January, 1969

Installation and Operating Instructions

for the PDP Family-of-Eight Computers

TENNECOMP TP-1351 MAGNETIC TAPE STORAGE UNIT

Serial No. _____

ERRATA SHEET

File software Page 41

In subroutine BLANK, the line

```
JMP     JUNK        /BIT FOUND, RESET INDEX
```

should be changed to

```
JMP     BLANK + 1   /BIT FOUND, RESET INDEX
```

As the program now is, the error code for wrong record size will be the same as for no record gap.

In subroutine ASSMBL, the sequence

```
TAD     M14
DCA     COUNTR
TAD     HDELEY
JMS     DELAY
```

should be rewritten as

```
TAD     HDELAY
JMS     DELAY
TAD     M14
DCA     COUNTR
```

As the program now is, the search routine will occasionally fail to detect the end of tape.

The Test/Operate switch has been moved from the front panel (pages 3 and 4) to the rear of the chassis and relabeled. In the "continuous" position, the motor runs as long as A.C. power is supplied to the unit. In the 'Program controlled" position the motor is turned on by a relay actuated under program control. For normal program handling operations the switch should be placed in the "program controlled" position so that the motor is turned off when the unit is not in use. For operations requiring fast start up of the tape (such as, recording short blocks) the switch should be in the "continuous" position so that no delay will be required to permit the motor to reach full speed .

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TENNECOMP TP-1351 MAGNETIC TAPE STORAGE UNIT

The TP-1351 "TENNETAPE" is intended for use with the PDP Family-of-Eight computers. The TENNETAPE is a high-speed I/O device capable of replacing most paper tape I/O, and operates at approximately 200 twelve-bit words per second in both read and record operations. The TENNETAPE was inspired by a less sophisticated unit constructed by J. J. H. Park of the National Research Council of Canada.

The TENNETAPE utilizes continuous-loop tape cartridges popular in the broadcasting industry for their reliability and ease of handling. Standard program cartridges have a capacity of 4096 computer words on each of their four tracks. Changing one cartridge for another is a five second operation and may be done with the tape in any position.

All functions of the TENNETAPE are software controlled except for track selection, which is by means of a four-position rotary switch. The processor is used to assemble words for writing and to disassemble words when reading. Only a single bit at a time is transferred between the processor and the tape unit. Since signals are transferred on a bit by bit basis, the FORMAT of the information is completely determined by programming. Record operations of the TENNETAPE are file-protected to prevent accidental destruction of valuable symbolic text, data, or programs.

In conjunction with the TP-1346 Automatic Loader, the TENNETAPE offers unique "one button" loading and starting of programs. The program proper is stored on the TENNETAPE; the tape reading routine is mechanically read into the computer by the Automatic Loader.

INTRODUCTION

Interface Unit

Serial information read or written by the tape unit is transferred to and from the computer by means of IOT pulses. The interface contains a 1 bit buffer (BIT FLAG) which is set when a "one" is read from tape. There are also provisions for writing a "one" on tape and sensing the Beginning-of-Tape reflective marker which is positioned at the splice in the continuous loop. The tape may be considered to have no "end" or "beginning," but one may not write over the splice without a chance of losing information.

The control contains two timing circuits which operate mechanical relays. One relay turns on the motor and engages the capstan and pinch roller (MOTOR/PINCH ROLLER RELAY) and the other relay switches the heads from a read configuration to a write configuration (WRITE MODE RELAY). The relay timing circuits hold the relays in for a specified time each time they are pulsed. The delay for the WRITE MODE relay is somewhat longer than the delay for the MOTOR/PINCH ROLLER RELAY so that the tape motion can stop before the READ/WRITE relay opens. Otherwise, some information on the tape might not be erased when starting and stopping the tape.

The device code (second and third octal digit of the instruction) is normally 37 but may be varied by clipping diodes on the device selector card in the interface. The code is denoted by XX in the following list of instructions.

Instructions

SKIP ON BIT AND PULSE MOTOR (TPSP)
Octal Code: 6XX1
(See computer manual for IOT execution time)
Operation: The BIT FLAG is sensed and if it is set (indicating a bit read from tape), the contents of the PC is incremented by one thereby skipping the next sequential instruction. The MOTOR/PINCH ROLLER RELAY of the transport is pulsed for 12 milliseconds. If a continuous loop of TPSP instructions is given, the MOTOR/PINCH ROLLER RELAY will remain engaged as long as the TPSP instruction occurs at least once every 12 milliseconds.

SKIP ON MARK AND CLEAR FLAG (TPMC)
Octal Code: 6XX2
(See computer manual for IOT execution time)
Operation: The Beginning-of-Tape photocell output is sensed and if it indicates the presence of a reflective marker, the contents of the PC is incremented by one, thereby skipping the next sequential instruction. The BIT FLAG is cleared. The output of the photocell is A.C. coupled and the mark must be in motion to be sensed. TPMC is normally combined with TPSP to search for the mark in the READ MODE or with TPWP to search for the mark in the WRITE MODE.

WRITE MODE AND PULSE MOTOR (TPWP)
Octal Code: 6XX4
(See computer manual for IOT execution time)
Operation: The READ/WRITE relay is pulsed for 55 millisec. (The relay requires about 1 millisec to pull in.) The READ/WRITE relay connects the tape head in the WRITE mode and begins to saturate the tape in the "zero" direction. When the READ/WRITE relay has pulled in, TPWP will also pulse the MOTOR AND PINCH/ROLLER RELAY for 12 millisec. Thus a continuous loop of TPWP will erase the tape.

WRITE MODE AND RECORD BIT (TPWB)
Octal Code: 6XX5
(See computer manual for IOT execution time)
Operation: The WRITE MODE RELAY is pulsed for 55 milliseconds and the MOTOR/PINCH ROLLER RELAY is pulsed for 12 milliseconds. A pulse is written on tape. If TPWB instructions are given, at least every 12 milliseconds, continuous tape motion will result.

WRITE MODE AND SKIP ON MARK (TPWM)
Octal Code: 6XX6
(See computer manual for IOT execution time)
Operation: A combination of TPWP and TPMC. Pulses the WRITE MODE RELAY for 55 milliseconds and the MOTOR/PINCH ROLLER RELAY for 12 milliseconds. The Beginning-of-Tape photocell output is sensed and if it indicates the presence of a reflective marker, the contents of the PC is incremented by one, thereby skipping the next sequential instruction. The BIT FLAG is also cleared. A continuous loop of TPWM is used to search for the Beginning-of-Tape mark erasing tape while waiting for the mark.

Operating Controls

Refer to the following sketch.

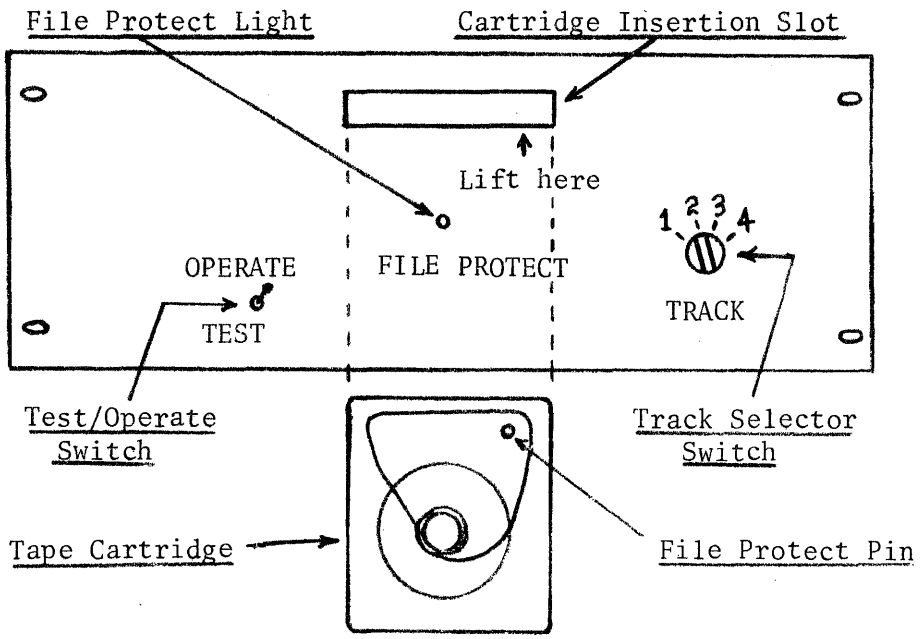


Figure 1. FRONT PANEL CONTROLS

The TAPE CARTRIDGE contains a continuous loop of tape. Standard lengths are 25 sec, 100 sec, and 400 sec (at 7 1/2 inches per second tape speed). The cartridge has provision for inserting a small plastic FILE PROTECT PIN. If the WRITE MODE is selected when a cartridge without a FILE PROTECT PIN is inserted in the transport, the FILE PROTECT LIGHT will come on, and the write circuits will be disabled. Thus, the FILE PROTECT PIN must be inserted before attempting to write on tape. The pin should be removed after the write operation in order to protect against accidental loss of information.

CAUTION: Stray magnetic fields may erase tape cartridges. Avoid placing cartridges within a few inches of tools which may have become magnetized or near transformers with external magnetic fields.

The CARTRIDGE INSERTION SLOT accepts tape cartridges. To insert, push the tape cartridge firmly into the front panel slot. To remove, lift up on the protruding end of the tape cartridge on the right hand edge where indicated, and pull gently out of the slot. The tape cartridge may not release if it is lifted at the incorrect spot.

The TRACK SELECTOR SWITCH selects one of four tracks on the tape. Set the switch to the track desired.

The TEST/OPERATE SWITCH is a manual override for control of the transport motor. In later units, this switch is positioned at the rear of the transport. The purpose of the switch is to reduce the delay time for starting the transport -- in the TEST position, the switch keeps the transport motor running continuously and the start-up time is minimal. When the switch is in OPERATE position, the transport motor is controlled by the computer, but takes a longer time to get the tape up to proper speed. Use of the transport for reading or writing short files requires the switch to be in TEST position; reading or writing one program per track may be done with the switch in either position.

OPERATION

Read and record operations of the TENNETAPE require short programs to be resident in the computer memory. Normally both programs are stored in the last page (200 words) of memory along with the RIM loader and are read into memory by the RIM loader.

Recording on the TENNETAPE is accomplished as follows:

(1) Read in the tape record routine from paper tape on the ASR-33 Teletype using the RIM loader;

(2) Insert a file protect pin into the hole in the cover of the tape cartridge to be used;

(3) Push the tape cartridge firmly into the front panel slot;

(4) Set the track selection switch to the desired channel;

(5) Set the computer's front panel switches to 7700_8 and press the load address switch, then the start switch;

(6) The computer will immediately halt. Set the initial octal address of the block of memory to be recorded on the computer front panel switches and press the continue switch;

(7) The computer will halt again. Set the final octal address of the block of memory to be recorded on the computer front panel switches and press the continue switch;

(8) Check the file protect light on the TENNETAPE front panel. If it is on, the record operation will not take place. If you have forgotten the file protect pin, stop the computer, remove the cartridge, and insert the file protect pin; and start the procedure over again at step (3);

(9) At the end of the record operation, the computer and the tape motion will halt. The cartridge may be removed by lifting up on its protruding end and pulling gently out of the front panel slot;

(10) Remove the file protect pin from the hole in the cover of the tape cartridge to prevent accidental destruction of the information just recorded.

Reading from the TENNETAPE is accomplished as follows:

(1) Read in the tape read routine from paper tape on the ASR-33 Teletype using the RIM loader;

(2) Push the tape cartridge firmly into the front panel slot;

(3) Set the track selection switch to the desired channel;

(4) Set the computer's front panel switches to 7600_8 and press the load address switch, then the start switch;

(5) Upon completion of the read operation, the computer and the tape motion will halt. The checksum will be displayed on the accumulator lights on the computer front panel. (Zero indicates a correct read operation, and non-zero indicates an error.)

For routine operation, it is convenient to prepare a systems cartridge which holds the record routine, a short binary loader, and a read-compare routine, rather than to obtain these routines from paper tape. Preparing a systems cartridge is facilitated by use of the system builder routine as follows:

(1) Read in the system builder routine from paper tape on the ASR-33 Teletype using the RIM loader;

(2) Insert a file protect pin into the hole in the cover of the tape cartridge to be used;

(3) Push the cartridge firmly into the front panel slot;

(4) Set the computer's front panel switches to 200_8 and press the load address switch, then the start switch;

(5) The computer will type out "Track 1 Record" and halt. Set the track selection switch to channel 1 and press the continue switch on the computer front panel. The record program will be recorded on tape;

(6) Step (5) will repeat for "Track 2 Short Binary Loader," "Track 3 Read-Compare," and "Track 4 Rim Loader." Set the track selection switch to the indicated channel at each halt and press the continue switch;

(7) Remove the cartridge from the front panel slot and remove the file protect pin from the hole in the cover of the cartridge;

(8) The teletype printout may be cut to size and used as a label for the contents of the system cartridge;

(9) The systems programs may now be read from the tape in the manner described above for reading. The "Record," "Short Binary Loader," and "Read-Compare" programs all start at 7700_8; only one of these is resident in the last page of memory at a time along with the "Read" program.

(10) The "Short Binary Loader" may be used to read binary tapes on the ASR-33 Teletype without the memory extension option;

(11) The "Read-Compare" may be used to check information recorded on tape with information resident in memory. Errors are indicated by the teletype bell, and an "O" or an "E" is typed at the end of the comparison indicating "O.K." or "Error."

PRINCIPLES OF OPERATION

Refer to the print of the Tape Unit Interface.

Write Mode

In the write mode of operation, information is recorded bit serial in the selected track by means of the WRITE ONE SHOT. The pulse width is 134 microsec. Typically, a timing pulse is recorded, followed by 12 bit pulses. Curve (1) of Figure 2 shows a timing pulse followed by bit pulses for a word containing 7253_8. The record mode of operation is selected by IOT-4, which causes closure of the WRITE MODE RELAY. The relay remains energized for 55 milliseconds each time the pulse is given. The time duration is determined by an 8 microfarad capacitor connected across the input of a W107 module. The IOT-4 pulse discharges the capacitor to zero volts, and the capacitor gradually charges up through the input circuit of the W107. The W107 is a special DEC module which consists of two inverters in tandem. The output is non-inverting. The first inverter requires only about .2 ma input for proper operation, rather than about 1 ma, as with the standard R107 inverter.

Read Mode

In the read mode of operation, the signal from the tape head appears as shown in Curve (2) of Figure 2. Two μ 709 operational amplifiers are used to amplify the head voltage. The amplified output signal goes to a Schmidt trigger circuit. The dashed line on Curve (2) of Figure 2 illustrates the Schmidt trigger threshold. When the signal goes more negative than the threshold the Schmidt trigger goes from -3 volts to ground, as shown on Curve (3) of Figure 2. The leading edge of the signal from the Schmidt trigger is used to set the BIT FLAG flip flop, as shown in Curve (4) of Figure 2. IOT-1 tests the state of this flip flop and causes a SKIP if the BIT FLAG is set. IOT-2 resets the flip flop.

In normal read operation, a series of IOT-1's is given to find the first timing pulse. Then an IOT-2 clears the BIT FLAG. Then, the processor is programmed to generate an IOT-1 in about 402 microsec, followed by 11 more IOT's every 268 microsec. These IOT-1's test the state of the BIT FLAG, which is then reset by IOT-2's. The extra delay following the timing pulse strobes the BIT FLAG half way between bit 0 and bit 1. The next IOT-1 strobes the BIT FLAG half way between bit 1 and bit 2, etc. This method of strobing gives a tolerance of approximately 125 microsec to timing errors. The cumulative timing error of the last IOT-1 which test bit 11 should be much less than 125 microsec.

On the PDP-8/S, the time delay for writing and reading is produced by the program loop which generates the write pulses and the strobe pulses. On faster computers, extra delay must be programmed in by means of delay sub-routines. The processor cycle time and the memory cycle of the PDP-8/S are separately adjustable and will vary somewhat. To insure compatibility between one computer and another, the cycles times will have to be adjusted to within the timing tolerance of the transport, or else the program can be "padded" by extra dummy instructions.

In the read mode, IOT-1 also pulses the MOTOR/PINCH ROLLER RELAY and causes it to close for 12 milliseconds. In addition to resetting the BIT FLAG, IOT-2 also tests the output of the Beginning-of-Tape mark photocell, causing a skip whenever the mark passes by the photocell.

File Protect

The presence of the FILE PROTECT PIN actuates two microswitches in the transport unit. One of these is connected in series with the write mode relay so that if the FILE PROTECT PIN is absent the heads are not connected in WRITE MODE. The other switch turns on the FILE PROTECT LIGHT if an attempt is made to select WRITE MODE without the FILE PROTECT PIN.

Tape Cartridges

Standard tape cartridges are loaded with Scotch Type 282 "sandwich" tape. Sandwich tape prolongs both the life of the tape head and the life of information stored on the tape. The tape is spliced with 3/8" of splicing tape on the back side, and a 3/8" strip of reflective tape is placed on the front side, trailing the splice by 1/4". The tape has from 1" to 2" of slack in the continuous loop; less slack causes jerky oepration while more slack may cause jamming of tape after it passes the pinch roller.

The TENNETAPE is provided with three standard program cartridges of 25 sec length and one 100 sec tape. Additional cartridges, with tapes of 25, 100, or 400 sec duration may be ordered from Tennecomp. Tennecomp cartridges are covered by the TENNETAPE warranty.

Users desiring to load their own cartridges should obtain satisfactory results with the following materials:

(1) FIDELIPAC Cartridges

(2) Scotch Type 154 Digital Tape

(3) Robbins Type TST-235 Splicing Tape

(4) Scotch Type 51-7/325 Alummized Sensing Tape

These materials can be obtained from Allied Electronics, 100 N. Western Avenue, Chicago, Illinois 60680. Substitutions of other type materials are not recommended.

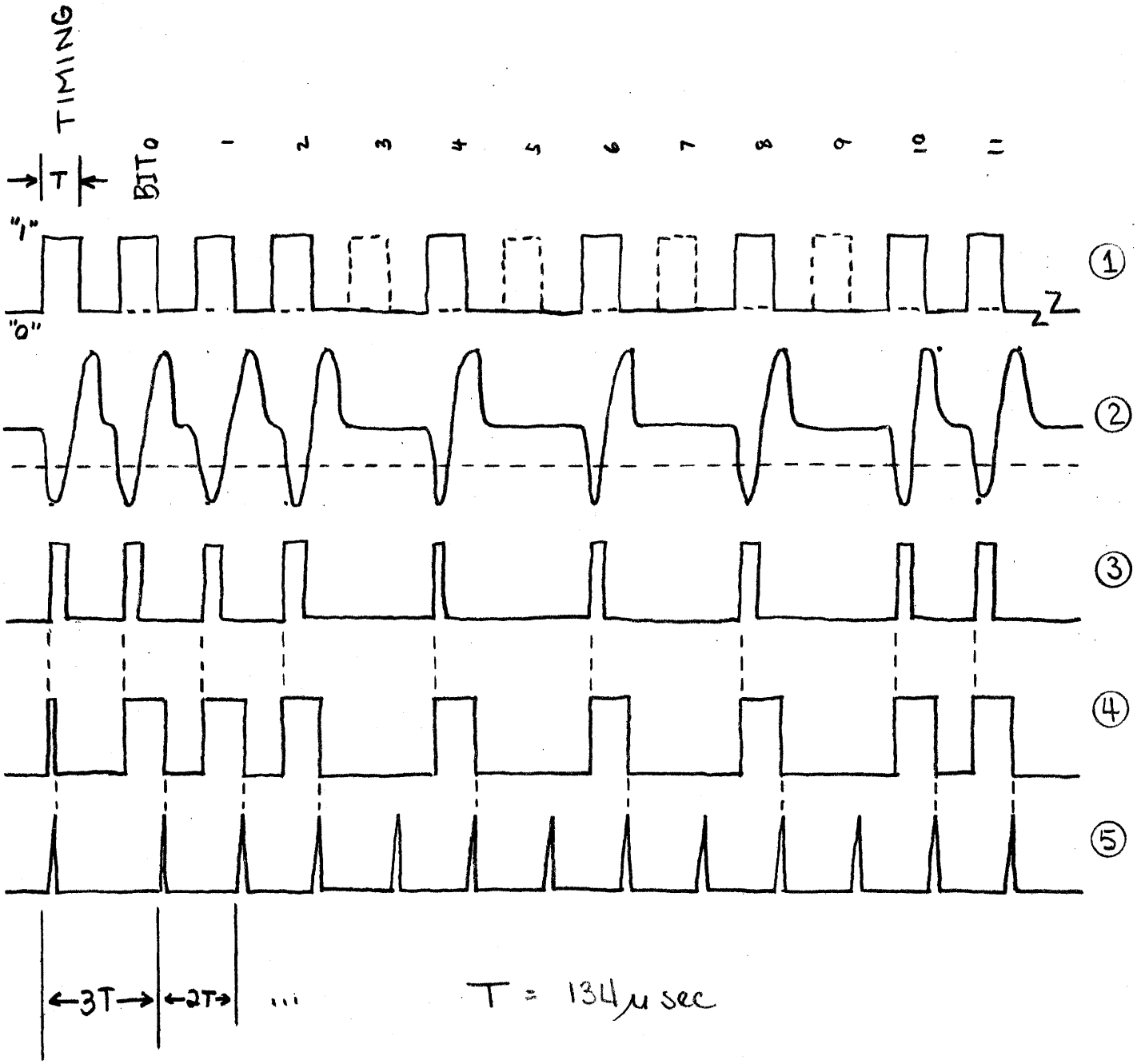


Figure 2. Tape Signals

PROGRAMMING

Recording

Refer to the listing of the TENNETAPE record routine. From the initial and final addresses, the processor calculates the negative of the number of words to be recorded. Then the write mode is selected and the tape started in motion, erasing previous information. A search for the reflective marker is started; when it is found, a three second delay of erase only is entered to insure that the tape is up to speed, and that the vicinity of the splice is past the head before actual recording begins. The first recorded word is the initial address, the second is the negative of the number of words recorded, and the rest but one are the desired information. The last word recorded is the checksum for the operation, namely the least significant 12 bits of the sum of all the recorded words.

Reading

Refer to the listing of the TENNETAPE read routine. A search loop for the reflective marker is entered, and upon exit a one second delay is entered to allow the splice to move past the head. The routine then searches for the timing mark of the first word which it takes as the initial address. The second word it takes for the negative of the number of words to read, and it then reads that number of words and deposits them in sequential memory locations starting at the initial address. The read routine keeps a checksum of all but the first two words. Upon reading all information words, the routine reads the next word as the recorded checksum and compares that checksum with the one it has calculated. The difference between the two checksums is placed in the accumulator and the routine halts.

The read program can easily be modified to do either of the following:

(1) Transfer control to some preassigned memory location when the calculated and recorded checksums agree;

(2) Compare (but not deposit) the information on tape with that in memory and ring the Teletype bell if the two do not agree. This read-compare operation is the best way to verify that record operations were successful.

Editing

Refer to the listing of EDIT-8 modifications for TENNETAPE I/O. The high speed reader options have been replaced by TENNETAPE I/O routines; otherwise editing is unchanged and operates according to the EDIT-8 manual. Text written on tape is blocked out in 574_8 word buffers for compatibility with PAL-III input; the operate/test switch must be in test position to get the tape up to speed rapidly.

The two least significant positions on the computer's front panel switches are used to denote tape input/output or Teletype input/output--one means TENNETAPE I/O, and zero means Teletype I/O.

One additional requirement is necessary for the TENNETAPE system. A dollar sign ($) must be the last character in any string of text for output; the last buffer most likely will not be exactly filled and the dollar sign is the symbol required to start output of the buffer.

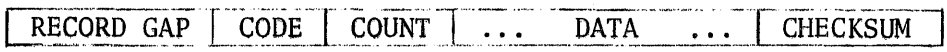
It should be noted that the space available for text in the editor has been reduced somewhat, but there remains ample storage space to handle one page of liberally annoted text.

Assembling

Refer to the listing of PAL-III modifications for TENNETAPE input. The high speed reader option has been replaced by TENNETAPE input routines; otherwise assembling is unchanged and operates according to the PAL -III manual. The operate/test switch must be in the test position to get the tape up to speed rapidly. The least significant bit on the computer front panel switches is used to denote TENNETAPE input or Teletype input; one means TENNETAPE input, and zero means Teletype input.

File Operations

Refer to the listings of the TENNETAPE file routines. The routines are quite general and require two pages of memory; more specific routines could be condensed into less space if necessary. All file operations should be done with the operate/test switch in test position unless the delays change to give more time for the tape to come up to speed. The format of files used by these routines is:



WBOT (Beginning Of Tape in Write mode) is necessary for initialization of any given track on a tape. The routine writes 1's at the end of tape and erases a short section of the tape to space the splice past the tape head. Upon return from WBOT, the tape is ready for writing files.

RBOT (Beginning Of Tape in Read mode) is used to find the beginning of tape. Upon return from RBOT, the tape is ready for reading files, and for writing files if the track has been previously initialized with WBOT.

WRITE is used to record the portion of memory from IA to FA. The file is identified with the CODE word specified by the contents of the AC when WRITE is called. The error return indicates that the end of tape was encountered during recording and the operation aborted, the tape being spaced to the beginning of tape point.

READ is used to read a file from the tape into the portion of memory from IA to FA; the code word is returned in the AC. The error return signifies one of the following errors has been made; the error flag word may be found in ERROR of the READ routine (READ + 102_8):

(a) The tape was not in an inter-record gap when READ was called (flag word = READ + 63_8). The tape was spaced to the next inter-record gap and the AC contains the code of the last record read;

(b) The size of the file on tape differs from the size called for (flag word = READ + 102_8). The tape was spaced to the inter-record gap and the code is in the AC;

(c) The checksum on tape differs from the checksum calculated during reading (flag word = READ + 51_8). The code is in the AC;

(d) The end-of-tape was encountered and the read operation was aborted (flag word = READ + 61_8). The tape was spaced to the beginning-of-tape point and the AC contains either the code word or 7777, depending on whether or not part of a record was there.

SPACE is used to skip over the number of files indicated by the contents of the AC when SPACE is called.

SEARCH is used to read a file with the code word specified by the contents of the AC when SEARCH is called. The error return indicates either that a file with the specified code was read incorrectly due to one of the error conditions discussed above with reference to READ (AC = 0) or that the end of tape was encountered without finding a file with the specified code (AC = -1). If the tape was not at the beginning of tape point when SEARCH was called, the proper file may have been on a prior portion of the tape and SEARCH should be called again to find it.

General Note

Due to the programmed delays for bit-to-bit timing in reading and writing, all tape operations should be protected from interrupts or data breaks during the inner read and write subroutines.

INSTALLATION

Installation of the TENNECOMP TP-1351 requires the following steps:

(1) Mount the transport and the interface units in a 19-inch relay rack. The transport requires 7 inches of rack height and the interface requires 5 1/4 inches of rack height.

(2) Connect the A.C. power cord to the rear of the transport unit.

(3) Connect D.C. power to both the transport and the interface. The D.C. power requirements are modest and can be supplied directly from the computer power supply. Power requirements are approximately:

+10 volts	100 ma
-15 volts	600 ma

Bus the power to each unit from the computer power supply using AMP FASTON type solderless connectors. Before proceeding to Step (4), check with a portable voltmeter that the proper voltages and polarities are present when the computer is turned on. **Refer to page 16 for details of power requirements.**

(4) Connect the transport to the interface with a standard 9 signal lead DEC type connector. The cable may be a shielded type with W021 connectors, or a ribbon type with W021 connectors. The shielded type is recommended when the transport and interface are in differenct enclosures or if the length exceeds 6 feet.

(5) Make sure the D.C. power is off and the computer is turned off. Connect the interface unit to the computer I/O bus. The standard method of I/O device connection on the PDP-8 family is to run the I/O bus from one device to another in "daisy chain" fashion. The PDP-8 I/O bus consists of 6 nine-signal cables as follows:

Cable 1 BAC_{0-8} (Accumulator Programmed Output)

Cable 2 BAC_{9-11}, IOP1, IOP2, IOP4, BT1, BT2, POW CLR

Cable 3 BMB_{0-5} (Buffered Memory Buffer Lines)

Cable 4 BMB_{6-11}

Cable 5 IC_{0-8} (Accumulator Programmed Input)

Cable 6 IC_{9-11}, SKIP, INT. REQ., CLEAR AC, B RUN.

The TENNECOMP Interface has two sets of 6 connectors in parallel so that the I/O bus may be run into one set and out the other. If the TENNECOMP Interface is located at the end of the "daisy chain," only one set of connectors will be used (although Cable 2 is sometimes terminated with a G009 card).

First decide where in the I/O bus you want to put the TENNECOMP tape unit interface. The simplest place is usually at the end of the chain, although it is equally satisfactory to break the chain and insert the interface.

On the minimum PDP-8/S system with only a progressor and a Teletype control, the tape unit interface may be connected onto the PT-08 Teletype control. The standard PT-08 cable assignments are as follows:

Cable 1 Connectors A6 and A7

Cable 2 Connectors B6 and B7

Cable 3 Connectors A8 and A9

Cable 4 Connectors B8 and B9

Cable 5 Connectors A13 and A14

Cable 6 Connectors B13 and B14

The connectors of the PT-08 are numbered A1 through A18 in the top row and B1 through B18 in the bottom row. Looking at the PT-08 from the wire-wrap side, A1 and B1 are on the left. Looking at it from the card and connector side, A1 and B1 are on the right.

On the minimum PDP-8 system, the I/O bus connectors are as follows:

Cable 1 Connector ME34

Cable 2 Connector MF34

Cable 3 Connector ME35

Cable 4 Connector MF35

Cable 5 Connector PE2

Cable 6 Connector PF2

On the minimum PDP-8/I, the negative I/O bus connectors are as follows:

Cable 1 Connector JO1

Cable 2 Connector JO2

Cable 3 Connector JO3

Cable 4 Connector JO4

Cable 5 Connector JO5

Cable 6 Connector JO6

Shielded connection cables with WO21 connectors are suggested if the computer is in another enclosure or if the cable length exceeds 6 feet. Otherwise, ribbon cables with WO21 connectors are satisfactory.

(6) When the A.C. power, D.C. power, interface-transport connector, and the six I/O bus connections have been made, give the system the "smoke test." Attempt to load a cell from the console switches. If the computer is not working correctly, disconnect the I/O bus cables and the D.C. power connections and reconnect them one at a time until the trouble appears. Check out the suspect cable for shorts, etc.

(7) Key in a short test program by hand as follows:

```
200   LAS        7604
      DCA  .+1   3202
      OPR        7000
      JMP  210   5210
      CLL        7100
      CML        7020
      JMP  200   5200
      OPR        7000
210   CLL        7100
      JMP  200   5200
```

This program will issue a continuous loop of instructions. The LAS allows the instruction to be changed from the key switches.

Insert a spare cartridge (without file protect pin). Load 200 into the program counter by means of the LOAD ADDRESS key. Put 6XX0 in the key switches and push START. (XX signifies the device code you have selected. XX = 37 is standard.)

Now lift switch register bit 11. The transport should start. Put bit 11 down and lift bit 9. The transport should now start in write mode with the FILE PROTECT ON. Finally, put bit 10 up also. The transport should continue to run and the LINK should come on momentarily when the Beginning-of-Tape mark comes around every 25 seconds.

If the system does not perform as expected, check for loose connectors or cards in the interface. Remove the top cover from the transport and see if the read amplifier card is securely in its socket, or if any components have come loose in shipment.

(8) Try recording a program on the cartridge, and then reading it back following the instructions under operation. If the system fails to read correctly, phone the plant or refer to the maintenance section.

Power

Plus 10 and minus 15 volts D.C. power must be made available for the Transport and Interface. The D.C. power can be supplied from the computer power supply if sufficient reserve capacity is present.

PDP-8/S — On a minimum PDP-8/S, ample power is available. Use the Red, Blue, and Black tabs at the rear of the central processor. On an expanded PDP-8/S, make sure that the power supply will not be overloaded.

PDP-8 — On a minimum PDP-8, ample power is available. Use the Red, Blue, and Black "Faston" tabs on the top of the power supply. There may be no extra tabs, in which case use a "branch".

PDP-8/I — On the PDP-8/I, standard voltages are +5, -15, and -30. In addition, an unfiltered +15 supply is used to power the panel lights. The -15 volt supply may be used directly. Extra Blue and Black tabs may be found on the power supply chassis. The +10 volt supply requirement may be derived from the computer's +15 volt supply by means of a Tennecomp 28004 Filter and Regulator board. Put a "branch" in the +15 volt tab coming out of the power supply going to an orange wire. Plug the 28004 board into A8 of the Tape Interface and connect the tab on the end to the +15 supply. Do not connect +10 to the normal "Faston" tab on the interface. The power for the Transport is bussed over to the tape transport.

PDP-8/L — The power supply for the PDP-8/L is not designed to supply any auxiliary units. The use of a separate plus 10, minus 15 volt power supply is recommended, such as the Tennecomp 28002 power supply.

Logic

The standard Tennecomp® TP-1351 is for negative logic operation with the PDP-8/S, PDP-8, and PDP-8/I. For the PDP-8/L or the positive logic version of the PDP-8/I, a positive logic interface or a TP-1351G negative logic conversion kit must be used. The conversion kit permits the unit to be used either with negative or positive logic models. The positive logic interface or converter is connected to the computer by means of three I/O cables. Detailed instructions are enclosed with the unit for installation.

MAINTENANCE

No periodic maintenance should be required. Generally, satisfactory performance can be obtained by observing common sense rules of cleanliness. Keep the tape cartridges stored in a protected place so that they do not pick up lint or grease.

Intermittent Operation of a Particular Cartridge

If a particular tape cartridge is giving trouble, remove the dust cover from the top of the transport so that an unobstructed view of the heads is obtained. Check to see if the tape is playing off the reel smoothly and is winding smoothly back on. Check to see if the pressure pad seems to be correctly aligned.

Intermittent Operation of all Cartridges

Remove the dust cover as above and visually inspect the transport parts. Check to see if the PINCH ROLLER is slipping. Try putting a short length of tape between the CAPSTAN and the PINCH ROLLER and see if the force is adequate to pull it from your fingers. If the CAPSTAN and HEAD are dirty or greasy, clean them with a tape head cleaning solvent. Robbins type TX-20 is adequate. Do not get solvent on the rubber PINCH ROLLER. It may be cleaned with a rag dampened with plain water or alcohol. Also give all exposed parts a good dusting if dirty or greasy.

If the transport still gives intermittent operation with a good tape, connect an oscilloscope to the input of the Schmidt trigger. The negative excursion of the signal while reading should be at least 5 volts below the baseline, and the signal should be clean and free from jitter. If the signal is appreciably less than 5 volts, the read amplifier is suspect.

Mark Sense Operation Faulty

If the mark sense circuit seems to be faulty, connect an oscilloscope to pin V of the transport connector. The signal should go from ground to at least -2.5 volts when the mark comes aorund. The photocell in the transport has a plastic shield which protects it from ambient light. Check for proper positioning of the shield if the voltage is less than normal. Check for burned out mark sense lamp.

Transport Inoperative

Check the MOTOR and PINCH ROLLER operation. Check the duration of the signals at the relays. The following program will generate WRITE MODE RELAY and MOTOR/PINCH ROLLER RELAY pulses (10 per sec) which can be observed on an oscilloscope.

```
200   TLS        6046
201   TSF        6041
202   JMP  201   5201
203   6XX5       6XX5
204   JMP  200   5200
205   JMP  200   5200
```

Check the current through the heads while writing a program. Measure the voltage across the 470 ohm resistor in series with the head in the transport enclosure. Use a dual probe oscilloscope with one probe on each side of the resistor. Set the preamplifier for summing operation with the polarity of one side reversed so that differential operation results. The 470 ohm resistor's only purpose is to allow the current to be monitored. The head current should vary about 2.1 ma either side of zero, and the waveshape should be approximately symmetrical.

COMPUTER TIMING COMPATIBILITY

The bit-to-bit timing for writing a tape with the TP-1351 is established by loops of instructions. There are speed variations between the different members of the PDP Family-of-Eight Computers, so that variations in the program must be made to achieve a standard bit-to-bit timing. The read routines also use loops of instructions to determine the "strobe" times for reading the tape.

If only one machine is to be used for writing and reading, there is no compatibility problem since the write and read times will be the same. But if it is desired to interchange tapes between the different computers, it is necessary to insure that the correct timing occurs in the write and the read routines.

The basic instruction timing characteristics of the PDP Family-of-Eight Computers are given below:

Computer	Instruction Timing	Clock
PDP-8	1.5 μ sec per cycle	Crystal Controlled
PDP-8/S Standard 4K Config.	6.2 to 6.3 μ sec per memory cycle plus 10 μ sec per processor cycle	Adjustable
PDP-8/S Extended Mem. or Data Break	8.0 μ sec per memory cycle plus 10 μ sec per processor cycle	Adjustable
PDP-8/I	1.5 μ sec per cycle	Adjustable
PDP-8/L	1.6 μ sec per cycle	Adjustable

All TENNETAPE programs use a delay loop for timing which has the instructions:

```
DELAY   NOP
        TAD  MDELAY
        IAC
        SZA
        JMP  .-2
        JMP  I  DELAY
MDELAY  -70
```

To accomodate slightly different execution speeds, it is only necessary to change the MDELAY constant in this program. The constant of 7710 (-70) is included with the standard software tapes. This is the correct constant for reading and writing on a computer with a 1.5 μ sec memory cycle.

To Adjust Timing Constant on PDP-8, PDP-8/I and PDP-8/L:

Read a short (25 sec) cartridge with the standard 268 μ sec bit-to-bit spacing. Change the MDELAY constant in the READ routine by keying in various values by hand or by using DDT. Find the maximum and minimum values of MDELAY which give correct operation (no checksum). These values should be near -70 and there should be at least a spread of 6 between the maximum value and the minimum value. Then use the middle of the range of satisfactory values of MDELAY thereafter.

To Adjust Timing on PDP-8/S

The PDP-8/S programs do not utilize a timing loop for bit-to-bit timing but are limited only by the maximum execution speed of the various instructions in the READ and WRITE subroutines. Instead of having a JMS to the delay routine, a NOP instruction is present. (Refer to the comments on the programs for the PDP-8/S differences.) Thus the PDP-8/S may not be adjusted for compatibility by changing the MDELAY constant. (The delay loop in the PDP-8/S is used only to establish the motion delays.) Instead the processor clock must be adjusted slightly to achieve the proper delay. Refer to TENNECOMP A-70431 for instructions for adjusting the processor clock.

PROGRAM LISTINGS

```
                /TENNETAPE RECORD ROUTINE
                *7660
7660   7000     DELAY,     NOP
7661   1266                TAD          MDELAY
7662   7001                IAC
7663   7440                SZA
7664   5262                JMP          .-2
7665   5660                JMP I        DELAY
7666   7710     MDELAY,    -70                      /"-2" FOR 8/S
7667   0034     HDELAY,    34
7670   7764     M14,       -14
7671   0000     CHKSUM,    0
7672   0000     STORE,     0
7673   0000     IA,        0
7674   0000     NWORDS,    0
7675   0000     COUNTR,    0
7676   1271     END,       TAD          CHKSUM
7677   4335                JMS          RECORD       /RECORD CALCULATED CHECKSUM
7700   7402     SETUP,     HLT
7701   7604                LAS                       /SET SWITCH REGISTER
7702   3273                DCA          IA           /TO INITIAL ADDRESS
7703   7402                HLT
7704   7604                LAS                       /SET SWITCH REGISTER
7705   7040                CMA                       /TO FINAL ADDRESS
7706   1273                TAD          IA
7707   3274                DCA          NWORDS       /NEGATIVE WORD COUNT
7710   6376     SEARCH,    TPWM                      /WRITE MODE, SKIP ON SPLICE
7711   5310                JMP          .-1
7712   1306     PAUSE,     TAD          WAIT         /SPLICE FOUND; DELAY TO LET
7713   3271                DCA          CHKSUM       /TAPE GET UP TO FINAL SPEED
7714   6374                TPWP
7715   4260                JMS          DELAY
7716   2271                ISZ          CHKSUM       /WILL BE ZERO AT DELAY END
7717   5314                JMP          .-3
7720   1273     BEGIN,     TAD          IA
7721   4335                JMS          RECORD       /RECORD INITIAL ADDRESS
7722   1274                TAD          NWORDS
7723   4335                JMS          RECORD       /RECORD NEGATIVE WORD COUNT
7724   1673     MORE,      TAD I        IA
7725   4335                JMS          RECORD       /RECORD DATA WORD
7726   1673                TAD I        IA           /ADD DATA WORD TO CHECKSUM
7727   1271                TAD          CHKSUM
7730   3271                DCA          CHKSUM
7731   2273                ISZ          IA           /INCREMENT LOCATION POINTER
7732   2274                ISZ          NWORDS       /INCREMENT WORD COUNT
7733   5324                JMP          MORE
7734   5276                JMP          END
```

```
7735  7000  RECORD,   NOP
7736  6375             TPWB                    /RECORD TIMING BIT
7737  3272             DCA        STORE
7740  1355             TAD        MEXTRA       /ADD SPACE BETWEEN WORDS
7741  3275             DCA        COUNTR
7742  4260             JMS        DELAY        /"AND I 0" FOR 8/S
7743  1272  BIT,       TAD        STORE
7744  7500             SMA
7745  7410             SKP                     /BIT WAS ZERO
7746  6375             TPWB                    /RECORD BIT FOR ONE
7747  7104             CLL RAL                 /SHIFT LEFT TO PREPARE
7750  3272             DCA        STORE        /FOR NEXT OUTGOING BIT
7751  4260             JMS        DELAY        /"NOP" FOR 8/S
7752  2275             ISZ        COUNTR
7753  5343             JMP        BIT          /MORE BITS YET IN WORD
7754  5735             JMP I      RECORD       /WORD COMPLETELY RECORDED
7755  7762  MEXTRA,    -16
            WAIT=7706
            TPWP=6374
            TPWB=6375
            TPWM=6376
```

```
BEGIN   7720
BIT     7743
CHKSUM  7671
COUNTR  7675
DELAY   7660
END     7676
HDELAY  7667
IA      7673
MDELAY  7666
MEXTRA  7755
MORE    7724
M14     7670
NWORDS  7674
PAUSE   7712
RECORD  7735
SEARCH  7710
SETUP   7700
STORE   7672
TPWB    6375
TPWM    6376
TPWP    6374
WAIT    7706
```

3273 3274
3137 0031
5764 4343
4772 4443
3076 4446
reverse
0306 1100
0306 1100
4311 0000
4311 0000
0306 1100

```
                /TENNETAPE READ ROUTINE
                *7600
7600  6371  SEARCH,  TPSP                    /PULSE MOTOR, SKIP ON BIT
7601  0001  ONE,     AND          1         /ESSENTIALLY A "NOP" STEP
7602  6372           TPMC                    /SKIP ON SPLICE
7603  5200           JMP          SEARCH
7604  1203  PAUSE,   TAD          WAIT      /SPLICE FOUND; DELAY TO LET
7605  3271           DCA          CHKSUM    /SPLICE MOVE PAST TAPE HEAD
7606  6373           TPSP TPMC
7607  7000           NOP
7610  4260           JMS          DELAY
7611  2271           ISZ          CHKSUM    /WILL BE ZERO AT DELAY END
7612  5206           JMP          .-4
7613  4236  BEGIN,   JMS          READ      /READ INITIAL ADDRESS
7614  3273           DCA          IA
7615  4236           JMS          READ      /READ NEGATIVE WORD COUNT
7616  3274           DCA          NWORDS
7617  4236  MORE,    JMS          READ      /READ DATA WORD
7620  3673           DCA I        IA
7621  1673           TAD I        IA        /ADD DATA WORD TO CHECKSUM
7622  1271           TAD          CHKSUM
7623  3271           DCA          CHKSUM
7624  2273           ISZ          IA        /INCREMENT LOCATION POINTER
7625  2274           ISZ          NWORDS    /INCREMENT WORD COUNT
7626  5217           JMP          MORE
7627  4236  END,     JMS          READ      /READ CHECKSUM
7630  7041           CIA                    /NEGATE RECORDED CHECKSUM
7631  1271           TAD          CHKSUM    /ADD CALCULATED CHECKSUM
7632  7402           HLT                    /USE "SZA" FOR AUTO-START
7633  7402           HLT                    /HALT IF CHECKSUM DIFFERENCE
7634  5635           JMP I        .+1       /START IF CHECKSUMS AGREE
7635  0200           200                    /AUTO-START POINTER
7636  7000  READ,    NOP
7637  6371           TPSP                   /SKIP ON TIMING MARK
7640  5237           JMP          .-1
7641  6372           TPMC                   /CLEAR BIT FLAG
7642  1270           TAD          M14       /DECIMAL -12
7643  3275           DCA          COUNTR
7644  1267           TAD          HDELAY    /"AND I 0" FOR 8/S
7645  4260           JMS          DELAY     /"AND 0" FOR 8/S
7646  7104  BIT,     CLL RAL                /SHIFT ONE LEFT TO PREPARE
7647  3272           DCA          STORE     /FOR NEXT INCOMING BIT
7650  4260           JMS          DELAY     /"NOP" FOR 8/S
7651  1272           TAD          STORE
7652  6373           TPSP TPMC              /SKIP ON AND CLEAR BIT FLAG
7653  7410           SKP                    /BIT WAS ZERO
7654  1201           TAD          ONE       /BIT WAS ONE
7655  2275           ISZ          COUNTR
7656  5246           JMP          BIT       /MORE BITS YET IN WORD
7657  5636           JMP I        READ      /WORD COMPLETELY ASSEMBLED
```

```
7660   7000   DELAY,     NOP
7661   1266              TAD          MDELAY
7662   7001              IAC
7663   7440              SZA
7664   5262              JMP          .-2
7665   5660              JMP I        DELAY
7666   7710   MDELAY,    -70                        /"-2" FOR 8/S
7667   0034   HDELAY,    34
7670   7764   M14,       -14
7671   0000   CHKSUM,    0
7672   0000   STORE,     0
7673   0000   IA,        0
7674   0000   NWORDS,    0
7675   0000   COUNTR,    0
              WAIT=7603
              TPSP=6371
              TPMC=6372

BEGIN    7613
BIT      7646
CHKSUM   7671
COUNTR   7675
DELAY    7660
END      7627
HDELAY   7667
IA       7673
MDELAY   7666
MORE     7617
M14      7670
NWORDS   7674
ONE      7601
PAUSE    7604
READ     7636
SEARCH   7600
STORE    7672
TPMC     6372
TPSP     6371
WAIT     7603
```

```
                /TENNETAPE READ-COMPARE ROUTINE
                *7636
7636  7000  READ,     NOP                        /NORMAL READ LOOP
7637  6371            TPSP
7640  5237            JMP         .-1
7641  6372            TPMC
7642  1270            TAD         M14
7643  3275            DCA         COUNTR
7644  1267            TAD         HDELAY         /"AND I 0" FOR 8/S
7645  4260            JMS         DELAY          /"AND 0" FOR 8/S
7646  7104  BIT,      CLL RAL
7647  3272            DCA         STORE
7650  4260            JMS         DELAY          /"NOP" FOR 8/S
7651  1272            TAD         STORE
7652  6373            TPSP TPMC
7653  7410            SKP
7654  1302            TAD         ONE
7655  2275            ISZ         COUNTR
7656  5246            JMP         BIT
7657  5636            JMP I       READ
7660  7000  DELAY,     NOP
7661  1266            TAD         MDELAY
7662  7001            IAC
7663  7440            SZA
7664  5262            JMP         .-2
7665  5660            JMP I       DELAY
7666  7710  MDELAY,    -70                        /"-2" FOR 8/S
7667  0034  HDELAY,    34
7670  7764  M14,       -14
7671  0000  CHKSUM,    0
7672  0000  STORE,     0
7673  0000  IA,        0
7674  0000  NWORDS,    0
7675  0000  COUNTR,    0
7676  0305  E,         305                        /ASCII CODE
7677  0317  O,         317                        /ASCII CODE
7700  6046  SEARCH,    TLS                        /INITIALIZE TELETYPE FLAG
7701  6371            TPSP
7702  0001  ONE,       1
7703  6372            TPMC                       /FOUND MARK?
7704  5301            JMP         SEARCH+1
7705  1304  SPLICE,    TAD         WAIT           /YES, DELAY TO SPACE
7706  3271            DCA         CHKSUM         /SPLICE PAST HEAD
7707  6373            TPSP TPMC
7710  7000            NOP
7711  4260            JMS         DELAY
7712  2271            ISZ         CHKSUM
7713  5307            JMP         .-4
7714  4236  BEGIN,     JMS         READ           /READ INITIAL ADDRESS
7715  3273            DCA         IA
7716  4236            JMS         READ           /READ WORD COUNT
7717  3274            DCA         NWORDS
```

```
7720   4236   MORE,     JMS          READ        /READ DATA WORD
7721   7041             CIA
7722   1673             TAD I        IA
7723   7640             SZA CLA                  /AGREE WITH MEMORY?
7724   5347             JMP          ERROR
7725   1271             TAD          CHKSUM      /YES, UPDATE CHECKSUM
7726   1673             TAD I        IA
7727   3271             DCA          CHKSUM
7730   2273   INCR,     ISZ          IA
7731   2274             ISZ          NWORDS
7732   5320             JMP          MORE
7733   4236   END,      JMS          READ        /READ CHECKSUM
7734   7041             CIA
7735   1271             TAD          CHKSUM
7736   7640             SZA CLA                  /AGREE WITH CALCULATION?
7737   5345             JMP          WRONG
7740   1277   RIGHT,    TAD          0           /YES, TYPE "0"
7741   6041             TSF
7742   5341             JMP          .-1
7743   6046             TLS
7744   7402             HLT
7745   1276   WRONG,    TAD          E           /NO, TYPE "E"
7746   5341             JMP          RIGHT+1
7747   6041   ERROR,    TSF
7750   5325             JMP          MORE+5
7751   1355             TAD          BELL
7752   6046             TLS                      /RING BELL FOR ERROR
7753   7200             CLA
7754   5325             JMP          MORE+5
7755   0207   BELL,     207
              WAIT=7704
              TPSP=6371
              TPMC=6372

BEGIN    7714
BELL     7755
BIT      7646
CHKSUM   7671
COUNTR   7675
DELAY    7660
E        7676
END      7733
ERROR    7747
HDELAY   7667
IA       7673
INCR     7730
MDELAY   7666
MORE     7720
M14      7670
NWORDS   7674
0        7677
ONE      7702
READ     7636
RIGHT    7740
SEARCH   7700
SPLICE   7705
STORE    7672
TPMC     6372
TPSP     6371
WAIT     7704
WRONG    7745
```

```
                /SHORT BINARY LOADER (LOW SPEED)
                *7700
7700    7200    BEGIN,      CLA
7701    3277                DCA         CHKSUM
7702    4343                JMS         FETCH
7703    5302                JMP         .-1         /SEES LEADER
7704    6034    GO,         KRS
7705    3276                DCA         COUNT       /SAVE PARTIAL CHECKSUM
7706    6036                KRB
7707    7106                CLL RTL
7710    7006                RTL
7711    7006                RTL
7712    6031                KSF
7713    5312                JMP         .-1
7714    6034                KRS
7715    3275                DCA         WORD        /SAVE ASSEMBLED WORD
7716    6036                KRB
7717    1276                TAD         COUNT
7720    3276                DCA         COUNT       /SAVE CHECKSUM
7721    4343                JMS         FETCH
7722    5336                JMP         END         /SEES TRAILER
7723    1275                TAD         WORD
7724    7420                SNL                     /DATA OR ORIGIN?
7725    5330                JMP         DATA
7726    3274    ORIGIN,     DCA         POINT       /RESET ORIGIN
7727    5332                JMP         UPDATE
7730    3674    DATA,       DCA I       POINT       /STORE DATA
7731    2274                ISZ         POINT
7732    1277    UPDATE,     TAD         CHKSUM      /UPDATE CHECKSUM
7733    1276                TAD         COUNT
7734    3277                DCA         CHKSUM
7735    5304                JMP         GO          /PROCESS NEXT WORD
7736    1277    END,        TAD         CHKSUM
7737    7041                CIA
7740    1275                TAD         WORD        /COMPARD CHECKSUMS
7741    7402                HLT                     /SHOW DIFFERENCE IN AC
7742    5300                JMP         BEGIN
7743    7000    FETCH,      NOP
7744    6032                KCC
7745    6031                KSF
7746    5345                JMP         .-1
7747    6034                KRS
7750    0354                AND         P200
7751    7650                SNA CLA
7752    2343                ISZ         FETCH       /SET RETURN FOR VALID WORD
7753    5743                JMP I       FETCH
7754    0200    P200,       200
                POINT=7674
                WORD=7675
                COUNT=7676
                CHKSUM=7677
```

```
                /EDIT-8 MODIFICATIONS FOR TENNETAPE I/O
                /BUFFERED INPUT-OUTPUT VERSION
                *56
0056    2522    END,        BUFBEG
                *114
0114    2522    BUFR,       BUFBEG
                *172
0172    1522    PTAPEI,     TAPEI
0173    1720    PNOMOR,     NOMORE
0174    0565    PFULL,      565
0175    0000    SWITCH,     0
                *1126
1126    7000    I750,       NOP             /WAS HIGH SPEED READER
1127    4572                JMS I           PTAPEI
1130    1357                TAD             MDOLAR
1131    7450                SNA             /IS CHARACTER A DOLLAR SIGN?
1132    4573                JMS I           PNOMOR
1133    1360                TAD             PDOLAR
1134    2175                ISZ             SWITCH
1135    5726                JMP I           I750
1136    5574                JMP I           PFULL
                *1153
1153    7000    OUTH,       NOP             /WAS HIGH SPEED PUNCH
1154    4756                JMS I           PTAPEO
1155    5753                JMP I           OUTH
1156    1620    PTAPEO,     TAPEO
1157    7534    MDOLAR,     -244
1160    0244    PDOLAR,     244
                *1244
1244    4646                JMS I           PSRCH
1245    5636                JMP I           TSTOUT
1246    1600    PSRCH,      SEARCH
                TSTOUT=1236
                *1257
1257    4661                JMS I           PLOOK
1260    7410                SKP
1261    1500    PLOOK,      LOOK
                *1500
1500    7000    LOOK,       NOP             /FIND SPLICE FOR READING
1501    6371                TPSP
1502    0001    ONE,        0001            /EFFECTIVE "NOP"
1503    6372                TPMC
1504    5301                JMP             .-3
1505    1373                TAD             WAITR
1506    3277                DCA             COUNT
1507    6373                TPSP TPMC
1510    7000                NOP
1511    4775                JMS I           PDELAY
1512    2277                ISZ             COUNT
1513    5307                JMP             .-4
1514    1063                TAD             CZ1
1515    3460                DCA I           KEYBRD
1516    3175                DCA             SWITCH
1517    7040                CMA
1520    3274                DCA             KEY
1521    5700                JMP I LOOK
                CZ1=63
                KEYBRD=60
```

```
1522  7000  TAPEI,    NOP          /TENNETAPE INPUT
1523  2274             ISZ          KEY
1524  5345             JMP          INHAND
1525  6373             TPSP TPMC    /START TAPE MOTION
1526  2274             ISZ          KEY
1527  5325             JMP          .-2
1530  1377             TAD          N574
1531  3274             DCA          KEY
1532  1372             TAD          PIOBUF
1533  3275             DCA          POINTR
1534  4350             JMS          READ
1535  3675             DCA I        POINTR
1536  2275             ISZ          POINTR
1537  2274             ISZ          KEY
1540  5334             JMP          .-4
1541  1377             TAD          N574
1542  3274             DCA          KEY
1543  1372             TAD          PIOBUF
1544  3275             DCA          POINTR
1545  1675  INHAND,    TAD I        POINTR
1546  2275             ISZ          POINTR
1547  5722             JMP I        TAPEI
1550  7000  READ,      NOP          /NORMAL TENNETAPE READ LOOP
1551  6371             TPSP
1552  5351             JMP          .-1
1553  6372             TPMC
1554  1376             TAD          N14
1555  3277             DCA          COUNT
1556  1374             TAD          HDELAY       /"AND I 0" FOR 8/S
1557  4775             JMS I        PDELAY       /"AND 0" FOR 8/S
1560  7104  BITS,      CLL RAL
1561  3276             DCA          SAVE
1562  4775             JMS I        PDELAY       /"NOP" FOR 8/S
1563  1276             TAD          SAVE
1564  6373             TPSP TPMC
1565  7410             SKP
1566  1302             TAD          ONE
1567  2277             ISZ          COUNT
1570  5360             JMP          BITS
1571  5750             JMP I        READ
1572  1724  PIOBUF,    IOBUFR
1573  5000  WAITR,     -3000
1574  0034  HDELAY,    34
1575  1677  PDELAY,    DELAY
1576  7764  N14,       -14
1577  7204  N574,      -574
            KEY=1474
            POINTR=1475
            SAVE=1476
            COUNT=1477
```

```
                *1600
1600    7000    SEARCH,     NOP         /FIND SPLICE FOR RECORDING
1601    6376                TPWM
1602    5201                JMP         .-1
1603    1317                TAD         WAITW
1604    3312                DCA         COUNTR
1605    6374                TPWP
1606    4277                JMS         DELAY
1607    2312                ISZ         COUNTR
1610    5205                JMP         .-3
1611    1072                TAD         HIGH
1612    3132                DCA         OUTDEV
1613    1307                TAD         M574
1614    3175                DCA         SWITCH
1615    1310                TAD         PBUFIO
1616    3311                DCA         ADDR
1617    5600                JMP I       SEARCH
                HIGH=72
                OUTDEV=132
1620    7000    TAPEO,      NOP         /TENNETAPE OUTPUT
1621    3711                DCA I       ADDR
1622    1711                TAD I       ADDR
1623    1315                TAD         NDOLAR
1624    7640                SZA CLA     /IS CHARACTER A DOLLAR SIGN?
1625    5230                JMP         NOTD
1626    1314                TAD         M3
1627    3175                DCA         SWITCH
1630    2311    NOTD,       ISZ         ADDR
1631    2175                ISZ         SWITCH
1632    5620                JMP I       TAPEO
1633    1316                TAD         WAIT
1634    3175                DCA         SWITCH
1635    6374                TPWP        /GET TAPE UP TO SPEED
1636    4277                JMS         DELAY
1637    2175                ISZ         SWITCH
1640    5235                JMP         .-3
1641    1307                TAD         M574
1642    3175                DCA         SWITCH
1643    1310                TAD         PBUFIO
1644    3311                DCA         ADDR
1645    1711                TAD I       ADDR
1646    4257                JMS         RECORD
1647    2311                ISZ         ADDR
1650    2175                ISZ         SWITCH
1651    5245                JMP         .-4
1652    1307                TAD         M574
1653    3175                DCA         SWITCH
1654    1310                TAD         PBUFIO
1655    3311                DCA         ADDR
1656    5620                JMP I       TAPEO
```

```
1657  7000  RECORD,   NOP        /NORMAL TENNETAPE RECORD LOOP
1660  6375             TPWB
1661  3313             DCA        STORE
1662  1306             TAD        N16
1663  3312             DCA        COUNTR
1664  4277             JMS        DELAY       /"AND I 0" FOR 8/S
1665  1313  BIT,       TAD        STORE
1666  7500             SMA
1667  7410             SKP
1670  6375             TPWB
1671  7104             CLL RAL
1672  3313             DCA        STORE
1673  4277             JMS        DELAY       /"NOP" FOR 8/S
1674  2312             ISZ        COUNTR
1675  5265             JMP        BIT
1676  5657             JMP I      RECORD
1677  7000  DELAY,     NOP
1700  1305             TAD        MDELAY
1701  7001             IAC
1702  7440             SZA
1703  5301             JMP        .-2
1704  5677             JMP I      DELAY
1705  7710  MDELAY,    -70       /"-2" FOR 8/S
1706  7762  N16,       -16
1707  7204  M574,      -574
1710  1724  PBUFIO,    IOBUFR
1711  0000  ADDR,      0
1712  0000  COUNTR,    0
1713  0000  STORE,     0
1714  7775  M3,        -3
1715  7534  NDOLAR,    -244
1716  6400  WAIT,      -1400        /"-3000" FOR 8/S
1717  4000  WAITW,     -4000
1720  7000  NOMORE,    NOP        /END OF INPUT IN THREE CHARACTERS
1721  1314             TAD        M3
1722  3175             DCA        SWITCH
1723  5720             JMP I      NOMORE
1724  1724  IOBUFR,    .
      BUFBEG=IOBUFR+576
      TPSP=6371
      TPMC=6372
      TPWP=6374
      TPWB=6375
      TPWM=6376
```

ADDR	1711
BIT	1665
BITS	1560
BUFBEG	2522
BUFR	0114
COUNT	1477
COUNTR	1712
CZ1	0063
DELAY	1677
END	0056
HDELAY	1574
HIGH	0072
INHAND	1545
IOBUFR	1724
I750	1126
KEY	1474
KEYBRD	0060
LOOK	1500
MDELAY	1705
MDOLAR	1157
M3	1714
M574	1707
NDOLAR	1715
NOMORE	1720
NOTD	1630
N14	1576
N16	1706
N574	1577
ONE	1502
OUTDEV	0132
OUTH	1153
PBUFIO	1710
PDELAY	1575
PDOLAR	1160
PFULL	0174
PIOBUF	1572
PLOOK	1261
PNOMOR	0173
POINTR	1475
PSRCH	1246
PTAPEI	0172
PTAPEO	1156
READ	1550
RECORD	1657
SAVE	1476
SEARCH	1600
STORE	1713
SWITCH	0175
TAPEI	1522
TAPEO	1620
TPMC	6372
TPSP	6371
TPWB	6375
TPWM	6376
TPWP	6374
TSTOUT	1236
WAIT	1716
WAITR	1573
WAITW	1717

```
                /PAL-III MODIFICATIONS FOR TENNETAPE INPUT
                /BUFFERED INPUT VERSION
                *115
0115    3065    IAM1,       SYTA-1
                *200
0200    5222    SPAL,       JMP         START
0201    7000    LOOK,       NOP         /FIND SPLICE BEFORE READING
0202    3156                DCA         SWITCH
0203    7604                LAS
0204    7010                RAR
0205    7630                SZL CLA
0206    5243                JMP         HREAD
0207    1054                TAD         LOREDI
0210    3020                DCA         AAA
0211    1131                TAD         TBUF
0212    3125                DCA         RBGN
0213    5601                JMP I       LOOK
0214    3125    TPUNM1,     DCA         RBGN
0215    6371                TPSP
0216    7000                NOP
0217    6372                TPMC
0220    5215                JMP         .-3
0221    5601                JMP I       LOOK
                SWITCH=156
                HREAD=243
                START=222
                LOREDI=54
                AAA=20
                TBUF=131
                RBGN=125
                *246
0246    5214                JMP         TPUNM1
                *271
0271    4201    INITAL,     JMS         LOOK
                *1441
1441    4651    READIN,     JMS I       PREAD
1442    1255                TAD         MDOLAR
1443    7450                SNA         /IS CHARACTER A DOLLAR SIGN?
1444    4653                JMS I       PNOMOR
1445    1254                TAD         PDOLAR
1446    2256                ISZ         FINISH
1447    5257                JMP         P1457
1450    5263                JMP         FULL1
1451    3006    PREAD,      READ
1452    1131                TAD         TBUF
1453    3060    PNOMOR,     NOMORE
1454    0244    PDOLAR,     244
1455    7534    MDOLAR,     -244
1456    0000    FINISH,     0
                FULL1=1463
                P1457=1457
```

```
                *3006
3006  7000  READ,     NOP
3007  1126            TAD         RKON
3010  7041            CIA
3011  1157            TAD         RCNT
3012  7640            SZA CLA
3013  5222            JMP         NOGAP
3014  1253            TAD         WAIT
3015  3257            DCA         COUNTR
3016  6373            TPSP TPMC   /GET TAPE UP TO SPEED
3017  4243            JMS         DELAY
3020  2257            ISZ         COUNTR
3021  5216            JMP         .-3
3022  6371  NOGAP,    TPSP
3023  5222            JMP        .-1
3024  6372            TPMC
3025  1254            TAD         N14
3026  3257            DCA         COUNTR
3027  1252            TAD         HDELAY        /"AND I 0" FOR 8/S
3030  4243            JMS         DELAY         /"AND 0" FOR 8/S
3031  7104  BITS,     CLL RAL
3032  3256            DCA         STORE
3033  4243            JMS         DELAY         /"NOP" FOR 8/S
3034  1256            TAD         STORE
3035  6373            TPSP TPMC
3036  7410            SKP
3037  1255            TAD         ONE
3040  2257            ISZ         COUNTR
3041  5231            JMP         BITS
3042  5606            JMP I       READ
3043  7000  DELAY,    NOP
3044  1251            TAD         MDELAY
3045  7001            IAC
3046  7440            SZA
3047  5245            JMP         .-2
3050  5643            JMP I       DELAY
3051  7710  MDELAY,   -70         /"-2" FOR 8/S
3052  0034  HDELAY,   34
3053  7000  WAIT,     -1000
3054  7764  N14,      -14
3055  0001  ONE,      1
3056  0000  STORE,    0
3057  0000  COUNTR,   0
3060  7000  NOMORE,   NOP         /END OF INPUT IN THREE CHARACTERS
3061  1265            TAD         N3
3062  3664            DCA I       PFINSH
3063  5660            JMP I      NOMORE
3064  1456  PFINSH,   FINISH
3065  7775  N3,       -3
3066  0000  SYTA,     0
            RKON=126
            RCNT=157
            TPSP=6371
            TPMC=6372
```

```
AAA      0020
BITS     3031                    /UPDATE OF JUNE, 1969
COUNTR   3057                    /FIXES PAUSE PSEUDO-OP
DELAY    3043                    *376
FINISH   1456          0376  4201          JMS     LOOK
FULL1    1463          0377  5446          POPJ
HDELAY   3052                    LOOK=201
HREAD    0243                    POPJ=5446
IAM1     0115
INITAL   0271          LOOK    0201
LOOK     0201          POPJ    5446
LOREDI   0054
MDELAY   3051
MDOLAR   1455
NOGAP    3022
NOMORE   3060
N14      3054
N3       3065
ONE      3055
PDOLAR   1454
PFINSH   3064
PNOMOR   1453
PREAD    1451
P1457    1457
RBGN     0125
RCNT     0157
READ     3006
READIN   1441
RKON     0126
SPAL     0200
START    0222
STORE    3056
SWITCH   0156
SYTA     3066
TBUF     0131
TPMC     6372
TPSP     6371
TPUNM1   0214
WAIT     3053
```

```
/          CALLING SEQUENCE:
/
/          TAD         CODE
/          JMS         WRITE
/          IA
/          FA
/          (ERROR RETURN)
/          (NORMAL RETURN)
/
WRITE,     NOP
           DCA         CODE
           TAD I       WRITE       /PICK UP INITIAL ADDRESS
           DCA         IA
           ISZ         WRITE
           TAD I       WRITE       /PICK UP FINAL ADDRESS
           CMA
           TAD         IA
           DCA         NWORDS
           ISZ         WRITE
           TAD         WDELAY      /WRITE RECORD GAP AND
           DCA         CHKSUM      /GET TAPE UP TO SPEED
           TPWP
           JMS         DELAY
           JMS         SPLICE
           ISZ         CHKSUM
           JMP .-4
           TAD         CODE        /WRITE CODE WORD
           JMS         RECORD
           JMS         SPLICE
           TAD         NWORDS      /WRITE WORD COUNT
           JMS         RECORD
           JMS         SPLICE
DUMP,      TAD         CHKSUM      /UPDATE CHECKSUM
           TAD I       IA
           DCA         CHKSUM
           TAD I       IA          /WRITE DATA WORD
           JMS         RECORD
           JMS         SPLICE
           ISZ         IA
           ISZ         NWORDS      /WRITTEN ALL DATA?
           JMP         DUMP
           TAD         CHKSUM      /YES, WRITE CHECKSUM
           JMS         RECORD
           TAD         SDELAY      /PAUSE TO LET READ-WRITE
           DCA         CHKSUM      /RELAY SWITCH TO READ MODE
           JMS         DELAY
           JMS         SPLICE
           ISZ         CHKSUM
           JMP         .-3
           ISZ         WRITE
           JMP I       WRITE
RECORD,    NOP                     /TENNETAPE RECORD LOOP
           TPWB
           DCA         STORE
           TAD         MEXTRA
           DCA         COUNTR
           JMS         DELAY       /"AND I 0" FOR 8/S
```

```
BIT,        TAD         STORE
            SMA
            SKP
            TPWB
            CLL RAL
            DCA         STORE
            JMS         DELAY       /"NOP" FOR 8/S
            ISZ         COUNTR
            JMP         BIT
            JMP I       RECORD
DELAY,      NOP
            TAD         MDELAY
            IAC
            SZA
            JMP         .-2
            JMP I       DELAY
SPLICE,     NOP
            TPMC                    /SPLICE FOUND?
            JMP I       SPLICE
            JMS         WBOT        /YES, SPACE TO BOT
            JMP I       WRITE
WDELAY,     -1400
SDELAY,     -700
MDELAY,     -70                     /"-2" FOR 8/S
MEXTRA,     -16
CHKSUM,     0
COUNTR,     0
NWORDS,     0
STORE,      0
CODE,       0
IA,         0
/
/           CALLING SEQUENCE:
/
/           JMS         WBOT
/           (NORMAL RETURN)
/
WBOT,       NOP
            TPWP TPMC               /TEST FOR SPLICE
            JMP         .-1
            TAD         M4
            DCA         NWORDS
            CMA                     /WRITE "7777" FOUR TIMES
            JMS         RECORD
            ISZ         NWORDS
            JMP         .-3
            TAD         BDELAY      /SET INDEX FOR SPACE
            DCA         CHKSUM
            TPWP                    /SPACE SPLICE PAST HEAD
            JMS         DELAY
            ISZ         CHKSUM
            JMP         .-3
            JMP I       WBOT
BDELAY,     -4000
M4,         -4
```

```
/          CALLING SEQUENCE:
/
/          TAD         CODE
/          JMS         SEARCH
/          IA
/          FA
/          (ERROR RETURN)
/          (NORMAL RETURN)
/
SEARCH,    NOP
           DCA         CODE
           TAD I       SEARCH      /PICK UP INITIAL ADDRESS
           DCA         JREAD+1
           ISZ         SEARCH
           TAD I       SEARCH      /PICK UP FINAL ADDRESS
           DCA         JREAD+2
           ISZ         SEARCH
JREAD,     JMS I       PREAD       /READ A FILE
           NOP
           NOP
           JMP         ERROR       /IF ERROR, WHAT KIND?
           CIA
           TAD         CODE
           SZA CLA                 /RIGHT CODE?
           JMP         JREAD
           ISZ         SEARCH      /YES, INCREMENT RETURN ADDRESS
           JMP I       SEARCH
ERROR,     CIA
           TAD         CODE
           SNA CLA                 /RIGHT CODE?
           JMP I       SEARCH      /YES, RETURN WITH AC=0
           TAD I       PERROR
           TAD         NEOT
           SZA CLA                 /END OF TAPE?
           JMP         JREAD
           CMA                     /YES, SET AC=-1 FOR RETURN
           JMP I       SEARCH
PREAD,     READ
PERROR,    READ+102
NEOT,      -READ-61


READ=WRITE+200                     /ASSUME CONSECUTIVE PAGES
TPMC=6372
TPWP=6374
TPWB=6375
$
```

```
/          CALLING SEQUENCE:
/
/          JMS         READ
/          IA
/          FA
/          (ERROR RETURN)
/          (NORMAL RETURN)
/
READ,      NOP
           TAD I       READ        /PICK UP INITIAL ADDRESS
           DCA         IA
           ISZ         READ
           TAD I       READ        /PICK UP FINAL ADDRESS
           CMA
           TAD         IA
           DCA         NWORDS
           ISZ         READ
           TPMC                    /CLEAR BIT FLAG
           TAD         RDELAY
           DCA         CHKSUM
           TPSP TPMC               /TEST FOR RECORD GAP
           SKP
           JMP         JUNK
           JMS         DELAY
           ISZ         CHKSUM
           JMP         .-5
           JMS         ASSMBL      /READ CODE WORD
           DCA         CODE
           JMS         SPLICE
           JMS         ASSMBL      /READ WORD COUNT
           CIA
           TAD         NWORDS
           SZA CLA                 /SIZE ERROR?
           JMP         SIZE
           JMS         SPLICE
GET,       JMS         ASSMBL      /READ DATA WORD
           DCA I       IA
           TAD         CHKSUM      /UPDATE CHECKSUM
           TAD I       IA
           DCA         CHKSUM
           JMS         SPLICE
           ISZ         IA
           ISZ         NWORDS      /READ ALL DATA?
           JMP         GET
           JMS         ASSMBL      /YES, READ CHECKSUM
           CIA
           TAD         CHKSUM
           SZA CLA                 /CHECKSUM ERROR?
           JMS         ERROR
           ISZ         READ        /NO, INCREMENT RETURN ADDRESS
RETURN,    TAD         CODE
           JMP I       READ        /CODE IN AC UPON EXIT
```

```
SPLICE,   NOP
          TPMC                    /SPLICE FOUND?
          JMP I       SPLICE
          JMS         RBOT        /YES, SPACE TO BOT
          JMS         ERROR
JUNK,     JMS         BLANK       /SPACE TO RECORD GAP
          JMS         ERROR
BLANK,    NOP
          TAD         RDELAY      /SET INDEX FOR BLANK TAPE
          DCA         CHKSUM
          TPMC                    /TEST FOR SPLICE
          SKP
          JMP         SPLICE+3
          TPSP                    /TEST FOR BIT
          SKP
          JMP         JUNK        /BIT FOUND, RESET INDEX
          JMS         DELAY
          ISZ         CHKSUM
          JMP         .-5
          JMP I       BLANK
SIZE,     JMS         BLANK       /SPACE TO RECORD GAP
          JMS         ERROR
ERROR,    NOP                     /ERROR CODE LOCATION
          JMP         RETURN
ASSMBL,   NOP                     /TENNETAPE READ LOOP
          TPSP
          JMP         .-1
          TPMC
          TAD         M14
          DCA         COUNTR
          TAD         HDELAY      /"AND I 0" FOR 8/S
          JMS         DELAY       /"AND 0" FOR 8/S
BIT,      CLL RAL
          DCA         STORE
          JMS         DELAY       /"NOP" FOR 8/S
          TAD         STORE
          TPSP TPMC
          SKP
          TAD         ONE
          ISZ         COUNTR
          JMP         BIT
          JMP I       ASSMBL
DELAY,    NOP
          TAD         MDELAY
          IAC
          SZA
          JMP         .-2
          JMP I       DELAY
```

```
MDELAY,    -70                    /"-2" FOR 8/S
HDELAY,    34
M14,       -14
CHKSUM,    0
STORE,     0
IA,        0
NWORDS,    0
COUNTR,    0
RDELAY,    -100
CODE,      0
/
/          CALLING SEQUENCE:
/
/          JMS         RBOT
/          (NORMAL RETURN)
/
RBOT,      NOP
           TPSP
ONE,       1
           TPMC                   /TEST FOR SPLICE
           JMP         .-3
           TAD         BDELAY     /SET INDEX FOR SPACE
           DCA         COUNTR
           JMS         DELAY
           TPSP, TPMC             /SPACE SPLICE PAST HEAD
           ISZ         COUNTR
           JMP         .-3
           JMP I       RBOT
BDELAY,    -4000
/
/          CALLING SEQUENCE:
/
/          TAD         +N
/          JMS         SPACE
/          (NORMAL RETURN)
/
SPACE,     NOP
           CIA                    /SET NEGATIVE INDEX
           DCA         SKIP
           JMS         READ       /READ A FILE
           0                      /WITH RIDICULOUS ARGUMENTS
           0                      /TO FORCE AN ERROR
           NOP
           CLA                    /IGNORE CODE WORD
           ISZ         SKIP
           JMP         SPACE+3    /SKIP ANOTHER FILE
           JMP I       SPACE      /FINISHED SKIPPING
SKIP,      0


TPSP=6371
TPMC=6372
$
```

ATTACHMENTS

Number	Title
27002	TP-1351 Tape Unit Interface
27003	TP-1351 Tape System Interface
26004	TP-1351 Tape System Transport
26005	TP-1351 Tape System Amplifier
26009	TP-1351 Tape Component Card

WARRANTY

TENNECOMP, Inc. warrants each computer peripheral product manufactured by it to be free from defective materials and workmanship. Tennecomp agrees to repair or replace, at our option, any defective part of any unit of its manufacture which under normal installation, use and service, discloses such defect, provided that the unit is delivered to us with all transportation charges prepaid to our plant or delivered to our authorized representative within one year from the date of delivery to the original purchaser.