APPLICATION PROGRAM BULLETIN

AUTOPLOTTER FOR THE IBM 1620

This bulletin describes an IBM 1620 program to plot graphs of computed results on a modified IBM 870 Document Writing System. AUTOPLOTTER can be used with either a 1620 card system or a paper tape system.

The basis of AUTOPLOTTER consists of reading into storage all data pertaining to a given graph and producing output which contains the control functions for each line on the 866 typewriter. Since each line is calculated and punched before the next is calculated, the image of the entire graph never has to be stored in the memory of the computer at one time. This allows the plotting of larger graphs with less core storage.

AUTOPLOTTER will accept the following type of information to produce the plot format desired by the user:

- The height (up to 20") and the width (up to 100") of the paper on which the graph is to be plotted.
- The margins to be allowed to the left of and below the plotting grid.
- The lowest or minimum value of x and y, to assist in automatically positioning the graph in the plotting grid area.
- The values of y (up to 5) for each x value.
- Whether the points on the graph are to be represented by dots or crosses and printed in red or black ink. This allows four distinct types of curves or plots.
- Whether the points are to be treated as bar graphs or curves. If the points are on a curve, the user may specify that the area between the points is to be filled in on a straight line or a smooth curved line (resulting from a second-order curve fitting).
- Whether scale numbers, alphameric titles or labels are to be printed on the graph paper, in what locations, and in red or black ink.

The modified IBM 870 Document Writing System has specially engineered graph-plotting typebar characters and special ten-to-the-inch vertical and horizontal spacing.

The IBM 866 Non-Transmitting Typewriter has 88 characters, as follows:

26 capital letters
10 numerical digits   for scale numbers, alphameric titles or labels
1 minus sign
1 period

25 dots
25 crosses   for plotting the points

The accuracy of plotting the points is enhanced by the positioning of the dots and crosses on the typebar face of the 25 special typebars and by the ten-to-the-inch vertical and horizontal spacing. Any one of 25 dots (or crosses) can be selected and printed for each point to be plotted on the graph in any character printing area. If each of the 25 typebars printed in the same character printing area, the result would be a pattern as illustrated in Figure 1.
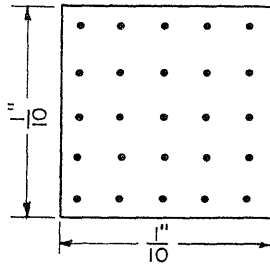

Figure 1. Enlarged view of character printing area.
Each of the 25 dots is positioned on a typebar .020
inches (vertical and horizontal) from the positioning
of the adjacent dots.

AUTOPLOTTER calculates where the curve passes through each character printing area and selects the typebar that describes a point on this curve.

EXAMPLE 1

To introduce the reader to AUTOPLOTTER, the plotting of a sine-cosine curve will be explained in detail in the following paragraphs:

Figure 3 is a listing of the input to AUTOPLOTTER. This data was easily generated by the FORTRAN source program shown in Figure 2.

Referring to Figure 3, the first digit on each line is an identification to AUTOPLOTTER of the type of information contained in the card (or paper tape record).

FORTRAN CODING FORM

Identification
73   80

Date _____
Page _____ of _____

C FOR COMMENT

STATEMENT NUMBER	Cont	FORTRAN STATEMENT
C		SAMPLE SINE-COSINE CURVE PLOTTING PROGRAM.
100		FORMAT (I5, I5, I5, I5, I5, I5, I5)
1		N=-500
		PUNCH 100, 1, 1000, 1000, 0, 0, 0, N
		PUNCH 100, 2, 32, 0, 11
		ANGLE=0.
		DELTA=3.1415926/50.
		DX=2.*3.1415926/1000.
		DY=2./1000.
		DO 2 I=1,100
		NANG=ANGLE/DX
		NSIN=SIN(ANGLE)/DY
		NCOS=COS(ANGLE)/DY
		PUNCH 100, 3, NANG, NSIN, NCOS
2		ANGLE=ANGLE+DELTA
		PUNCH 100, 6
		PAUSE
		GO TO 1
		END

Figure 2. FORTRAN source program for sine-cosine example.

The first line is a type 1 card and identifies the size of the plotting paper (10.00" wide by 10.00" high), the distance from the left-hand margin of the paper to minimum x value (0), the distance from the bottom of the paper to the minimum y value (0), the minimum x value (0), and the minimum y value (-5.00).

The x and y values assigned to these points do not have to be true minimums, as long as they insure that the graph does not go off the plotting surface.

The second line is a type 2 card and contains information relative to the type 3 cards that follow. In this example the (3) indicates that the distance between successive points is to be filled in with straight-line segments. The (2) indicates that there will be two y values (sine and cosine) for each x value given. The first set of y values is to be plotted with crosses, using black ribbon (00); the second set of y values is to be plotted with dots, using black ribbon (10).

The type 3 cards contain the x values and the corresponding y values expressed in hundredths of an inch. The first type 3 card shows that when x is equal to 0, the sine of x is equal to 0, and the cosine of x is equal to 5.00. These are the actual dimensions on the graph paper. The programmer has chosen in this case to let five inches on the graph paper equal 1.00 for the actual equation. Similarly, in the x direction, ten inches on the graph paper represents 2π (360°).

1	1000	1000	0	0	0	-500
2	32	00	10			
3	0	0	500			
3	10	31	499			
3	19	62	496			
3	29	93	491			
3	39	124	484			
3	49	154	475			
3	59	184	464			
3	69	212	452			
3	79	240	438			
3	89	267	422			
3	99	293	404			
3	109	318	385			
3	119	342	364			
3		364	342			
3	429	385	318			
3	439		293			
3	449	154				
3	459	124	-484			
3	469	93	-491			
3	479	62	-496			
3	489	31	-499			
3	499	0	-500			
3	509	-31	-499			
3	519	-62	-496			
3	529	-93	-491			
3	539	-124	-484			
3	549	-154	-475			
3	559	-184	-464			
3	569	-212	-452			
3		-240	-438			
3	939		-422			
3	949		404			
3	959	-124				
3	969	-93	491			
3	979	-62	496			
3	989	-31	499			
6						

Figure 3. Listing of input data cards for sine-cosine example.

The listing in Figure 3 does not show all the type 3 cards used to create the graph shown in Figure 4. One hundred sets of points were generated from the FORTRAN program in Figure 2. While the use of FORTRAN is at the programmer's discretion, the data input to AUTOPLOTTER is in FORTRAN fixed-point format.
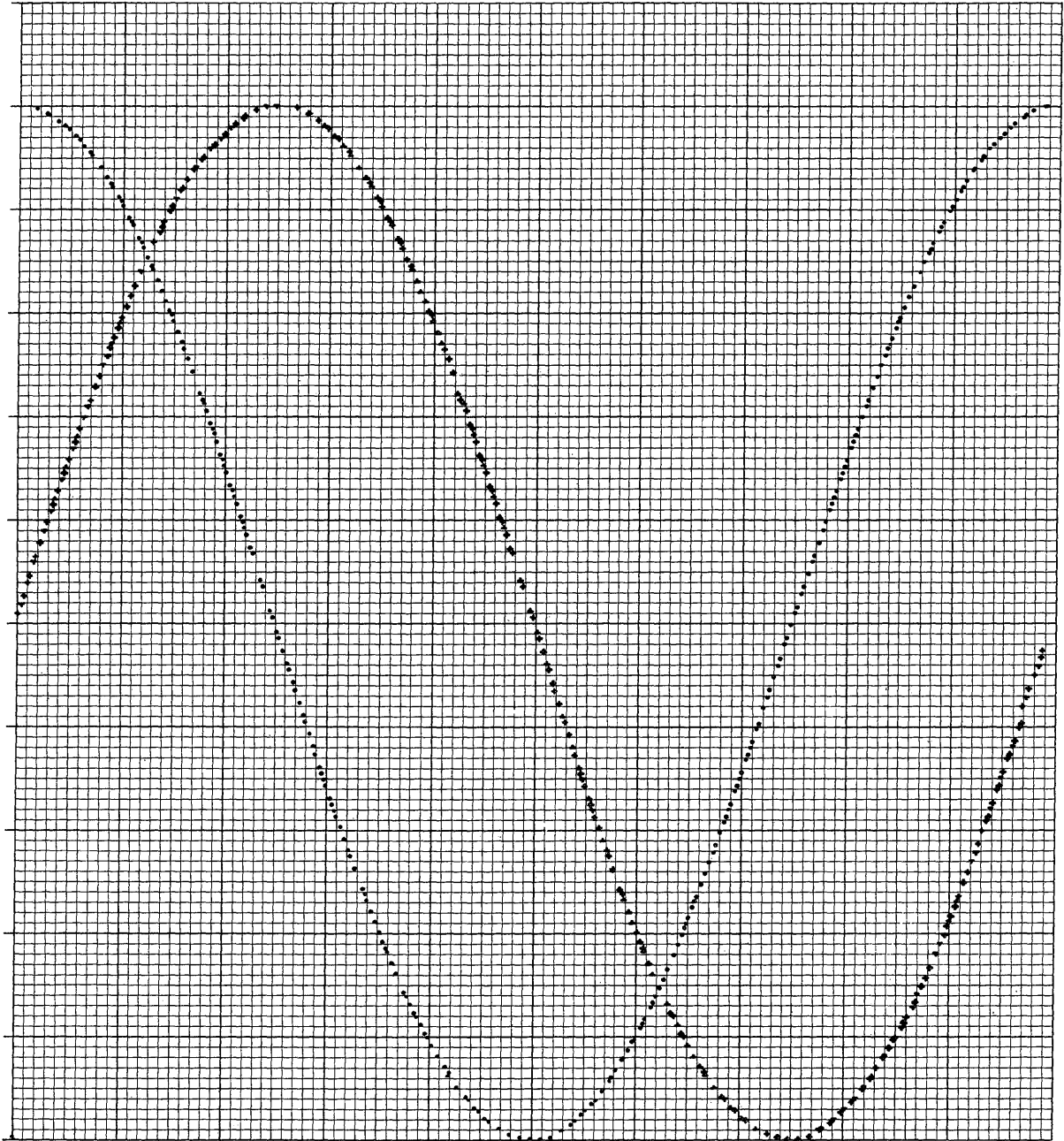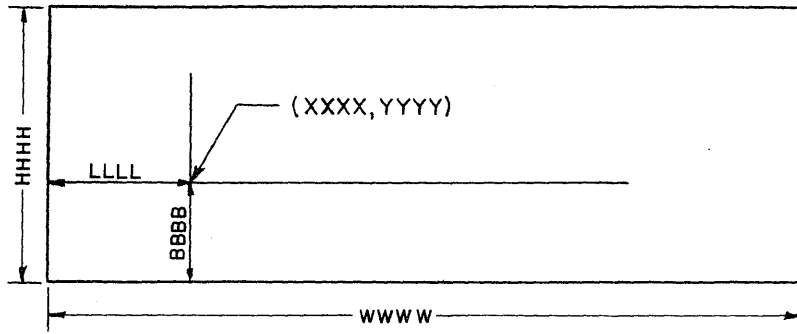

Figure 4. Graphical output for sine-cosine example.

AUTOPLOTTER STATEMENTS

AUTOPLOTTER will accept six types of statements. The following is a more complete explanation of each type. All fields in all cards comprise five columns. Whenever a dimension is given, it is always expressed in hundredths of an inch.

TYPE 1 — SIZE STATEMENT

WWWW HHHH LLLL BBBB XXXX YYYY

WWWW	Width of the plotting paper.
HHHH	Height of the plotting paper.
LLLL	The left margin expressed as the distance from the left edge of the graph paper to the value of x assigned by XXXX of this statement.
BBBB	The bottom margin expressed as the distance from the bottom of the graph paper to the value of y assigned by YYYY of this statement.
XXXX	
	Value of x and y respectively, assigned to origin point.
YYYY	

Note: To keep graph from extending into margins, the above values must not be greater than the lowest or minimum value assigned to x and y respectively in any type 3 statement.

TYPE 2 — FILL STATEMENT

	TN	CR	CR	CR	CR	CR

T   One-digit code describing the plot according to the following:

    0 – Points are to be plotted as discrete points, as in the type 3 cards, without automatic fill-in.

    1 – Points are to be treated as the top ends of vertical bar graphs extending from the x axis.

    2 – Points are to be treated as the right ends of horizontal bar graphs extending from the y axis.

    3 – Points are to be connected by straight-line segments.

    4 – Points are to be connected by a second-order curve fit, resulting in curved lines which pass through each point furnished.

N   The number of y values (maximum five) for each x value given.

CR   Two-digit code to describe how each of the possible five curves defined by the y values is to be plotted:

    C   Points to be indicated by:

        0 – crosses

        1 – dots

    R   Color of ribbon to be used to print the points is:

        0 – black

        1 – red

TYPE 3 — POINT STATEMENTS

XXXX YYYY YYYY YYYY YYYY YYYY

These are the actual data cards for the points to be plotted. As many as five y values may be assigned to each x value. All values are given in hundredths of an inch. Each curve represented by a y value will print according to the corresponding CR code assigned in the fill statement.

TYPE 4 — LABEL STATEMENTS

XXXX YYYY   PR

This type card is used to position the label on the graph and to designate the color of ribbon to be used to print the label contained in the card immediately following:

XXXX

Location along x and y axis respectively where the first
YYYY   character is to be printed.

P   Printing plane:

0 - label is to run horizontally from the first character.

1 - label is to run vertically from the first character.

R   Color of ribbon to be used to print label is:

0 - black

1 - red

The label card that immediately follows each type 4 card may contain any of the 26 letters of the alphabet, the numerals 0 through 9, the period or the minus sign.

TYPE 5 — SCALE STATEMENTS

XXXX YYYY NNNN VVVV IIII   PR

The type 5 card has been provided for the special labels used to identify the plot at each inch mark.

XXXX	
YYYY	Identifies the location of the low-order digit of the lowest value on the scale.
NNNN	The actual number of scale numbers to be printed on the scale. (If a graph is ten inches high and is to have a scale number at each of the eleven inch marks, NNNN would be 11.)
VVVV	The actual values to be printed at the first scale mark.
IIII	The increment (amount) to be added to each scale number to obtain the next ascending scale number to be printed.
P	Printing Plane:
	0 - scale is to run horizontally from the first value.
	1 - scale is to run vertically from the first value.
R	Color of ribbon to be used to print the scale is:
	0 - black
	1 - red

TYPE 6 — ENDING STATEMENT

The type 6 card indicates the end of one graph to the program.

There are no program restrictions on the number of points per curve, the number of scales or labels per graph, or the number of different graphs which may be described by a single FORTRAN program.

The input to AUTOPLOTTER has been arranged to be easily produced by FORTRAN programs. One format statement can be used for all the output statements, except, of course, the labels. FORTRAN provides an easy mechanism for the programmer to generate the points to be plotted and to perform the necessary scaling.

EXAMPLE 2

The following example will illustrate the use of the IBM 1620 AUTOPLOTTER program to produce graphs of torque converter efficiency, input speed, torque, and speed ratio (all versus output RPM) from transmission dynamometer test data.

Figure 5 is a listing of the input data cards for AUTOPLOTTER. The output cards were processed through the modified 870 Document Writing System to create the graph illustrated in Figure 6. Note that this graph includes labels and scales.

```
+1+1100+1600  +270 +170   +0      +0
+2   +44   +01  +11   +00   +10
+3    +0  +502   +0  +370   +0
+3  +100  +452 +300  +370 +135
+3  +200  +400 +535  +374 +265
+3  +300  +346 +675  +384 +392
+3  +400  +304 +755  +400 +500
+3  +500  +270 +810  +420 +600
+3  +600  +244 +835  +440 +685
+3  +700  +222 +845  +464 +755
+3  +800  +204 +840  +490 +820
+4 +100+1080   +00
TRANSMISSION DYNAMOMETER DATA ANALYSIS
+4 +100+1060   +00
TRANSMISSION NUMBER 1620-870.
+4 +100+1020   +00
DATE 1-22
+4 +100+1000   +00
OPERATOR--SMITH    SHIFT--2
+4 +100 +980   +01
CONVERTER OUTPUT TEMP 220 DEG F
+4 +200  -40   +00
OUTPUT SPEED IN RPM
+4 -180+1000   +11
EFFICIENCY IN PER CENT
+4  -80 +900   +11
TORQUE RATIO X 1000
+4 -180 +400   +10
SPEED RATIO X 100
+4  -80 +300   +10
INPUT SPEED
+5  +10  -20    +8  +0 +250  +00
+5 -110   +0   +10  +0  +10  +10
+5  -10   +0   +10  +0 +500  +10
+6
```

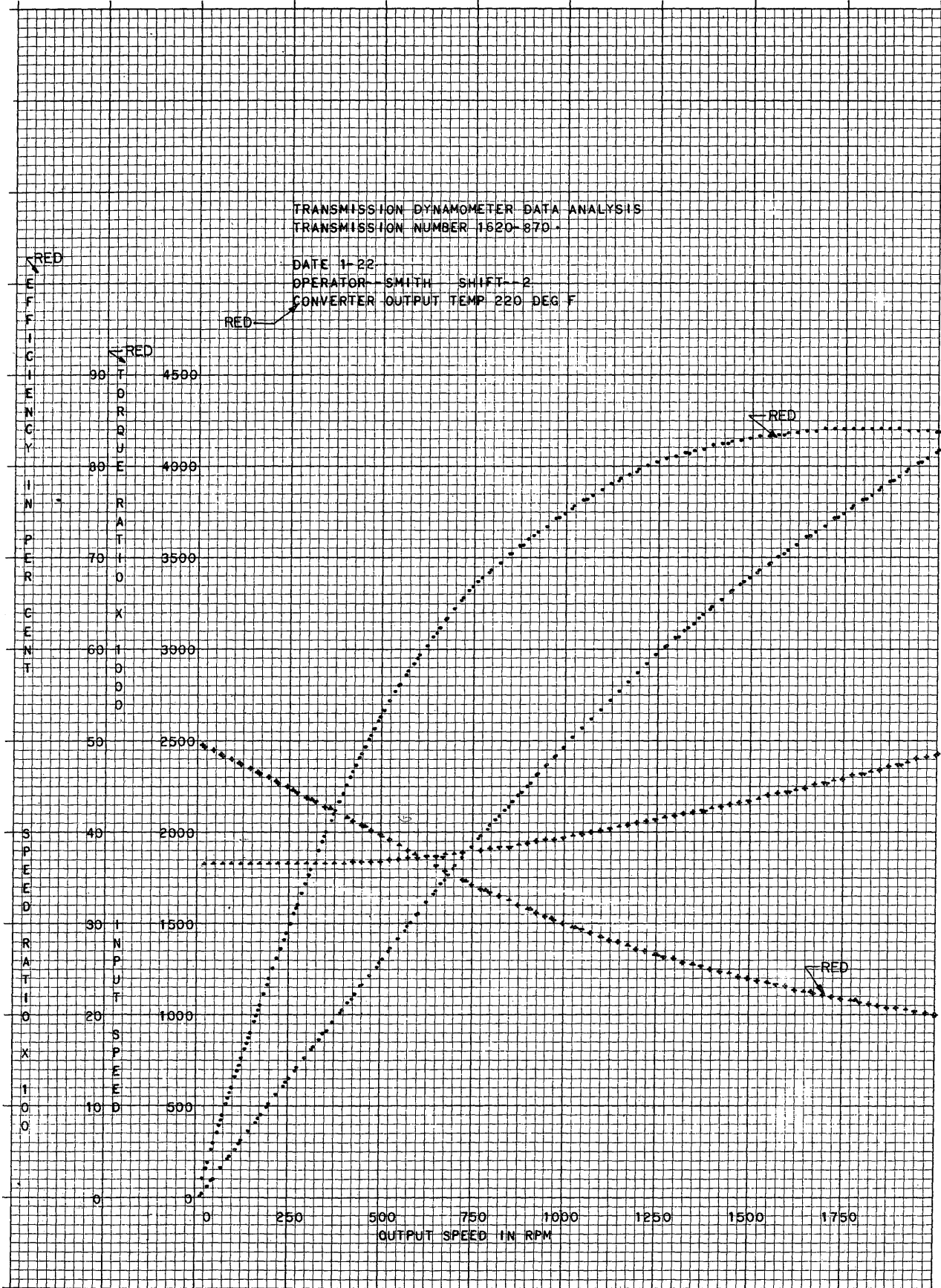Figure 5. Listing of input data cards to the 1620 AUTOPLOTTER.

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Figure 6. Graphical output from the IBM 870 Document Writing System (866 typewriter).

MACHINE CONFIGURATION

This program is available for either a card system or an eight-track paper tape system:

IBM 1620 DATA PROCESSING SYSTEM

1620 Central Processing Unit, Model 1

1622 Card Read Punch, Model 1 (for cards)

1621 Paper Tape Reader, Model 1 (for tape)

IBM 870 DOCUMENT WRITING SYSTEM

836 Control Unit, Model 1 (for cards)

834 Control Unit, Model 3 (for tape)

866 Non-Transmitting Typewriter, Model 5, with the following features:

- RPQ M02566 — complete set of special typebars for graph plotting (88 characters)
- RPQ M92212 — special line spacing of ten lines per inch
- Color control — special feature # 1975 or 1976
- Carriage:
    12" standard
    16" in lieu of standard — special feature #1801
    20" in lieu of standard — special feature #1802
    (depending on requirement for height of graph-y axis)
- Pin-feed platen
    12" carriage — special feature #9506
    16" carriage — special feature #9507
    20" carriage — special feature #9508

EXECUTION TIMES

A problem such as Example 2 takes one minute on the 1620 card system and six minutes on the 1620 paper tape system. Larger or smaller graphs have a proportionate effect on machine time. The time required by the 870 Document Writing System averages five to ten minutes per graph, depending on the number of points and labels furnished.

Note: For further information, contact your local IBM representative.

DYNAMOMETER DATA REDUCTION SAMPLE PLOT
TYPICAL DATA SET - HYPOTHETICAL ENGINE
1620 USERS GROUP - 26 FEBRUARY 1962

CORR BHP

CORR TORQUE

BMEP

BSFC X 100

RPM