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AUTHOR	Bossert, William H.; Oettinger, Anthony G.
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ABSTRACT

One of the objectives of Project TACT is to determine the potential of a gamut of educational media. The working papers in this set have a basis in pictorial information produced through computer graphics. These papers are intended to serve as a basis for sharpening questions, delineating the context within which the answers might be significant, and determining whether or not interesting experiments are feasible and rewarding. (Author/MK)

Working Papers #2

MATERIALS TOWARD THE COMPARATIVE ANALYSIS OF PRESENTATION TECHNIQUES

April 1971

Project TACT

Technological Aids to Creative Thought

William H. Bossert
Anthony G. Oettinger } Principal Investigators

Harvard University

Cambridge, Massachusetts

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NOTE

The series of Project TACT Working Papers is issued for the use of Project TACT research staff and the seminars Applied Mathematics 271 and Natural Sciences 131 associated with the project.

It may be of interest also to those who wish to follow our work with greater timeliness and at closer range than more formal reports permit.

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Materials Toward the Comparative Analysis of Presentation Techniques

One of the objectives of Project TACT is "to determine the real potential of an appropriate gamut of educational media in a laboratory situation where political and institutional problems are minimized and where the choice of equipment and the pattern of instruction can be made to flow logically from the intellectual structure of the material to be presented and the capabilities and needs of the students."

Interest in this question arises from the hope of finding ways to teach or learn that are significantly superior in effectiveness or significantly lower in cost than prevailing methods and preferably both.

Where such analyses have been attempted in the past, the difficulties of identifying significant variables and the presence of a large number of uncontrollable variables have led to serious experimental difficulties. Because of the impact of conclusions on vested interests, the results of such studies have also led to vigorous controversy. Useful background reading on these aspects of the problem includes Philip D. Smith, Jr.'s A Comparison of the Cognitive and Audio-Lingual Approaches to Foreign Language Instruction, a product of the Pennsylvania Foreign Language Project, published by the Center for Curriculum Development, Inc., Philadelphia, Pennsylvania, 1970. The entire October 1969 issue of The Modern Language Journal is devoted to critiques of the reports on which Smith's book is based.

The working papers in this set present this problem in the context of Project TACT. They are intended to serve as a basis for sharpening questions that should be asked, delineating the context within which the answers might be significant and determining whether or not interesting experiments are feasible and potentially rewarding.

All of the materials presented here have in common a basis in pictorial information produced through the medium of computer graphics. It is assumed that the use of this medium is itself justified. In the first example, given in Appendices I and II, this follows from the fact that the substance of the presentation itself is a self-description of graphical techniques for which any other medium would be, at best, a surrogate. In the second example, given in Appendix IV, the merit of the assumption rests on the fact that the amount of calculation required to produce the images would be impractical without some form of computer assistance.

However, once the pictures are available, namely once the investment in the hardware and software necessary to produce them can be taken for granted, there remains a spectrum of alternative methods of distribution, delivery and use of the pictorial material and associated prose material.

The description of "Display Formating Techniques of THE BRAIN" given in Appendix II may be taken as a reference form of the presentation of its subject matter. The illustrations are still photographs taken with a Polaroid camera directly from THE BRAIN's cathode ray tube screen.

The prose of Appendix II is identical with the narration of a motion picture available at our laboratory, both in the form of 16 mm film and one-inch videotape suitable for playback on one-inch Sony VTR's. The pictures in the written version are essentially a discrete sample of the continuum of pictures in the motion picture versions. A fourth form of presentation, which might prove useful for comparison, is not available but could be readily produced should it prove desirable to do so. This form would consist of a set of slides identical with the images of the written version accompanied by narration on an audio tape. The issues to be considered in comparing the several modes of presentation may usefully be grouped under the headings of pedagogical, technological and economic factors.

Among the economic factors of interest, are the projected preparation/use ratio (see Report no. 4 for definition) and the patterns and costs of the distribution mechanisms that are available to bring the presentations to individuals or groups of users.

The technological factors of flexibility, generality, complexity and comfort defined in Report no. 4 and others defined in Run, Computer, Run should also be considered here.

If one grants that film and videotape presentations of identical material are equivalent so far as they impinge on pedagogical factors, the choice between these modes would be determined entirely by economic and technological factors. For the material described in Appendix II, where the differences in resolution and other characteristics of films and videotapes are of no apparent significance, this assumption seems reasonable. Appendix I describes a first attempt at differentiating between the videotape and film media on economic and technological grounds.

Economic and technological factors which, in other research areas, might most appropriately be left to the consideration of industry, assume in the realm of instructional technology a very special importance within the context of the school or university. This is a direct consequence of the fact that, in this realm, the members of a university play a role not only in research and teaching without any intrinsically more direct involvement with the object of teaching and research, but also are themselves both originators and consumers of the devices and processes of instructional technology. In short, in this realm, unlike the vast majority of others of concern to a university, there is a direct and immediate <u>operational</u> involv[illegible], as well as the normal teaching and research involvement. So long as instructional technology is developing rapidly and fraught with many unknowns, the assumption of responsibility for assessing, acquiring and employing instructional technology cannot be left to routine administrative procedures as is the case with more established supporting goods and services used in a university's operations.

Where two modes of presentation are not as self-evidently equivalent as film and videotape in the example of appendix II, differences in <u>both</u> costs and effectiveness must be assessed to provide a basis for choice. How much research effort is to be devoted to assessing these differences depends, in part, on a prior judgment regarding the magnitude of differences likely to be found. It depends also on whether such research is likely to produce insights of a more fundamental and longer lasting nature than those limited to operational impact. To the extent, for example, that a research program might shed light on fundamental questions of perception, cognition or learning, it might prove very attractive whether or not a significant direct impact on operational costs or benefits is foreseen.

The comparison between motion pictures and stills-in-text [illegible] on important unsolved problems concerning our relative capacities to perceive and assimilate information through the eye as opposed to th[illegible], through linear script as opposed to two- or higher-dimensional pictorial materials and through stills as opposed to dynamic presentations.

Appendix III presents some notes on factors for comparison of the relative effectiveness of the three essentially distinct modes of presentation.

The critical question is how to sharpen the set of questions implicit in the first three appendices and the related motion picture and slide-sound material into a research strategy and to assess whether or not the potential payoff of following the most promising strategy makes it worth-while to pursue deeper investigations.

The material in Appendix IV illustrates a mode of presentation which, on its face, would appear to have both distinct advantages in effectiveness over slide and motion picture presentations as well as the advantages in cost and flexibility inherent in print-on-paper technology at the present time.

While motion-picture media lend themselves to the dynamic unfolding of events in time, at any instant only one image is presented on the screen and the burden of remembering the history of the development is left entirely to the memory of the viewer. Multiple slide presentations, although capable only of displaying discrete samples of a continuous pictorial sequence, nevertheless lend themselves to the simultaneous viewing of more than one sample.

With present technology, the number of samples tends to be limited to three at most, requires a number of copies of each slide equal to the number of screens and raises all of the logistic and cost problems attendant to multiple slide presentations. By comparison, the number of images that can simultaneously be displayed on a single page of normal size can be in the teens with appropriate detail and resolution.

The first question that suggests itself is whether indeed the simultaneous presentation of multiple images in a sequence materially assists in the comprehension of unfolding events and the comparison of successive stages. If the answer is in the affirmative, the further question arises as to what happens when the number of simultaneous images goes beyond what can comfortably be encompassed within a fixed field of view or a re-reasonable sweep of the page.

It is interesting to speculate as to whether the fact that this question does not appear to have received much consideration is a consequence of a prior finding that there is no significant advantage to this approach, a finding buried in the literature or in the tradition of professionals. On the other hand, the production of image sequences -- which has become so easy with computer graphics -- formerly required considerably greater investment of time and effort when traditional techniques of drafting and animation were required. It is therefore possible that the question has arisen and become significant only because of new possibilities opened by computer graphics.

Appendix I

On-Line Videographic Output*

by

Robert E. DesMaisons

October 19, 1970

* This was an invited report presented at a special session on "Applications of Video Graphics" at the 1970 UAIDE Conference under partial support of NSF Contract GY-6181 and a contract between Harvard University and the IBM T.J. Watson Research Center.

The remarks I would like to make concern the use of an on-line videographic medium in producing a finished presentation of graphical material. The actual content of the videographic presentation in question resulted from work done at Harvard University, under a contract with IBM Research and an NSF grant, in which some of the graphical techniques of an interactive computer system, entitled THE BRAIN, were being documented using the system itself. The graphical output was generated on a Tektronix storage scope-scan converter unit which allowed simultaneous video recording on our 1-inch Sony videocorder.

Considerable time and effort were spent in preparing the graphical content of the presentation by programming the computer system to generate successive graphical frames; but the important point to note is that this preparation of the computer system would have been necessary whether the recording of the material was made on videotape, on Polaroid slides, on the CALCOMP plotter, or on a movie film. And so one need only be concerned with the relative economics, time, and dynamics of the recording media after the computer system has been setup with the content of the presentation.

The 16 mm film which accompanies this paper is a direct copy of the actual videotape recording to which I have been referring. In fact there are places in the film where it is evident that this is a copy of video output; but what should be noted from the film is the dynamic value of presenting the graphical material in this form and its ability to "get the point across" as compared to a corresponding slide presentation or paper report on the same material.

During the early stages of working on this presentation, a draft of the script was reviewed by some of the people in the IBM graphics research group who commented very politely, "Yes - that's very nice." - but who, upon seeing it coupled with the actual graphic presentation via the computer remarked with much more enthusiasm, "Now I really understand the points that you're trying to make!". So it was clear that the content of the presentation required a strong graphical boost in order to attain some degree of clarity. But what made the construction of the report a relatively easy and inexpensive job was the combination of the graphics with the video.

Once the content of the video script had been decided upon, it took a total of two hours recording and editing time to produce the final 30-minute videotape. Thus, two hours of my time plus the computer time used during the recording, and the cost of the videotape reel comprised the total cost of the actual recording itself - or on the order of $2 per minute of videotape output.

However, working with the videotape during developmental stages of the graphical presentation does not preclude the possibility of eventually producing a film to allow for wider distribution of the end product. The film which accompanies this paper was copied from the videotape at approximately $10 per minute for the initial answer print and $50 total for each subsequent copy. These figures can then be contrasted to the estimated costs of producing a film directly from the scope without any use of the videotape. One would make the assumption again that the graphical script had been programmed into the computer beforehand, that the filming would be done by a non-professional, and that the end product would be a film of similar quality. Based on these assumptions the cost estimates for producing the 30-minute film (raw stock, laboratory processing and editing) are in the vicinity of $2000 or $65 per minute.

Considering the convenience of viewing immediately what is being recorded, the cost factors involved, and the fact that the videotape can be reused, added to and edited, it seems logical that the combination of video with the graphics has significantly more to offer than does film with the graphics - at least on the non-professional level.

I would like to stress the fact that the production of the videotape recording - aside from suggestions and criticisms on the content of the material - was a one-man effort. This includes the computer programming, the audio script, and particularly the videotaping and editing. This is neither a pat-on-the-back nor an apology, but simply a statement that with this type of videographic setup it is possible for someone without any elaborate filming background and with no more video recording and editing knowledge than that gained by reading the instruction manual on how to operate the video recorder - can produce a presentable piece of graphical material at considerably less cost than a direct film and with considerably more editing flexibility than a direct film.

Given the appropriate content of the material, it is possible to significantly improve the dynamic effectiveness of the material over what might be obtained with slides or a paper presentation. And, lest I alienate forever all those people who believe "The movie is the thing", one still has the option of turning the videotape into a film for wider circulation and availability.

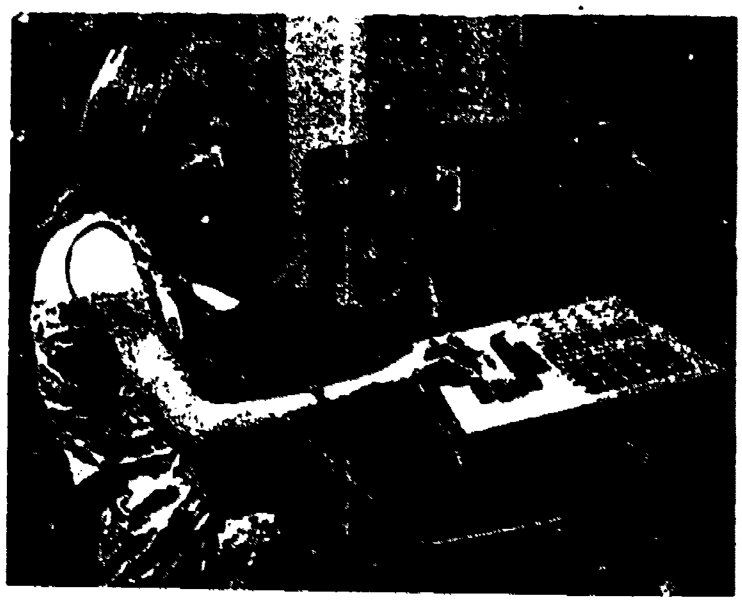
Appendix II

DISPLAY FORMATTING TECHNIQUES OF THE BRAIN

by

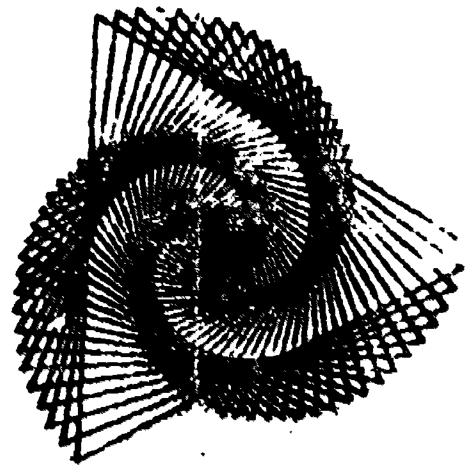
Robert DesMaisons

This presentation was developed at Harvard University with the partial support of a Contract with the IBM Thomas J. Watson Research Center and of NSF Grant NSF/GY-6181.



The terminal that you see here belongs to an interactive computer system entitled THE BRAIN. The hardware consists of keyboard input with function upper keyboard and typewriter lower keyboard, along with a storage scope CRT for output.

The system itself was designed to place the power of the computer at the user's fingertips with a minimum of man-machine interface. Clearly, one of the most powerful means of communicating information is the graphic display, and so considerable effort was made to provide THE BRAIN with flexible graphic capabilities. Since the use of the storage scope prevents a dynamic type of display in the refreshing sense, we've thought of the scope as simply a reusable piece of paper. This "page" concept of the scope is fundamental to our user's construction of a graphic display.



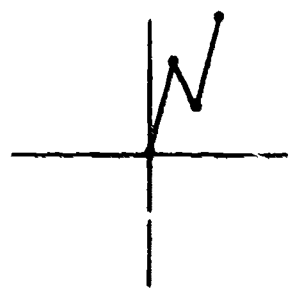
The user must specify a great deal of information about the format of his graphs, and since the input is limited to the keyboard, this information must be input via a symbolic type of format language. A format consists of a string of keywords arranged in arbitrary order and selected by the user from the available options of the format language. Some of the keywords are followed by arguments or may be modified by other keywords. But before describing some of these keywords in detail, it should be worthwhile to discuss some of the basic concepts into which the keywords fit.

```
X = (0,1,2,3)
Y = (0,4,2,6)

Z =(-1,-1) (-2,3),(4,-2),
     (-1,-1)
```

Within THE BRAIN system arrays are either structured as real or complex. Here the arrays X and Y are real and the array Z is complex. X is defined as the four component array consisting of real values 0, 1, 2, and 3, while the four components of Z consist of the complex numbers (-1, -i), the second component (-2, +3i); and so forth.

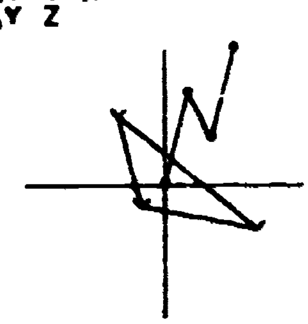
A user requests a curve to be mapped to the screen by using the DISPLAY operator followed by either two real arguments or a single complex argument.

```
X = (0,1,2,3)
Y = (0,4,2,6)

Z =(-1,-1),(-2,3),(4,-2),
    (-1,-1)

DISPLAY Y X
```



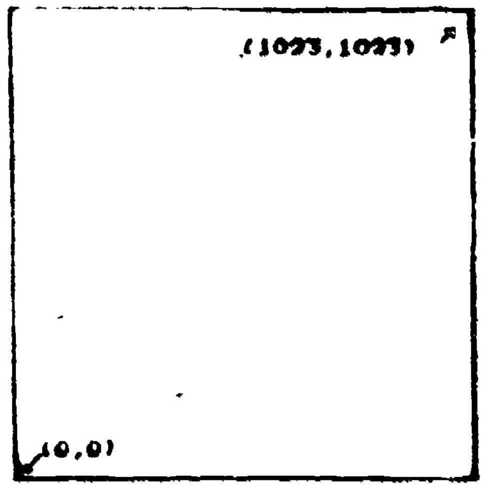
In this case we have asked for the display of the two real arrays, Y vs. X, where Y corresponds to the ordinate and X to the abscissa. The component by component matching of Y and X results in the points (0,0), (1,4), (2,2), and (3,6) being mapped to the screen with connected line segments between those points. If we were to ask for the display of Z, the single argument Z is all that is required since the DISPLAY operator knows by the data characteristics assigned to Z that it is a complex array.

```
X = (0,1,2,3)
Y = (0,4,2,6)

Z =(-1,-1),(-2,3),(4,-2),
    (-1,-1)

DISPLAY Y X
DISPLAY Z
```

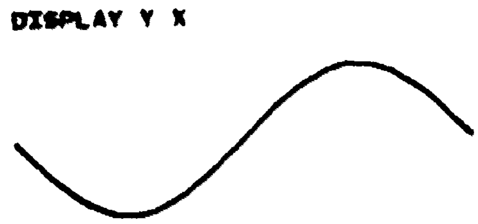


It can then map the real part of Z onto the abscissa of the Cartesian plane, and the imaginary part of Z onto the ordinate. Likewise, the connected line segments normally connect the points of the array resulting in what can be viewed as an arc in the complex plane.

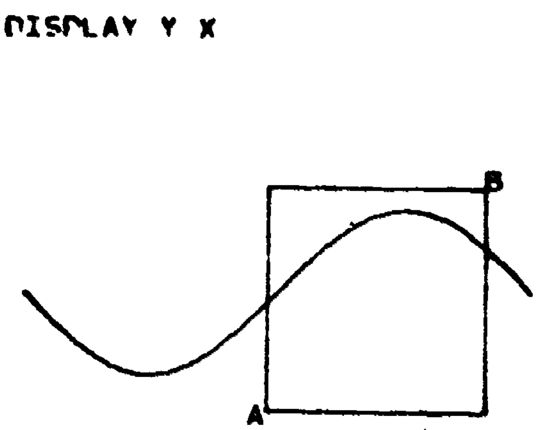
In general, during the display, number pairs which represent points on a Cartesian co-ordinate system are mapped onto points of the two dimensional plane of the output scope.



The addressable points of the scope co-ordinate system range from 0,0 in the lower left corner to 1023,1023 in the upper right corner. It is this co-ordinate system with which the user defines the viewport, or that physical area of the screen which will be used to display his curves.

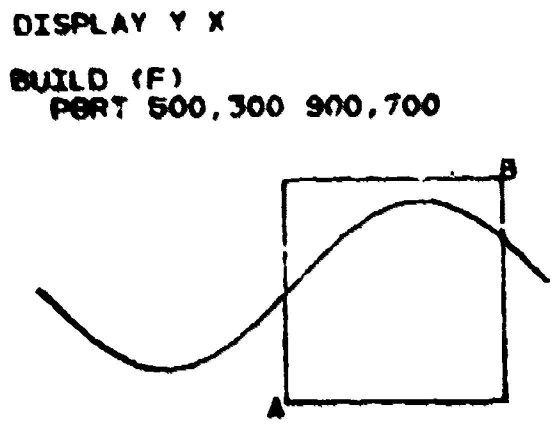


Here you see the sine curve as represented by the arrays Y vs. X drawn on the full screen under the standard format. If, however, we were interested in having our curve appear in a particular area of the screen, for instance, if we wanted the sine curve to be drawn in this area,

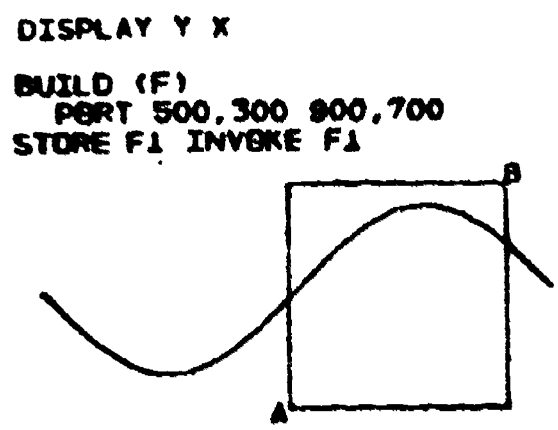


we could do so by simply changing the viewport. This is done by building a format and specifying the diagonal points of the viewport rectangle indicated here as A and B.

The way a user builds a format is in the same fashion as he builds any string of keypushes; that is, by calling upon the BUILD operator, specifying that he is building a format, and then listing his keywc

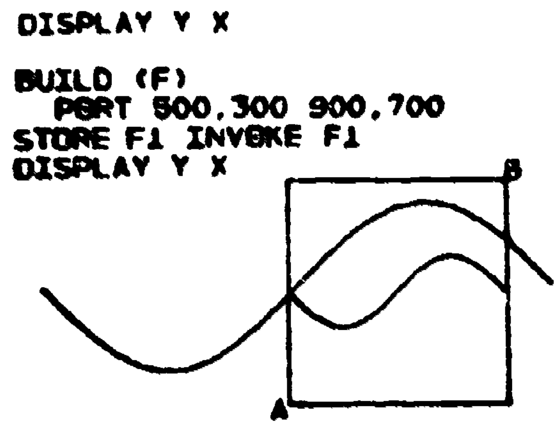


In this particular case we're interested in building a new viewport, so we use the keyword PORT followed by the scope co-ordinates that correspond to A and B of the rectangle. We then store this string of keypushes as a format under any given name;

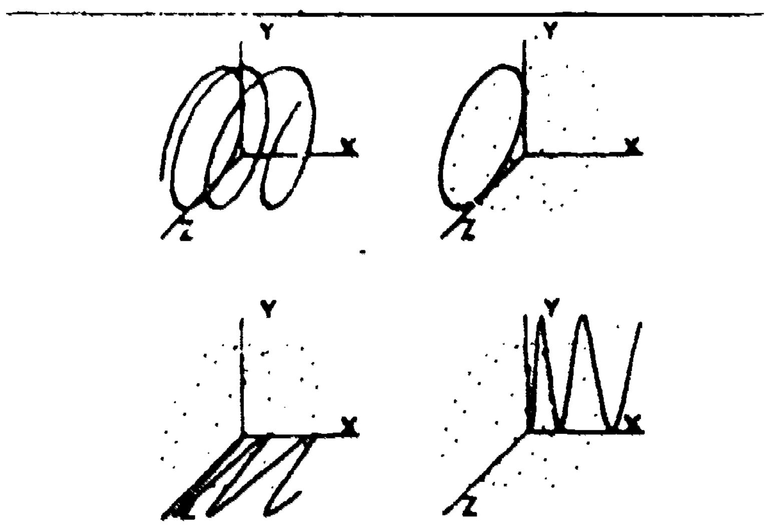


here, we've chosen to store it under the name F1 and we may then invoke F1 as the current format, or that format which exerts control over the DISPLAY operator.

If we now display Y vs. X,



we see the same mathematical representation moved to a particular location on the screen without having modified either the X or the Y functions in any mathematical sense.



As an example of using the viewport option to obtain multiple graphs, this display uses four different formats, each defining a separate viewport in the four quadrants. In the upper left quadrant, a two dimensional axonometric view of a three dimensional curve in X, Y, and Z is shown. The other three quadrants repeat that curve in dot mode along with the solid curves representing the projection in the Y-Z plane, the X-Z plane, and the X-Y plane, respectively.

Apart from the concept of the viewport as defining a rect   in the scope co-ordinate system, is the notion of defining a "window" in the Cartesian co-ordinate system. We refer to a "window" as that portion of the Cartesian co-ordinate system that is being mapped onto the viewport and there are several ways that this window may be specified.

Window Techniques

	Automatic	Manual
Fixed	Auto/Fixed	Manual/Fixed
Variable	Auto/Variable	Manual/Variable

If the user wishes the system to decide the window limits, by examining the X and Y functions being displayed and choosing the appropriate scaling --- this is considered an automatic technique. Whereas, if the user wishes to specify the window limits himself, we refer to this as a manual technique. Also within these two categories, the user has the option of having the window limits remain fixed for all curves drawn on a given page, thus making all the curves be in true relationship with one another. Or, all the curves may be drawn on their own scale and the window limits will thus vary for a given page.

To illustrate the effects of these four techniques, we can consider the three curves, defined as

A. Sin (X) vs. X

B. Cos (X) vs. X

C. Sin (X) vs. Cos (X)

where $-\pi \leq X \leq \pi$

To create the array X within THE BRAIN system, a user would call upon the INT operator specifying the domain and the number of equally spaced points to be chosen within that domain.

INT -π π 100 ⇒ X

Here, we have created in the working register 100 equally spaced components between $-\pi$ and $+\pi$. We can then store a permanent copy of this array under the name X.

Calling on the SIN operator performs the si.e function on the contents of the working register and we can then store a copy of the result u: .. the name Y.

```
INT -π π 100 = X
SIN = Y
```

Displaying Y vs. X then results in the first curve Sin X vs. X.

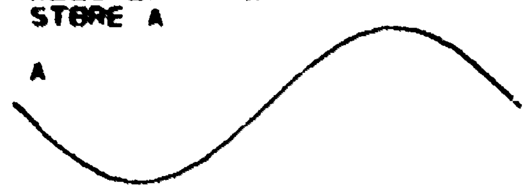
```
INT -π π 100 = X
SIN = Y
DISPLAY Y X
```

Since we will be viewing this curve several times while describing the window techniques, we can store this sequence of keypushes as an operator under a single name in order to avoid repeating the keypushes again. We do this by calling upon the BUILD operator, listing the keypushes, and STOREing the sequence as a user-defined operator under the name A.

```
BUILD
 INT -π π 100 = X
 SIN = Y
 DISPLAY Y X
STORE A
```

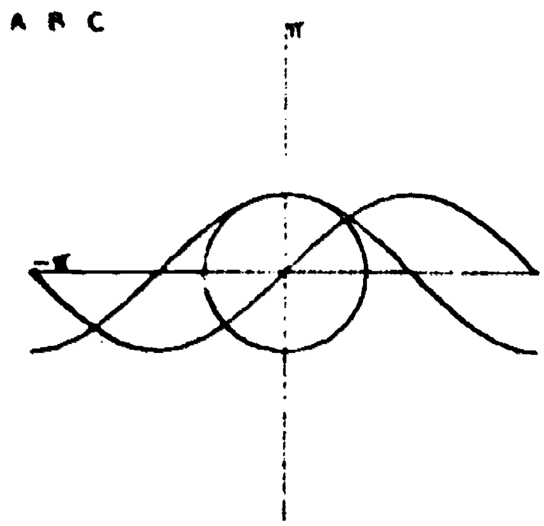
Now by calling the operator A, we effectively execute the whole string of keypushes with one command.

```
BUILD
 INT -π π 100 = X
 SIN = Y
 DISPLAY Y X
STORE A

A
```



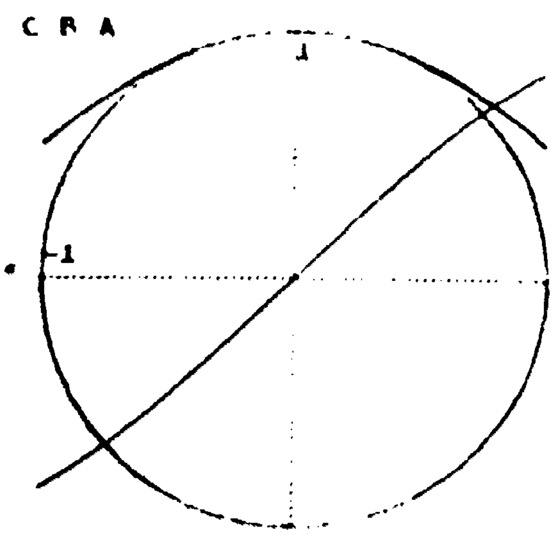
In a similar manner the operators B and C have been constructed beforehand to display the curves COS X vs. X and SIN X vs. COS X.

In the case of the automatic-fixed technique, which is the default option used in the standard format, the display of the curves A, B, and C, appear with the A curve fixing the window limits for itself and for the B and C curves.



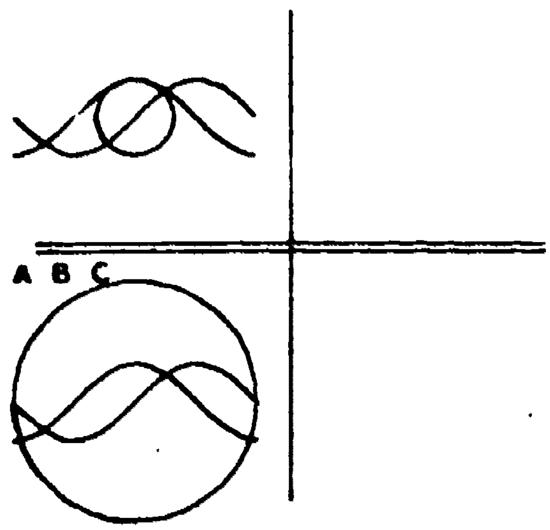
The limits were automatically chosen by the system as $-\pi$ and $+\pi$ on the abscissa and $-\pi$ and $+\pi$ on the ordinate. The value, π, was chosen because it happens to be the maximum absolute value of all the components of both the ordinate and the abscissa.

If they had been displayed in reverse order, however, the page of display would look differently, even under the same technique.



This is because the limits are fixed by the C curve as -1 and +1 on both axes. Thus only the mathematical representation of the subsequent curves B and A which fall within those limits will appear within the viewport.

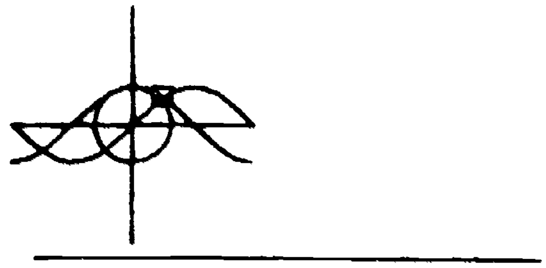
With the automatic-variable technique the order of the curves makes no difference, although once again, one obtains a different eventual page of display. In the lower quadrant we can see that the display of each curve effectively changes the window limits according to its own extent and is done so automatically by the system.



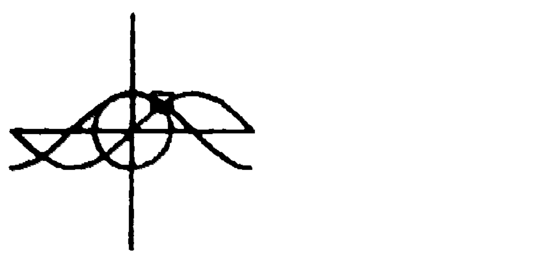
This technique provides the maximum detail for each curve with the obvious cost being that the relationship between curves will not necessarily be a true one.

In the manual-fixed technique the order in which the curves are displayed also makes no difference in the final page. However, the limits of each mathematical representation, likewise, have no effect upon the window limits. The user defines the diagonal points of the window rectangle as a direct part of the format --- this implies that he knows the window limits when he builds the format.

If, for example, we wish to look at this particular section of the Cartesian co-ordinate system where the three curves are intersecting,

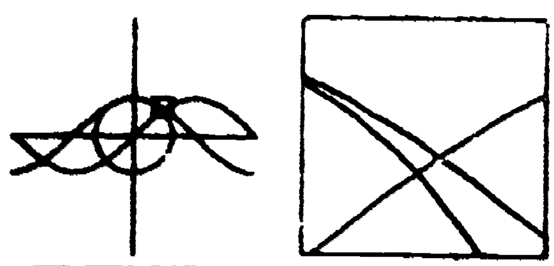


we could build a format and specify the keyword "Fixed", giving the arguments which correspond to the diagonal points of that small rectangle. In this case these are the Cartesian co-ordinates (.5,-.5) and (1,1).



FIXED .5,.5 1,1 .

If we then invoke that format and display the curves A, B, and C, we see only that part of each function which falls within the given window.



FIXED .5,.5 1,1 A B C

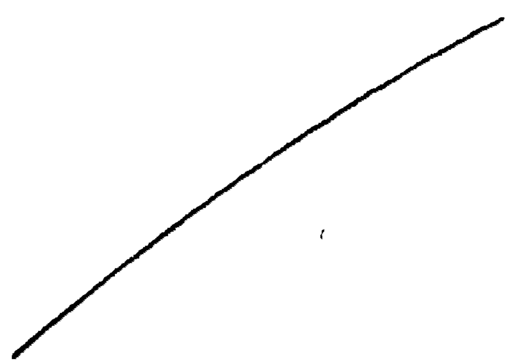
When using the manual-variable technique, the user again specifies the window limits himself, although he can change them with different displays on the same page without directly changing the format. This is done by using variable names as part of the format and then changing those variables in between displays. If we were to build a format and specify the key word "Variable" followed by two arguments such as R and S we could then store this string of keypushes as a format under, say, F2, and invoke F2.

```
BUILD (F)
   VARIABLE R S
STORE F2 INVOKE F2
```

LOAD .5,.5 = R LOAD 1,1 = S

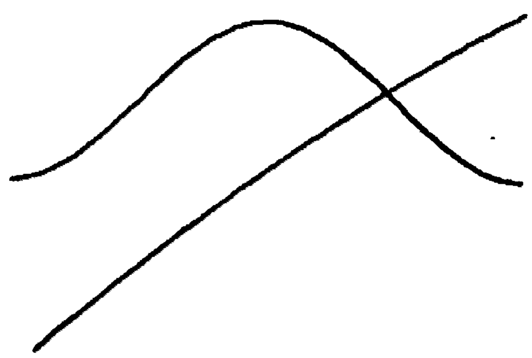
Then defining the values R and S --- here, we've chosen R and S as the same Cartesian co-ordinates which defined the rectangle in the previous case --- and displaying the A curve, we see that portion of the A curve which appeared in the fixed window of the previous example.

LOAD .5,.5 = R LOAD 1,1 = S
A



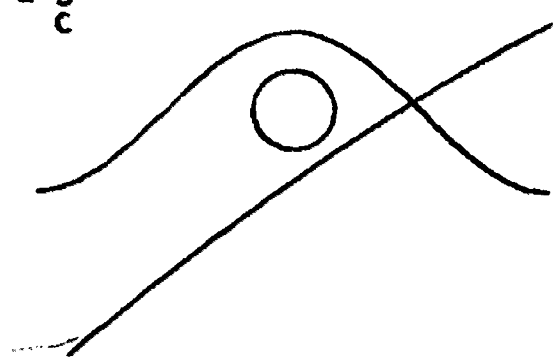
However, on the same page, we can now change the values of R and S to run the full range between $-\pi$ and $+\pi$ on both axes. Then, displaying the B curve, we see the full cosine.

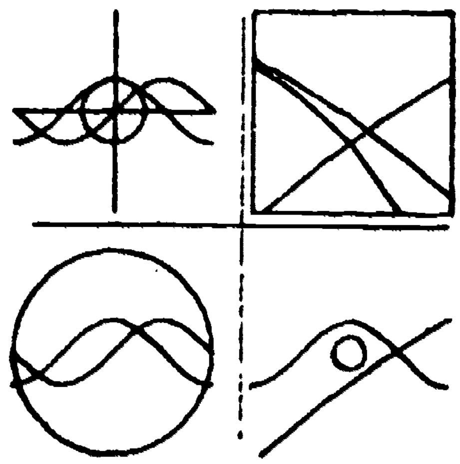
```
LOAD .5,.5 = R LOAD 1,1 = S
  A
LOAD -π,-π = R LOAD π,π = S
  B
```



And once again, we can change the values of R and S to now include the range from -2π to $+2\pi$ on both the X and Y axes; and viewing the C curve, we see the circle in a different perspective.

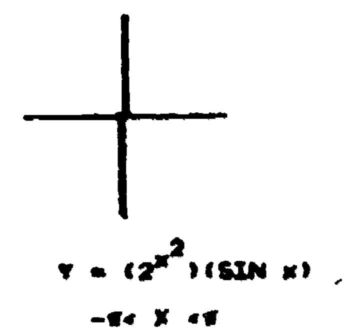
```
LOAD .5,.5 = R LOAD 1,1 = S
  A
LOAD -π,-π = R LOAD π,π = S
  B
LOAD -2π,-2π = R LOAD 2π,2π
= S
  C
```



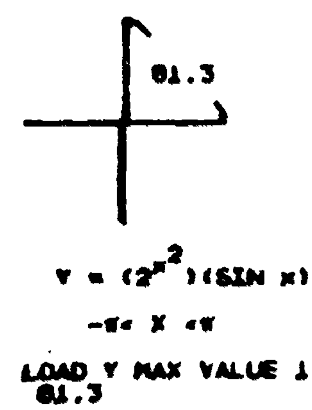


In reviewing the four techniques, you can see in the upper left quadrant the results of the automatic-fixed technique, where the system decides the window limits and on each page the window limits are specified and determined by the first curve; all subsequent curves then fit within those window limits. Below that is the automatic-variable technique, where again, the system determines the window limits, but, on a given page, each curve resets those window limits for itself, giving the maximum detail but perhaps destroying the true relationship between curves. In the upper right hand corner, we see the effects of the manual-fixed technique, where the user specifies the limits and each subsequent curve fits within those limits. While below that is the manual-variable technique where the user specifies the limits, but on a given page, in between each display, he is able to change those limits.

One of the format default options is that the scale factors for the X and Y directions are set equal so that the true shape of the curve is preserved. If we look at the particular curve defined as $Y = 2^{X^2} \cdot \sin X$, where X ranges from $-\pi$ to $+\pi$, and actually display Y vs. X, we see with the given resolution of the scope very little in terms of distinguishing characteristics of the curve.

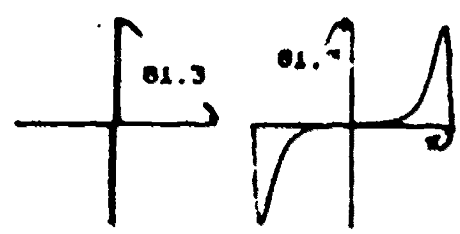


This is due to the fact that X is ranging from $-\pi$ to $+\pi$, while Y is ranging over a much larger set of values. If in fact, we look at the maximum value of Y, we can see that it is 81.3.



Since the maximum of both the X and Y extents, together, determine the window boundary, both the extents in the X direction and Y direction have the maximum value 81.3.

When the user chooses to specify either of the manual techniques, the relationship between the abscissa and the ordinate is frozen. However, this relationship is alterable with both of the automatic techniques, simply by further modifying the format. If the user specifies in his format the STRETCH option, then the X and Y scale factors are independently arrived at with the maximum extent of the curve in each direction determining the window limits in that direction separately.



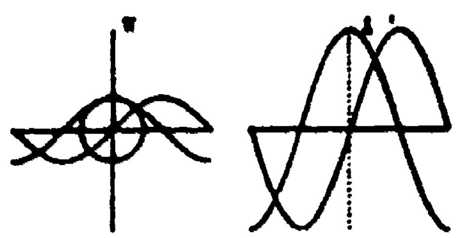
$Y = (2^{x^2})(\text{SIN } x)$

$-\pi < X < \pi$

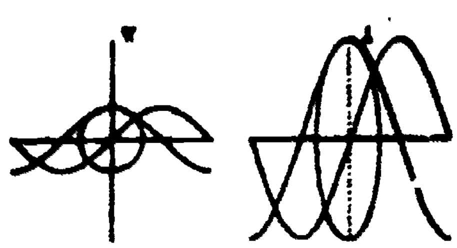
LOAD Y MAX VALUE 1
81.3

If we now look at the same curve, using the Stretch option, we see that more detail is shown in terms of understanding the shape of the curve, but we must remember that the range of values on the X axis is going from $-\pi$ to $+\pi$ and is not equal to the range of values on the Y axis, which still has a maximum of 81.3 and a minimum of -81.3.

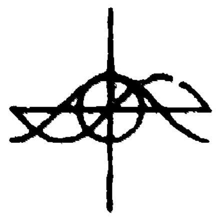
It is possible for the user to be confused in using the Stretch option and some care must be taken in doing so. We can look at our standard display of the A, B, and C curves, where the X and Y directions are determined as equal between $-\pi$ and $+\pi$ in both the X and Y directions. If we use the stretch option with, again, the A and B curves, the sine and cosine, we see that, although the limits are unequal in the X and Y directions, the sense of the curve is still realized.



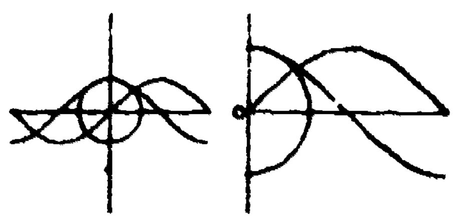
However, if we were to draw the C curve, the distortion from the circle to an ellipse is very evident due to the fact that the X and Y directions are no longer in true relationship to one another.



Another of the default options sets the (0,0) point of the Cartesian co-ordinate system at the center of the viewport.

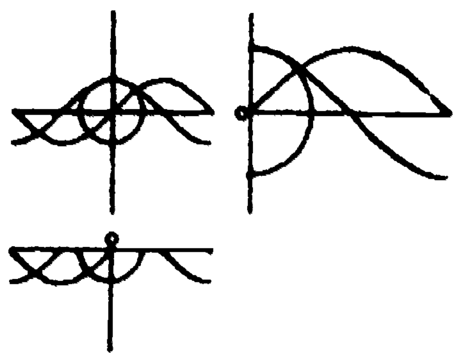


Again, with the two manual techniques, this point is frozen by the user-specified window limits. Within the automatic technique, the user can modify the format to set the zero value of X at the left side of the viewport, at the right side, at the center, or some location in between, depending on the extent of the curve in the negative and positive X directions.

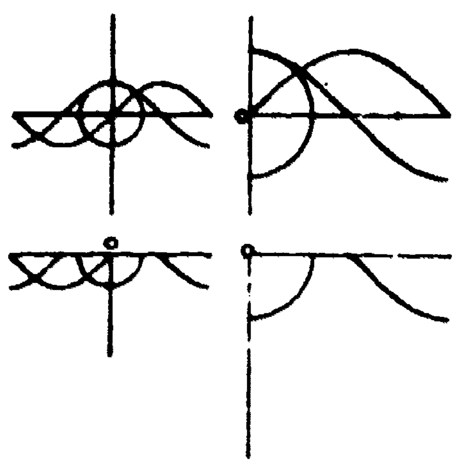


In this viewport we see one of these particular options. Here, we're setting the zero value of X at the left side of the viewport and as a result we see only those portions of the A, B, and C curves which fall in the positive X direction.

Similarly, options are available to set the zero value of Y at the top of the viewport, in the middle, the bottom of the viewport, or somewhere in between, and we next see the option of setting the Y value of zero at the top of the viewport with the corresponding A, B, and C curves only visible in the negative Y direction.

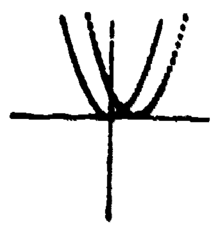


We could also combine these two options and in this case set the (0,0) value of the Cartesian system at the upper left corner of the viewport.

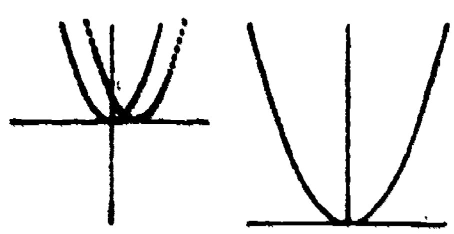


Again, we see only the portion of the A, B, and C curves that fall in that particular quadrant.

To illustrate the use of that format option which allows the (0,0) value to float anywhere within the window, we can consider the two parabolas, one centered about the origin, the other displaced slightly;

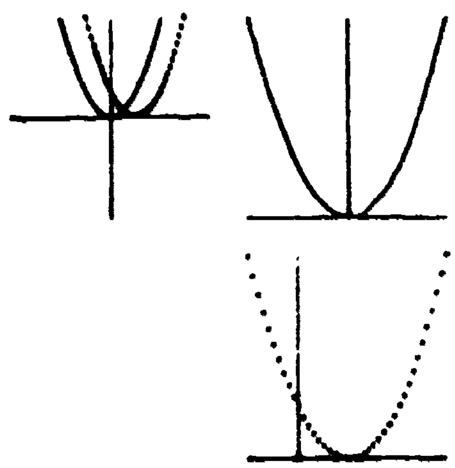


and we see them here drawn on the standard format with the (0,0) point of the Cartesian system at the center of the viewport. If we have defined a format which contains the option of letting the (0,0) value float anywhere within the viewport, and we then display the parabola which centers about the origin,



we can see that the curve fills the viewport as much as possible with the (0,0) value at the bottom center.

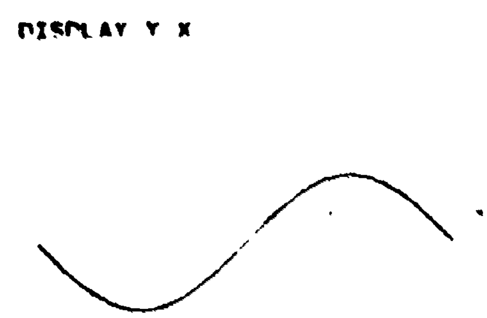
However, if we use the same option in a new quadrant with this tim the displaced parabola, we see again that tne curve fills the viewport but as a result the zero value of X now is somewhat to the left of center.



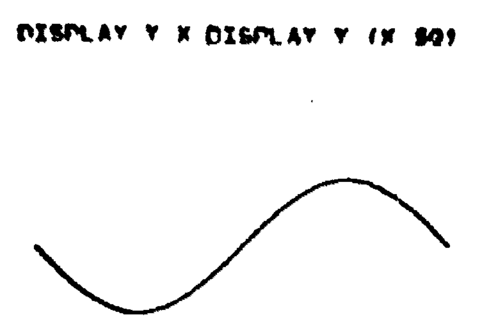
Uther of the format options are somewhat independent of the viewport and window concepts. Included in these are the logarithmic scaling, titles, axes, and beam positioning options.

Normally, when the user combines some form of text together with his displays, the position of the beam at the completion of a display will return to the previous textual location.

For example, if the user is echoing his keypushes, the command to display Y vs. X appears on the screen followed by his actual display.

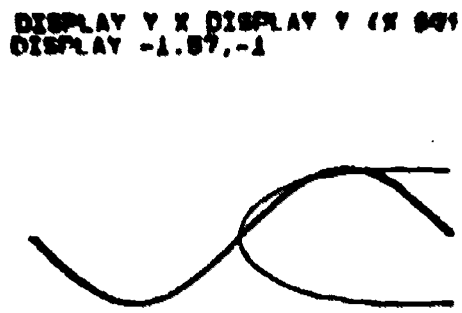


The echoing of the second command to display Y vs. X^2 begins where the previous echoing ended rather than where the display ended.

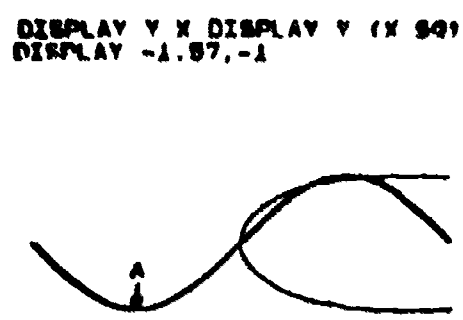


This allows for some degree of separation between the text material and the display.

There are times, however, when allowing the beam to stay where it is at the end of the display is useful, particularly, in labelling points of the curve. If we had invoked a format using this option we might label a particular point, say the point $(-\pi/2,-1)$, by calling on the DISPLAY operator to display the single point;

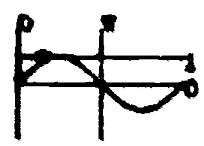


and then with the beam remaining there, display our desired labelling characters.



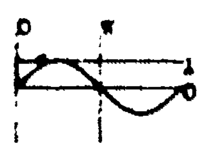
This turns out to be an effective means of pointing directly at a mathematical co-ordinate, since one need not know where that point falls on the scope co-ordinate system.

If the user wishes either or both of his axes of display be on a logarithmic scale, he can do so by specifying the appropriate keywo[illegible] [illegible]is format. To illustrate these options, we can consider the array X defined between 0 and 2π. If the scaling is linear on both axes and we display Sin X vs. X, we see the curve and the point (1,1), which we can use as a reference point, labelled with the asterisk character.

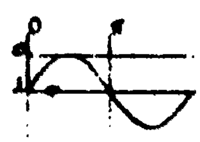


SIN X vs. X

If we invoke a format with the Y-axis logarithmic and at the same time exponentiate the sin function, these two steps in effect cancel one another out and we preserve the shape of the curve.



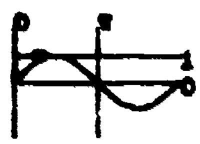
SIN X vs. X



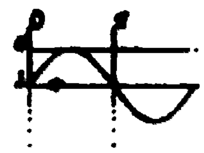
$e^{SIN\ X}$ vs X

However, the point (1,1) is now in a different position relative to the curve because of the log scaling of the Y-axis.

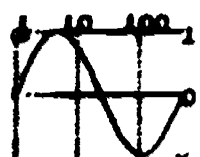
Similarly, if we invoke a format which sets the X-axis logarithmic and we display Sin X vs. (X exponentiated), again the sine shape is preserved but the reference point (1,1) is at a different location.



SIN X vs. X



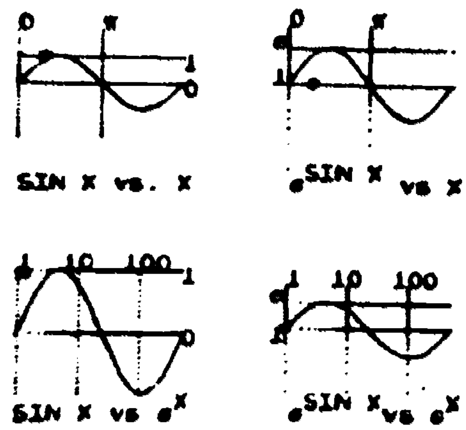
$e^{SIN\ X}$ vs X



SIN X vs e^X

And finally, we see both axes logarithmic and both of the original functions exponentiated with our reference point at a fourth position.

We might also note that the formats which were used to illustrate the log scaling also used the title option to place the identifying characters at the bottom of each viewport.

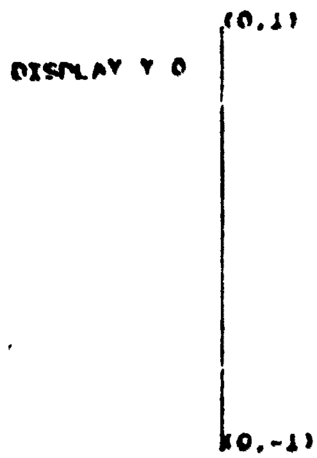


If, as an example, we wished to look at the contents of the format which controlled the upper right quadrant, we would do so by calling on the system operator SHOW followed by the name of that format, F14.

```
SHOW F14

 TITLE "eSIN X VS X"
FREEX FREEY LOGY
PORT 540,540 990,990
```

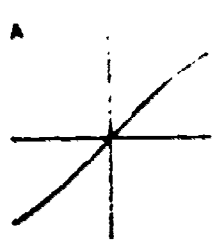
We can then see the contents of that format, which consist of the title option, the options for a floating zero value of X and Y, the options for log scaling of Y and the viewport options specifying the upper right corner of the scope.

Many users like to have their axes drawn with the graph, and although a format option for axes was planned, it was never implemented. So, users within THE BRAIN system draw axes by displaying horizontal and vertical lines. Here, we've done this with DISPLAY Y vs. zero, where Y is a real linear array ranging from -1 to +1.

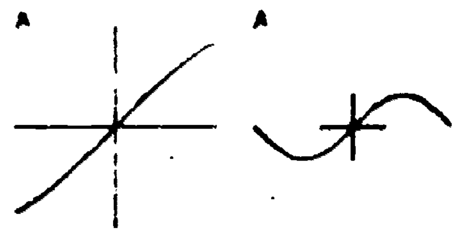


The result is a vertical line from the point (0,-1) to (0,+1). This works fine for the manual window techniques or the automatic-variable technique, but with the automatic-fixed technique there is a problem.

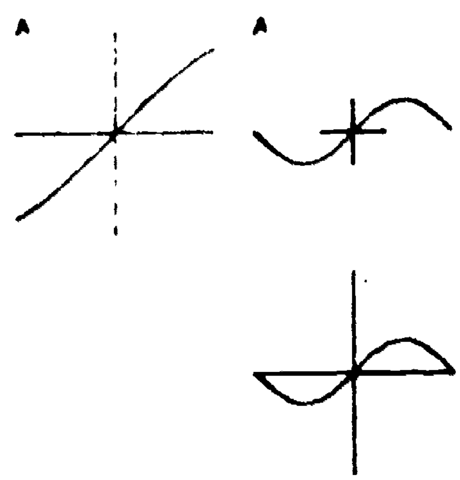
If the axes are drawn first, they determine the window co-ordinates and the following curves do not appear through the proper window.



One solution is to draw the curve first and then the axes.

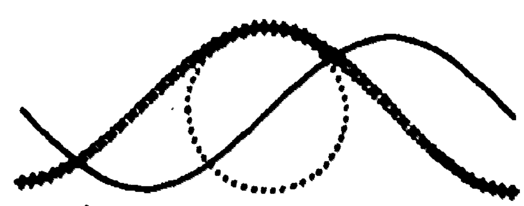


Or, one can use a separate format for drawing the axes;



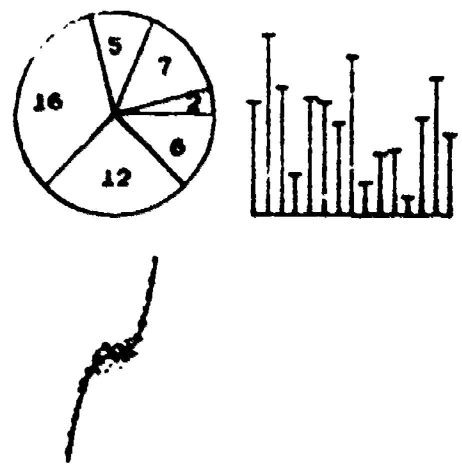
but the best and final solution, however, would be to implement an axes format option.

There is a display feature that doesn't come under format control, but which is nevertheless a useful tool in constructing a graphic page. This is the ability to have any character, system defined or user defined, displayed at the points of the curve in place of the connected line segments in between points. This is specified simply by following the DISPLAY operator with that particular character in parentheses and then giving the normal function arguments.



Here we see the A curve with the regular connected line segments, the B curve with the plus character drawn at each of the points and the C curve with a period character.

Although fairly simple mathematical functions have been u. il- lustrating these various formatting techniques, the techniques themselves can be applied to the more general problem of controlling the construction of a graphic page. The material for the graphic page may arise from many varied applications, from the pie-chart, to histograms, to least squares curve fitting;



and yet, the problems of translating the data in a <u>mathematical</u> sense to a page of information in a <u>graphic</u> sense requires some flexible controls with which the user can perform that translation.

In our formatting objectives and options we've attempted to provide this flexibility by making a careful distinction between the scope's displayable area as a viewport and the displayable area or window on the mathematical functions; and then, within that distinction, by allowing the user to vary his viewport and vary his window in such a way as to obtain his desired graphic page without having to mathematically manipulate his data.

Appendix III

Notes on Factors for Comparison

Robert DesMaisons

The description of "display formatting techniques of THE BRAIN" given in Appendix II is now available in the first 3 of the following 4 forms:

1. Written version (Appendix II)
2. 16 mm film (with sound)
3. Videotape (also with sound)
4. Slide-audio tape sequence (slides identical to the phorographs of (1) and audio tape identical to sound portion of (2) and (3)

If we're to perform some form of evaluation on the material and the media, we have to first consider the attributes of each form.

Are the people being tested going to view the material in one-shot fashion with no chance for reviewing portions of the presentation? If so, the film, videotape, and slide sequence allow a fair comparison with one another since the input to the viewer can be controlled. It's more difficult to control input to a reader of the written version, since he can always re-read a paragraph if it is not clear the first time.

If the subject wants to review certain portions of the presentation, this might point out weaknesses in the content or the clarity of its expression. But how important is the ability to review the material? Does the ease of review encourage the use of one form over another? The written version would clearly have an advantage if the subject were allowed to look back over the material since it's easier to find what you're looking for on paper than hunting back and forth on a film, videotape or slide-tape sequence.

The dynamics of the film or videotape presentations and the effect on understanding the material should be examined in matching · · (2) or (3) versus (1) or (4).

Some of the obvious concepts to be tested as indices of effective learning would be:

1) The Window vs. Viewport; how do they differ, when do you use one or the other?

2) What are the differences between Automatic-Fixed, Automatic-Variable, Manual- Fixed, and Manual-Variable format options?

3) What is a format in THE BRAIN system?

4) How does one create a format, store a format, use a format or look at it?

5) How do you put a curve into the upper-right quadrant of the screen?

6) How would you look at only that portion of a curve that fell in the negative X direction?

7) What does the Stretch option do and when would it be worth using?

8) How do you label a particular point on a curve?

Would subjects learning through one medium answer these questions any better than those learning through another medium? With review allowed or without?

If the subjects knew already how to use THE BRAIN system in all areas other than the display, would this have any effect upon how they digested the material of the presentation and which medium was more successful?

Appendix IV

SOME ILLUSTRATIONS OF AN INSTRUCTIONAL TECHNIQUE TO TEACH THE RELATION OF POLE-ZERO CONFIGURATIONS TO TIME DOMAIN FUNCTIONS

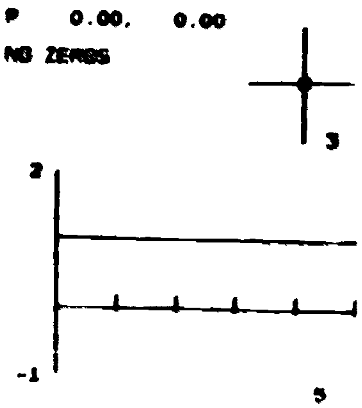
The following are typical examples of an instructional technique suggested by A. G. Oettinger in which illustrations are concatenated so that the learner can observe previously presented illustrations simultaneously so that comparisons can be easily made with the current illustration.

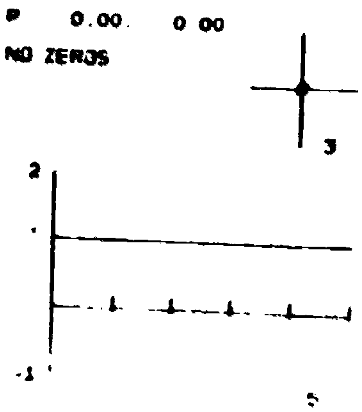
The application here is an attempt to help the student relate pole-zero configurations to corresponding functions in the time domain.

The illustrations were prepared from 35 mm slides taken of displays generated by THE BRAIN.

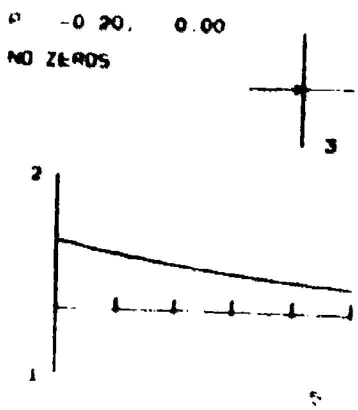
ILLUSTRATION OF THE TIME RESPONSE CORRESPONDING

TO ONE REAL POLE

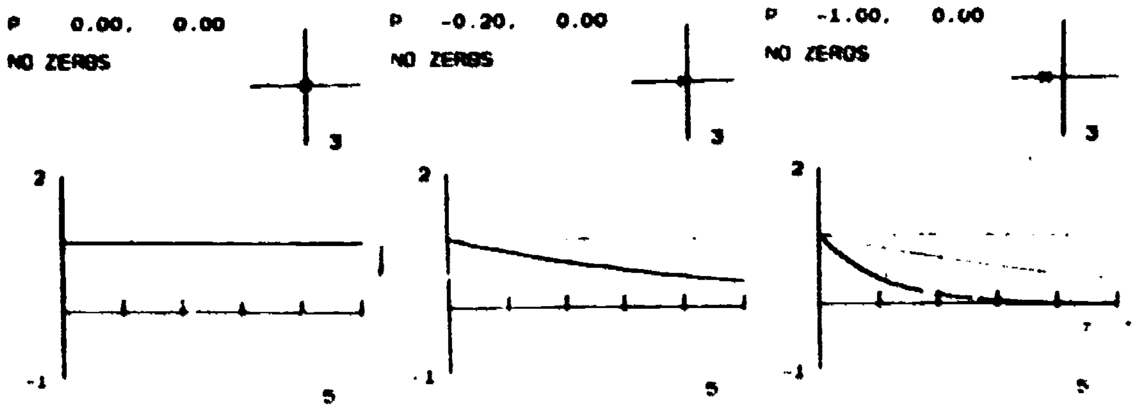

P 0.00, 0.00
NO ZEROS
3
2
-1
5



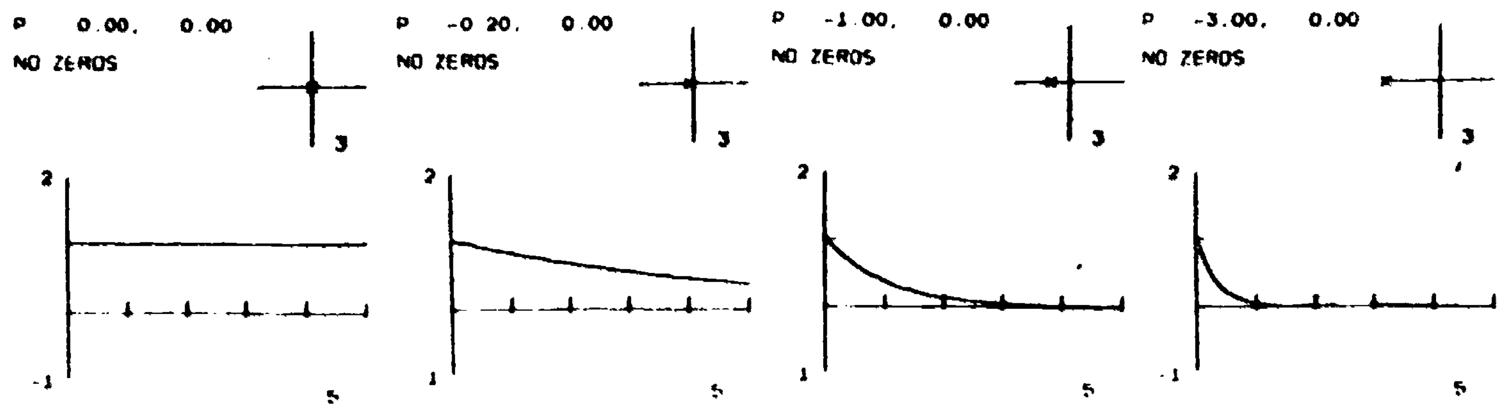
0.00, 0.00
NO ZEROS
3
2
-1
5



-0.20, 0.00
NO ZEROS
3
2
1
5

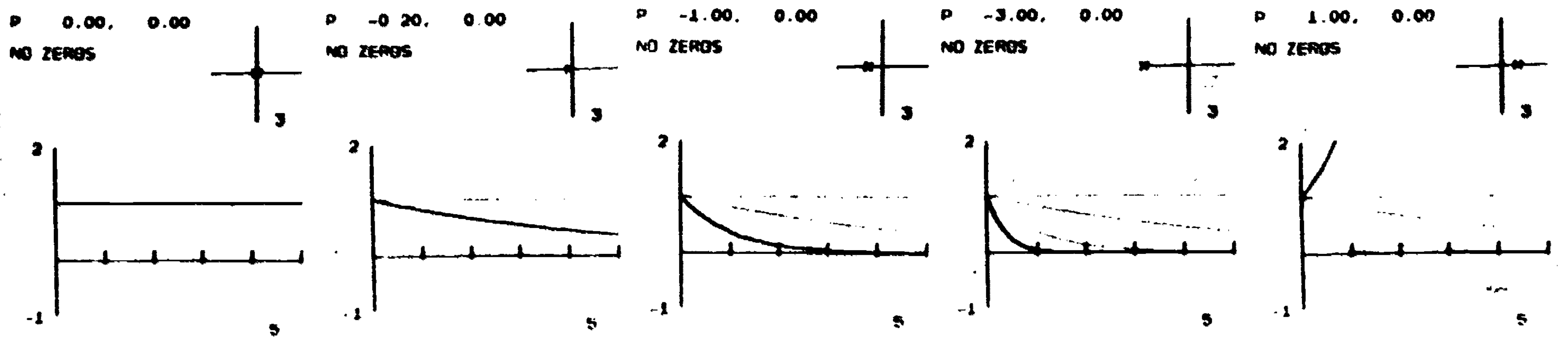


P 0.00, 0.00
NO ZEROS
3
2
-1
5
P -0.20, 0.00
NO ZEROS
3
2
-1
5
P -1.00, 0.00
NO ZEROS
3
2
-1
5

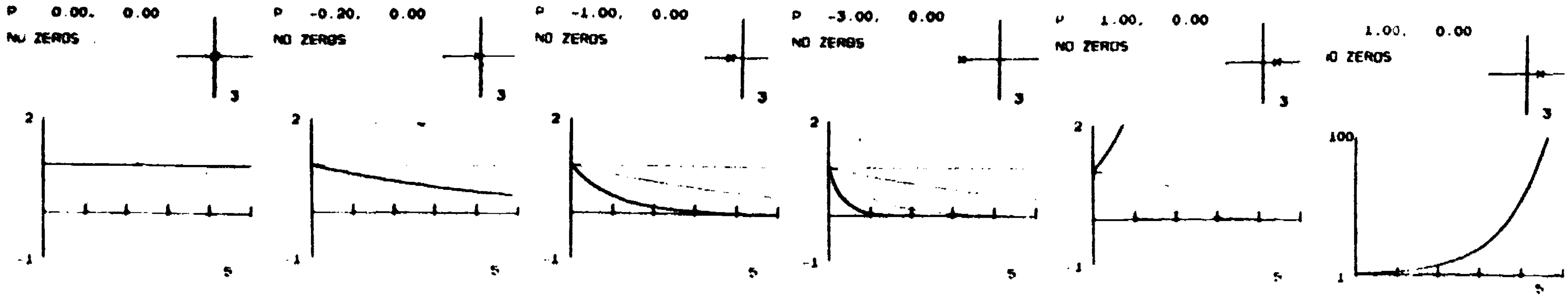


These time functions are decaying exponentials of the form $y = e^{-t/\tau}$.
The curves are characterized by a single parameter called the time constant
This is the time for the function to decay approximately 2/3 (actually 0.63
from its initial value to its final settling value.

SEE IF YOU CAN FIND THE RELATION BETWEEN THE TIME CONSTANT AND
THE LOCATION OF THE CORRESPONDING POLE.



What value do you think the time function corresponding to the pole at +1 will have at time t=5 sec?



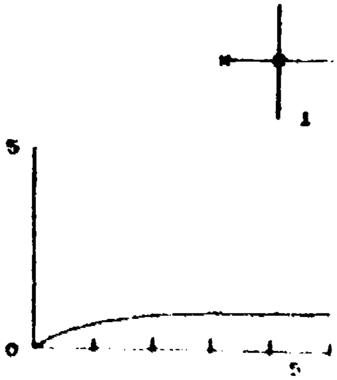
IV-8

ANS: 149

6 i

ILLUSTRATION OF THE TIME RESPONSE CORRESPONDING

TO TWO REAL POLES WITH ONE AT THE ORIGIN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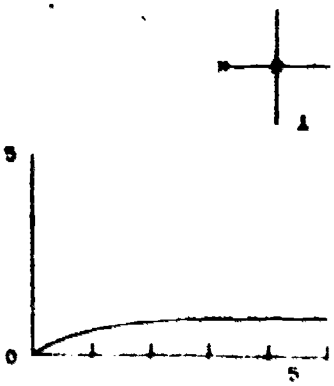
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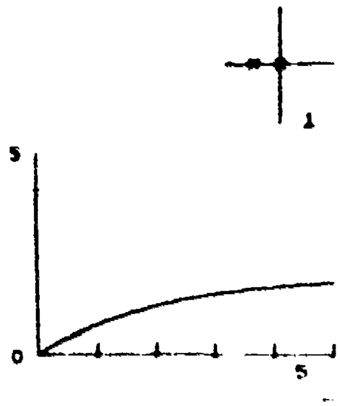
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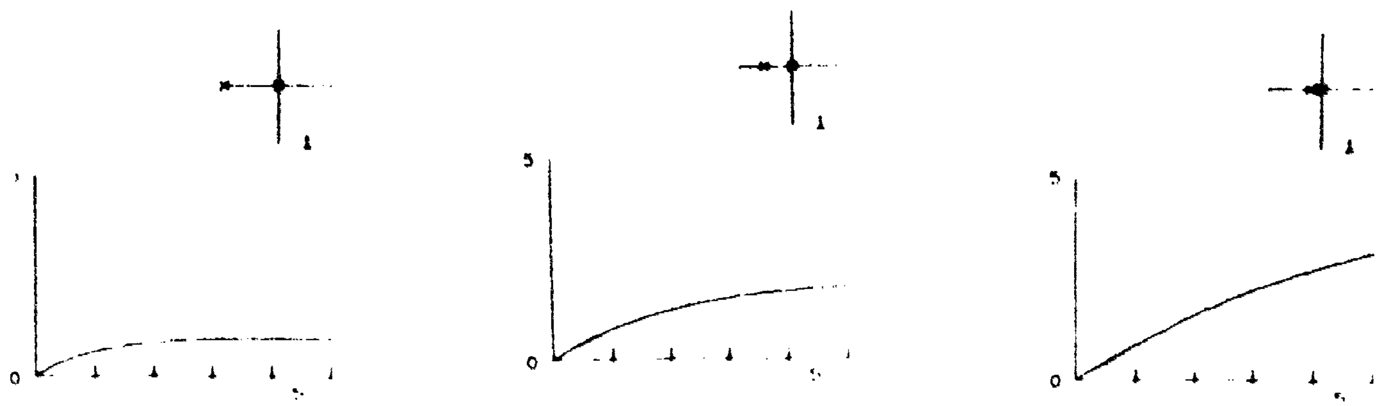
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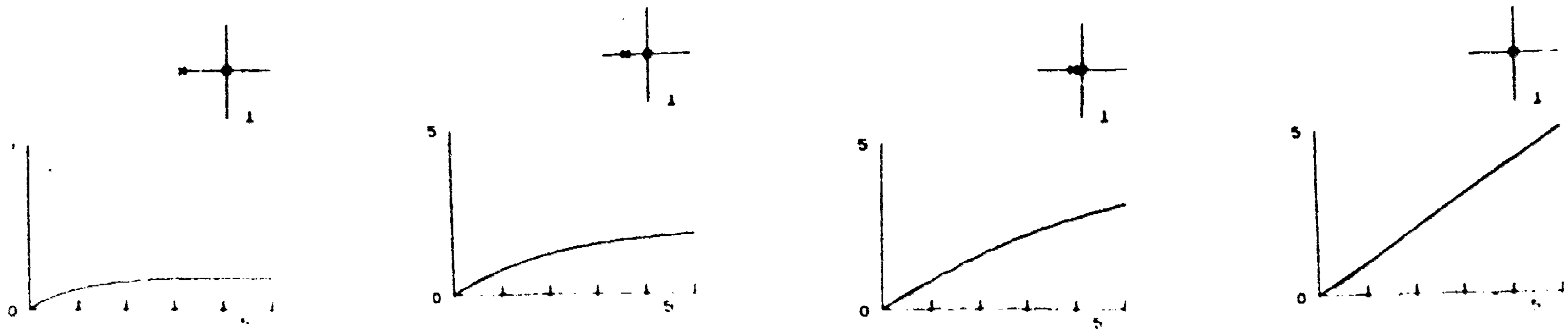


IV-13

What is the time function corresponding to two poles located at the origin?

IV-14

ILLUSTRATION OF THE PARTIAL FRACTION EXPANSION METHOD

FOR DETERMINING THE TIME FUNCTION

CORRESPONDING TO SEVERAL REAL POLES

DISCUSSION

We have seen that a single real pole corresponds to an exponential function in the time domain. If we have a pole-zero configuration with more than one real pole, the resulting time function can be expressed as the sum of exponentials of the form $y = Ae^{\alpha t}$ corresponding to each pole.

The constant α is determined by the location of the pole on the real axis. For a pole on the negative real axis, α is equal to the negative reciprocal of the time constant $(-1/\tau)$.

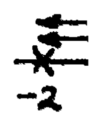
The coefficient A corresponding to a given single pole can be determined using the following rule:

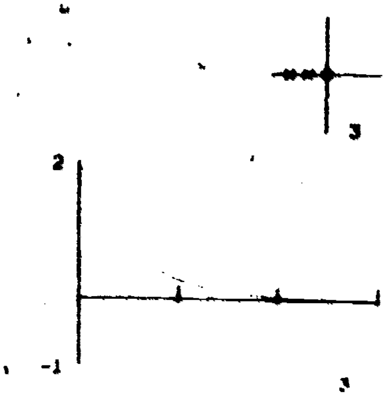
i) draw a vector to the pole under consideration from each other pole and from each zero.

ii) then the coefficient A is given as:

$$A = \frac{\text{product of the vectors from the zeros}}{\text{product of the vectors from the poles}}$$

For example the coefficient corresponding to the pole at -2 for the configuration shown is $A = (-2)/(-1) = 2$.

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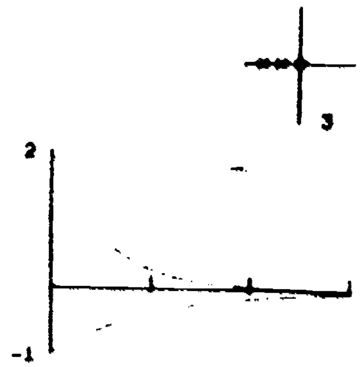
-1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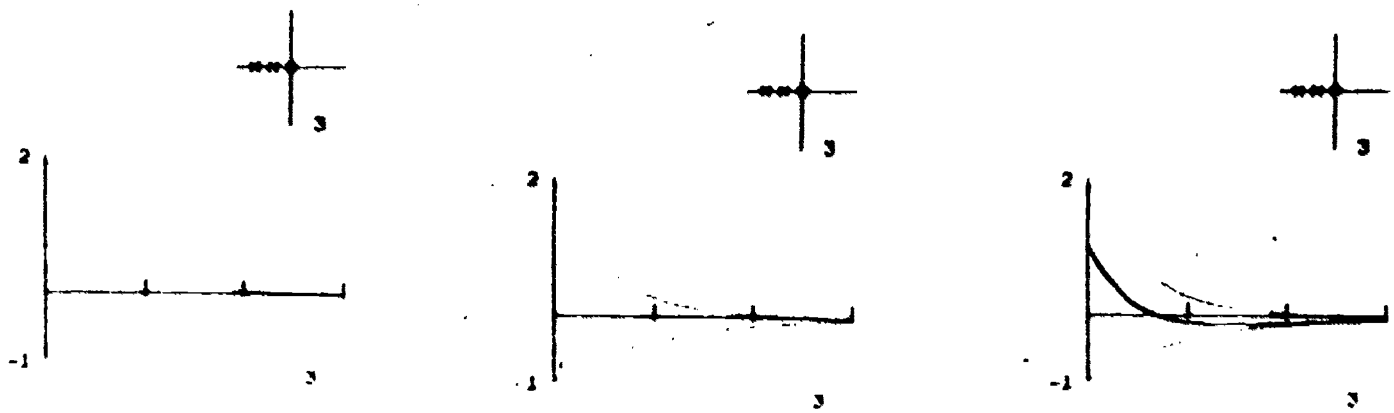
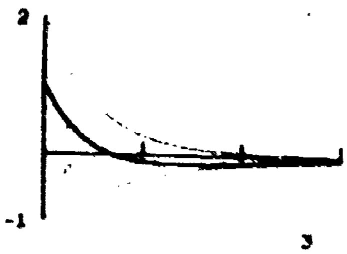

3
2
-1
3
3
2
-1
3
3
2
-1
3

ILLUSTRATION OF THE CANCELLATION OF A POLE AND A ZERO


3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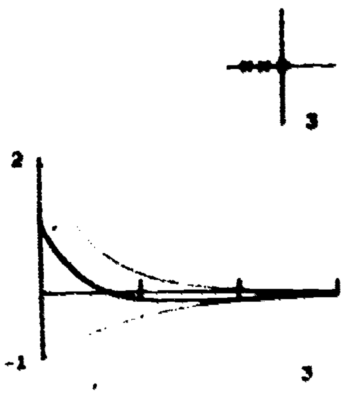
3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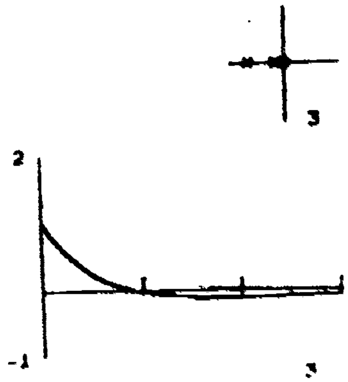
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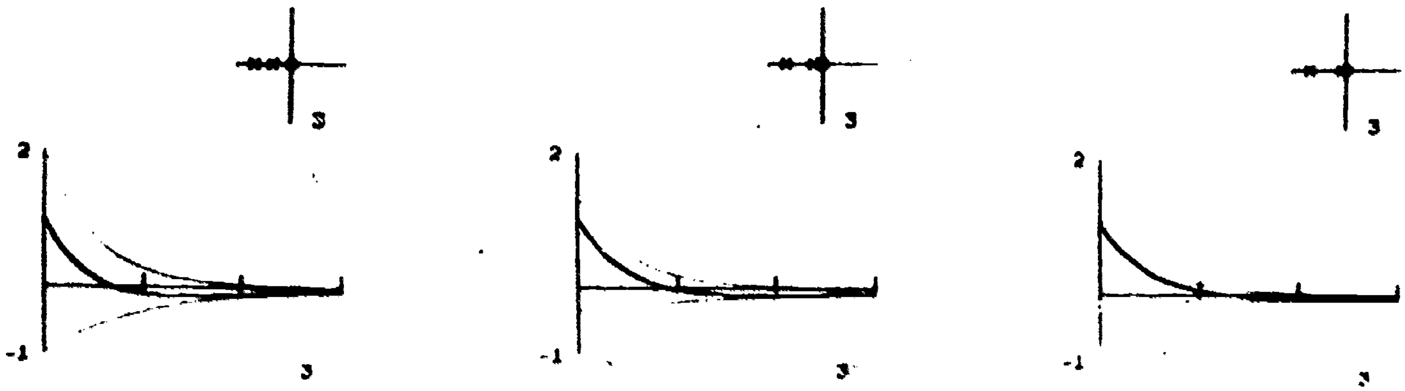
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-1
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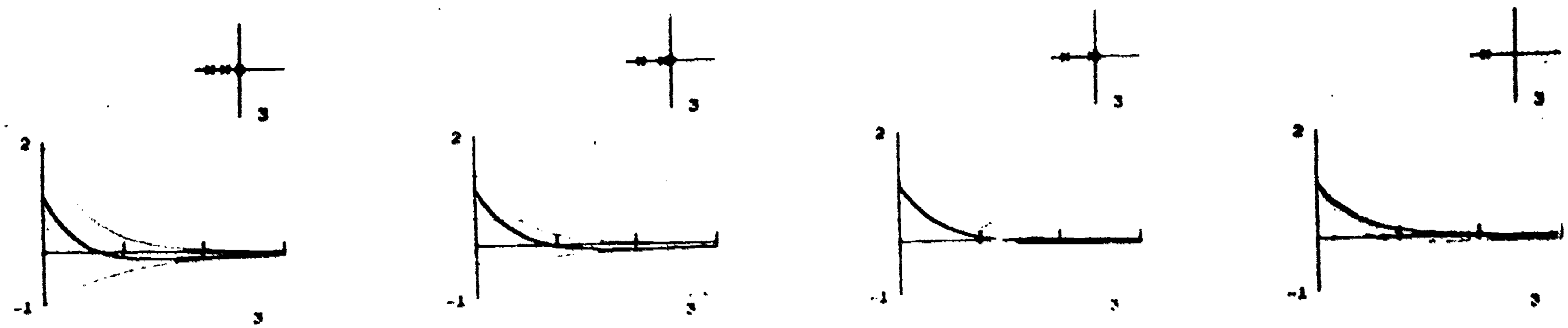
2
-1
3



What happened to the
zero at the origin?