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A STATISTICAL DATA PLOTTER (NULLI IV)

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ABSTRACT

A device is described which enables an operator to feed information in the form of random numbers into the machine and read out the data at any time in graphical form.

Photostat Price \$ 3.30

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Available from the
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A STATISTICAL DATA PLOTTER
(NULLI IV)

I. Introduction

In the course of an engineering development program, it occasionally becomes necessary to classify and plot volumes of data to determine the statistical spread of the data as well as certain sigma points. The task in many cases is extremely time consuming as well as tedious. In a typical example, the engineer or technician is required to first classify the data into discreet intervals, count the number of observations in each interval and proceed to plot the information in graphical form. Nulli IV has been developed to automatically perform this process in an attempt to reduce the time required to analyze data as well as to relieve the tedium involved. Several photographs of the device are included in the appendix to show relative size of components.

II. Functions and Principles of Operation

In statistically plotting data with the intention of producing a histogram-type graph, several manual steps are normally involved:

- (1) From the data, the size of the interval must be determined.
- (2) The maximum and minimum interval are chosen such that all the data will fit into the graph space allotted.
- (3) The number of observations which fit into each interval are manually counted and recorded on an auxiliary sheet of paper.
- (4) The graph is manually plotted from the recorded observations.

To obtain the same graph automatically, several basic operations are involved; namely:

- (1) Classification - the random numbers must be classified into the proper interval, which must be predetermined.
- (2) Counting - number of observations per interval must be counted.
- (3) Storage - as each bit of information is introduced, it must be stored until read-out or until the machine is reset.
- (4) Conversion - the data in digital form must be converted into an analogue voltage for plotting.
- (5) Scan - the storage units are scanned sequentially and the data plotted on a graph to show the number of observations in each interval.

The operations required by the operator prior to the insertion of information are:

- (1) Selection of interval size
- (2) Selection of minimum interval.

III. Block Diagram

For a workable device, Nulli IV must perform three distinct steps. First, it must allow the data to be read in; second, it must scan and plot; and third, it must reset. These three operations offer a logical breakdown of the device into block diagrams, which are shown in Figures 1, 2 and 3.

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Figure 1 - Read-in

Figure 2 - Plot

Figure 3 - Reset

- (a) Read-in: The keyboard is a desk-type console which connects to the control unit with a single cable. It consists of two rows of push buttons for introducing the data into the machine as well as a bar to actuate the read-in mechanism.

The minimum tens selector is a ten-pole ten-position switch to allow the selection of the minimum tens interval. To enable a selection of interval size, a sixty-pole three-position switch permits a selection of three interval sizes: 1, 2, or 5. Storage is accomplished by means of a telephone stepping relay, one step representing one observation. By using an additional double-pole relay, the twenty-position telephone switch capacity can be effectively doubled so that the maximum capacity per interval becomes 40.

- (b) Plot: The information in the storage unit is scanned with another stepping switch controlled by a multivibrator. A twenty-pole ten-position switch controls the minimum units interval. Two outputs from the scanner include both X and Y information.
- (c) Reset: To remove the information from the storage units, the scanner energizes each storage unit individually and returns the step switch to the zero position.

Three power supplies are included: an unregulated supply for the storage units, a regulated one for the multivibrator and dc amplifier, and a battery for the recorder.

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IV. Features and Limitations

(a) Features

- (1) Read-out can be accomplished at any time and a graph can be plotted in about 15-20 seconds.
- (2) Information can be stored indefinitely.
- (3) The limitation on speed depends upon the operator's ability to punch numbers into the device rapidly.
- (4) Nulli IV is portable and can be rolled from one office to another.
- (5) All storage units are plug-in and can be easily replaced if one becomes defective.
- (6) Periodic graphs can be made to determine how the data is spreading as a function of total number of observations.

(b) Limitations

- (1) A total of only 20 intervals are available and a device of this storage principle with more intervals would be rather impractical.
- (2) Nulli IV is further limited by the fact that a total of only 39 observations can be counted in any one interval. However, this limitation could easily be overcome by using the same principle of storage but multiple telephone relays. The capacity could be increased to 400 per storage interval with the use of two such units.
- (3) Care is required so that numbers beyond the setting of the machine are not read in. In some cases the number will not be admitted; however, in other cases, it will be classified and counted in some interval within the range.
- (4) Since the storage units cannot be stepped backward, no provision is made to remove information once it has been placed into storage. Since the read-in bar must be depressed for read-in, it is possible to check the depressed buttons prior to admission of the number.

V. Results of Speed Test and Reliability

A test was devised to determine the time advantage gained by using Nulli IV. A total of 467 numbers were tabulated and individuals were tested on the time required to produce a histogram by conventional manual methods as compared with the time required using Nulli IV. Since the basic preliminary procedure is the same for both methods, the individuals were given the interval size as well as the minimum interval and proceeded to produce the graph.

		NULLI IV METHOD		MANUAL METHOD	
		Time (min)	Errors	Time (min)	Errors
Individual I	(1)	21	2	34	0
	(2)	20	2	35	2
	(3)	17	1		
Individual II	(1)	23	0		
Individual III	(1)	16	4	28	1

Table I

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Table I lists the results of time trials of three individuals. Individual II was not available for a manual test. Averaging only those two who completed the test shows that considerable time was saved by using Nulli IV.

Average using Nulli = $18\frac{1}{2}$ minutes, 2 errors
Manual average = $32\frac{1}{3}$ minutes, 1 error

The time saving amounted to 43% and it was agreed that the tedium was reduced considerably. Plans are being considered to permit operation of Nulli IV directly from a Berkeley read-out printer. This would eliminate the manual read-in process entirely and would increase the time saving to 100%. Since some statistical data can be recorded using this printing device, the concept of having it read-in the data would be practical.

An average of one more operator error resulted using Nulli IV, but the manual method, being more tedious would probably increase the error at a faster rate as a function of time. The machine malfunctioned during the first two trials, but it had not been adjusted after lubrication. It did not malfunction for the remainder of the runs after the storage units were properly checked.

More trials would be required to make conclusive evidence but these preliminary results serve as a guide to the advantages that can be gained.

VI. Conclusions

Several conclusions can be made from the tests.

Nulli IV:

- (1) provides a time saving of about 40%,
- (2) can provide a 100% time saving if feasible to read information in directly from a Berkeley printer,
- (3) decreases the tedium involved,
- (4) initially causes an increase in errors,
- (5) is portable (see appendix),
- (6) can plot a graph as a function of total number of observations,
- (7) is limited by the fact that only 20 intervals with 39 observations per interval can be plotted,
- (8) can be used for data with approximately 0 to 450 total observations,
- (9) cannot subtract a number admitted, and
- (10) is not totally idiot-proof and requires some knowledge of operation principles.

VII. Appendix

Several photographs are included in this section to familiarize the reader with size and concept of Nulli IV.

Figure 4 - shows the control and storage unit with the Mosely recorder mounted on the top. A close-up of the control panel is shown in Figure 5. All of the preliminary adjustments and controls instructing the machine to reset or plot are on the panel. The buttons at the right are merely for testing purposes.

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Figure 6 includes the desk console for admitting the numbers into the storage system. The procedure is to punch one button in each column, followed by depression of the read-in bar. The repeat switch allows the buttons to be reset or left in the last position as desired. The indicator light shows if the admission occurs.

One plug-in storage unit is shown in figure 7. There are twenty units such as this in Nulli IV. Maintenance problems are reduced considerably with this replaceable device.

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Figure 4 -- Control unit with Recorder

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Figure 5 -- Control Panel

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Figure 6 - Desk Console

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Figure 7 -- Storage Unit

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