance in AM and PM pieces. Following this, the program requests the maximum number of ARCS (hooks) from each piece. This value should always be 10 unless excessive computation times result. Small values compute faster but produce less cost-effective solutions. Following this the runcut statistics are printed -- in this case large pay hours because swing runs have not yet been hooked. Moving on to Figure 3.10, the computer

Figure 3.9

```
====> OPTHOOK  NCON 1115

OPTHOOK: VERSION I

ENTER MAXIMUM # OF ARCS FOR EACH NODE (PIECE) IN THE
SWITCHING NETWORK (RANGE FROM 1 TO 10):

====> 10

MAXIMUM # OF SWITCHING ARCS      =   10

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              32   TOTAL PLATFORM    1173:05
          NO. OF LONG STRAIGHTS             0   TOTAL ALOW TIME     42:14
          NO. OF MATINEE STRAIGHTS          0   TOTAL SPRD BONUS     0:00
          NO. OF PM STRAIGHTS              38   TOTAL PAID TRAV.    22:48
          NO. OF OWL STRAIGHTS              0   TOTAL OVERTIME      17:25
          NO. OF EARLY SWINGS               0   TOTAL REPT/T-IN     58:45
          NO. OF REGULAR SWINGS             0   TOTAL STRAIGHTS        76
          NO. OF LATE SWINGS                0   TOTAL SWINGS            0
          NO. OF NIGHT SWINGS               0   TOTAL TRIPPERS        159
          NO. OF AM TRIPPERS               64   TOTAL RUNS             76
          NO. OF MID-DAY TRIPPERS          21
          NO. OF PM TRIPPERS               74
          NO. OF FOUR DAY RUNS              0   TOTAL COST        1552:35
```

Figure 3.10

```
DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)

====> YES

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =   0:0


TRIPPER PENALTY PARAMETER =   0:0

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)

====> NO

DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)

====> NO
```

asks if the OPTHOOK step should be executed, a no response here would terminate the OPTHOOK prior to hooking. Next, the computer asks if a tripper penalty is needed or if swing run piece boundaries should be examined for cost savings (the SHIFTER). In this example we answer no to both questions. Figure 3.11 displays the results of the hooking analyses. Eighty-nine swing runs have been created without changing the straight runs with a total cost of 1,257.2 pay hours in about 12 minutes computing time on the PC computer. The cost of the manual hooks for this depot was 1,262.7 hours, some 5.5 hours more expensive.

Figure 3.11

```
NODES=    178     EDGES=   1594
HOOKING PASS NO.      1 COMPLETED
PAY TIME SAVED THIS PASS  295:24,   89 CHANGES MADE THIS PASS

OPTHOOK: VERSION 1

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS          26   TOTAL PLATFORM   1173:05
          NO. OF LONG STRAIGHTS         0   TOTAL ALOW TIME     9:07
          NO. OF MATINEE STRAIGHTS      2   TOTAL SPRD BONUS   45:43+
          NO. OF PM STRAIGHTS          29   TOTAL PAID TRAV.    7:32
          NO. OF OWL STRAIGHTS          0   TOTAL OVERTIME     21:43+
          NO. OF EARLY SWINGS           3   TOTAL REPT/T-IN    36:30
          NO. OF REGULAR SWINGS        67   TOTAL STRAIGHTS       57
          NO. OF LATE SWINGS           18   TOTAL SWINGS          89
          NO. OF NIGHT SWINGS           1   TOTAL TRIPPERS         0
          NO. OF AM TRIPPERS            0   TOTAL RUNS           146
          NO. OF MID-DAY TRIPPERS       0
          NO. OF PM TRIPPERS            0
          NO. OF FOUR DAY RUNS          0   TOTAL COST       1257:11

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)

====> NO
```

Finally, the computer asks if we want to re-execute the OPTHOOK step. We answer no since the solution presented is satisfactory. If trippers had resulted we might have wanted to try a non zero tripper penalty to eliminate them. The OPTHOOK automatically renumbers the runs created into the standard SEPTA sequence and so the schedule is now complete.

3.6 Tripper Elimination Methods

In the previous Allegheny Depot example, the initial execution of the optimal hooking routine produced a solution that was both efficient in terms of total pay hours required and consistent with the noon-to-night scheduling practice. However, this hooking algorithm will sometimes produce solutions with trippers for one of three reasons:

1. The schedule requires fewer pay hours and/or runs with trippers included, given the straight runs and pieces input.
2. There was an odd number of swing run pieces forcing a tripper.
3. There was no cost-effective way to hook the AM and PM pieces given the extreme interpretation (depot-wide rather than by line) of noon-to-night included in the automatic hooking algorithm.

The third reason results from programming conventions in the automatic algorithm. Noon-to-night is incorporated at the depot level. That is, no run that starts after 8:00 AM in the entire depot will finish before a run that starts before 8:00 AM. This interpretation is more extreme than the current scheduling practice which imposes noon-to-night at the route level, ignoring violations involving only a few minutes. Optional provisions are included in the OPTHOOK command to deal with these situations.

The following example illustrates the use of the TRIPPER penalty. Succeeding examples illustrate the use of the ALLSWING option and the piece boundary shifter.

3.6.1 The Tripper Penalty

The TRIPPER penalty is embedded in the conversational portion of the OPTHOOK command. This penalty increases the cost (pay hours) of trippers above the value implicit in the union contract and in that way encourages

the minimum cost algorithm to eliminate trippers in one of two ways:

1. Create additional swing runs.

2. Create additional straight runs and rehook remaining swing runs.

The example, given in Figures 3.12-3.19, shows the value of the tripper penalty is increased incrementally by the schedule maker and the hooking algorithm reexecuted until the tripper disappears. Figure 3.12 displays the results of the AM/PM piece analysis for an alternate set of swing run pieces and straight runs for the Allegheny Depot. Since there is an odd number of pieces (165), it is impossible to solve this problem without a tripper. A NOON setting of 1110 puts the odd tripper into the PM part of the schedule which, for purposes of this example, is taken as more desirable from the point of view of garage operations and OPTHOOK is run with a NOON setting of 1110. The results of the first pass through OPTHOOK are shown in Figures 3.13 and 3.14.

Figure 3.12

```
====>SPECIALS NOON 1115

 SUMMARY OF SPECIAL PIECES

  83 A.M. PIECES  SMALLEST   1:25  LARGEST   6:26  EARLIEST 0549    LATEST

  82 P.M. PIECES  SMALLEST   1:34  LARGEST   6:07  EARLIEST 1136    LATEST
?
====>SPECIALS NOON 1110

 SUMMARY OF SPECIAL PIECES

  82 A.M. PIECES  SMALLEST   1:25  LARGEST   6:26  EARLIEST 0549    LATEST 1614

  83 P.M. PIECES  SMALLEST   1:34  LARGEST   6:07  EARLIEST 1112    LATEST 2107
?
====>OPTHOOK NOON 1110

OPTHOOK: VERSION 1

ENTER MAXIMUM # OF ARCS FOR EACH NODE (PIECE) IN THE
SWITCHING NETWORK (RANGE FROM 1 TO 10):
====>10

MAXIMUM # OF SWITCHING ARCS     =   10
```

Figure 3.13

```
RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              36  TOTAL PLATFORM   1173:05
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME    45:19
          NO. OF MATINEE STRAIGHTS          7  TOTAL SPRD BONUS    0:00
          NO. OF PM STRAIGHTS              39  TOTAL PAID TRAV.   19:50
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME     19:42+
          NO. OF EARLY SWINGS               0  TOTAL REPT/T-IN    56:45
          NO. OF REGULAR SWINGS             0  TOTAL STRAIGHTS       82
          NO. OF LATE SWINGS                0  TOTAL SWINGS           0
          NO. OF NIGHT SWINGS               0  TOTAL TRIPPERS       145
          NO. OF AM TRIPPERS               60  TOTAL RUNS            82
          NO. OF MID-DAY TRIPPERS          14
          NO. OF PM TRIPPERS               71
          NO. OF FOUR DAY RUNS              0  TOTAL COST       1528:48+

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =   0:0

TRIPPER PENALTY PARAMETER =  0:0

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>NO
```

Figure 3.14

```
DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>NO

 NODES=    105     EDGES=   1478
 HOOKING PASS NO.     1 COMPLETED
 PAY TIME SAVED THIS PASS  533:29,   82 CHANGES MADE THIS PASS

OPTHOOK: VERSION I

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              27  TOTAL PLATFORM   1173:05
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME     8:11+
          NO. OF MATINEE STRAIGHTS          4  TOTAL SPRD BONUS   46:22
          NO. OF PM STRAIGHTS              31  TOTAL PAID TRAV.    6:58
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME     26:29+
          NO. OF EARLY SWINGS               1  TOTAL REPT/T-IN    36:15
          NO. OF REGULAR SWINGS            68  TOTAL STRAIGHTS       62
          NO. OF LATE SWINGS               13  TOTAL SWINGS          82
          NO. OF NIGHT SWINGS               0  TOTAL TRIPPERS        1
          NO. OF AM TRIPPERS                0  TOTAL RUNS          144
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                1
          NO. OF FOUR DAY RUNS              0  TOTAL COST       1262:04

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES
```

The initial runcut statistics (Figure 3.13) show that no hooks are in place. A tripper penalty of 0:00 is applied and the resulting schedule (Figure 3.14) shows, as expected, one PM tripper. OPTHOOK then asks if we want to re-execute the step. We do. But since the solution is attractive we first exit OPTHOOK, examine the tripper with the report command (Figure 3.15) and check for illegal runs. Since everything is legal, we save it as ALGHOK1 (or any unused name containing up to eight characters), reentering the OPTHOOK routine by typing OPTHOOK NOON 1110 as before.

Figure 3.15

```
====>REPORT TRIPPERS DETAIL

RUN +----BLK----+--ON----OFF--+--ON----OFF--+--ON----OFF--+-ALW-+-OT-+-PAYS
175 T        1991|             |             |ALl542  1907ALl   0 |  0 | 5:07
 >> RTES:  48**** PLTFM:  3:25   SPD ALw:   0:00  PAID TVL:  0:00   PAY:  5.1
 >> TIME ON: 15:42   TIME OFF: 19:07
?
====>REPORT ILLEGAL DETAIL
?
====>SAVE FILE ALGHOK1
?
====>OPTHOOK NOON 1110

OPTHOOK: VERSION I

ENTER MAXIMUM # OF ARCS FOR EACH NODE (PIECE) IN THE
SWITCHING NETWORK (RANGE FROM 1 TO 10):
====>10

MAXIMUM # OF SWITCHING ARCS     =    10

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              27  TOTAL PLATFORM   1173:05
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME     8:11+
          NO. OF MATINEE STRAIGHTS          4  TOTAL SPRD BONUS   46:22
          ETC.
          ETC.
          NO. OF PM TRIPPERS                1
          NO. OF FOUR DAY RUNS              0  TOTAL COST       1262:04
```

The second iteration (Figure 3.16) is somewhat different in that the hooks created in the first execution still exist. This difference brings up the possibility of a spread equalization penalty. This penalty tries to standardize spread as much as possible, penalizing swing runs with less than average and greater than average spread. The principal effect of this penalty is to increase total pay hours while making only marginal improvement in the distribution of swing run spreads. It is recommended that a

Figure 3.16

```
ENTER THE NUMBER OF HOOKS PER RUN WILLING
TO PAY TO EQUALIZE SPREAD FOR SWING RUNS
IN FORM   HH:MM
====>0:00

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =  0: 0

TRIPPER PENALTY PARAMETER =  0: 0

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>YES

ENTER TRIPPER PENALTY IN FORM HH:MM
====>0:30

DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>NO

 NODES=    165     EDGES=   1553
 HOOKING PASS NO.     2 COMPLETED
 PAY TIME SAVED THIS PASS    1:03,   28 CHANGES MADE THIS PASS
```

value 0:00 be always input to deactivate this option. Next, the program asks if a tripper penalty other than zero should be used. We answer yes, and put in 0:30 or one-half pay hour penalty per tripper. The resulting schedule is shown in Figure 3.17. Since a tripper is still present,we must

Figure 3.17

```
OPTHOOK: VERSION I

RUNOUT STATISTICS:

          NO. OF AM STRAIGHTS              27  TOTAL PLATFORM    1173:05
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME      8:38
          NO. OF MATINEE STRAIGHTS          4  TOTAL SPRD BONUS    45:31
          NO. OF PM STRAIGHTS              31  TOTAL PAID TRAV.     6:58
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME      26:22+
          NO. OF EARLY SWINGS               1  TOTAL REPT/T-IN     36:15
          NO. OF REGULAR SWINGS            68  TOTAL STRAIGHTS        62
          NO. OF LATE SWINGS               13  TOTAL SWINGS           82
          NO. OF NIGHT SWINGS               0  TOTAL TRIPPERS          1
          NO. OF AM TRIPPERS                0  TOTAL RUNS            144
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                1
          NO. OF FOUR DAY RUNS              0  TOTAL COST        1261:32+

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES
```

increase the tripper penalty and try again. In Figure 3.18 we increase the tripper penalty to 10:00, or ten hours per tripper, and this has the result (Figure 3.19) of eliminating the tripper by making an additional straight run, which also results in an increased cost of about three-fourths of a pay hour and one additional run.

Figure 3.18

```
ENTER THE NUMBER OF HOURS PER RUN WILLING
TO PAY TO EQUALIZE SPREAD FOR SWING RUNS
IN FORM   HH:MM
====>0:00

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =  0: 0

TRIPPER PENALTY PARAMETER =  0:30

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>YES

ENTER TRIPPER PENALTY IN FORM HH:MM
====>10:00


DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>NO


 NODES=    165     EDGES=   1555
 HOOKING PASS NO.     4 COMPLETED
 PAY TIME SAVED THIS PASS   -2:31,   31 CHANGES MADE THIS PASS
```

Figure 3.19

```
OPTHOOK: VERSION I

RUNCUT STATISTICS:


          NO. OF AM STRAIGHTS              27  TOTAL PLATFORM   1173:05
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME    11:06+
          NO. OF MATINEE STRAIGHTS          4  TOTAL SPRD BONUS   45:35+
          NO. OF PM STRAIGHTS              32  TOTAL PAID TRAV.     7:25
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME      25:33
          NO. OF EARLY SWINGS               1  TOTAL REPT/T-IN     36:15
          NO. OF REGULAR SWINGS            68  TOTAL STRAIGHTS        63
          NO. OF LATE SWINGS               13  TOTAL SWINGS           82
          NO. OF NIGHT SWINGS               0  TOTAL TRIPPERS          0
          NO. OF AM TRIPPERS                0  TOTAL RUNS            145
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                0
          NO. OF FOUR DAY RUNS              0  TOTAL COST        1262:45


DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>NO
```

The schedule maker must now decide which solution is preferred -- one tripper versus one more run and an additional three-fourths of a pay hour. If the garage manager thinks he can fill the tripper on a daily basis without increasing the number of extra men, this solution is better since it saves one run. If not, perhaps it is better not to have the tripper, since it is a potential source of aggravation in daily garage operations.

3.6.2 Manual Analysis of Noon-to-Night with the ALLSWING Option

The noon-to-night scheduling practice is intended to accomplish two goals: (1) to humanize the schedule by minimizing the number of runs with a large spread, and (2) to control schedule costs resulting from the union contract's spread penalty. These long spread runs are most undesirable from the driver's point of view and therefore are penalized in the union contract. The spread penalty in the current union contract is shown graphically in Figure 3.20. Spreads in excess of 10:30 are penalized severely. Given this penalty, the cost minimizing nature of OPTHOOK is for the most part adequate to control spread without resorting to an arbitrary time of demarcation such as 8:00 AM as in current noon-to-night scheduling practice. To allow less restrictive analysis of schedule spread, the ALLSWING option has been provided within OPTHOOK. This option always results in a less expensive hooking solution than the one resulting from current noon-to-night practice and also eliminates any trippers created by noon-to-night constraints. The schedule maker must review the runs created for excessive spread, correcting any undesirable runs by switching pieces with other swing runs, bearing in mind that any change he makes will increase the cost of the schedule.

Figures 3.21 through 3.33 display in detail an example of using the ALLSWING option to eliminate trippers and reduce schedule costs. The results of the preliminary use of the OPTHOOK command with noon-to-night are displayed in

Figure 3.20

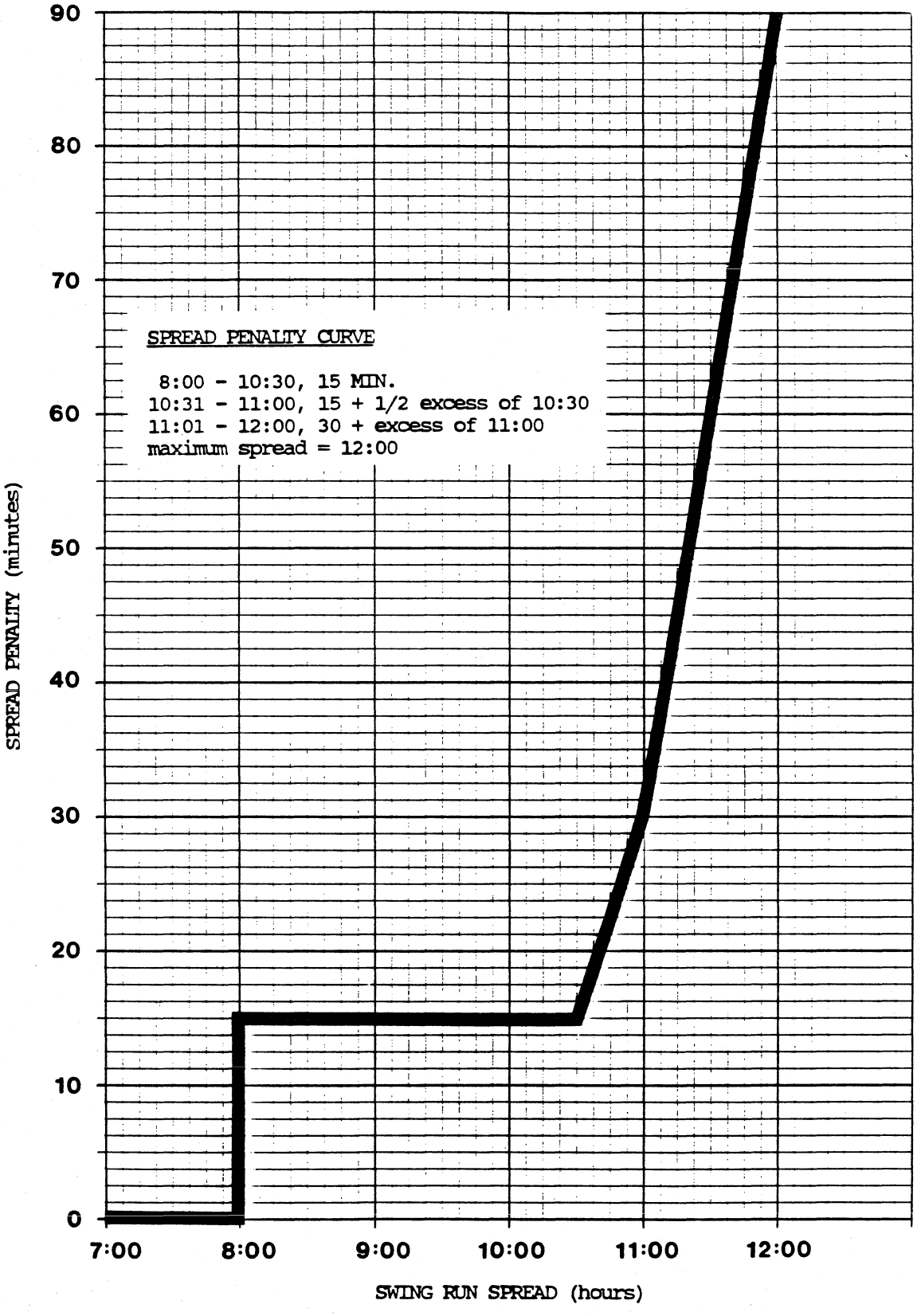

SPREAD PENALTY CURVE
8:00 - 10:30, 15 MIN.
10:31 - 11:00, 15 + 1/2 excess of 10:30
11:01 - 12:00, 30 + excess of 11:00
maximum spread = 12:00
SPREAD PENALTY (minutes)
90
80
70
60
50
40
30
20
10
0
7:00
8:00
9:00
10:00
11:00
12:00
SWING RUN SPREAD (hours)

Figure 3.22. Although reasonably good in terms of overall schedule costs, four PM trippers were formed by the depotwide application of noon-to-night, given the swing run pieces input. Since trippers can be a nuisance to

Figure 3.21

```
OPTHOOK: VERSION 1

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              40   TOTAL PLATFORM    1563:51
          NO. OF LONG STRAIGHTS             0   TOTAL ALOW TIME      5:24+
          NO. OF MATINEE STRAIGHTS          2   TOTAL SPRD BONUS    41:31
          NO. OF PM STRAIGHTS              42   TOTAL PAID TRAV.     9:27
          NO. OF OWL STRAIGHTS              0   TOTAL OVERTIME      22:36+
          NO. OF EARLY SWINGS               4   TOTAL REPT/T-IN     49:15
          NO. OF REGULAR SWINGS            68   TOTAL STRAIGHTS        84
          NO. OF LATE SWINGS               36   TOTAL SWINGS          109
          NO. OF NIGHT SWINGS               1   TOTAL TRIPPERS          4
          NO. OF AM TRIPPERS                0   TOTAL RUNS            193
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                4
          NO. OF FOUR DAY RUNS              0   TOTAL COST        1647:12

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>NO

?
====>SAVE FILE CALOPT1
?
```

Figure 3.22

```
====>OPTHOOK NOON 1115

OPTHOOK: VERSION 1

ENTER MAXIMUM # OF ARCS FOR EACH NODE (PIECE) IN THE
SWITCHING NETWORK (RANGE FROM 1 TO 10):
====>10

MAXIMUM # OF SWITCHING ARCS     =    10

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              40   TOTAL PLATFORM    1563:51
          NO. OF LONG STRAIGHTS             0   TOTAL ALOW TIME      5:24+
          NO. OF MATINEE STRAIGHTS          2   TOTAL SPRD BONUS    41:31
          NO. OF PM STRAIGHTS              42   TOTAL PAID TRAV.     9:27
          NO. OF OWL STRAIGHTS              0   TOTAL OVERTIME      22:36+
          NO. OF EARLY SWINGS               4   TOTAL REPT/T-IN     49:15
          NO. OF REGULAR SWINGS            68   TOTAL STRAIGHTS        84
          NO. OF LATE SWINGS               36   TOTAL SWINGS          109
          NO. OF NIGHT SWINGS               1   TOTAL TRIPPERS          4
          NO. OF AM TRIPPERS                0   TOTAL RUNS            193
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                4
          NO. OF FOUR DAY RUNS              0   TOTAL COST        1647:12

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES
```

garage foremen, an attempt is made to eliminate them. After saving the preliminary solution as CALOPT1, a 10:00 tripper penalty is tried (Figures 3.23 and 3.24). The results (Figure 3.25) show that the trippers were eliminated by making four additional straight runs. The

Figure 3.23

```
ENTER THE NUMBER OF HOURS PER RUN WILLING
TO PAY TO EQUALIZE SPREAD FOR SWING RUNS
IN FORM   HH:MM
====>0:00

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =  0: 0

TRIPPER PENALTY PARAMETER =  0:30

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>YES

ENTER TRIPPER PENALTY IN FORM HH:MM
====>10:00

DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>NO

 NODES=    222      EDGES=   2117
 HOOKING PASS NO.     2 COMPLETED
 PAY TIME SAVED THIS PASS  -14:29,   53 CHANGES MADE THIS PASS
```

Figure 3.24

```
OPTHOOK: VERSION 1

RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              41   TOTAL PLATFORM   1563:51
          NO. OF LONG STRAIGHTS             0   TOTAL ALOW TIME    15:26
          NO. OF MATINEE STRAIGHTS          5   TOTAL SPRD BONUS   42:57+
          NO. OF PM STRAIGHTS              42   TOTAL PAID TRAV.   10:21
          NO. OF OWL STRAIGHTS              0   TOTAL OVERTIME     21:22
          NO. OF EARLY SWINGS               3   TOTAL REPT/I-IN    49:15
          NO. OF REGULAR SWINGS            69   TOTAL STRAIGHTS       88
          NO. OF LATE SWINGS               36   TOTAL SWINGS         109
          NO. OF NIGHT SWINGS               1   TOTAL TRIPPERS         0
          NO. OF AM TRIPPERS                0   TOTAL RUNS           197
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                0
          NO. OF FOUR DAY RUNS              0   TOTAL COST      1653:57+

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>NO
?
====>UNDO ALL
197 RUNS UNDONE.
?
```

high cost of this solution (1653:57+) and the fact that 197 runs were required makes it undesirable and the CALOPT1 solution is restored (Figure 3.25) after undoing all runs. Be sure to undo all runs prior to restoring a previous solution. Failure to do this can lead to unpredictable results in terms of the resulting runcut.

Figure 3.25

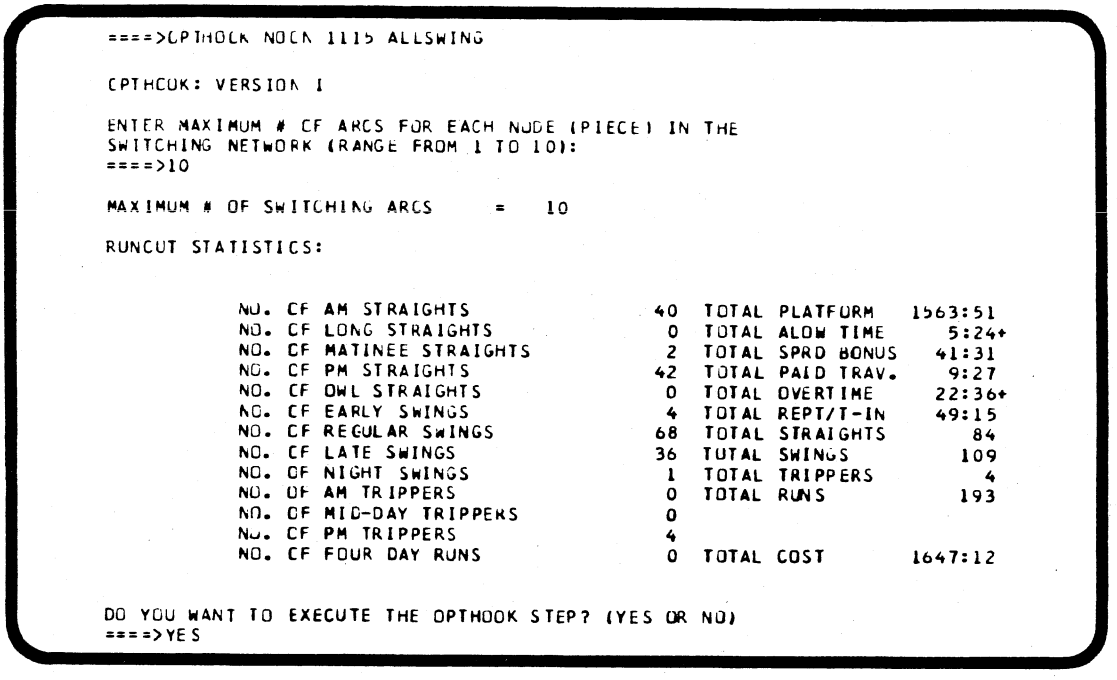
```
====>RESTORE FILE CALOPT1 SER 1 LABELS R L

READING DATA FOR LINE GROUP    852 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP   852 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP     42 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP    42 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP     30 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP    30 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP     63 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP    63 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP    917 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP   917 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP     85 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP    85 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP     76 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP    76 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
READING DATA FOR LINE GROUP     46 DIVISION    0 SERVICE    1
THE BLOCKDATA FOR LINE GROUP    46 DIVISION    0 SERVICE    1
    HAS ALREADY BEEN READ
ETC.
ETC.
?
```

Figures 3.26 and 3.27 display the use of the ALLSWING option to eliminate these trippers. The results displayed in Figure 3.28 show that noon-to-night trippers have been eliminated with a savings of almost four pay hours. Clearly, noon-to-night doesn't reduce schedule costs in the OPTHOOK environment. Before examining the results for undesirable runs and/or excessive spreads, an attempt is made to manually impose noon-to-night at the route level. The most useful summaries for analyzing run start time/finish time characteristics are the run diagram created by the command DIAGRAM FINAL (Figure 3.28) and the DETAIL and PRINTER options of the REPORT command. Figure 3.29 displays a portion of the run diagram with a noon-to-night violation (Run 151) and Figure 3.30 the correspond-

ing REPORT printer output.

Figure 3.26



```
====>OPTHOOK NODE 1115 ALLSWING

OPTHOOK: VERSION 1

ENTER MAXIMUM # OF ARCS FOR EACH NODE (PIECE) IN THE
SWITCHING NETWORK (RANGE FROM 1 TO 10):
====>10

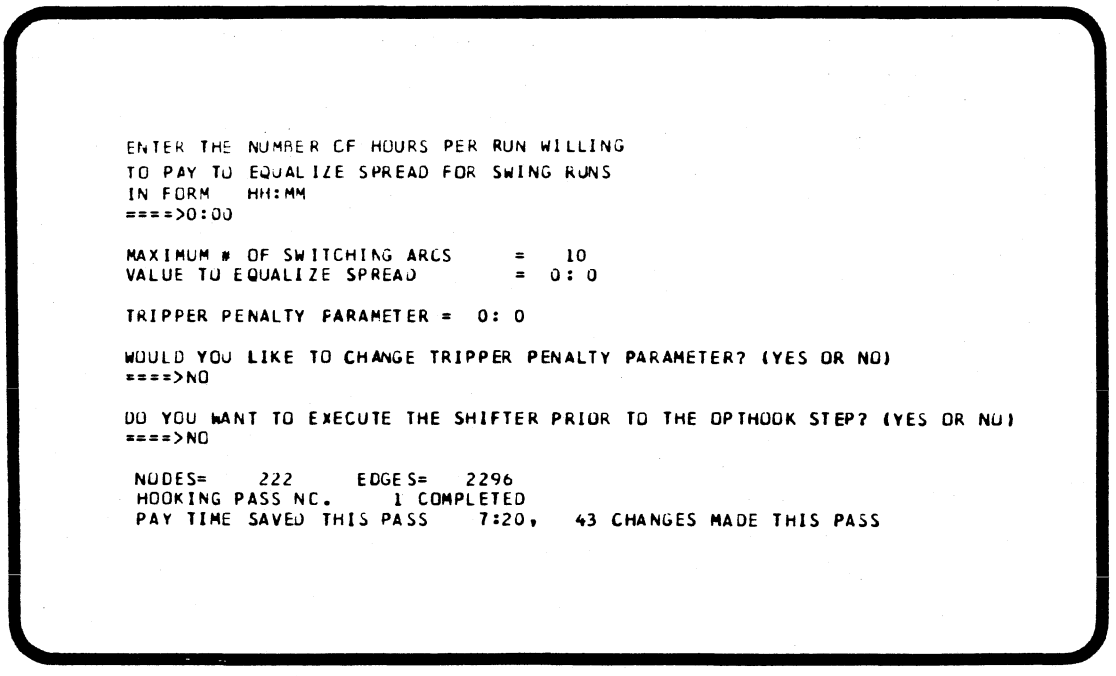
MAXIMUM # OF SWITCHING ARCS      =    10

RUNOUT STATISTICS:

          NO. OF AM STRAIGHTS              40  TOTAL PLATFORM    1563:51
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME      5:24+
          NO. OF MATINEE STRAIGHTS          2  TOTAL SPRD BONUS     41:31
          NO. OF PM STRAIGHTS              42  TOTAL PAID TRAV.      9:27
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME       22:36+
          NO. OF EARLY SWINGS               4  TOTAL REPT/T-IN      49:15
          NO. OF REGULAR SWINGS            68  TOTAL STRAIGHTS         84
          NO. OF LATE SWINGS               36  TOTAL SWINGS           109
          NO. OF NIGHT SWINGS               1  TOTAL TRIPPERS           4
          NO. OF AM TRIPPERS                0  TOTAL RUNS             193
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                4
          NO. OF FOUR DAY RUNS              0  TOTAL COST         1647:12

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES
```

Figure 3.27



```
ENTER THE NUMBER OF HOURS PER RUN WILLING
TO PAY TO EQUALIZE SPREAD FOR SWING RUNS
IN FORM   HH:MM
====>0:00

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =  0: 0

TRIPPER PENALTY PARAMETER =  0: 0

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>NO

DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>NO

 NODES=    222     EDGES=   2296
 HOOKING PASS NO.     1 COMPLETED
 PAY TIME SAVED THIS PASS    7:20,   43 CHANGES MADE THIS PASS
```

Figure 3.28

```
CPTHCCK: VERSION I

RUNCUT STATISTICS:

          NO. CF AM STRAIGHTS              40  TOTAL PLATFORM   1563:51
          NO. CF LONG STRAIGHTS             0  TOTAL ALOW TIME     6:20+
          NO. CF MATINEE STRAIGHTS          2  TOTAL SPRD BONUS   42:19
          NO. CF PM STRAIGHTS              42  TOTAL PAID TRAV.    9:39
          NO. CF OWL STRAIGHTS              0  TOTAL OVERTIME     21:22+
          NO. CF EARLY SWINGS               2  TOTAL REPT/T-IN    48:45
          NO. CF REGULAR SWINGS            70  TOTAL STRAIGHTS       84
          NO. CF LATE SWINGS               38  TOTAL SWINGS         111
          NO. CF NIGHT SWINGS               1  TOTAL TRIPPERS         0
          NO. CF AM TRIPPERS                0  TOTAL RUNS           195
          NO. CF MID-DAY TRIPPERS           0
          NO. CF PM TRIPPERS                0
          NO. CF FOUR DAY RUNS              0  TOTAL COST       1643:32

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>NO
?
====>DIAGRAM FINAL
?
====>SAVE FILE CALALSWG
?
```

The key to manually imposing noon-to-night is to find runs with similar pieces elsewhere in the schedule where the route level start-finish time configurations allow correcting the noon-to-night violation by switching pieces without creating new noon-to-night problems. The SWITCH command is used to implement these manual adjustments in Figure 3.31. There are two possibilities for correcting Run 151. Switching with Run 124 and switching with Run 125. The switch with Run 125 is selected because it results in a smaller increase in schedule cost (1:24). The REPORT command is used to check the resulting runs which are legal and desirable.

The other noon-to-night problem (Run 295) was corrected with switch between Runs 248 and 295. In order to verify that noon-to-night is satisfied, the runs are renumbered (RENUMBER FINAL) to incorporate these changes into the run diagram and the diagram regenerated (Figure 3.32). The resulting solution saved as CALFINAL has increased pay by about 1-1/2 hours over the ALLSWING solution. Four viable solutions have been generated; the schedule maker must now select the best schedule for implemen-

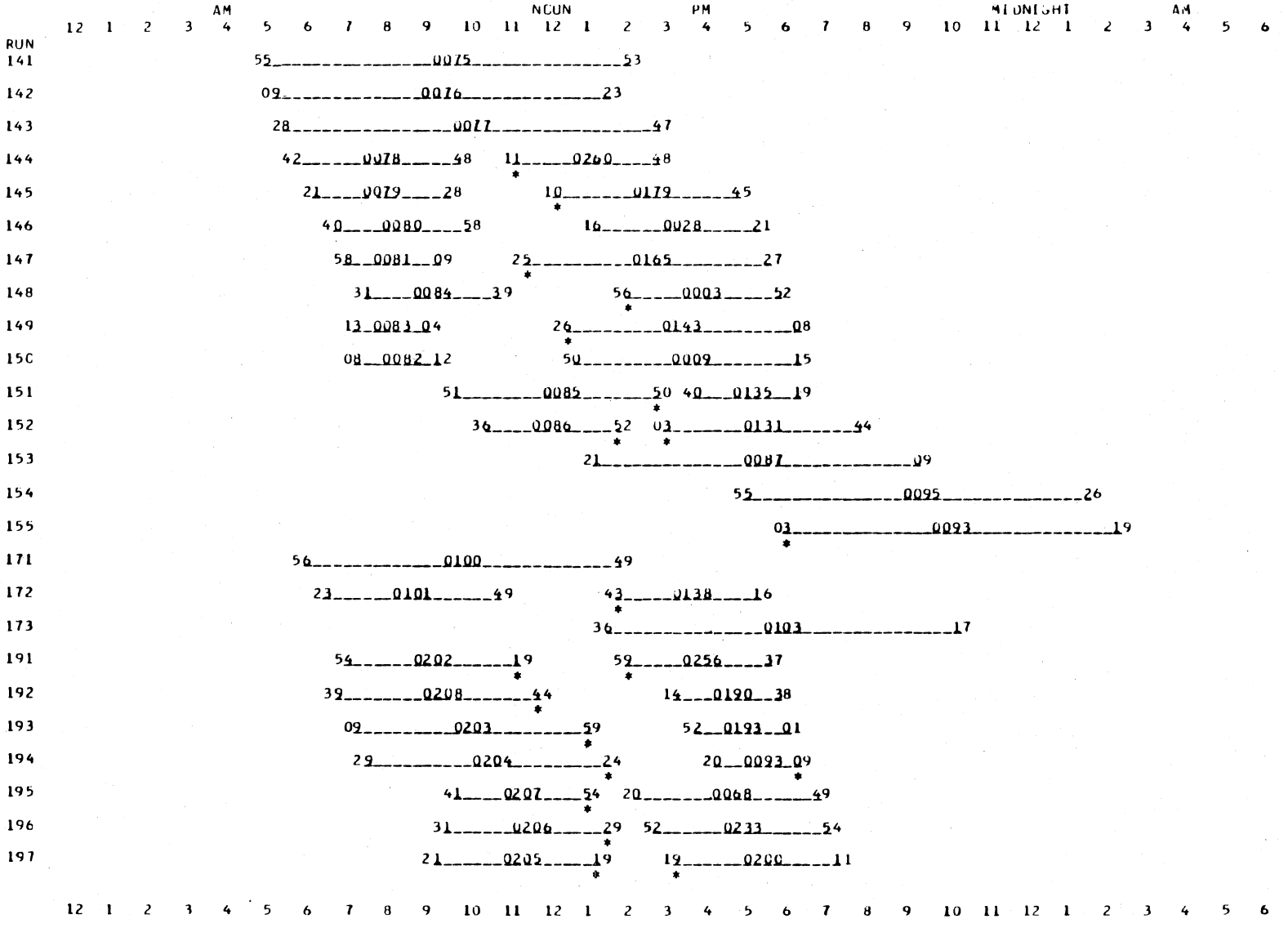

AM
NOON
PM
MIDNIGHT
AM
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
RUN
141 55 0075 53
142 09 0076 23
143 28 0077 47
144 42 0078 48 11 0260 48
145 21 0079 28 10 0179 45
146 40 0080 58 16 0028 21
147 58 0081 09 25 0165 27
148 31 0084 39 56 0003 52
149 13 0083 04 26 0143 08
150 08 0082 12 50 0009 15
151 51 0085 50 40 0135 19
152 36 0086 52 03 0131 44
153 21 0087 09
154 55 0095 26
155 03 0093 19
171 56 0100 49
172 23 0101 49 43 0138 16
173 36 0103 17
191 54 0202 19 59 0256 37
192 39 0208 44 14 0190 38
193 09 0203 59 52 0193 01
194 29 0204 24 20 0093 09
195 41 0207 54 20 0068 49
196 31 0206 29 52 0233 54
197 21 0205 19 19 0200 11
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6

Figure 3.29

RUCUS II
SEPTA
RUNCUTTING

RUN NO.	BLOCK NO. 1	2	3	PIECES OF WORK								PLATFORM 1	2	3	PLAT FORM	PAID TRAV	ALOW TIME	OVER TIME	SPRD	SPRD BONUS	REPT T-IN	TOTAL PAY
				CL	CL			MT	CL													
147	81-	-165		658	909			1125	1727			211	602		813	0	0	6+	1029	15	15	8:34+
>> RTES:	46 911		TIME ON:	6:58		TIME OFF:	17:27		PAY:	8.6												
				CL	CL			BZ	CL													
148	83-	-143		713	904			1226	1808			151	542		733	0	0	0	1055	27+	15	8:00+
>> RTES:	46 852		TIME ON:	7:13		TIME OFF:	18:08		PAY:	8.0												
				CL	CL			CL	CL													
149	82-	- 9		709	912			1250	1815			204	525		729	0	0	0	1107	37	15	8:06
>> RTES:	46 40		TIME ON:	7:08		TIME OFF:	18:15		PAY:	8.1												
				CL	OS			CL	CL													
150	85-135			951	1450			1540	1819				459	239	738	0	7	0	828	15	15	8:00
>> RTES:	46 852		TIME ON:	9:51		TIME OFF:	18:19		PAY:	8.0												
				CL	CL			CL	CL													
151	84-	-129		731	1039			1349	1830			308	441		749	0	0	0	1059	29+	15	8:18+
>> RTES:	46 852		TIME ON:	7:31		TIME OFF:	18:30		PAY:	8.3												
				CL	OS			BZ	CL													
152	86-131			1036	1352			1503	1944				316	441	757	0	0	0	908	15	15	8:12
>> RTES:	46 852		TIME ON:	10:36		TIME OFF:	19:44		PAY:	8.2												
								CL	CL													
153	87							1321	2109					748	748	0	12	0	748	0	15	8:00
>> RTES:	46****		TIME ON:	13:21		TIME OFF:	21:09		PAY:	8.0												
								CL	CL													
154	95							1655	2526					831	831	0	0	15+	831	0	15	8:45+
>> RTES:	46****		TIME ON:	16:55		TIME OFF:	25:26		PAY:	8.8												
								OS	CL													
155	93							1806	2619					813	813	3	0	8	816	0	15	8:24
>> RTES:	46****		TIME ON:	18:03		TIME OFF:	26:19		PAY:	8.4												

Figure 3.30

Figure 3.31

```
====>SWITCH RUNS 124 151
 SWITCH COMPLETED - PAY HOURS INCREASED BY    1:52
?
====>SWITCH RUNS 124 151
 SWITCH COMPLETED - PAY HOURS REDUCED BY    1:52
?
====>SWITCH RUNS 125 151
 SWITCH COMPLETED - PAY HOURS INCREASED BY    1:24
?
====>REPORT RUN 125

RUN +----BLK-----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
125 | 24-    -12 9|CL 659  1102CL|              |CL1349  1830CL|   0 | 22 |10:07
 >> RTES:  43 852 PLTFM:  8:44   SPD ALW:   1:01  PAID TVL:  0:00   PAY: 10.1
 >> TIME ON:  6:59   TIME OFF: 18:30

?
====>REPORT RUN 151 DETAIL

RUN +----BLK-----+--ON-----OFF--+--ON-----OFF--+--ON-----OFF--+-ALW-+-OT-+-PAYS
151 | 84-    -   3|CL 731  1039CL|              |CZ1356  1752CL|  41 |  0 | 8:00
 >> RTES:  46  40 PLTFM:  7:04   SPD ALW:   0:15  PAID TVL:  0:00   PAY:  8.0
 >> TIME ON:  7:31   TIME OFF: 17:52

?
====>SWITCH RUNS 248 295
 SWITCH COMPLETED - PAY HOURS INCREASED BY    0:14
?
====>RENUMBER FINAL
?
```

Figure 3.32

```
====>DIAGRAM FINAL
?
====>REPORT DETAIL OFF

          NO. OF AM STRAIGHTS              40  TOTAL PLATFORM    1563:51
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME      7:16+
          NO. OF MATINEE STRAIGHTS          2  TOTAL SPRD BONUS    42:33
          NO. OF PM STRAIGHTS              42  TOTAL PAID TRAV.     9:39
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME      21:49+
          NO. OF EARLY SWINGS               2  TOTAL REPT/I-IN     48:45
          NO. OF REGULAR SWINGS            70  TOTAL STRAIGHTS        84
          NO. OF LATE SWINGS               38  TOTAL SWINGS          111
          NO. OF NIGHT SWINGS               1  TOTAL TRIPPERS          0
          NO. OF AM TRIPPERS                0  TOTAL RUNS            195
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                0
          NO. OF FOUR DAY RUNS              0  TOTAL COST        1645:09
?
====>SAVE FILE CALFINAL
?
```

tation based on schedule cost and attributes. Figure 3.33 displays selected attributes from these four schedules and the all manual solution that was implemented. From this figure it is clear that in a computerized environment noon-to-night in itself does not reduce either the pay hours required to service the schedule or the number and severity of runs with large spreads. The ALLSWING solution is superior in all respects to the manually adjusted schedule and the all manual schedule that was implemented. Only the original OPTHOOK solution is of comparable interest as it has two fewer runs. The choice between these two solutions is probably determined by the garage manager's willingness to accept four trippers.

Figure 3.33

Results Callowhill - Summer 1986

	All Manual	OPTHOOK	OPTHOOK (ALLSWING)	OPTHOOK Manual Noon-to-Night
Total Runs	195	193	195	195
Total Pay Hours	1653:12+	1647:11	1643:32	1645:09
Trippers	0	4	0	0
Spread Bonus	44:08	41:31	42:19	42:33
No. Runs Spread ≥	8	3	4	5
Worst Spread	11:57	11:16	11:18	11:31

3.7 Use of the Piece Boundary Shifter

The OPTHOOK command also has the capability to automatically shift swing run piece boundaries in order to reduce pay hours, provided that such shifts do not alter straight runs. Effective use of this option requires that a reasonably efficient set of hooks be in place prior to executing the shifter. For this reason, use of the shifter should be reserved for the latter stages of swing run hooking analysis. Figures 3.34 to 3.38 show an example where the shifter is used to reduce the pay hour increase required

to eliminate a tripper. The initial solution shown in Figure 3.34 contained one tripper which resulted from an odd number of swing run pieces. The use of the shifter (Figure 3.35 and 3.36) reduced the cost of this solution by 2-1/2 pay hours so that the tripper penalty could be utilized (Figure 3.37) to eliminate this tripper by creating an additional straight run (Figure 3.38) without increasing pay hours. The piece boundary shifter should be routinely tried in the later stages of generating a runcut after saving the current solution.

Figure 3.34

```
====>OPTHOOK NOON 1110

OPTHOOK: VERSION I

ENTER MAXIMUM # OF ARCS FOR EACH NODE (PIECE) IN THE
SWITCHING NETWORK (RANGE FROM 1 TO 10):
====>10

MAXIMUM # OF SWITCHING ARCS      =    10


RUNCUT STATISTICS:

          NO. OF AM STRAIGHTS              40  TOTAL PLATFORM   1563:51
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME     8:46
          NO. OF MATINEE STRAIGHTS          2  TOTAL SPRD BONUS   42:19+
          NO. OF PM STRAIGHTS              43  TOTAL PAID TRAV.    9:27
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME     22:28+
          NO. OF EARLY SWINGS               3  TOTAL REPT/T-IN    49:00
          NO. OF REGULAR SWINGS            69  TOTAL STRAIGHTS       85
          NO. OF LATE SWINGS               37  TOTAL SWINGS         110
          NO. OF NIGHT SWINGS               1  TOTAL TRIPPERS         1
          NO. OF AM TRIPPERS                0  TOTAL RUNS           195
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                1
          NO. OF FOUR DAY RUNS              0  TOTAL COST       1647:54


DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES
```

Figure 3.35

```
ENTER THE NUMBER OF HOURS PER RUN WILLING
TO PAY TO EQUALIZE SPREAD FOR SWING RUNS
IN FORM   HH:MM

0:00

MAXIMUM # OF SWITCHING ARCS      =   10
VALUE TO EQUALIZE SPREAD         =  0:0

TRIPPER PENALTY PARAMETER =  0:0

WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>NO

DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>YES


 SHIFTING PASS NO.   1 COMPLETED
 6 CHANGES MADE THIS PASS

 NODES=    222     EDGES=   2098
 HOOKING PASS NO.     1 COMPLETED

 PAY TIME SAVED THIS PASS    3:15,   38 CHANGES MADE THIS PASS
```

Figure 3.36

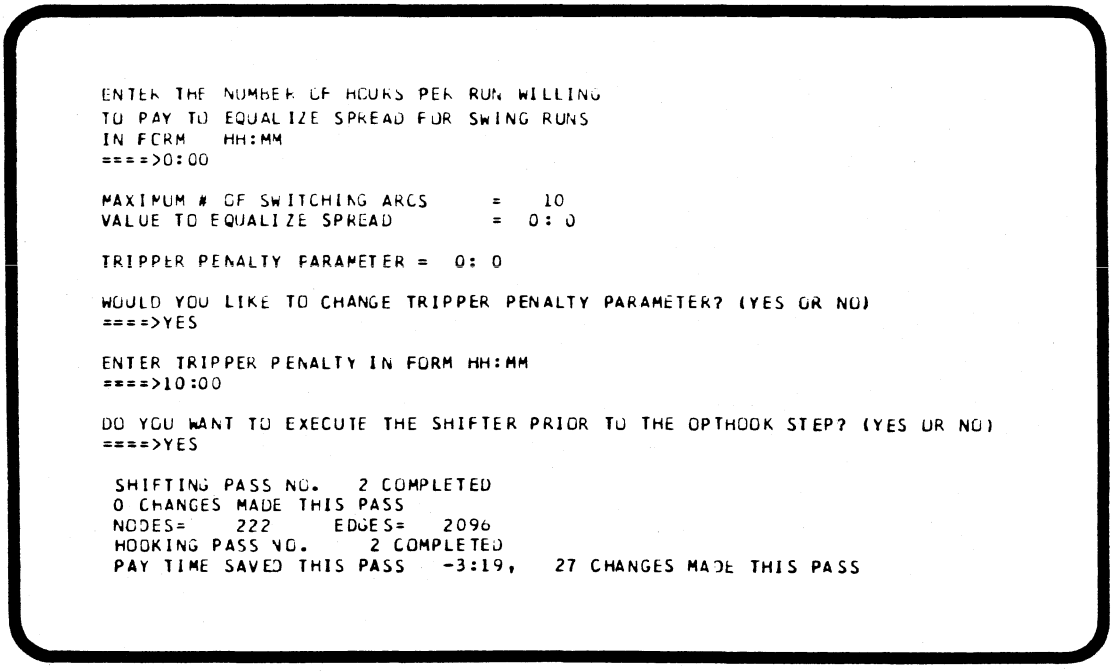
```
OPTHOOK: VERSION I

RUNCUT STATISTICS:


          NO. OF AM STRAIGHTS              40  TOTAL PLATFORM   1563:51
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME     8:04
          NO. OF MATINEE STRAIGHTS          2  TOTAL SPRD BONUS   41:35
          NO. OF PM STRAIGHTS              43  TOTAL PAID TRAV.    9:33
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME     21:17+
          NO. OF EARLY SWINGS               2  TOTAL KEPT/T-IN    49:00
          NO. OF REGULAR SWINGS            70  TOTAL STRAIGHTS       85
          NO. OF LATE SWINGS               37  TOTAL SWINGS         110
          NO. OF NIGHT SWINGS               1  TOTAL TRIPPERS         1
          NO. OF AM TRIPPERS                0  TOTAL RUNS           195
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                1
          NO. OF FOUR DAY RUNS              0  TOTAL COST       1645:22+


DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>YES
```

Figure 3.37



```
ENTER THE NUMBER OF HOURS PER RUN WILLING
TO PAY TO EQUALIZE SPREAD FOR SWING RUNS
IN FORM   HH:MM
====>0:00

MAXIMUM # OF SWITCHING ARCS      =    10
VALUE TO EQUALIZE SPREAD         =   0:0

TRIPPER PENALTY PARAMETER =  0:0

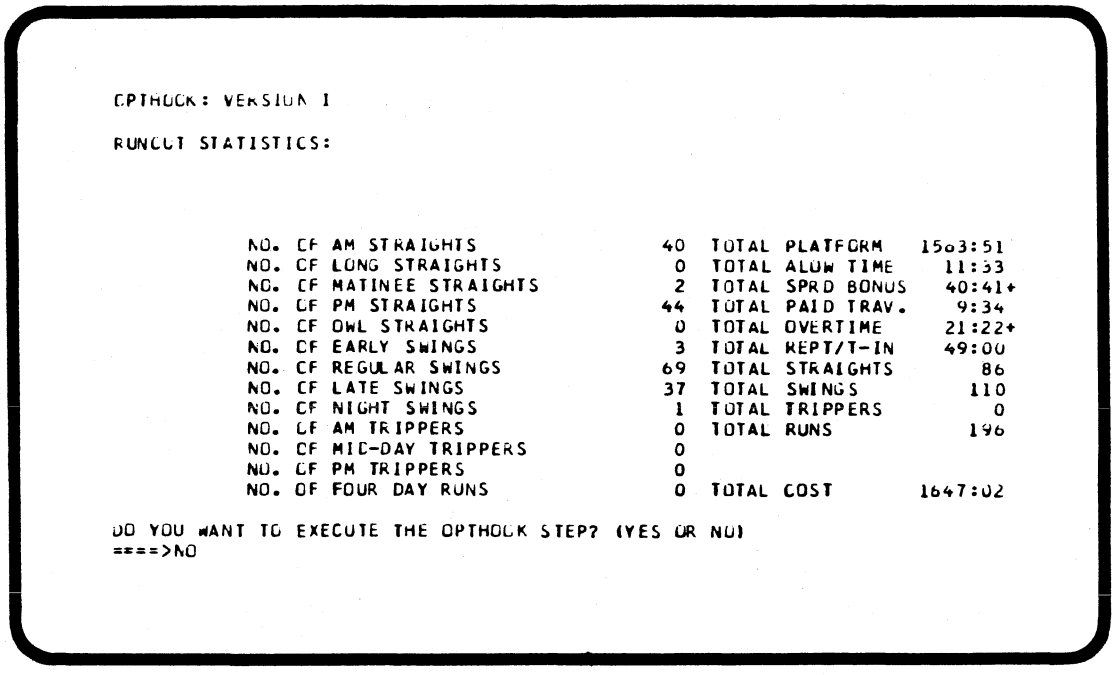
WOULD YOU LIKE TO CHANGE TRIPPER PENALTY PARAMETER? (YES OR NO)
====>YES

ENTER TRIPPER PENALTY IN FORM HH:MM
====>10:00

DO YOU WANT TO EXECUTE THE SHIFTER PRIOR TO THE OPTHOOK STEP? (YES OR NO)
====>YES

 SHIFTING PASS NO.   2 COMPLETED
 0 CHANGES MADE THIS PASS
 NODES=    222     EDGES=   2096
 HOOKING PASS NO.    2 COMPLETED
 PAY TIME SAVED THIS PASS   -3:19,   27 CHANGES MADE THIS PASS
```

Figure 3.38



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OPTHOOK: VERSION 1

RUNOUT STATISTICS:

          NO. OF AM STRAIGHTS              40  TOTAL PLATFORM    1503:51
          NO. OF LONG STRAIGHTS             0  TOTAL ALOW TIME     11:33
          NO. OF MATINEE STRAIGHTS          2  TOTAL SPRD BONUS    40:41+
          NO. OF PM STRAIGHTS              44  TOTAL PAID TRAV.     9:34
          NO. OF OWL STRAIGHTS              0  TOTAL OVERTIME      21:22+
          NO. OF EARLY SWINGS               3  TOTAL REPT/T-IN     49:00
          NO. OF REGULAR SWINGS            69  TOTAL STRAIGHTS       86
          NO. OF LATE SWINGS               37  TOTAL SWINGS         110
          NO. OF NIGHT SWINGS               1  TOTAL TRIPPERS         0
          NO. OF AM TRIPPERS                0  TOTAL RUNS           196
          NO. OF MID-DAY TRIPPERS           0
          NO. OF PM TRIPPERS                0
          NO. OF FOUR DAY RUNS              0  TOTAL COST        1647:02

DO YOU WANT TO EXECUTE THE OPTHOOK STEP? (YES OR NO)
====>NO
```

APPENDIX I

I. A GENERAL DISCUSSION OF SCHEDULE CONSTRUCTION

Schedules are constructed based on service requirements, employee demands, and SEPTA policies with respect to certain practices and economies. Factors that are considered in schedule making include:

1. Original schedule for the route
2. Traffic survey sheets
3. Running time sheets for the route
4. Knowledge of union provisions
5. Knowledge of SEPTA policies

If an analysis of the passenger counts shows that adequate service is being provided without waste, and that employee demands and SEPTA requirements are satisfactorily met, the original schedule is left intact and in use. However, if any change is required, for any of the above reasons, the old schedule must be revised, and a new schedule made. In the following discussions, technical terminology is used where appropriate. These terms are defined in the attached glossary.

What is a good schedule? This question is difficult to answer. Not only do people vary in their interpretations, but one individual's interpretation may change from time to time. It is possible, within limitations, to construct a schedule to fit the desires of the vehicle operators, bearing in mind that improvements in one feature might result in introducing other undesirable features. Depot superintendents should

recognize that they have an obligation to pass on information regarding drivers preferences and recommendations so that these requests can be considered when making the new schedule. However, the superintendent must also recognize that decreasing the overall spread time of swing and long straight runs will probably necessitate trippers that he must fill on a daily basis. An additional number of extra drivers may also be required.

Effects of Making Schedule Changes

The kind of schedule produced depends upon the influences brought to bear on the schedule-maker. Schedule making has been compared to a puzzle composed of numerous pieces of various shapes and sizes that must be fitted together. They can fit together in a variety of ways. When one piece is changed, the shape of the finished result is likely to change. It is important to remember that changing the schedule in one way may necessitate other changes.

Changing the characteristics of the schedule, such as the number of trips, running time, the length of routes, layovers, number of vehicles necessary for various periods of the day, time of maximum load periods of the route, or how late in the evening or early morning service is required, may affect the composition of runs in the schedule and their classification. Typical impacts of major factors influencing schedule construction are discussed in the paragraphs that follow.

Changes in Vehicle Trips

An increase or decrease in the vehicle trips included in a schedule can have one or several effects upon the schedule. The vehicle blocks for the period or periods affected will change. This may cause an increase or a decrease in the number of trippers and/or runs and may cause the spread penalty, minimum day penalty, premium time, and/or tripper penalty to change.

When a schedule is increased or decreased by one or more trips, the labor requirements depend upon the configuration of the existing schedule. If the new or deleted trips are trippers, then it may be necessary to only adjust the headway during the period involved with trippers added or subtracted from the schedule. Should these trips be incorporated into or eliminated from existing runs, a new schedule must be constructed.

Change in Running Time

Running time can be increased without cost only if it can be accomplished by an increased headway which, of course, means poorer service and possible overloading of vehicles. The only other possibilities would be to reduce layovers, and/or to increase the number of vehicle blocks. This, of course, means more pay hours and could also require the purchase of additional vehicles if the running time increase occurs during the peak period of the day.

This usually works in reverse if running times are reduced - that

is, fewer trips, possibly fewer vehicles, and/or increased layovers. A change in layover duration, or in the length of a route, would have the same general effect on pay hours and vehicle requirements as a change in running time. Modifying running times, the length of the layovers, or a change in route length will require the development of a new schedule.

The Number of Vehicles Required for Periods of the Day

This is the deciding factor in determining the number and spread of swing runs. A Sunday schedule is usually most desirable, that is, all straight runs. The elimination of swing runs and trippers is possible because the vehicle requirements for all time periods remain nearly constant. A Saturday schedule is similar to a Sunday table, although the increase in the number of vehicles during the peak periods (which are relatively close together), may cause a few low-spread swing runs. However, a weekday table may require up to 100 percent or more vehicles during peaks than during the base period. Furthermore, as these peaks are further apart, a much greater number of swings with a high spread are required.

Two routes, which might otherwise appear to be similar, may because of the difference in peak load times have different run characteristics, especially in the overall spread of swing runs. Late night riding on some routes makes the addition of extra trips on late runs necessary. This may require highly paid late runs, adjustments to the spread of swing runs, or even cause p.m. trippers.

The Trunk Portion of Routes

When a route has one or more scheduled turnback points along the line, or when two routes use the same street for an appreciable distance, a common point on line(s) is established at or near the point where the routes converge, and vehicles at this point are spaced to conform with passenger demand. This spacing often results in abnormal layovers.

One Route Operating from Two Depots

Trip requirements govern the number of vehicles which operate over the route from each of the depots. The schedule is made in two sections, one for each depot. Vehicle blocks are allocated to the depot nearer to the point on the line where service originates. Likewise, as service is reduced, a given vehicle returns to the nearer depot. As this turn-in may not coincide with the vehicle block's pull-out, it may be necessary to shift the starting times of trips to make the pull-out and pull-in depots coincide. Once the trips are allocated to each depot, the number and classification of runs for each are determined as in any other schedule.

Relief Points and Allowance for Relief Travel Time

Relieving drivers in between the ends of a route can reduce the pay hours for some driver runs. When the relief point is en route, the pay of the driver runs can be more closely held to an average because of the ability to split a vehicle trip between two runs. The placement of the relief point on a line is governed by proximity to the depot and travel facilities available for reaching that point. When an employee is

required to travel from the place of report to his vehicle out on a line, or from his vehicle out on a line to the depot in finishing a run, such travel will be classed as platform work and the travel time alloted included in the scheduled work hours of the run. No such allotment will be made for travel time during the break period of a swing run, unless the employee is required to report or turn in.

II. A SYNOPSIS OF SCHEDULE CONSTRUCTION TECHNIQUES

Service in each half-hour period should be sufficient to transport the public to and from their respective places of business, schools, etc., at a safe and economical speed. This service is determined from the average load count by half-hour periods from the traffic survey, the carrying capacity of equipment used, the time of day, (base or peak) and the vehicles available.

Running Time

Running time is determined by personal observation, and by making checks at specified points along the line. The result of these checks, after giving proper consideration to service stops, traffic light control, street conditions, (width and other traffic), type of equipment operated and other factors, may necessitate the establishment of different running times between certain points along the line for various times of the day. Inasmuch as there may be as much as 2 minutes difference in running time between periods, and the headway might also be 2 minutes, it can easily be seen that we must graduate running time during trips that are made when time periods change.

Vehicle Trips

Before proceeding with the construction of the schedule, we must analyze the traffic survey. We must look for conditions of overloading or too much service before determining the number of vehicles required

per half-hour period in the new schedule.

For instance, if during any half-hour period it becomes apparent that fewer vehicles could carry the passenger load, headways are reduced. In analyzing the traffic survey, it necessary to keep in mind the requirements for both directions of the route. The sum total of all vehicles necessary for each half-hour period in the direction requiring maximum service represents the number of trips required for the day.

The approximate headway for each half-hour period is computed by dividing 30 minutes by the number of vehicles for the period. For instance, if 3 vehicles are required, the headway would be considered to be 10 minutes. Headway is reduced or increased on the basis of this analysis. To determine which time will be listed first on the table, we usually use the same time as the original table.

Layovers

The principal purpose of having layovers is to provide a cushion in the schedule. In other words, a bus is scheduled to pull into a loop or a terminal a certain number of minutes before it is scheduled to leave again. If it arrives late, it can still leave on time on the next trip. It must be understood that, while this time can be used by bus drivers for personal needs or rest, it is not guaranteed. A layover must be scheduled after completion of each round trip of a run, except the last round trip of a run or of a half of a swing run. The time scheduled for such layover, where the scheduled operating time of the round trip is fifty or more minutes, shall be not less than five minutes, except that

one layover in each straight run and in each half of a swing run may be less than such minimum time, and layovers scheduled during the owl period may be less than such minimum time. Increasing or decreasing the minimum layover has the same effect as increasing or decreasing the running time. Increasing either could result in more vehicles being required to provide the same service, which might even necessitate the purchase of an additional vehicle. Unless the service being provided can be reduced by eliminating several trips, the additional cost is in direct proportion to the increase in either running time or layover time.

Manual Vehicle Blocking Analysis

Beginning with the first vehicle out of the depot, we place starting times for succeeding vehicles across the work sheet -- horizontally -- leaving ample space to allow for reduced headway later in the day. When we have gone across the sheet until we have reached a time that can be the second trip of the first bus or trolley, this trip is placed beneath the first trip shown on the table. A simple method of determining when a starting time for a trip can be placed under the first trip on the table is to add the round trip running time and the layover time to the first time on the table. The first leaving time for a trip which is equal to or beyond this sum (first time and running time and layover) becomes the second trip of the first block.

This same rule will also apply in determining the second trip of the second car or bus out of the depot (or block), and of the second trip of the third bus out of the depot, etc. The BSOLVE command with OPT M of

the vehicle scheduler program automates the calculation and selection aspects of this blocking method.

It is obvious that the total number of vehicles required to operate a route is determined by the peak load period of the day. As service requirements fall off, vehicle headways are increased. Increased headways in turn cause increased layovers at the terminal points of the line. Excessive layovers indicate that service requirements have fallen off to a point where vehicles can be removed from service. When the increased layovers caused by increased headway have reached fifteen minutes, they can be considered to be lunch layovers for runcutting purposes. The trip following that during which a fifteen-minute lunch layover has been scheduled need show only a five-minute layover.

During the base period, it is sometimes desirable to maintain service levels beyond that actually required by demand by reducing headways rather than increasing layovers beyond agreement requirements. For example, a round trip running time of 80 minutes, plus the required layover time of 5 minutes, equals 85 minutes. Ridership based service requirements indicate that a 9 minute headway is necessary, but a 9 minute headway will require 9-4/9 buses. Since we can't very well use 9-4/9 buses, we must use 10 vehicles. This will allow either a reduced headway of 8-1/2 minutes, or an increased layover time. Public good will be enhanced with the reduced headways which provides better service.
By setting up the vehicle blocks as heretofore described, we can determine the number of vehicles required for the A.M., the Noon Base, the P.M., and the Evening Base.

Block Numbers

When the vehicle blocks are established, the vehicle trips lose their identity as such, and are merged into blocks. The first vehicle leaving the terminal is usually identified as Block #1. Block #2 and subsequent blocks would be those vehicle runs following Block #1 (not in time, but in position on the schedule). The computerized runcut program requires that all vehicle blocks from a depot be given a unique number.

The Preparation of Driver Runs

The vehicles necessary for each of the above four periods of the day, the trips per driver run, and the total trips of the table, are determine the number of driver runs. Trips per driver run are determined approximately by dividing the minimum day run stated in minutes (8 hours x 60 or 480 minutes) by the round trip time plus the average layover. The number of trips per run can be reduced where necessary to compensate for added allowances such as the swing run penalty. The total number of vehicle trips, divided by this estimate of trips per run, results in a tentative number of driver runs, which is used as a guide in developing the final driver runs.

The Effect of the Union Agreement on Economical Runcutting

From the standpoint of vehicle operators, working conditions are largely determined by what appears on the schedule. It is often the working conditions, more than the pay, that determine the run chosen by a driver. In order to operate a transportation system, it is necessary to

have some runs with less desirable working conditions than others. Provisions have been made, as a result of union agreements or SEPTA policies, to impose a system of restrictions and penalties on the schedule makers, in order to insure that the schedule represents the best working conditions possible.

These restrictions may take the form of limits within which work must be accomplished or be premiums paid to the driver (which will be referred to as penalties) whenever a run includes allowable but undesirable working conditions. As each limitation or penalty is discussed, an attempt will be made to interpret the reasons for it.

Swing run allowance

Swing runs are generally not considered desirable by bus drivers because of the long work day though some drivers may like them. The greater the overall spread time, the greater the penalty specified in the union contract. A time allowance will be made for each swing run -- the greater of 15 minutes or one minute for each two minutes in excess of ten hours, but less than eleven hours; minute for minute for spreads in excess of eleven hours but not in excess of twelve hours, and 1-1/2 minutes for each minute in excess of twelve hours although current scheduling practice prohibits spreads in excess of 12 hours. The schedule maker must consider the cost of the penalty for putting swing runs in the table versus the cost of using trippers and short straight runs to cover peak period service.

Spread Overall

From the bus drivers' standpoint, the most undesirable swing runs are those which have a large "spread overall." Most people would not like a run which necessitated starting work at an early hour, having a large unpaid gap in the middle of the day and then completing the day's work at a late hour at night. Over the years, maximum spread time has been reduced until present SEPTA policy limits the maximum spread for any swing run to 12 hours. This policy is followed diligently in the making of schedules, even though it makes the job difficult at times and requires accepting other penalties.

In order to maximumize economy, it is essential to minimize the overall spread when hooking or combining A.M. and P.M. load line vehicles into swing runs. To do this manually is a difficult undertaking requiring considerable expertise and ingenuity from the schedule-maker, but the computerized optimal hooking methods discussed in chapter 3 are very effective in computerizing this process.

Minimum Lunch Layover

This time may be used partly as cushioning time, exactly the same as layover time; it is scheduled but not guaranteed. However, these longer layovers are primarily intended to improve working conditions by giving vehicle operators a better opportunity to eat lunch. A meal layover will be scheduled in each straight run or swing run piece in which the scheduled platform time equals 6-1/2 hours or more. Such scheduled meal

layover time shall be not less than fifteen minutes. SEPTA may schedule a drop-back or relief for such meal layover and a run for which such a drop-back or relief is scheduled will be classed as a straight run and paid as such. Lunch time layovers will increase the overall spread of some swing runs.

Minimum Day

A day's work is a straight or a swing run. The pay time for a day's work shall be not less than a minimum day. The minimum day, when the work is performed on weekdays or Saturdays will be eight hours pay time. When performed on Sundays, or on weekdays and Saturdays when holiday schedules are operated, the minimum day will be six hours pay time. The pay time for straight and swing runs should be eight hours or more for weekdays or Saturdays, and six hours or more for Sundays or holidays. The actual work time plus the swing allowance for swing runs, should not be less than six or eight hours as appropriate to prevent paying for work not performed by the drivers.

Premium Time

Work time, excluding lateness, performed in excess of eight hours in any one day will be classed as overtime work and paid as such. To avoid penalty, the work time of runs should not exceed eight hours.

Trippers

A tripper is a scheduled run for which the work hours total less than five hours and 20 minutes. Trippers are not subject to the minimum

day provision. The pay time will be one and one-half times the scheduled work hours thereof, whether performed as overtime or not. Pay time for any tripper will not be less than two hours. If possible, trippers should be avoided, because a.m. trippers are often late pull-outs and the p.m. trippers early pull-ins. It is often possible to reduce spread time penalties by incorporating these trips into swing runs.

Preliminary Cutting of Driver Runs by Classification

The approximate distribution of driver runs follows:

Late Straight Runs - Because the overall spread of hours from the a.m. load line to the finishing time of the late evening vehicles is too great to permit a crew to work both of these periods on the same day, these evening vehicles are tentatively designated as late crew runs.

Swing Runs. - The p.m. load line vehicles not designated as late runs tentatively establish the number of swing runs.

Early Straight Runs - The difference between a.m. load line vehicles and swing runs tentatively establishes the number of early straight runs. However, these runs cannot exceed the number of Noon Base vehicles, unless Day Relief swing runs are made, as explained below. Early straight runs are developed by cutting a day's work from the start of early vehicle blocks which are sufficient in length. Early straights should be cut from blocks that are among the first to leave the depot.

Day Relief Swing Runs and Noon and Night Swing Runs - Swing runs usually work both the a.m. and in the p.m. load lines. However, for various reasons it may be necessary to break up some of the early straight runs into day relief swing runs, i.e., swing runs which are relieved at the end of their day's work and usually do not work the p.m. load line. It may also be necessary to break up some of the late runs into Noon and Night swing runs. These swing runs are usually a relief at the beginning of their day's work and do not work the a.m. load line.

Some Guidelines for Fine-Tuning a Runcut

Following the preliminary specification of the runcut, the runs must be fine-tuned to minimize the schedule cost, insure accordance with the union contract, and obtain the concurrence of the garage manager. In order to accomplish this, the schedule-maker may apply a combination of manual and computerized techniques.

Shifting Trips - In fine-tuning the driver runs, it will be necessary to shift trips. Considerable skill is required in doing this, and it represents one of the difficult parts of the schedule-maker's job. Some factors which require consideration follow:

(1) The first consideration is to eliminate one-vehicle trip pieces, because swing runs with one trip in a leg are undesirable from a policy and cost standpoint. This may be

accomplished by cutting a 2-2 combination, instead of a 1-3 combination from a block. The shifter option of the OPTHOOK and OPTIMIZE commands of the computerized runcut program are effective in shifting trips between runs to reduce schedule cost.

(2) When making up late runs or early runs, a further consideration is to avoid leaving a single trip as a piece whenever possible.

(3) Whenever possible, late runs should pull out from the depot before the P.M. load line. The vehicle blocks may need to be reconfigured to accommodate this pull-out. This may be done by shifting trips from a long vehicle block to move up the start of a short P.M. vehicle block. It may be necessary to shift other vehicle trips between these blocks to accommodate the move.

(4) After the necessary shifting has been done to provide a reasonable number of late runs which conform to the principles mentioned here, the remaining trips which operate through the p.m. load line are scheduled as parts of swing runs.

Swing Run Hooking - When the early and late straight runs have been established and eliminated from further consideration, the remaining pieces in the a.m. and the p.m. are counted. If an equal number of each is found, these may possibly be hooked into swing runs. However, if the

number of a.m. and p.m. pieces are not equal, the number of pieces may be increased by dividing an early straight or a late straight into two or three pieces.

The general procedure for swing run hooking is to prepare a table with a.m. pieces in a column on one side and p.m. pieces on the other, both columns arranged in order of starting time. Starting from the top down, each a.m. piece is hooked with the first legal p.m. piece not already incorporated into a run. The preliminary hooking scheme resulting from this process is then refined by switching pieces between runs to either reduce schedule cost or to incorporate leftover pieces into legal runs. The OPTHOOK command of the computerized runcutter, detailed in chapter 3 of this report, can generate a legal minimum cost swing runs automatically from swing run pieces.

APPENDIX II

A GLOSSARY OF SCHEDULE-MAKING TERMS

Block Number	The method by which vehicles are identified on a schedule.
Drop Back	A case where it is necessary for the vehicle to be in continual service, and the operator leaves the vehicle to take another, thereby gaining the advantage of the difference in headway or headways for a required layover or meal time.
Day's Work	Consists of a straight or a swing run.
Headway	The scheduled interval of time between two vehicles going in the same direction on the same route.
Layover	Period provided between the scheduled arrival and departure of a vehicle at its terminal.
Load Line Vehicle	Those vehicles that operate through the A. M. or the P. M. peaks.
Load Line	The periods of the day when the maximum number of vehicles are used.
Minimum Day	As provided in the present Union Agreement, a minimum day (when the work is performed on weekdays or Saturdays) will be eight hours' pay time, and when performed on Sundays, or on weekdays and Saturdays on which holiday timetables are operated, will be six hours' pay time.
Minimum Layover	As provided in the Union Agreement, the time scheduled for a layover, where the scheduled operating time of the round trip is fifty or more minutes, shall not be less than five minutes, except that one layover in each straight run and in each half of a swing run may be less than such minimum time, and layovers scheduled during the owl period may be less than such minimum time.
Meal Layover	A period of not less than fifteen minutes will be scheduled in each straight run in which the scheduled platform time equals seven or more hours.

(Continued)

Overall Spread	The elapsed time between the beginning and the ending of a run.
Platform Work	The operation of passenger vehicles revenue and in non-revenue service by appointed operators.
Premium Time	Work time, excluding lateness, performed in excess of eight hours in any one day.
Pull-Out	Time required for a vehicle to travel from the depot to a point on the line to give service.
Pull-In	Time required for a vehicle to travel from a point on the line, after giving service, to the depot.
Relief	Changing of drivers when a vehicle is in service along the route.
Run or Driver Run	A unit of work, composed of a combination of trips, which may be operated by one man.

(a) *Straight Run* - A continuous unit of work; one without a break; may be preceded by work "early" or "late," to differentiate the time of day during which it starts.

(b) *Swing Run* - A run which has two parts; one divided by a time interval into parts. It works during the A. M. and the P. M. load line.

(c) *Day Relief Swing Run* - A swing run which is or could be relieved at the day's work and usually does not work on the P. M. load line.

(d) *Noon and Night Swing Run* - A swing run which would or could be a relief at the beginning of the day's work, and does not work on the A. M. load line.

(e) *Owl Run* - A run operating during the late evening and early morning hours.

Running Time	The operating time allotted between points on a route.
Relief or Travel Time	Pay time authorized to employees for traveling from depot to relief point, or from relief point to depot.
Spread Penalty	A time allowance for all swing runs.
Trip	Operation of a vehicle in both directions between terminals, constituting a round trip.
Schedule (or Timetable)	A table which indicates the times that vehicles should leave various designated locations.
Traffic Count	A check made by various methods to determine the number of passengers on each vehicle.
Traffic Card	The forms on which the traffic count is recorded.
Tripper	A scheduled run that is less than a day's work.
Time Points	Locations between ends of route, designated for check of headway.
Vehicle Block	The time a vehicle is scheduled to be on the street -- continuous (no relation to the number of drivers who operate vehicle).
Work Time	Platform time plus relief or travel time.