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TITLE	PAL12A ASSEMBLER
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SOURCE LANGUAGE	PAL12A

PAL12A IS A 4K ASSEMBLER OPTIMIZED FOR THE PDP-12/B OR PDP-12/A RUNNING UNDER THE 4K DIAL-V2 MONITOR. IT IS BASED ON MACRO-8 OF MARCH, 1971 (DEC-08-CMAB), AND PROVIDES MANY FUNCTIONS NEVER BEFORE AVAILABLE IN A LINCTAPE ORIENTED ASSEMBLER FOR CONFIGURATIONS THIS SMALL (AT THE UNFORTUNATE EXPENSE OF A VERY FEW OF THE LESS OFTEN USED FUNCTIONS OF THE DIAL ASSEMBLER). THESE FUNCTIONS INCLUDE LITERALS AND OFF-PAGE LINKS (IN PMODE), "LISTAPE", "CHAIN", A CORE USAGE MAP, "FIXTAB" AND "EXPUNGE", "" OPERATOR, AND "%" OPERATOR. NOTE THAT THIS PROGRAM MAKES NO PROVISION FOR THE ASSEMBLY OF CODE INTO MORE THAN THE LOWEST 4K, ALTHOUGH FIELD 1 OUTPUT FROM THE DIAL ASSEMBLER WILL BE TREATED PROPERLY BY THE CHAIN OPTION. THE FOLLOWING DISCUSSION ASSUMES THAT THE READER IS FAMILIAR WITH BOTH THE DIAL ASSEMBLER AS SPECIFIED IN "DEC-12-SE2D-D" AND THE MACRO-8 ASSEMBLER AS DESCRIBED IN "PROGRAMMING LANGUAGES, 1972".

COMPATIBILITY WITH DIAL

THE PAL12A LANGUAGE IS BASICALLY COMPATIBLE WITH THAT OF DIAL; HOWEVER, THE FOLLOWING POINTS SHOULD BE NOTED:

1. EXPUNGE AND FIXTAB PSEUDO-OPS SERVING THE SAME FUNCTION AS IN MACRO-8 HAVE BEEN INCLUDED. EXPUNGE ALSO DISABLES THE ROUTINES THAT READ THE DIAL PERMANENT SYMBOL TABLES IN FROM BLOCKS 341 & 342 ON "PMODE" & "LMODE" PSEUDO-OPS.
2. ALL OPCODES THAT ARE NOT IN THE DIAL PERMANENT TABLES MUST BE DEFINED AT THE VERY BEGINNING OF THE PROGRAM, AND THE DEFINITIONS MUST BE FOLLOWED BY A FIXTAB. IF EXPUNGE IS USED, ALL OPCODES MUST BE DEFINED THIS WAY. (FIXTAB AND EXPUNGE SHOULD BE USED ONLY AT THE BEGINNING OF THE SOURCE.)

ALL CODING OF THE FORM:

```
CLA
INC .+1
INC=2000
TAD I .+10
```

MUST BE CHANGED TO:

```
INC=2000
FIXTAB
.
.
.
CLA
INC .+1
TAD I .+10
```

BECAUSE THE ADDRESS PORTION OF THE INC INSTRUCTION WILL NOT BE ASSEMBLED PROPERLY IN THE FIRST CASE. HOWEVER:

TAD INC
INC=-.20

IS PERFECTLY LEGAL AND WILL ASSEMBLE PROPERLY. (SEE "MRI RECOGNITION", PAGE 14-61 OF PROG. LANG.)

3. "LM" AND "PM" PSEUDO-OPS ARE INCLUDED, WITH THE SAME SIGNIFICANCE AS LMODE AND PMODE, RESPECTIVELY. (LMODE AND PMODE ARE ALSO INCLUDED.)

4. DIAL PROMISES 896 SYMBOLS, BUT USING MORE THAN 192 WITH 4K CAUSES THE SYMBOL TABLE TO BE TRADED IN AND OUT FROM AN I/O DEVICE. IN A NON-DISK SYSTEM, THIS MAKES AN ASSEMBLY AN ALL-DAY JOB. PAL12A HAS A MAXIMUM SYMBOL CAPACITY OF APPROXIMATELY 320(10) SYMBOLS--ALL RESIDING IN CORE. THE MAXIMUM CAPACITY MAY BE EXTENDED BY UP TO 64(10) SYMBOLS THROUGH THE USE OF THE EXPUNGE PSEUDO-OP.

5. THE VALUE TABLE GIVEN ON PAGE 3-3 OF "SE2D-D" APPLIES ONLY TO TAGS, NOT TO SYMBOLS DEFINED WITH "=".

6. "\" HAS BEEN EXTENDED TO WORK WITH NEGATIVE AS WELL AS POSITIVE LEFT ARGUMENTS.

7. "(", ")", "[", AND "]" ARE INCLUDED TO CONTROL LITERALS (SEE MACRO-8).

8. THE OPERATOR "%" HAS BEEN ADDED TO PERFORM THE FOLLOWING OPERATION:

1%2==100+2

MOREOVER:

LMODE
-1%==7677
PMODE
-1%==7700

("\" ALSO TREATS NEGATIVE NUMBERS PROPERLY.)

9. THE "FIELD" PSEUDO-OP HAS BEEN DELETED.

10. BOTH FUNCTIONS OF THE "LISTAPE" PSEUDO-OP (LISTING ON TAPE AND CHAIN ASSEMBLIES) ARE CONTROLLED BY SWITCH REGISTER OPTIONS IN PAL12A (SEE THE SECTION ON OPERATING PAL12A).

11. "LIST" STATEMENTS ALWAYS APPEAR IN LISTINGS.

12. "EJECT" WORKS ON THE TELETYPE.

13. NO CONDITIONAL ASSEMBLY PSEUDO-OPS ("ASMIF(X) N" OR "ASMSKP N") ARE INCLUDED.

14. "SAVSYM" AND "LODSYM" ARE NOT INCLUDED.

15. DOUBLE QUOTE (") FOLLOWED BY ANY CHARACTER GIVES THE DIAL SIXBIT CODE FOR THE OBJECT CHARACTER (SEE MACRO-8). BE VERY CAREFUL IN FOLLOWING THIS CHARACTER WITH A RETURN.

16. "Z" IS INCLUDED FOR COMPATIBILITY AND IS JUST AS WORTHLESS AS IN DIAL.

17. THE FOLLOWING PSEUDO-OPS MAY BE HUNG ON THE END OF LINES (FOR EXAMPLE, "LINC LM", OR "TAD I 2 EJECT".):

PMODE	PM	LMODE	LM	LIST	NOLIST
EJECT	EXPUNG	FIXTAB	OCTAL	DECIMAL	

18. SEMICOLONS PROVIDE THE SAME FUNCTION AS IN DIAL, BUT THEY NEVER INCREMENT THE LINE NUMBER.

19. THERE IS NO PROVISION FOR A LINE PRINTER IN PAL12A.

20. WHEN BEGINNING AN ASSEMBLY, DIAL DUMPS A BLOCK OF GARBAGE AT 400 (CONTAINING LOCATIONS 4000-4377) IN THE BINARY WORKING AREA, AND MAKES AN ENTRY IN THE CORE CONTROL MAP THAT CAUSES THIS BLOCK ALWAYS TO BE LOADED, EVEN IF NO CODE IS ASSEMBLED THERE. PAL12A NEVER OUTPUTS GARBAGE. THIS ALLOWS CHAIN ASSEMBLIES TO INCLUDE CODE FOR LOCATIONS 4000-4377 IN ANY SOURCE, NOT JUST IN THE LAST ONE IN SEQUENCE. IT ALSO TENDS TO SHORTEN BINARY FILES, SINCE ANY FILE THAT DOES NOT USE LOCATIONS 4000-4377 WILL BE ONE BLOCK SHORTER WHEN ASSEMBLED BY PAL12A RATHER THAN DIAL.

21. PAL12A DOES NOT USE THE EXTENDED TAPE UNITS, THUS SOURCES MAY COME ONLY FROM UNITS 0 & 1. HOWEVER, THE PROGRAM DOES USE EXTENDED BLOCK ADDRESSING. THIS ALLOWS PROGRAMS LOCATED IN THE HIGH FILE AREA OF A LONG DIAL TAPE (BLOCKS 1000-1577) TO BE ASSEMBLED WITHOUT BEING MOVED TO LOWER BLOCKS.

22. UNLIKE DIAL, PAL12A SIMPLY ASSUMES THAT A VALID DIAL PERMANENT SYMBOL TABLE WILL RESIDE AT BLOCKS 341 & 342 OF THE OPPOSITE UNIT FROM THAT CONTAINING THE SOURCE. (DIAL CHECKS FOR A VALID TABLE, AND IF IT DOES NOT FIND ONE, IT USES THE TABLE FROM THE UNIT WITH THE SOURCE.) BOTH TAPES SHOULD CONTAIN VALID DIAL SYSTEMS WHEN USING PAL12A.

23. IF LISTING LIMITS ARE SPECIFIED BY THE OPERATOR, ANY LIST OR NOLIST PSEUDO-OPS IN THE SOURCE WILL BE IGNORED.

24. THE SYMBOL TABLE AND THE STORAGE AREA FOR THE LISTING OCCUPY THE SAME AREA OF CORE. THE SYMBOL TABLE HAS PRIORITY OVER THE LISTING. THIS CAUSES LISTING LINES TO BE TRUNCATED WHEN THE PROGRAM BEING ASSEMBLED USES MANY SYMBOLS (THAT IS, WHEN THE ASSEMBLER IS NEAR ITS FULL SYMBOL CAPACITY).

PAL12A OPERATING PROCEDURES

PAL12A IS STORED AND USED AS A SELF-STARTING

BINARY FILE IN THE DIAL FILE AREA, IN MUCH THE SAME WAY AS PIP. (IT STARTS AT 04020(8).) WHEN PAL12 IS LOADED, IT WILL HALT TO ALLOW SETTING OF THE SWITCH OPTIONS. SETTING SENSE SWITCH 5 TO 1 WILL SKIP THE HALT.

THE RIGHT SWITCHES ARE INTERPRETED AS FOLLOWS:

```

00 S BINARY OUTPUT PASS
01 S CORE MAP PASS
02 S LISTING PASS & LISTING
03 S LISTAPE PASS
04 S SYMBOL TABLE PRINTING (CLEARED BY 02 & 03)
05 E QUICK LIST MODE (HARD LISTING ONLY)
06 S CORE MAP PRINTING
07 E CHAIN (PRESERVE CORE CONTROL & MAP BLOCKS)
08 E GET SOURCE FILENAME AND UNIT FROM KEYBOARD
09 E GET LISTING LIMITS FROM KEYBOARD
10 S PRINTING OF "LG" MESSAGE

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(S=SUPPRESS; E=ENABLE)

THE KEYBOARD INPUT OF THE FILENAME, UNIT, AND LISTING LIMITS IS HANDLED BY A MODIFIED QANDA IN WHICH THE FOLLOWING CHARACTERS HAVE SPECIAL SIGNIFICANCE WHEN RECEIVED FROM THE KEYBOARD:

```

004 CTRL/D RESTART DIAL
011 CTRL/I CONVERTED TO TAB (047)
012 LN FD ENDS INPUT FOR CURRENT FIELD
014 CTRL/L MOVES CURSOR 1 POSITION LEFT
015 CAR RET ENDS INPUT FOR CURRENT DISPLAY
022 CTRL/R MOVES CURSOR 1 POSITION RIGHT
[ALL OTHER CONTROL CODES IGNORED.]
043 HASH IGNORED
047 QUOTE IGNORED
057 / IGNORED
077 ? IGNORED
100 AT IGNORED
137 L ARROW IGNORED
175 ALT ERASES ALL INPUT ON CURRENT DISPLAY
177 RUB ERASES CURRENT CHARACTER

```

CTRL/D (CODE 004) MAY BE STRUCK AT ANY TIME WHILE THE PROGRAM IS RUNNING TO RESTART DIAL.

TO SAVE CORE, PAL12A IS WRITTEN IN SUCH A WAY AS TO BE IMPOSSIBLE TO RESTART AFTER IT HAS BEEN STARTED ONCE. IF SOME MISTAKE HAS BEEN MADE, DO NOT EVER ATTEMPT TO RESTART THE PROGRAM AT 04020(8). INSTEAD, USE CTRL/D OR THE CONSOLE TO GET BACK TO DIAL, THEN RELOAD THE PROGRAM.

PAL12A OUTPUTS

1. ERRORS WILL BE OUTPUT TO THE TELETYPE ON EVERY PASS EXCEPT THE LISTAPE, WHEN THEY GO OUT TO THE TAPE.

2. THERE ARE NO OUTPUTS BUT ERRORS ON THE FIRST PASS.

3. ON THE SECOND PASS, THE BINARY IS OUTPUT TO BLOCKS 370-407 IN THE BINARY WORKING AREA ON UNIT 1. A CORE CONTROL MAP IS ALSO CREATED AT BLOCK 447. THE BLOCKS RESERVED FOR CODING IN THE UPPER 4K OF AN 8K MACHINE (410-427) ARE NOT TOUCHED.

4. ON THE THIRD PASS, A CORE USAGE MAP IS GENERATED AT BLOCKS 440 & 441 OF UNIT 1. IF RSW(06)=0, A CORE MAP WILL BE PRINTED OUT AT THE END OF THE PASS. BELOW IS A TYPICAL MAP LINE:

```
0200 FFFF FFFC 01FF 8000 0000 0000 0000 0000
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AT THE FAR LEFT IS THE ADDRESS (IN OCTAL) OF THE FIRST WORD REPRESENTED ON THE LINE. TO THE RIGHT OF THE ADDRESS ARE GROUPS OF IBM HEX DIGITS*. EACH HEX DIGIT MAY BE DECODED INTO A FOUR BIT CODE DESCRIBING THE USE OR DISUSE OF FOUR MEMORY WORDS BY THE PROGRAM JUST ASSEMBLED (A 1 INDICATES USE, A 0 DISUSE). THE LINE ABOVE SHOWS THAT LOCATIONS 200-235 & 247-260 ARE USED, WHILE 236-246 & 261-377 ARE UNUSED. NOTE THAT THE MAP SHOWS ONLY LOCATIONS INTO WHICH THE ASSEMBLER PLACES CODE. OTHER AREAS OF CORE MAY BE USED AS BUFFERS BY THE OBJECT PROGRAM WITHOUT INDICATION IN THE MAP.

* IBM HEXADECIMAL:

0=0000	4=0100	8=1000	C=1100
1=0001	5=0101	9=1001	D=1101
2=0010	6=0110	A=1010	E=1110
3=0011	7=0111	B=1011	F=1111

5. IF THE CHAIN OPTION IS SPECIFIED (RSW(07)=1), THE OLD LOADER CORE CONTROL MAP IS PICKED UP FROM BLOCK 447, AND THE NEW MAP IS MERGED WITH IT TO FORM THE OUTPUT MAP. DESPITE THE FACT THAT PAL12A WILL NOT ASSEMBLE CODE FOR THE HIGH 4K, THE MERGE CODING IS WRITTEN IN SUCH A WAY THAT ANY CODING IN EITHER 4K FIELD THAT HAS ALREADY BEEN ASSEMBLED (AND IS NOT OVERWRITTEN DURING THE CURRENT ASSEMBLY) WILL BE EXTANT IN THE FINAL OUTPUT. ALSO, CHAIN CAUSES ANYTHING ALREADY IN BLOCKS 440 & 441 (WHICH MAY CONTAIN TRADED-OUT DIAL SYMBOL TABLE) TO BE MERGED WITH THE CORE MAP OUTPUT PRODUCED IN PASS 3 (440 & 441 ARE CLEARED IF RSW(07)=0).

6. LISTINGS AND QUICK LISTINGS HAVE THE SAME FORMAT AS IN DIAL, WITH SOME EXTRANEIOUS SPACES REMOVED TO SPEED THEM UP. THE ONE EXCEPTION TO THIS IS THAT IN PAL12A, THE FULL 12-BIT ADDRESS OF EACH WORD IS PRINTED EVEN UNDER THE LMODE PSEUDO-OP (THE ABOVE ALSO APPLIES TO THE LISTAPE). A SYMBOL TABLE WILL BE OUTPUT AT THE END OF BOTH THE LISTING AND LISTAPE PASSES REGARDLESS OF THE SETTING OF RSW(04).

7. LISTAPES ARE OUTPUT TO UNIT 1 STARTING AT BLOCK 0. THERE IS NO CHECK FOR EXISTING FILES, SO BE CAREFUL! THE LISTAPE IS OUTPUT IN STANDARD DIAL SIXBIT CODE, 2 CHARACTERS PER WORD. BECAUSE OF THIS, AND BECAUSE OF THE SPACES

REMOVED, LISTAPES GENERATED BY PAL12A ARE NOT COMPATIBLE WITH ANY DEC "CREF" PROGRAMS. NOTE THAT THE LISTAPE CODING WILL USE THE GIVEN LISTING LIMITS PROPERLY, BUT THAT IT IS IMPOSSIBLE TO SEND A QUICK LISTING TO THE TAPE. THE LISTAPE CODING GENERATES ONLY FULL LISTINGS.

PAL12A ERROR MESSAGES

PAL12A OUTPUTS ITS ERROR MESSAGES IN THE SAME FORMAT AS DIAL (NNNN EE), BUT ITS ERROR CODES CORRESPOND TO THOSE OF MACRO-8, WITH THE FOLLOWING EXCEPTIONS:

1. "IM", "MP", AND "XX" ARE DELETED.
2. "TX" IS INCLUDED TO FLAG AN UNCLOSED "TEXT" PSEUDO-OP. PAL12A RETURNS TO DIAL IMMEDIATELY AFTER TYPING THE "TX".
3. PAL12A ALSO RETURNS TO DIAL AFTER TYPING AN "SE".
4. WHEN AN "ID" IS CAUSED BY A TAG BEING DEFINED TWICE, THE VALUE OF THE TAG IS RESPECIFIED AS IN DIAL, SO THAT BOTH OCCURRENCES OF THE TAG WILL BE FLAGGED ON THE SECOND AND LATER PASSES. (MACRO-8 DOES NOT RESPECIFY THE VALUE.) IF THE "ID" IS CAUSED BY ATTEMPTED REDEFINITION OF A PSEUDO-OP OR PERMANENT SYMBOL, NO RESPECIFICATION OCCURS.
5. "US" ERRORS WILL CAUSE THE SYMBOL COUNT GIVEN AT THE BEGINNING OF THE SYMBOL TABLE TO DISAGREE WITH THE NUMBER OF SYMBOLS PRINTED OUT.

ASSEMBLING PAL12A

IT IS RECOMMENDED THAT THE FOLLOWING PROCEDURE BE FOLLOWED TO ASSEMBLE A PAL12A BINARY FROM THE SOURCES:

1. ASSEMBLE THE FILE PAL12A-1 USING AN EXISTING BINARY OF PAL12A AND MAKING SURE THAT THE CHAIN OPTION IS OFF.
2. ASSEMBLE PAL12A-2 WITH THE CHAIN OPTION ON.

(IF THE SOURCES ARE CORRECT, THERE SHOULD BE NO ERRORS AND NO LINKS FOR EITHER FILE.)

IF THE TWO SOURCES HAVE EACH BEEN ASSEMBLED AND SAVED AS BINARY FILES, THE FILES MAY BE COMBINED INTO A PAL12A BINARY WITH AN "ADD BINARY" COMMAND IF THE FOLLOWING RESTRICTIONS ARE OBSERVED:

1. THE BINARY WORKING AREA MUST BE ZEROED BEFORE DOING ANY "ADD BINARY" COMMANDS.
2. THE PAL12A-1 BINARY FILE MUST BE ADDED TO THE WORKING AREA FIRST.

PAL12A TAPE USAGE

BESIDES THE BLOCKS ALREADY CITED (370-427, 440-441, 447, AND 0 TO THE END OF THE LISTAPE), PAL12A ALSO USES BLOCKS 430-433 IN THE BINARY WORKING AREA ON UNIT 1 FOR STORAGE OF THE FOLLOWING OUTPUT ROUTINES:

430 CORE MAP (WORDS 0-177)
431 LISTING " "
432 LISTAPE " "
433 SYMBOL TABLE (WORDS 0-377)

THESE BLOCKS ARE WRITTEN OUT AT THE BEGINNING OF EVERY PAL12A ASSEMBLY, REGARDLESS OF WHETHER OR NOT THE ROUTINES ARE USED IN ANY GIVEN ASSEMBLY. THIS SHOULD NOT CAUSE ANY DIFFICULTY, BECAUSE DIAL USES THESE BLOCKS FOR TRADING USER SYMBOLS WHEN IT HAS MANY. (THE SAVSYM AREA IS FURTHER DOWN THE TAPE.)

