GRAPHICAL SUBROUTINES FOR THE IBM 1800
USING THE TV SCREEN AND THE PRINTERS

(PART I)*

(In view of the future PSB development)

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The purpose of this note is to explain how to use the plotting subroutines CPLOP, CPLOC, PLTXY and the printing subroutine PRTXY.

These subroutines are part of the various programs envisaged for the orbit observation in the rings and in the transfer line of the PSB.

Remarks

a) These subroutines are written in Assembler language, Fortran compatible, and are already operating in Time Sharing System TSX; they will be converted into the Multi-Programming System MPX for spring 1971.

b) All those subroutines are coded non-reentrant and are stored on disk drive 1.

*) Part II will be distributed when the modifications due to MPX change over are done. Some new specifications for the printing subroutine will also be given.
# TABLE OF CONTENTS

1. Introduction

2. Description and use of the subroutines
   2.1 INITL
   2.2 PTPLT
   2.3 CPLOP
   2.4 CPLOC
   2.5 Example
   2.6 PLTXY
   2.7 PRTXY

3. Comments
   3.1 CPLOP
   3.2 CPLOC
   3.3 PRTXY

Acknowledgements

References

Figures
1. Introduction

In view of the future development of the PSB and its control by computer, it appeared to be useful to write some general purpose programs for the graphical presentation of parameters acquired and results calculated\(^1\),\(^2\).

With the graphic mode plotting subroutine, the following features can be considered:

- 1 point mode,
- 1024 points mode,
- vector mode.

The character plotting subroutine now gives the possibility of starting the message directly from any point on the scope.

Subroutine PLTXY has been written because many users wished to refer their curves to axes. It realizes an automatic scaling of the curve to the scope dimensions. The graduation of the axes is constant (up to now), but a graduation depending on the scaling could be envisaged (when the change over to MPX System takes place) if it were considered to be useful. With this subroutine, it is possible to trace the curves in three different modes (Fig. 1):

- point mode,
- vector mode,
- histogram mode.

Thus, several curves could be superimposed for comparison, provided they are all on the same scale.

Finally, the user can get a hard copy of his graph, curve by curve, on the line-printer (30 s/curve) or on the 1816-printers (9 min/curve!), with the printing subroutine PRTXY which possesses the same features as PLTXY, except the vector mode.

The description of these subroutines is given in the following paragraphs. Their flow charts can be found at the end of this report (underlined names near the arrows are program labels). Listings are available at the computer room.
2. Description and use of the subroutines

2.1 INITL

a) This subroutine initiates the plotting routines by resetting the memoscope and/or providing white background, depending on the value of the control word of the calling subprogram (e.g. CPLOP). It enqueues the coreload "RESET" in order to avoid intempestive erasing of the scope, and resets the counter 26 to erase the scope only 6 minutes after the beginning of plotting.

b) Calling sequence:

\[
\text{CALL INITL} \\
\text{DC NAME}
\]

where NAME is merely the name of the calling subprogram.

c) A delay of about 300 milliseconds is provided twice in case the scope is erased (approximate time needed by the screen to recover).

d) Length in words: /54 = 84.

Length in time:
- with erasing of the scope : 700 ms
- without erasing of the scope: 1.6 ms.

e) Called subprograms:
- UNQ (RESET)
- COUNT (counter 26 queues MREST after 6 minutes)
- DAOP.

f) Index registers used: 1,3.
2.2 **PTPLT**

a) This subroutine plots 1 point on the display scope.

b) The calling sequence is:

```
CALL PTPLT
```

c) The coordinates of the point to be plotted are stored in the skeleton common at addresses SKF60 (for X) and SKF60-1 (for Y):

```
MEMOX EQU SKF60
MEMOY EQU SKF60-1
```

d) A delay of about 100 microseconds is provided to allow the hardware to convert the previous data.

e) Length in words: /3A = 58

Length in time: 270 µs.

f) Called subprograms: none

g) Index register used: 1
2.4 CPLOC

a) This program plots alphanumeric characters on the memoscope and can only be called by an Assembler written main program because of the impossibility to write an EBCDIC message in Fortran.

b) Calling sequence (Assembler only):

```
CALL CPLOC
DC CW
DC LOC
DC ADR - 1

CW DC /xxxx

LOC DC 800 (X)
DC 25 (Y)

DC END-ADR
ADR EBC .MESSAGE.
END BES 0
```

c) The control word CW is the address of the hexadecimal word which is as follows:

- Bit 0 set ( /8000) erases the scope and resets the beam position.
- Bit 1 is set ( /4000) to plot characters.
- Bit 4 set enables the subroutine (only if bit 1 is set: /4800) to plot the message starting from any position of the scope.
- Bit 15 set ( /0001) gives white background by inverting the gain of the CRT (not possible with the present CRT).

d) The word LOC is used only if bit 4 ( /0800) of the control word is set. In that case, LOC is the first address of the starting point coordinates (X, Y) of the message.

Otherwise, if bit 4 is not set, "DC LOC" can be any constant or address (in order to save one word). Then, the message begins normally at the upper-left corner of the screen, i.e. at coordinates \( \begin{cases} X = 0 \\ Y = 930 \end{cases} \).
e) The word ADR-1 is the address of the word count (two characters per word) preceding the message.

- The characters must be specified in EBCDIC.

- Some characters have a special card code:

<table>
<thead>
<tr>
<th>Character</th>
<th>Card Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>New line</td>
<td>0 - 5 - 9</td>
</tr>
<tr>
<td>Carriage return</td>
<td>11 - 5 - 9</td>
</tr>
<tr>
<td>Less than</td>
<td>&lt;</td>
</tr>
<tr>
<td>Left parenthesis</td>
<td>(</td>
</tr>
<tr>
<td>Plus</td>
<td>+</td>
</tr>
<tr>
<td>Exclamation mark</td>
<td>!</td>
</tr>
<tr>
<td>Right parenthesis</td>
<td>)</td>
</tr>
<tr>
<td>Per cent</td>
<td>%</td>
</tr>
<tr>
<td>Underscore</td>
<td>—</td>
</tr>
<tr>
<td>Greater than</td>
<td>&gt;</td>
</tr>
<tr>
<td>Question mark</td>
<td>?</td>
</tr>
<tr>
<td>Colon</td>
<td>:</td>
</tr>
<tr>
<td>Number</td>
<td>#</td>
</tr>
<tr>
<td>Apostrophe</td>
<td>'</td>
</tr>
<tr>
<td>Equal</td>
<td>=</td>
</tr>
<tr>
<td>Quotation mark</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

- One display can contain a maximum of 15 lines of 41 characters, i.e. 615 characters.

f) If bit 1 of the control word is set (/4000), control is returned after the message word count address (DC ADR-1). Otherwise, control is returned after the control word:

e.g.

<table>
<thead>
<tr>
<th>ASSEMBLER (only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CALL</td>
</tr>
<tr>
<td>CPLOC</td>
</tr>
<tr>
<td>DC</td>
</tr>
<tr>
<td>CW</td>
</tr>
<tr>
<td>*</td>
</tr>
</tbody>
</table>

| CW     | DC     | /8000 |

- As for CPLOP (par. 2.1 f), the beam is positionned at X = Y = 0 after plotting.

h) Length in words: /136 = 310

Length in time:
- erase and reset of the scope = 700 ms
- message of 10 characters = 57 ms
- message of 100 characters = 560 ms

i) Called subprograms:
- INITL
- PTPLT
- DAOP

j) Index registers used: 1, 2, 3
2.5 Example

Figure 2 shows what can be done by the subroutines mentioned above and is obtained by test coreload TPCLA. To get out of this coreload, push down all data switches. That coreload could be useful to adjust the CRT for intensity, focus, and scaling.

2.6 PLTXY

a) This subroutine is a general display routine which plots curves and axes (with fixed graduation up to now) on the display scope. It is the one mentioned on Fig. 6 of Ref. 2. The curves can be generated in three different modes:

- point mode
- vector mode
- histogram mode.

These three modes are shown in Figure 1 for the same elliptical curve (50 points).

b) Calling sequence:

in ASSEMBLER

```assembly
CALL PLTXY
DC CW
DC N
DC XTABLE
DC YTABLE
DC XMIN
DC XMAX
DC YMIN
DC YMAX
CW DC /xxxx
N DC Nb.
XTABLE BSS Nb.
YTABLE BSS Nb.
XMIN DC 2043
XMAX DC 23457
YMIN DC -16981
YMAX DC 12644
```

in FORTRAN

```fortran
* ONE WORD INTEGERS
DIMENSION IXTAB (N), IYTAB (N)
DATA ICW /Zxxxx/, N /nnnn/
DATA IXMIN, IXMAX, IYMIN, IYMAX/2043, 23457, -16981, 12644/
CALL PLTXY (ICW, N, IXTAB(N), IYTAB(N), IYMIN, IXMIN, IXMAX, IYMIN, IYMAX)
```
c) The control word CW is the address of the hexadecimal word which is as follows:
- Bit 0 is set ( /8000) to erase the scope and reset the beam position.
- Bit 1 set ( /4000) enables the subroutine to plot axes.
- Bit 2 set ( /2000) is for point mode plotting.
- Bits 2 and 3 set ( /3000) give vector mode plotting.
- Bits 2 and 4 set ( /2800) give histogram mode plotting (Fig. 1).
- Bit 15 set ( /0001) inverts the gain of the screen in order to have white background (not possible with the present CRT).

d) N is the address of the number of points to be plotted. There are normally no limits for N, except those given by the computer size: the maximum should be 32767 points (16-bit registers) but since the size of variable core is 8 K and that the program itself needs some space, there should not be more than 6000 coordinates, or 3000 points per curve!

e) XTABLE and YTABLE are the addresses of the first point of X and Y tables.

f) XMIN, XMAX, YMIN, YMAX, are the addresses of the drawing boundaries, which are normally the curve boundaries. If one wants to draw several curves in the same axes, the same boundaries should be taken for each curve.

Remark: The differences \( \Delta X = XMAX - XMIN \) and \( \Delta Y = YMAX - YMIN \) must be smaller than 32767 \( (2^{15} - 1) \) in order to avoid overflow of the computer registers capacity.

g) PLTXY calls the CPLOP subroutine so that the CRT beam is set at \( X = Y = 0 \) after plotting.

h) Length in words: \( /15A = 346 \)
Length in time :
- erase and reset of the scope = 700 ms
- axes only = 370 ms
- 10 points only = 35 ms
- 10 vectors of 10 points = 190 ms

i) Called subprogram: CPLOP.

j) Index registers used: 1, 2, 3.

k) An example of the use of PLTXY routine is given in Fig. 3. It is a simulation of an orbit and dipole display, in the same axes. The orbit is drawn in vector mode and the dipoles in histogram mode.
2.7 PRTXY

a) This subroutine is a general printing routine with nearly the same characteristics as PLTXY. It prints the curves, curve by curve, on the line-printer (about 30 seconds) and/or on the 1816-printers of the computer room and of the linac terminal (about 9 minutes!). The curves can be printed in two different modes:
- point mode
- histogram mode

b) Calling sequence (the same as for PLTXY):

**in ASSEMBLER**

```
CALL PRTXY
DC CW
DC N
DC XTABL
DC YTABL
DC XMIN
DC XMAX
DC YMIN
DC YMAX
•
CW    DC /xxxx
N     DC Nb.
XTABL BSS Nb.
YTABL BSS Nb.
XMIN DC 2043
XMAX DC 23457
YMIN DC -16981
YMAX DC 12644
```

**in FORTRAN**

* ONE WORD INTEGERS

```
DIMENSION IXTAB(N), IYTAB(N)
DATA ICW/Zxxxx/, N/nmn/,
DATA IXMIN, IXMAX, IYMIN, IYMAX/2043, 23457, -16981, 12644/,
•
CALL PRTXY (ICW, N, IXTAB(N), IYTAB(N), IXMIN, IXMAX, IYMIN, IYMAX).
```
c) The control word CW is the address of the word which is as follows:
- Bit 8 is set ( /0080) to print the curve on the line-printer.
- Bit 9 is set ( /0040) to print on the computer room 1816-printer.
- Bit 10 is set ( /0020) to print on the linac room 1816-printer.
- Bit 12 is set ( /0008) to have histogram printing mode.

d) N is the address of the number of points to be printed.
A maximum of 100 points is available for each curve.
On the same line (120 spaces), the accuracy is 1 point per word, i.e. 60 points with a space between each two points.

e) XTABLE and YTABLE are the addresses of the first point of X and Y tables.

f) XMIN, XMAX, YMIN, YMAX, are the addresses of the drawing boundaries (see PLTXY, par. 2.6 f).

g) On the line-printer, a page feed is provided before and after each drawing.
On the 1816-printers, 4 lines are skipped before and after each printing.

h) Length in words: /410 = 1040
Length in time :
- on line-printer : 30 s
- on 1816-printers : 9 min.

i) Called subprograms:
- PRNT1 (PRNTN)
- TYPE1
- TYPE5.

j) Index registers used: 1, 2, 3.

k) Figures 4 and 5 give, as an example of printing, the same curves as those plotted on the memoscope by PLTXY (Fig. 3).
Figure 4 shows the orbit display, in the normal point mode.
Figure 5 shows the dipoles display, in histogram mode.
Each curve is printed on one page (always with axes), i.e. 64 lines of 120 points (but with a maximum of 60 points on each line).
3. Comments

3.1 CPLOP

In vector mode plotting, good definition for the vector is obtained by plotting a point every four spaces so that the longest vector is drawn with 256 points (it takes a maximum of 256 x 430 μs = 110 ms). In addition, in order to have approximately the same precision for the vector in one direction, the greatest amplitude in X or Y is taken into account to determine the steps in the other direction; those steps are obviously discrete, they are calculated as follows (if ΔX is assumed to be greater than ΔY):

\[ X = X_1 + \frac{(S.N.DX)}{ΔX} \]
\[ Y = Y_1 + \frac{(S.N.DY)}{ΔY} \]  

(1)

where . S = 4 is the step,
- \( X_1, Y_1 \) are the starting coordinates of the vector,
- \( X_2, Y_2 \) are the ending coordinates of the vector,
- \( DX = X_2 - X_1 \quad DY = Y_2 - Y_1 \)
- \( ΔX = |DX| \quad ΔY = |DY| \)

and where N (starting from 0) is increased by 1 until \( X > X_2 \). (ΔX is replaced in(1) by ΔY if ΔY > ΔX).

The computation must be done as in (1) and not as, for example:

\[ X = X_1 + S.N.(DX) \]

The which could introduce a truncation error greater than step S.

3.2 CPLOC

One character is generated by a grid of 5 x 6 = 30 points. The space-lengths between the points of the character are:

- 4 CRT-points in the X direction
- 8 CRT-points in the Y direction,

so that one character area is equal to 16 x 40 CRT-points.
Since spaces are needed between the characters and the lines, the total area for one character is 25 x 65 CRT-points, i.e. 9 points between the characters and 25 points between the lines. The digital registers of the CRT contain 10 bits, so that the screen has a total area of 1024 x 1024 points. It is the reason why a maximum of 615 characters can be plotted on the present CRT (15 lines of 41 characters).

3.3 PRTXY

a) Because the line-printer prints one line in one go, a 60 word buffer (120 characters) called MESSP must be prepared before each printing. Since it is not easy to prepare such a buffer with a floating origin (position of Y axis, which can vary from 1 to 120), the buffer contains 120 words with a fixed origin in the middle and a floating starting point (-N: see listing) preceded by the word count (60).

b) For each line, one must store in the buffer the Y axis position and all the points which have an ordinate equal to the line to be printed (L = Y); those points must be located in the buffer at a position given by the abscissa X, which depends on the parity of X (because there are two characters per word).

c) When the number of the line to be printed is equal to the X axis ordinate (L = Y₀), one must store in the buffer a set of dashes (-) and I's(I) which represent that axis, without forgetting to place the possible points of the curve in the right position.

d) After the printing of one line, the buffer is erased. If a histogram mode printing is wanted, that erasing does not take place until the X axis is encountered. In that mode, for all negative ordinates (i.e. after the printing of the X axis), all the negative points must be printed and they are erased.
one after the other when their ordinate minus one is equal to the number of the line printed (see program under "ERASE" label).

ACKNOWLEDGEMENTS

I would like to thank Messrs. H. van der Beken, A. Daneels, K. Pedersen, E. Ratcliff and W. Remmer for their useful comments.

REFERENCES

1. A. Daneels, Proposal for the software for the PSB orbit observation and measurements, SI/Note DL/70-11.

2. A. Daneels, Proposals for the software for the PSB Q-measurements and display, SI/Note DL/70-13.

3. CPLOT Program (Computer Room, Library 1).
Fig. 2

Fig. 3
POINTS PLOTTING SUBROUTINE

CALL CPL0P
DC CW
DC ADR

ADR/ BSS 1 IN 1 POINT MODE
/ BSS 4 IN VECTOR MODE
/ BSS 1024 IN 1024 POINTS MODE

CW DC //XXXX
/8000 : RESET SCOPE
/2000 : 1 POINT MODE
/100 : VECTOR MODE
/0 : 1024 POINT MODE
/001 : WHITE BACKGROUND

ENT CPL0P
SAVE INDEX REGISTERS

CALL INI For RESET AND/OR WHITE BACKGROUND

POINT 1 POINT

NO

VECTOR MODE
YES

NO

1024 POINTS MODE

YES

1024 POINTS MODE

NO

P1024

YES

CALL PTOPL PLOT THAT POINT

P1024

NO

CALL PTOPL PLOT THAT POINT

YES

SAVE THE 1024 POINTS PLOTTED

YES

EXIT

CALL PTOPL SET BEAM AT POSITION X.Y

SET DISPLAY IN POSITION "READ"

RESTORE INDEX REGISTERS

RETURN

Fig. 6
SUBROUTINE USED FOR PLOTTING

PTPLT

CALL PTPLT

ENT PTPLT

PICK UP POINT COORDINATES

YES

IS DISPLAY BUSY

NO

SET ANALOG VOLTAGES OF THE CRT

DELAY

\sim 100 \mu \text{sec}

YES

IS DISPLAY BUSY

NO

INTENSIFY THE POINT & RESET FOR NEXT

RETURN

INNL

CALL INNL

DC NAME (NAME OF THE CALLING PROGRAM)

ENT INNL

CALL UNQ REMOVE MINIMAL "RESET" FROM QUEUE

SET DISPLAY IN POSITION "STORE"

CALL COUNT TO ERASE THE SCOPE AFTER 6 MINUTES

COUNTER 16 TIMES RESET "RESET" AFTER 6 MINUTES

RESET

YES

DELAY

\sim 300 \text{ msec}

SET DISPLAY IN POSITION "ERASE"

SET DISPLAY IN POSITION "STORE"

DELAY

\sim 300 \text{ msec}

NEXT

WHITE BACKGROUND WANTED

WHITE

YES

INVERT GAIN OF DISPLAY

RETURN

Fig. 8
PRINTING SUBROUTINE

CALL PRDX
DC CW
DC N
DC XTABL
DC YTABL
DC XMIN
DC XMAX
DC YMIN
DC YMAX
...
N DC NB, (MAXIMUM 100 POINTS)
XTABL BSS NB,
YTABL BSS NB,
XMIN DC XXXXX CAN BE NEGATIVE
XMAX DC XXXXX OR POSITIVE
YMIN DC XXXXX
YMAX DC XXXXX
CW DC XXXX

/00000 PRINT ON LINE PRINTER
/0040 = PRINT ON MCR, TYPEWRITER
/0002 = PRINT ON LINAC, TYPEWRITER
/0008 = HISTOGRAM PRINTING

PRINT 2
COMPUTE MESSAGE ADDRESS AND SET WORD COUNT

YES MESSAGE ON LINE PRINTER
YES ON MCR TYPEWRITER
NO MESSAGE ON MCR TYPEWRITER

YES CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES ZOBZ
NO ERASE

YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.

YES PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1
NO PRINT X, Y AT Xo,1 AT Xo,1

YES HISTOGRAM PRINTING
NO THEMIST

YES HISTOGRAM PRINTING
NO THEMIST

NO HISTOGRAM PRINTING
YES MESSAGE ON MCR, type.
NO CARRIER RETURN ON MCR, type.
NO CARRIER RETURN ON LINAC, type.
INTERNAL SUBROUTINES USED FOR PRXY

SCALES THE X AND Y TABLES FOR PRINTING

1. **Table**
   - If YES, set $X = 1$
   - If NO, set $X = $remainder
   - $X = a + (2a)\
   - Add 1 to $X$
   - $Y = 60 + (X, 7)\
   - $Y = 60 + (X, 7)\
   - **RETURN**

2. **Compute the Maximum of Actual Y Table and the Corresponding X and Y**
   - $Y_{max} = T_{y}$
   - $X_{max} = T_{x}$
   - **RETURN**

3. **Add One to Coordinate if Remainder Exceeds or**
   - If YES, set $X = X + 1$
   - If NO, set $Y = Y + 1$
   - **RETURN**

4. **Needs a New Page to Avoid Interference With Another Program**
   - **LINE, PRINTED**
   - **RETURN**

5. **Skip to Next Page**
   - **RETURN**

6. **Store One Point in the Message Buffer**
   - If YES, set $X$ at 0
   - If NO, set $Y$ at 0
   - **MAXXY**
   - **RETURN**

7. **Store 'b' in Message Buffer at Location T**
   - **RETURN**

8. **Store 's' in Message Buffer at Location T**
   - **RETURN**

**Fig. 12**