MLM-1640 (LD)

ELECTRONIC COMPUTING GAGE SYSTEM FOR MONITORING ASSEMBLY OPERATIONS

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ABSTRACT

An electronic computing gage with IBM card punch was found to be a practical system for monitoring the critical steps in the crimping process of the assembly of some parts. In the crimping process a plastic part is compressed into a metal cup to obtain an assembled component without gaps. Dimensional data of the plastic part and metal cup are recorded on a printed tape and on IBM cards, which are used to program a computer to calculate the standard deviation of the lot. Lot acceptance is statistical and is based on the standard deviation of the lot. The electronic computing gage compares the height of the assembled components before and after crimping and indicates whether or not an acceptable assembly (without gaps) has been made. This system eliminates the need for the manual calculation of height and recording of data at the production site, thereby increasing the reliability of the assembly process at a decrease in cost.

INTRODUCTION

As part of the crimping process of the assembly of parts or components a plastic cylinder is compressed into a metal cup; the resulting assembly must not have any gaps between the cylinder and cup in order to be acceptable. The precision essential in the crimping operation in the assembly of parts requires that the entire assembly operation be closely monitored and that all assembly data be recorded. In addition, design specifications require that the standard deviation of the specific crimping dimensions for the lot of parts be calculated and used as the basis for acceptance or rejection of the lot.

Formerly, a manual air gage method was used to monitor the crimping operation. This method of monitoring required that the operating personnel perform the necessary calculations for determining the acceptance of an individual component assembly; the data were then transposed for entry into the lot records and for purposes of key punching to obtain a card for use in programming the computer to calculate the standard deviation of the lot.

An electronic gage linked with computing and data recording components was found to be a more practical system for obtaining closer control of the crimping operation. Although stacked components (i.e., assembled, but not crimped) of a part pass through the crimping stage individually or in series, gage memory limitations prevent operation of the gage in a parallel entry mode.

DESCRIPTION OF GAGING SYSTEM

The specially designed electronic computing gage with an IBM Model 024 card punch was developed to monitor the in-process assembly operation (crimping process) of a part and to record its final height. The computation is automatic, and the data are recorded on a 4.00 in. (101.6 mm) tape at the gage and on an IBM card by the card punch, which can be remotely located. The gage results are printed on tape by a Model 155 data printer (Non-Linear System, Inc., Del Mar, California). The gage console and fixture are shown in Figure 1, and a close-up of the gage fixture is shown in Figure 2.

The application of an electronic gage computing and recording system to the crimping process eliminates the possibility of human error in performing calculations of height at the production site and in the recording

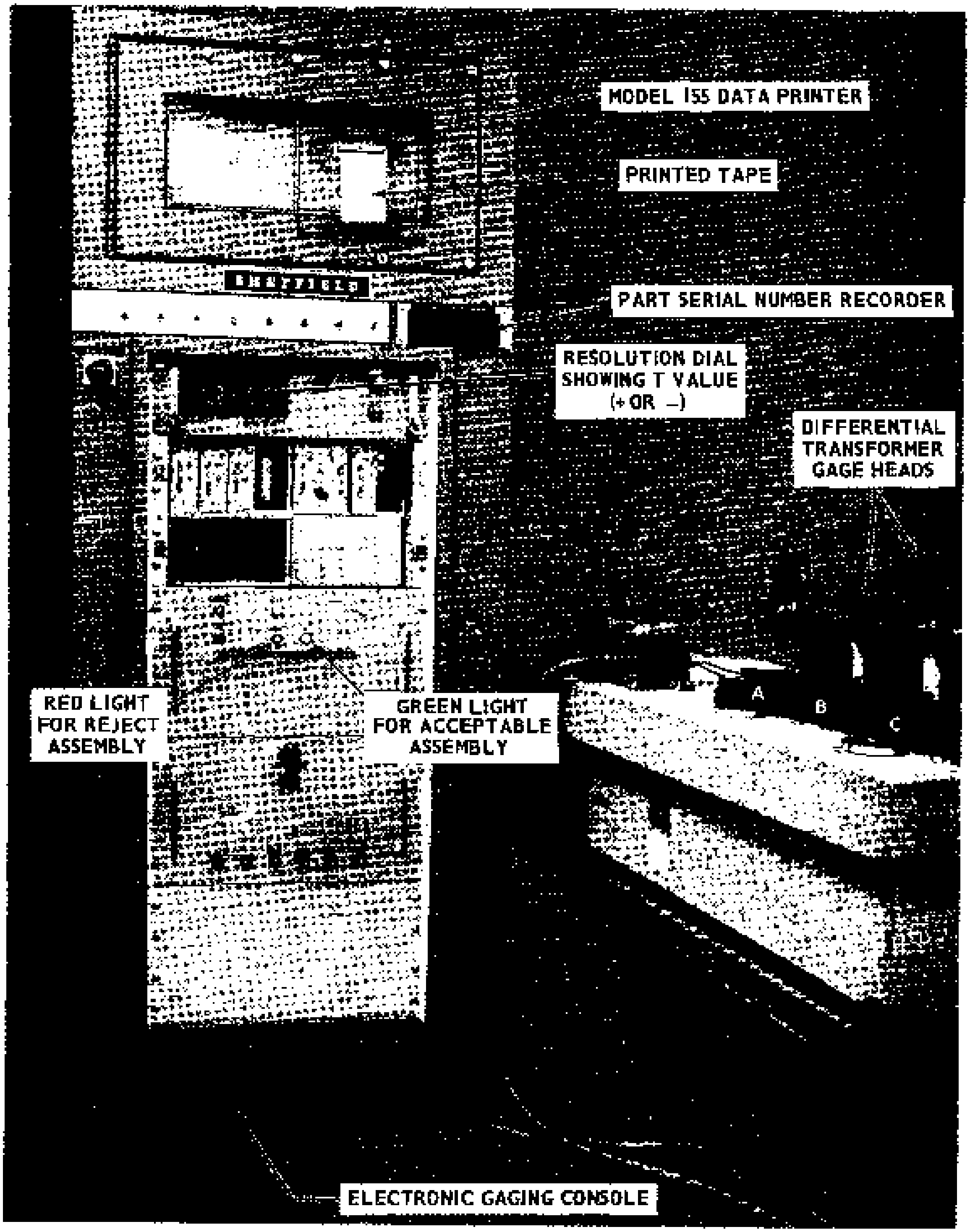

FIGURE 1 - Electronic gage console and fixture.

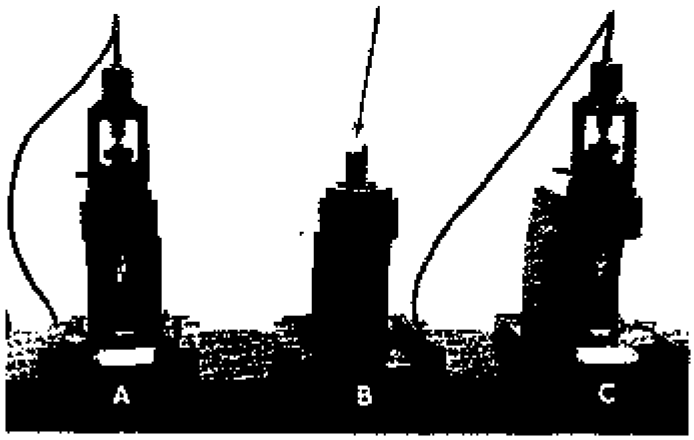

FIGURE 2 - Gage fixture showing three differential transformer gage heads (A, B, and C) used in conjunction with electronic gage console.

of data. A manual key punch operation is also eliminated. The IBM cards are processed, and a computer program is used to analyze the data statistically. The Model 155 data printer at the gage provides operating personnel with current information on the operation of the crimping process.

The designations A, B, and C located on the gage fixture shown in Figure 2 are differential transformer gage heads and refer also to the components of the part. Although the computer module of the gage was originally developed to algebraically add the measured sizes of a three piece component to obtain its theoretical height, a two piece component uses only designations A (plastic cylinder) and C (metal cup). The designation B refers to the third part of a three piece component, e.g., sleeve. After assembly, the actual or final height of the part (cylinder and cup) is measured and compared to the theoretical height. The individual assembled part is accepted if there is agreement between actual and theoretical size within an allowable preset limit.

Acceptance of the lot is on a statistical basis. The E dimension is the algebraic sum of the stacked components (A+B+C) of the part; the T dimension is the difference between the theoretical and actual height of the stacked components. A negative T value reveals that a compression exists between component A (cylinder) and component C (cup), and the assembly is acceptable as indicated by a green light on the electronic computing gage. Conversely, a positive T value reveals that a gap exists between the stacked components, and the assembly is rejected as indicated by a red light on the electronic computing gage.

GAGE SPECIFICATIONS

A block diagram of the gaging system is shown in Figure 3. The primary considerations that were used for the gage specifications are listed as follows:

1. Three differential transformer gage heads having a maximum gaging range of 0.010 in. (0.254 mm) were used to measure the three components of a part in sequence. Although two-piece parts were assembled, gage head dimension B was added into the final assembly dimension.

2. The gaging amplifiers that were used are capable of responding to incremental changes as small as 0.000010 in. (0.000254 mm) over the entire gaging range.

3. An additive voltage network algebraically added the output of the gaging amplifiers.

4. A differential voltage comparative network permitted the operator to dial in the allowable assembly tolerance.

5. A reject network with operating tolerance lights provided a visual indication of part classification.

6. An analog-to-digital converter operated a tape printer.

7. The necessary electronic interface for an IBM Model 024 card punch was used.

8. A five-digit thumb wheel, number switch was provided for use by the operator to record (by means of a dial) the part serial number.

GAGE OPERATION

The operator places Part A in Fixture A, Part B in Fixture B, and Part C in Fixture C, and then records (by means of a dial) the part serial number (five digits, such as 10768). The cycle start button sets the gage and the printer in operation: the part serial number is printed out; the printer "indexes" (distinguishes the part serial number from the dimensional data); Part A deviation is read and printed; Part B deviation is read and printed; and Part C deviation is read and printed.

Part deviations will be displayed visually (digital display showing + or -) and then stored in a memory band (4-hr maximum storage time); Part A is then removed from Fixture A.

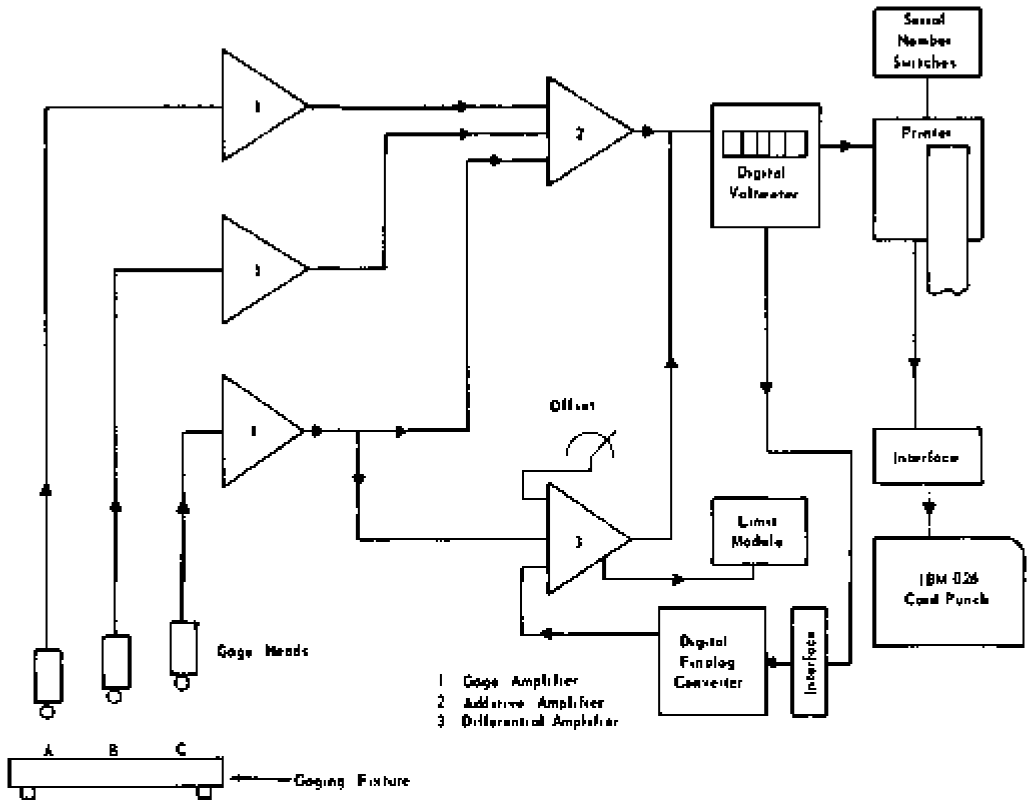

FIGURE 3 - Block diagram of electronic computing gage system.

Parts A, B, and C are then assembled and designated as Part ABC; Part ABC is placed in Fixture C (same fixture used for Part C but with the mean masters for Parts A and B); the stored deviation signals of Parts A, B, and C are then added algebraically to obtain dimension E and compared to the measured deviation of Part ABC. If the deviation of Part ABC exceeds that of the algebraic sum of Parts A, B, and C, the part is rejected. If the deviation of Part ABC is equal to or less than the algebraic sum of Parts A, B, and C, the part is accepted.

The deviation signal of Part ABC is printed on the digital printer and also fed into the necessary interface to operate the IBM card punch. The IBM card punch only records the deviation of Part ABC.

When the system is used to check the deviation of a two-piece part, A and C or assembled Part AC, channel B should be turned off, thereby showing a deviation of 0. Final checking of the assembly is done with gage head B for all cases (Part AC and Part ABC).

Figure 4 is a reproduction of a typical printed tape of the gaging results with an explanation of the symbols. The tape is read from bottom to top. The tape printout format shown in Figure 4 applies to a two-piece assembly.

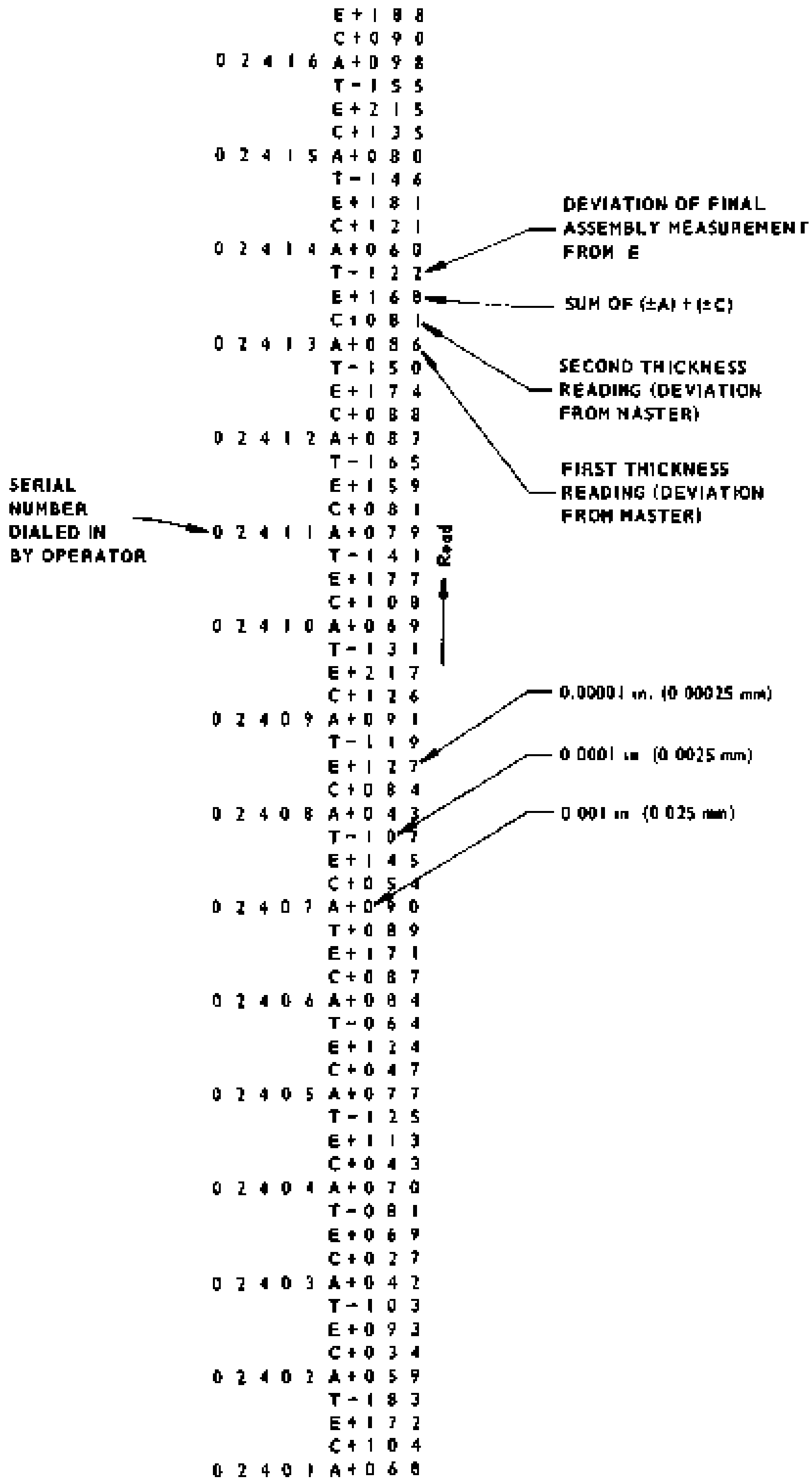

FIGURE 4 - Typical printed tape of the gaging results for a two-piece assembly as printed by the Model 155 data printer.

Figure 5 shows a typical punched IBM card (which is included on the tape printout format) for a two-piece assembly using an IBM Model 024 card punch.

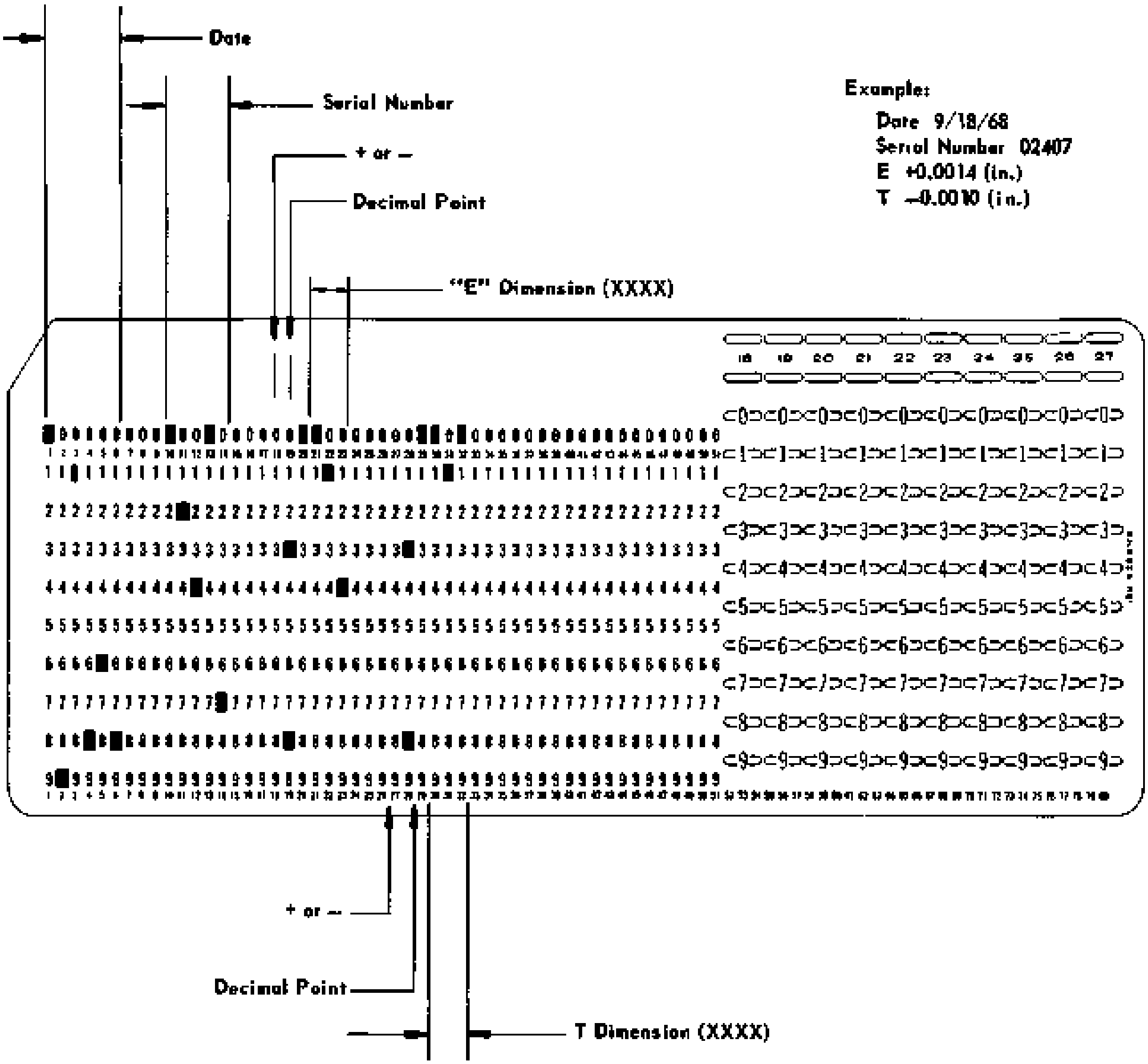

FIGURE 5 - Typical punched IBM card format for a two-piece assembly.

COMPUTER PROGRAM

Using the IBM cards punched by the electronic computing gage, the IBM Model 360 computer is programmed to calculate the average height ($\bar{X}$) and the standard deviation of the height. In addition, a frequency diagram (Figure 6) and control charts (Figure 7) can be plotted by the computer from these data.

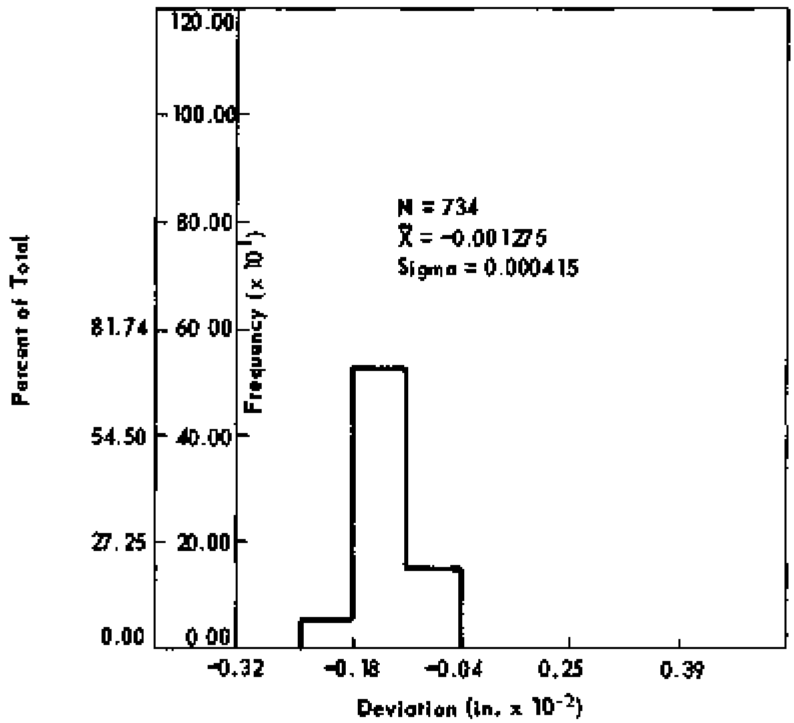

FIGURE 6 - Frequency diagram plotted by IBM Model 360 computer.

CONCLUSION

The application of an electronic gaging computing and recording system for monitoring assembly operations was successful in that it eliminated (1) manual calculations at the production site, (2) manual recording of data and (3) key punching. Consequently the reliability of the assembly process was increased at a decrease in cost.

Future systems for similar applications will incorporate a memory storage so that assemblies will be able to pass through the system in parallel as well as in series.

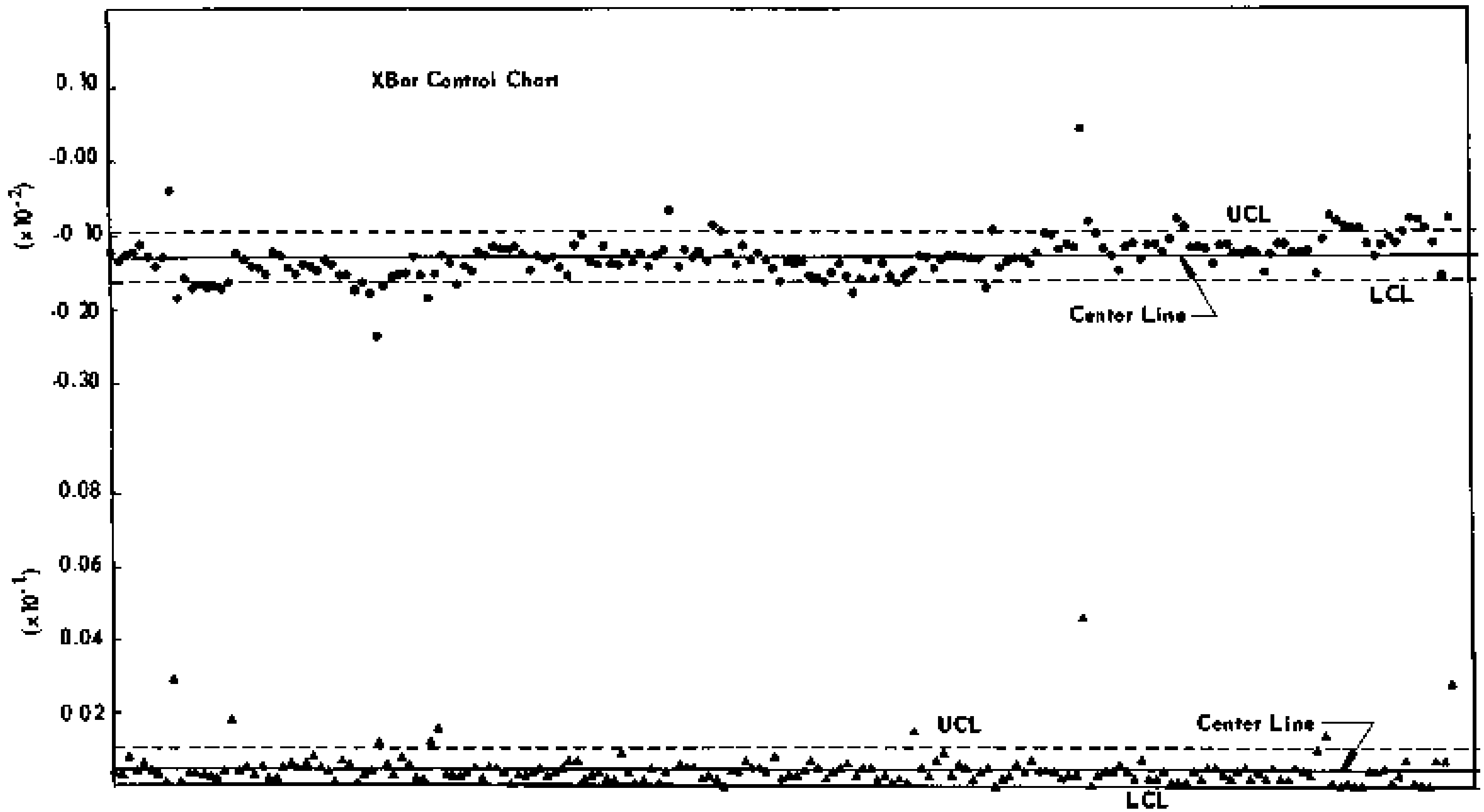

FIGURE 7 - Control charts can be plotted by computer from data produced by the gaging system.