Significant breakout detection and projection from a neutral corridor during time series analysis
by Weidong Weng

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Industrial & Management Engineering
Montana State University

Abstract:
The neutral corridor is an important pattern formed within a time series. By studying neutral corridors, we can obtain two pieces of valuable information for decision making by engineering managers. One is when the time series has broken out of the neutral corridor, the other is to determine how far the time series will move upward or downward after it breaks out.

A pattern comparison method has been developed for breakout signal detection. The neutral corridor can be regarded as a group of observations with a similar pattern. Once the pattern is violated, the neutral corridor will not last, and the time series breaks out of the corridor. By using ModelWare software, a similarity value was computed to quantitatively measure the similarity between new observation and the original data called Reference Data. This similarity value was then compared with a predetermined threshold value. If the similarity value exceeded the threshold value, a breakout signal was detected. A total of 20 neutral corridors were detected for the breakout signal and correct and timely signals were obtained for all of them.

To project the movement out of the neutral corridor, the author has derived a mathematical model that reveals the cause-and-effect relationship between the projection and its previous consolidation. A neutral corridor can be viewed as an energy building zone. Once the time series breaks out, the energy will be transferred and drive the time series to move. Further research concerning this mechanism needs to be conducted. However, the model was validated by 26 neutral corridors formed by historical market security data. It was observed that 23 out of the 26 obtained less than 7% percent error for the projection.

SIGNIFICANT BREAKOUT DETECTION AND PROJECTION FROM A NEUTRAL CORRIDOR DURING TIME SERIES ANALYSIS

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APPROVAL

of a thesis submitted by

Weidong Weng

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The neutral corridor is an important pattern formed within a time series. By studying neutral corridors, we can obtain two pieces of valuable information for decision making by engineering managers. One is when the time series has broken out of the neutral corridor, the other is to determine how far the time series will move upward or downward after it breaks out.

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CHAPTER 1

INTRODUCTION

In recent years, it has become increasingly clear that pattern analysis has gained a lot of power in the time series forecasting area. A neutral corridor is a pattern representing a range wherein supply and demand are at a standoff. The study of neutral corridors in this paper results in two pieces of valuable information.

1. Detection of significant breakout signals out of the neutral corridor. This will answer the question when and in which direction the time series will move out of the consolidation area and that nontrivial movement will ensue.
2. Projection of movements. This will answer how far the time series will move resulting from the previous neutral corridor.

Neutral Corridor

Although different methods are used to defined a neutral corridor, only two horizontal lines are needed to construct a neutral corridor. The top line is called "upper boundary" or "resistance line", and the bottom one is called "lower boundary" or "support line".

To draw these two horizontal lines, two points are needed to be identified, which are called "valid top" and "valid bottom" respectively. These two points are usually determined in the earlier period of a consolation. They represent the highest and lowest value that the time series has reached. See Figure 1 on the following page for a neutral corridor in which A stands for the "valid top" and B represents the "valid bottom".

A neutral corridor can last for one week, several months, or several years. Relatively long consolidations will eventually result in spectacular breakouts and create pleasant opportunities. Only neutral corridors of at least 50 points were of interest.

Breakout versus Shakeout

Breakout means that the time series moves out of either boundary of the neutral corridor significantly, and it will sustain this movement later on. This movement will keep going, until at least, it is away from the broken boundary at a distance of more than the width of the neutral corridor. Sometimes it may turn back toward the boundary instantly, but very soon, it will take off again without oscillating within the neutral corridor.

Shakeout means that the time series moves out of the neutral corridor insignificantly, and will turn back to the neutral corridor before it is away from the broken boundary at a distance of the width of the neutral corridor, and continue to oscillate within the neutral corridor. Figure 1 also shows this kind of shakeout.

Energy Accumulation and Transfer

When time series oscillate within neutral corridors, battles are being waged between sellers and purchasers, as for example, producers and consumers. The buyers move the prices to the upper boundary of a neutral corridor but fail to keep the rally going. The sellers then

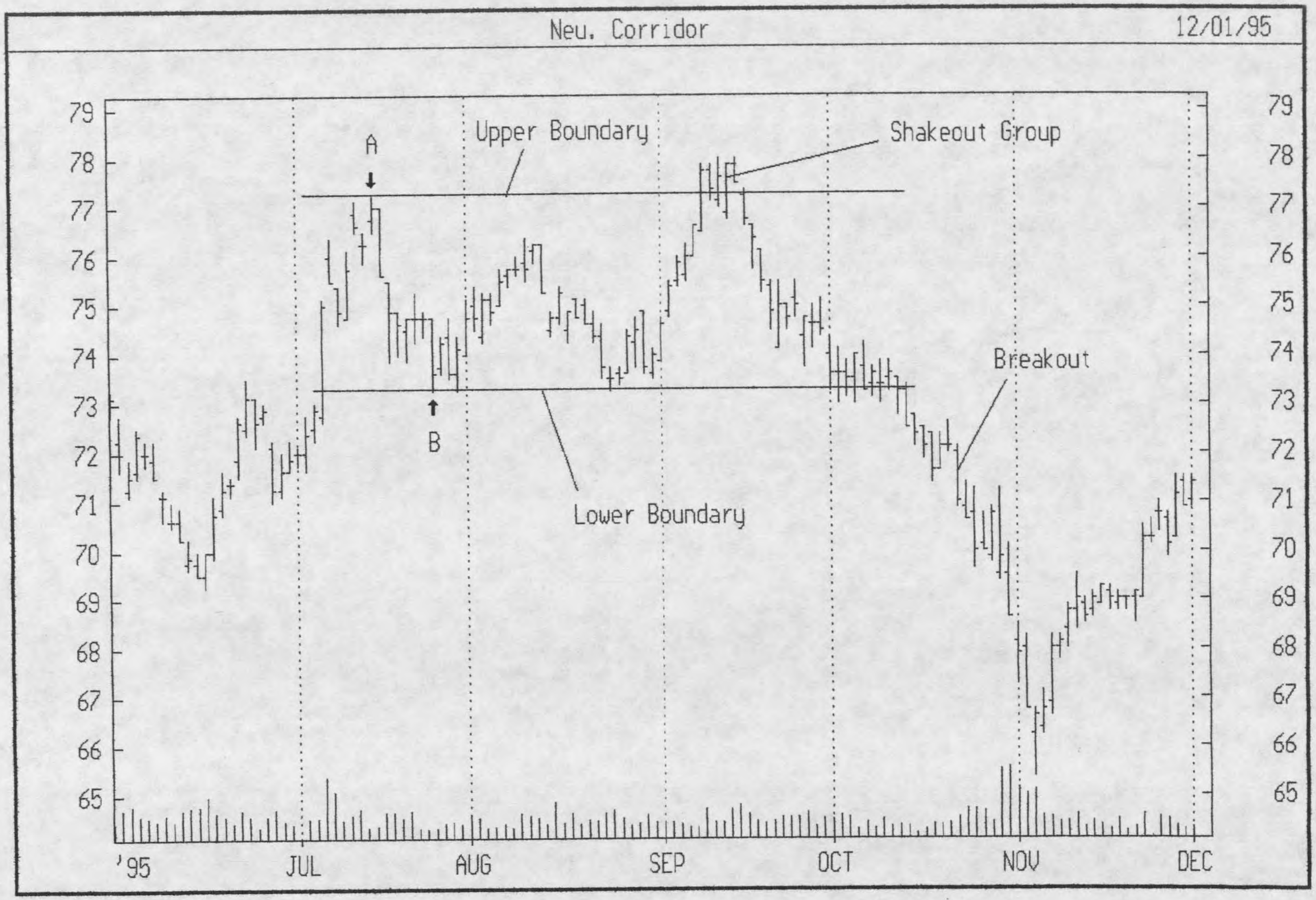

Figure 1. An Example of a Neutral Corridor

take over and move prices back down to the lower boundary of the neutral corridor. This phenomenon is analogous to twisting a spring. The more twisting, the more energy will be accumulated. Finally, one group or the other dominates and succeeds in moving the series out of the neutral corridor. The energy therefore starts to dissipate. The series is driven to move upwards or downwards until the energy is totally exhausted. At the same time, the time series has reached a new top or bottom. Price moves are usually proportional to their preceding consolidation area. There is a cause-and-effect relationship existing, which will be discussed further in Chapter 4.

Pattern and Pattern Violation

Twins resemble each other, since they have similar patterns in appearance, which is exhibited by the eyes, nose, face, and so on. It is not only for these organs to be resembled, but also they should combine in the similar way.

This is exactly what happens in the neutral corridor. Instead of the eyes, nose, and face, some specific variables were chosen to reflect the pattern of a neutral corridor. The data of these variables within a neutral corridor were stored as a reference library. When new data became available, they were compared to the reference data regarding the pattern. The *similarity* value will be computed which gives the information about how similar the pattern of the current observation is compared to the original pattern.

If the similarity is less than a predetermined threshold value, the original pattern has been violated, the time series has broken out of the neutral corridor. Otherwise there is no pattern violation, and the neutral corridor will continue.

Data for Analysis

The author tried to find neutral corridors formed by engineering data through various ways such as searching in the library and the Internet. Unfortunately, this effort was finally given up because of the extreme difficulties to access the data sources. Even some production data were available, but they failed to form neutral corridors due to their short time periods. In view of this, data from market securities were used for analysis [9]. Using data from market securities has some other advantages:

1. Many neutral corridors can be identified.
2. Accurate, timely, and readily available.
3. Ease of verification.
4. Possibility to utilize some commercial software for data analysis.

CHAPTER 2

LITERATURE REVIEW

A neutral corridor was first named by Schillings [7] for a pattern that represents supply and demand at a standoff.

Some other analysts call it *consolation area* [1] or *rectangles* [5]. "Every price trend, takes a breather from time to time. It is a period of indecision when the pressure of buyers and sellers balance each other out" [2]. A neutral corridor itself doesn't provide an opportunity for the decision making. "Once it comes out of the consolidation, an opportunity does exist, since a direction has been indicated". Unfortunately, "there is no way to know how long the trading range is going to last."

Currently, the author has not found that any quantitative analysis has been done in detecting significant breakout signals from a neutral corridor. However, Pring [5] found some heuristic rules were used by some forecasters.

The same situation is found for the Breakout Projection. The energy building in a neutral corridor has been observed by forecaster Arms. "Price move is usually proportional to their preceding consolidation area" [1]. However, not any mathematical model has been developed to reveal the cause-and-effect relationship between the neutral corridor and its following breakout movement.

The author was then encouraged by Dr. Schillings to do some basic research on both of the breakout detection and projection using quantitative techniques; hence, this thesis.

CHAPTER 3

TOOLS FOR ANALYSIS

ModelWare

Background

ModelWare is a generic modeling tool developed by Teranet IA Incorporated, Vancouver, BC, Canada, which can be applied for signal processing, prediction, decision/control and diagnostic/classification problems [5]. At the heart of modelware is Teranet's Universal Process Modeling (UPM) algorithm.

How ModelWare works

Figure 2 shows the mechanism of how ModelWare works. First, variables to be used to model the system are selected. Then data are collected for these variables from the system and a Reference Library is built. This Reference Library can be thought of as the "captured knowledge" of how the system or process behaves under known conditions. ModelWare requires no equations to describe how variables of the system relate to one another. The system data itself contains all the information about how the system works.

Once the Reference Library has been built, ModelWare is ready to predict system behavior for new input data known as Observed Data. Modelware makes a prediction for all variables for each observation in turn. The prediction then is compared to the observation.

If the observation deviates from the prediction, the system is no longer operating within its range of historical performance.

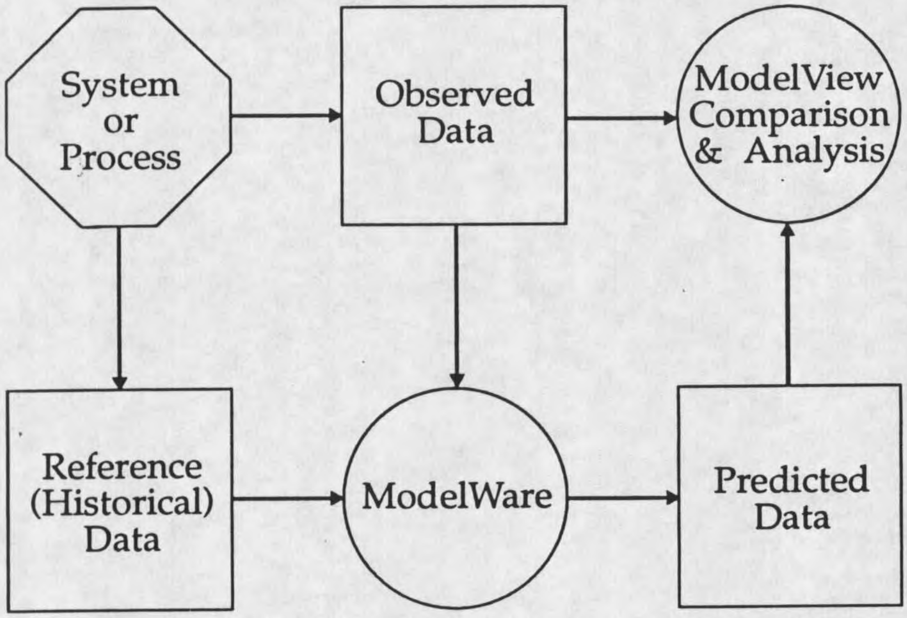

Figure 2. How ModelWare Works

The UPM Algorithm

The UPM algorithm consists of six basic steps:

1. Get the next observation to model from the input file and compute the similarity between this observation and all the examples in the Reference Library file. The measure of similarity is a single number between 0.0 and 1.0 which indicates how mathematically similar one set of numbers are with another. A value of 1.0 means that the two sets of data numbers are identical.

2. Pull out from the Reference Library those examples that are most similar to the input observation. The minimum and maximum number of examples pulled out can be set by the user.

3. Compute a single weighting coefficient for each example pulled out from the Reference Library. This coefficient is a measure of the contribution the example makes to the final prediction.

4. Compute the predicted value for each data variable in turn, by summing, in turn, all the products for a particular variable's value in each of the most similar Reference Library examples with the corresponding coefficient associated with each most similar example. Figure 3 shows an example of this procedure.

	Ref. Image 1	Ref. Image 2	Ref. Image 3
Element 1	3.0	6.5	4.0
Element 2	2.5	1.9	2.7
Element 3	4.0	4.8	5.6
Element 4	1.6	2.1	2.6
Element 5	7.1	9.0	9.9

●

0.6	Coefficient of Ref. Image 1
0.3	Coefficient of Ref. Image 2
0.1	Coefficient of Ref. Image 3

Prediction for element 1 = (3.0 x 0.6) + (6.5 x 0.3) + (4.0 x 0.1) = 21.50
Prediction for element 2 = (2.5 x 0.6) + (1.9 x 0.3) +(2.7 x 0.1) = 7.47
Prediction for element 3 = (4.0 x 0.6) + (4.8 x 0.3) + (5.6 x 0.1) = 17.36
Prediction for element 4 = (1.6 x 0.6) + (2.1 x 0.3) + (2.6 x 0.1) = 16.16
Prediction for element 5 = (7.1 x 0.6) + (9.0 x 0.3) + (9.9 x 0.1) = 32.25

Figure 3. Calculation of Predicted Value

5. Validate the prediction by computing the similarity of the prediction with the input observation.

6. Repeat steps 1 through 5 until all input observations have been modeled.

Several Important Terms

Eight important terms are used in the paper.

1. System

   System refers to any object, or collecton of objects, that can be represented by sets of numbers. Industrial processes naturally fall into this category because the parameters that control the process are usually monitored by physical sensors that provide numerical outputs as a function of time. As a less obvious example, a diverse group of financial indicators could also be taken as a system. Notice that this definition of a system does not imply that there is any causal or dependent relationships among any of the measured parameters.

2. Element (variable)

   Element refers to a measured parameter within the system.

3. Image

   Image refers to a set of element measurements taken at a single moment in time. Given simultaneous values for all elements, it is possible to completely specify the state of a system at that moment. System behavior over time can then be represented as a time-stamped series of images.

4. Reference Library

Reference library refers to a collection of images that describes the system as it operates under known and proper conditions. This library will typically consists of ten to hundreds of images completely encompassing all of the extreme values of the system's operation in each element. Any subsequent images taken of the system in operation should be similar to one or more images in the reference library, providing the system is still operating normally, or at least in a previously observed fashion.

5. Model

A mathematical formula created by ModelWare for each image of the observed data file. Each formula produces a predicted, or modeled, data image. Running a model file produces the formula and the modeled data. The formula is derived by analyzing the reference data of the system being modeled. This formula is not available to the ModelWare user.

6. Model file

A file that contains information necessary to create a model. After a model file is run, it also contains the modeled, or predicted, data created by the model.

7. Modeling

Modeling means the action of synthetically generating values for the elements in a "predicted image", based on some combination of an observed image and the reference library. This definition does not necessarily require any understanding of the system itself and there are no equations that represent the nature of the system mathematically.

8. ID file

The identity file is used to create a model. This file contains information about the data elements. ID file can be edited to determine whether or not an element will be used for modeling. For example, Element 1 can be in the Reference Data, but it can be changed to “passive” by editing the ID file, and Element 1 will then not be used to make a model.

Application

ModelWare was used to detect significant breakout signals. First, the similarity value of a new image was computed with respect to the reference data. Then, this similarity value was compared to the threshold value. If the threshold value was exceeded, a breakout signal was detected.

Shewhart's Control Charts

Background

Shewhart's control charts were first developed by Walter Shewhat in 1931 for process quality control [3]. As a Bell Labs statistician, Shewhart established from the very beginning the overarching philosophy that drives the control chart concept.

There are two process characteristics that are of general interest in the statistical process control scenario, the mean level of the process and the amount of variation in the process.

Construction of Control Charts

The following simple steps define the procedures necessary to set up X-bar and R control charts.

1. Calculation of sample means:

$$\bar{X}_i = \sum_{j=1}^{n} X_{ij}/n \ ,$$

where X_{ij} is the jth measurement, j = 1, ..., n, in the ith sample and where n = sample size.

2. Calculation of the spread or dispersion within the ith sample R_i:

$$R_i = X_{largest} - X_{smallest} \ .$$

Because of its simplicity and ease of calculation, the range, R_i, is commonly employed as a measure of within-sample variability.

3. Calculation of the grand sample average which is the arithmetic average of all the available sample averages. This grand sample average is an estimate of the process mean μ_x and becomes the centerline of the control chart:

$$\bar{\bar{X}} = \frac{\sum_{i=1}^{k} X_i}{k} ,$$

where k is the number of samples being used to set up the control chart.

4. Calculation of the average of the sample ranges:

$$\bar{R} = \frac{\sum_{i=1}^{k} R_i}{k} .$$

5. The range of samples of size n is related to the standard deviation of the population by the formula:

$$\frac{E(R)}{\sigma_x} = d_2 ,$$

where d_2 is a function of the sample size under an assumed normal distribution of X's. Values of d_2 for varying sizes of n are conveniently found in most of the statistical quality control books [3].

6. Control limits for X-bar chart.

The limits are in the form:

grand average ± 3 sigma of sample average.

According to the Central Limit Theorem for large value of n: if $X_1, X_2, \ldots, X_n$ are outcomes of a random variable X with mean μ_x and variance σ_x^2, the mean of X's is distributed approximately with normal distribution of mean μ_x and variance σ_x^2/n [4]. The standard error of the mean is:

$$\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{n}} \ .$$

Then, by substituting $E(R)/d_2$ for σ_x, and R-bar for E(R), the formulas for the upper and lower limits of the control chart are

$$UCL = \bar{\bar{X}} + \frac{3\bar{R}}{d_2\sqrt{n}} \ ,$$

and

$$LCL = \bar{\bar{X}} - \frac{3\bar{R}}{d_2\sqrt{n}} \ .$$

7. The distribution for R is not easily determined and is not symmetric about its mean value. However, in the interest of simplicity and ease in establishing the R chart, symmetrical $\pm$ 3-σ_R limits have been adopted, if the lower limit is less than 0, a lower limit of 0 is used. Statistical theory has established the relationship between the standard deviation of the range and the standard deviation of the quality characteristic X:

$$\sigma_R = d_3\sigma_X \ ,$$

where d_3 is a known function of n, the subgroup size. Again, substituting for σ_x and E(R) yields

$$\sigma_R = \frac{d_3\bar{R}}{d_2} \ .$$

Therefore, 3-sigma control chart limits for the ranges are given by

$$\bar{R} \pm 3\left(\frac{d_3}{d_2}\right)\bar{R}\ .$$

These control limits can be further simplied to the forms

$$UCL = D_4\bar{R}\ ,$$

and

$$LCL = D_3\bar{R}\ ,$$

where D_4 and D_3 are functions of n. Values for D_4 and D_3 are tabulated for use [3].

Zones in the Control Chart

By dividing the distance between the upper and lower control limits on the X-bar chart, three zones defined by 1-, 2-, and 3-sigma boundaries were obtained. See Figure 4.

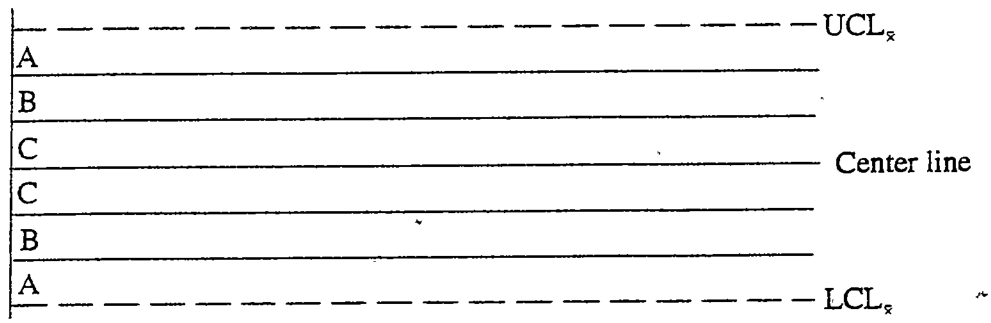

Figure 4. Control Chart Zones

Oscillations within these three zones will make different contributions to the projection. See Chapter 5, pages 30-47 for more detail.

Application

Shewhart's control chart methodology was applied for the projection of the breakout of a neutral corridor. Observations within a neutral corridor were viewed as coming from a process. For the market security data, within every trading day, four price values, Open, High, Low, and Close, were generated. These four values formed a subgroup. The parameters characterizing a control chart such as process mean, process sigma, and mean range were computed from these subgroup data. A mathematical model was built involving these parameters.

Software

Statgraphics is a PC software package integrating a wide variety of statistical functions [8]. It is intended for use in a broad range of industrial, service, and educational applications by data analysts familiar with the concepts underlying the procedures. Here, it was used for data analysis and control-chart setup.

Compression

Neutral Corridors studied in this paper consisted of at least 50-observation samples. To facilitate data analysis, a compression technique was applied. The compression function in MetaStock was used. A stock-trading day comprises one period. For example, nine-period compression means to compress nine-period data to one-period data. The result of nine-period compression is illustrated in Table 1. Refer to Figure 5 on Page 23 for Neutral Corridor 2. Refer to Figure 6 on Page 33 for nine-period compressed Neutral Corridor 2.

Table 1. Results of 9-period Compression

New Open	The Open of the first period
New High	The higest High during the nine periods
New Low	The lowest Low during the nine periods
New Close	The Close of the last period

CHAPTER 4

BREAKOUT DETECTION

A neutral corridor is formed by a group of observations having similar pattern. Once this pattern is violated, the neutral corridor terminates, and a significant breakout has taken place.

ModelWare software was used to formulate a measurement of the magnitude of pattern violation. A threshold value was set to determine a significant signal.

Rules Setup

Rules established by the author are as follows:

Element (Variable)

Based on knowledge of the market securities, seven elements were chosen to characterize the neutral corridor, These are:

1. Open = opening price of a trading day
2. High = highest price of a trading day
3. Low = lowest price of a trading day
4. Midpoint (MP) = (1/2) (High + Low)
5. Close = closing price of a trading day
6. Volume = number of traded shares in a trading day

7. Range × Volume (R × V) = (High - Low) × Volume

Open, High, Low, and Close are four direct price observations from the Market. The fluctuation of these observations tells "What is happening" [1], and, they are the crucial factors to determine the investor's action.

Price change can bring about elation or depression, but volume usually elicits only a yawn. However, volume is a very valuable piece of information. It tells "How it is happening" [1]. The author believes volume is one of the driving forces for price change. Observing the market, it has been found that usually volume decreases when the security is following the neutral corridor, and when the security breaks out of the neutral corridor in either direction, the volume jumps up. This phenomenon is very useful for the pattern violation detection.

As the consolidation progresses, the buyers and sellers get closer to one another since both of them become exhausted trying to force the stock in their direction. This results in a convergence of the range. Once the limits of the consolidation are violated, range increases with volume.

Data

Data for analysis consists of two categories:

1. Reference data: data from the beginning of the neutral corridor to one period before the current period with shakeout data removed.
2. Observed data: data from the last period to the current period.

Similarity Threshold Value

For convenience, similarity is denoted by capital "S". If $S < 0.73$, pattern violation is detected and the series has broken out of the corridor. If $S >= 0.73$, pattern violation has not been detected, and the series has not broken out of the neutral corridor. This threshold value was determined by the author 's experiments. It provides an empirical confidence level and can be revised based on the user's experience and confidence-level requirement.

Procedures

Historical Data forming Neutral Corridor 2 were used to illustrate the procedure. Both shakeout and breakout were presented. See Figure 5 for Neutral Corridor 2.

1. Import data files.

Import both reference and observed data files, which are in Lotus 1-2-3 format, into ModelWare and convert to ModelWare's binary file format. Table 2 shows the reference data (7/10/95 to 9/8/95). Table 3 shows the Observed Data for each modeling (9/11/95 to 9/15/95). Each time, only the current image with the last image of the reference data were used as observed data. The reason for using the last image of the reference data was to make the observation continuous.

2. Create an ID file.

The ID file specifies how each element was used in creating the model.

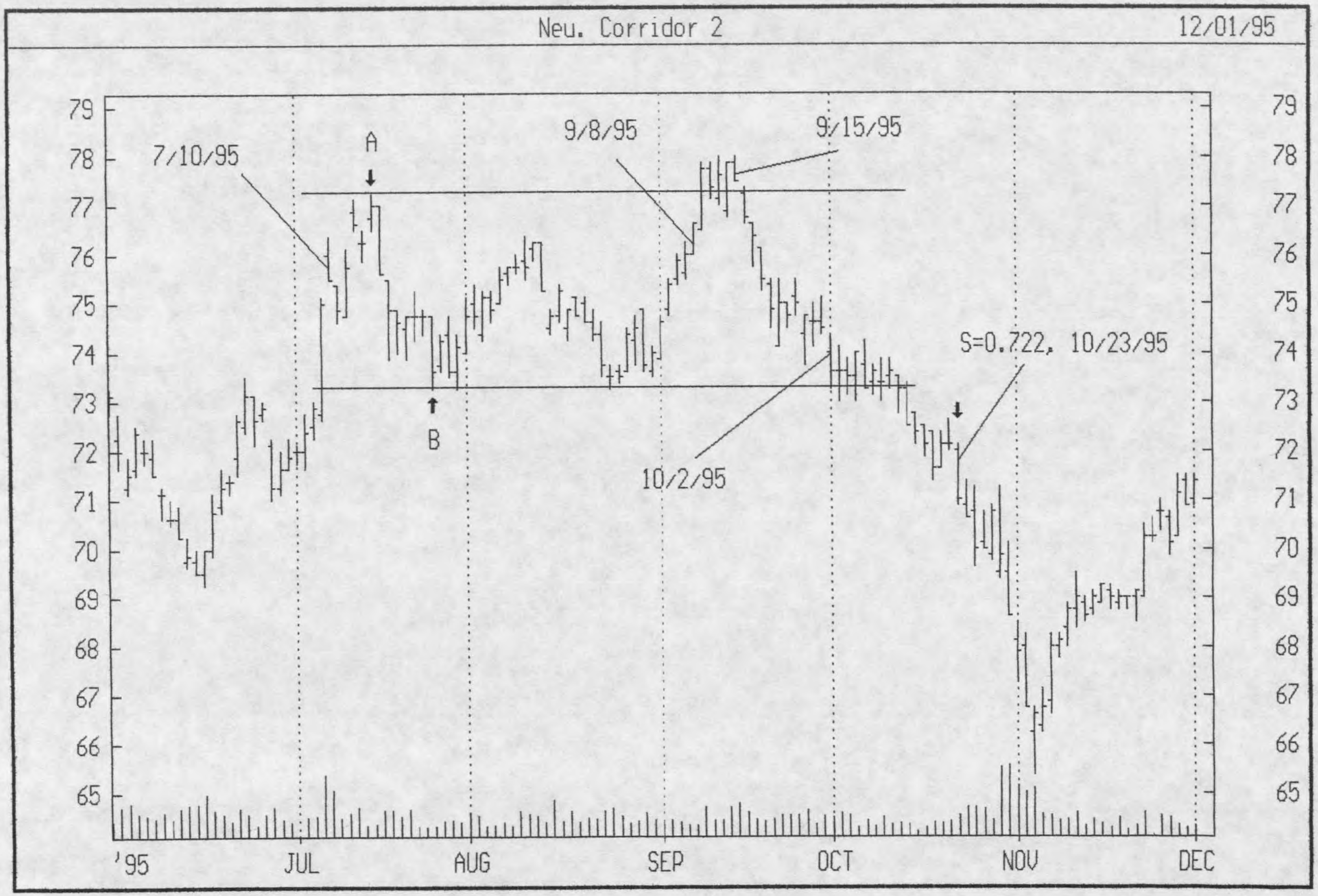

Figure 5. Breakout Detection for Neutral Corridor 2

Table 2. Reference Data for Neutral Corridor 2 Breakout Detection

Date	Open	High	Low	MP	Close	Volume	R×V
07/10/95	76.000	76.375	75.500	75.9375	75.500	17428	15249.5
07/11/95	75.375	75.375	74.625	75	74.875	7473	5604.75
07/12/95	74.750	76.125	74.750	75.4375	75.750	9332	12831.5
07/13/95	76.875	77.125	76.500	76.8125	76.625	11510	7193.75
07/14/95	76.250	76.500	75.875	76.1875	76.250	5005	3128.125
07/17/95	76.750	77.250	76.500	76.875	77.000	5329	3996.75
07/18/95	77.000	77.000	75.625	76.3125	75.625	10538	14489.75
07/19/95	75.500	75.500	73.875	74.6875	74.875	10373	16856.13
07/20/95	74.875	74.875	74.000	74.4375	74.625	8045	7039.375
07/21/95	74.500	74.750	73.875	74.3125	74.750	10576	9254
07/24/95	74.750	75.250	74.250	74.75	74.750	4666	4666
07/25/95	74.750	74.875	74.375	74.625	74.750	4319	2159.5
07/26/95	74.750	74.750	73.250	74	73.625	4626	6939
07/27/95	73.750	74.375	73.625	74	74.250	6407	4805.25
07/28/95	74.375	74.750	73.500	74.125	73.625	6856	8570
07/31/95	73.625	74.375	73.250	73.8125	74.125	5883	6618.375
08/01/95	74.000	75.125	74.000	74.5625	74.750	9764	10984.5
08/02/95	75.000	75.375	74.500	74.9375	74.750	8033	7028.875
08/03/95	74.375	75.250	74.250	74.75	75.125	4753	4753
08/04/95	75.125	75.250	74.625	74.9375	74.875	5121	3200.625
08/07/95	75.000	75.750	75.000	75.375	75.500	6061	4545.75
08/08/95	75.625	75.750	75.375	75.5625	75.750	4603	1726.125
08/09/95	75.750	76.000	75.625	75.8125	75.750	9845	3691.875
08/10/95	75.875	76.375	75.500	75.9375	75.750	8963	7842.625
08/11/95	76.125	76.250	75.875	76.0625	76.250	8306	3114.75
08/14/95	76.250	76.250	75.250	75.75	75.250	6094	6094
08/15/95	74.500	74.875	74.375	74.625	74.750	13872	6936
08/16/95	74.750	75.375	74.625	75	75.250	6429	4821.75
08/17/95	74.500	74.875	74.250	74.5625	74.875	10149	6343.125
08/18/95	75.125	75.125	74.750	74.9375	74.750	6070	2276.25
08/21/95	75.000	75.125	74.625	74.875	74.625	7453	3726.5
08/22/95	74.625	74.875	74.250	74.5625	74.375	7178	4486.25
08/23/95	74.375	74.625	73.500	74.0625	73.750	9953	11197.13
08/24/95	73.500	73.750	73.250	73.5	73.500	11146	5573
08/25/95	73.625	73.750	73.375	73.5625	73.500	8209	3078.375
08/28/95	73.625	74.500	73.625	74.0625	74.375	5626	4922.75
08/29/95	74.250	74.750	73.750	74.25	74.500	6503	6503
08/30/95	74.875	74.875	73.625	74.25	73.750	9238	11547.5
08/31/95	73.625	74.125	73.500	73.8125	74.000	6651	4156.875
09/01/95	73.875	74.750	73.875	74.3125	74.625	6011	5259.625
09/05/95	74.875	75.500	74.750	75.125	75.375	6726	5044.5
09/06/95	75.500	76.000	75.375	75.6875	75.875	6012	3757.5
09/07/95	75.625	76.250	75.500	75.875	76.000	5028	3771
09/08/95	76.000	76.625	76.000	76.3125	76.625	4786	2991.25

Table 3. Observed Data (9/11/95 to 9//5/95)

	Date	Open	High	Low	MP	Close	Volume	R×V
Model 1	9/08/95	76	76.625	76	76.313	76.625	4786	2991.25
	9/11/95	76.5	77.875	76.5	77.1875	77.75	11403	15679.13
Model 2	9/08/95	76	76.625	76	76.3125	76.625	4786	2991.25
	9/12/95	77.75	77.875	77.125	77.5	77.375	6882	5161.5
Model 3	9/08/95	76	76.625	76	76.3125	76.625	4786	2991.25
	9/13/95	77.125	77.875	77	77.5	77.625	6588	6588
Model 4	9/08/95	76	76.625	76	76.3125	76.625	4786	2991.25
	9/14/95	76.875	77.875	76.75	77.3125	77.875	11639	13093.88
Model 5	9/08/95	76	76.625	76	76.3125	76.625	4786	2991.25
	9/15/95	77.875	78	77.5	77.75	77.5	12816	6408

3. Create the model file.

Create a model file with ModelWare that corresponds to specific reference data, observed data, and the ID file.

4. Run the model file

ModelWare runs the model file to produce predicted data, also called the "modeled data".

After the model file has finished running, the " Modeling Data" dialog box appears. Table 4 below shows this box. Table 5 shows the contents of the box.

Table 4. The Modeling Data Dialog Box

Model File: corridor2.mdl

Identity File: corridor2.idy

Reference File: corridor2_r.bin

Observed File: corridor2_o.bin

Modeling Image: 2 of 2

Similarity: 0.790 Avg: 0.895

Condition: Normal Select: 5

Output Message: Model Process Finished

From Table 4, S = 0.790 > 0.73. So no significant signal has been detected on 9/11/9. Similar models were established, respectively, for 9/12/95, 9/13/95, 9/14/95, and 9/15/95. The results are shown in Table 6. No significant signals were found during those days. However, these were shakeouts.

As time moved on, it was found that the security turned back to the neutral corridor, and continued to oscillate within the corridor. The shakeout data was considered as noise and was not added to the reference data for future detection.

Identical procedures were performed from 10/3/95 to 10/23/95, and the results are displayed in Table 7.

Table 5. Contents of "Modeling Data" Dialog Box

Model File	The name of the model file being modeled.
Identity File	The name of the identity file.
Reference File	The name of the reference data file.
Observed File	The name of the observed data file.
Modeling Image	The number of the image currently being modeled and the number of images in the observed data file. For example, 2 of 2 means that this is the 2nd image of 2 observed data images.
Similarity	The similarity for the last image modeled.
Avg.	The average similarity for all the images modeled.
Condition	The similarity condition of the last image modeled. The condition can be: * "normal"-the last image modeled had a similarity factor greater than the similarity threshold value. * "abnormal"-the last image modeled had a similarity factor less than the threshold value.
Select	The number of images selected from the reference file to create the last image model.
Output Message	A message concerning the output of the modeling process. The message can be "Model Process Finished" or an error message.

Table 6. Results of Breakout Detection for Neutral Corridor 2 (9/12/95 to 9/15/95)

Date	Similarity	Result
9/12/95	0.804	no breakout
9/13/95	0.8709	no breakout
9/14/95	0.8558	no breakout
9/15/95	0.8115	no breakout

Table 7. Results of Breakout Detection for Neutral Corridor 2 (10/3/95 to 10/23/95)

Date	Similarity	Conclusion
10/3/95	0.932	no breakout
10/5/95	0.919	no breakout
10/10/95	0.949	no breakout
10/12/95	0.927	no breakout
10/13/95	0.861	no breakout
10/16/95	0.789	no breakout
10/17/95	0.795	no breakout
10/18/95	0.782	no breakout
10/19/95	0.775	no breakout
10/20/95	0.809	no breakout
10/23/95	0.722	breakout

On 10/23/95, $S = 0.722 < 0.73$ = threshold value, the market security had gained enough strength to break out of the neutral corridor in the down direction.

This technique was applied to a total of 20 neutral corridors for signal detection, and gave correct and timely breakout signals for all of them. A selection of nine more neutral corridors with their breakout signals is displayed in Appendix A.

Remark

The pattern violation methodology provides a practical tool for breakout signal detection. The similarity threshold value is empirical and can be revised based on the confidence level the user wants to achieve. The higher the threshold value, the lower the confidence and the higer the risk for the user in breakout detection.

CHAPTER 5

BREAKOUT PROJECTION

It would be wonderful to be able to project the vertical amplitude with reasonable accuracy of a time series upon breaking out of a neutral corridor. If it could be predicted when the next top was going to occur, it would be possible to take the maximum advantage of this move and make the greatest profits from it, if profit was the objective.

Price Shift Formulas

In Chapter 1, the author has already discussed energy building in a neutral corridor, and energy dissipating after the time series breaks out of the neutral corridor. There is a direct cause-and-effect relationship between the neutral corridor and its following projection. An empirical mathematical model was developed by the author for this effort. This model shows that the price shift comes from two parts. The first part is the average shift which is proportional to the number of subgroups after compression, and energy built within A, B, and C zones will contribute to the projection by their corresponding frequency that data appears within these zones. The second part is the variability, which is reflected by R-bar. The procedures to derive the formulas are illustrated below.

Magnitude of the breakout price shift is:

$$\Delta = \frac{k}{2}[w_1\sigma + w_2(2\sigma) + w_3(3\sigma)] + \frac{\bar{R}}{2},$$

where,

k: number of subgroups after compression

σ: standard deviation of X-bar, calculated from one subgroup of four observations:

Open, High, Low, and Close

R-bar: mean range

w_1: frequency of sample means appearing within Zone C (Refer to Figure 4)

w_2: frequency of sample means appearing within Zone B

w_3: frequency of sample means appearing within Zone A

Suppose the number of sample means appearing within Zones C, B, and A are denoted as n_1, n_2, and n_3, respectively. Then,

$$w_1 = \frac{n_1}{k},$$

$$w_2 = \frac{n_2}{k},$$

$$w_3 = \frac{n_3}{k}.$$

Substitution into the breakout price shift, yields the price shift formulas:

$$\Delta = \frac{\sigma}{2}(n_1 + 2n_2 + 3n_3) + \frac{\bar{R}}{2}.$$

The potential maximum price of the movement will be:

$$PU = \overline{\overline{X}} + \Delta \ .$$

The potential minimum price of the movement will be:

$$PL = \overline{\overline{X}} - \Delta \ .$$

Procedures

Time Series can break out of either the upside or downside of the corridor. Two scenarios were illustrated using the formulas for the breakout projection.

Scenario 1: Break out of the lower boundary

Historical data forming Neutral Corridor 2 were applied to this technique to show the procedures:

* Identify a neutral corridor. See Figure 5 for Neutral Corridor 2.
* Detect breakout signal out of the neutral corridor using the method in Chapter 3.The breakout direction can also be identified at the same time. For Neutral Corridor 2, the direction was down.
* Use MetaStock Compression function to obtain a compressed neutral corridor. Here, nine-period compression was conducted. Refer to Figure 6 for the compressed neutral corridor. The rule of thumb for using the proper compression scenarios is as follows:

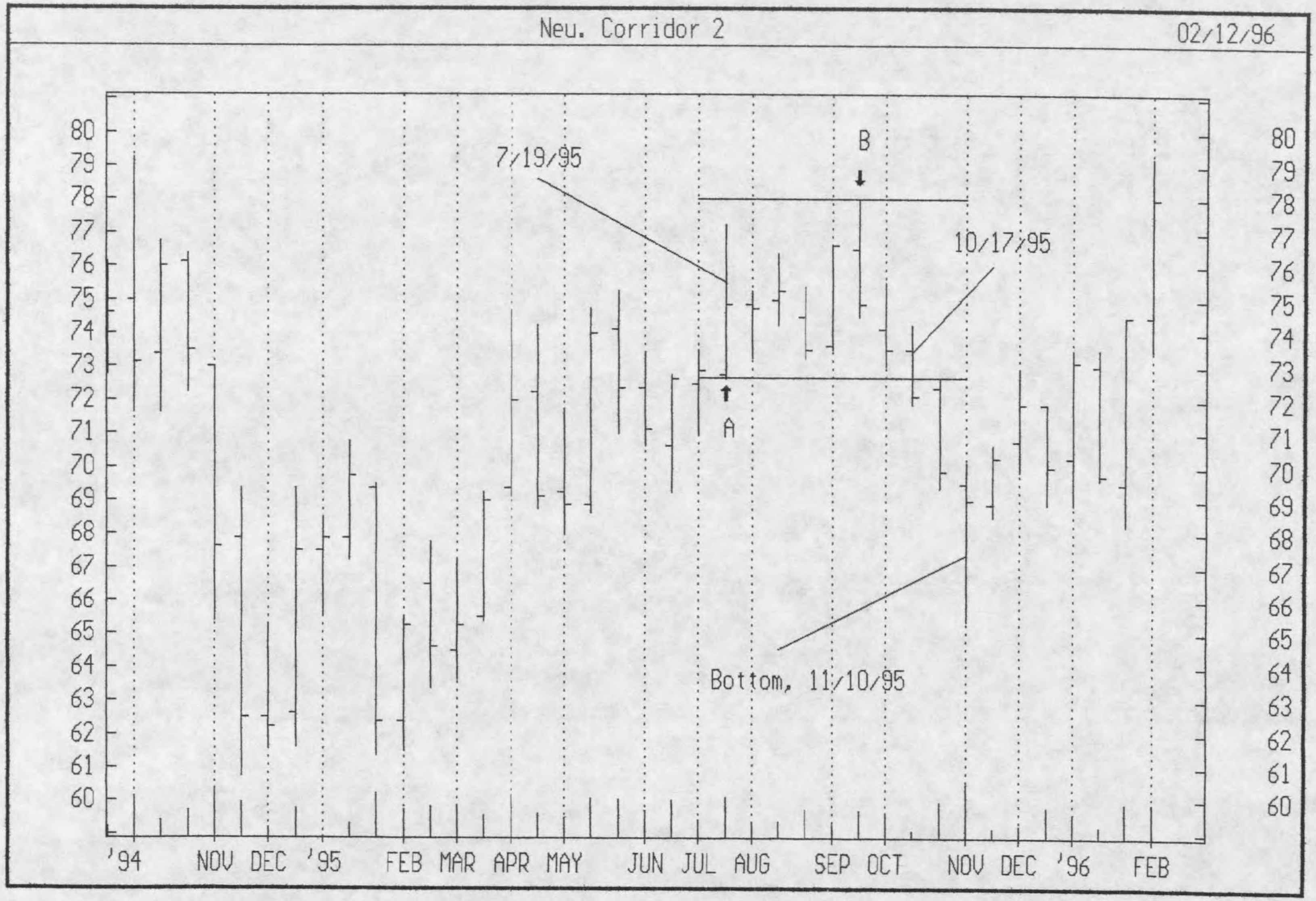

Figure 6. 9-period Compressed Neutral Corridor 2

1. Get as *clean* as possible a neutral corridor, *clean* means the neutral corridor has little shakeout.

2. Pick the number of compressed subgroups to fall within a range of 5 to 12.

* Record the compressed data. See Table 8 for the data, where k = 8 subgroups.

* Import the data to Statgraphics for further analysis, The results are shown in Table 9 and Table 10.

* Count the number of X-bar points appearing in Zones C, B, and A, respectively. If a point happens to be on one of the zone boundaries, this point wiil be counted within the inner zone which the boundary defines. See Figure 7.

Zone C: $n_1 = 4$

Zone B: $n_2 = 2$

Zone A: $n_3 = 2$

Table 8. 9-period Compressed data for Neutral Corridor 2:

Date	Open	High	Low	Close
7/19/95	72.75	77.25	72.625	74.875
8/01/95	74.875	75.25	73.25	74.25
8/14/95	75	76.375	74.25	75.25
8/25/95	74.5	75.375	73.25	73.5
9/8/95	73.625	76.625	73.5	76.625
9/21/95	76.5	78	74.5	74.875
10/4/95	74.125	75.5	73	73.5
10/17/95	73.5	74.25	71.875	72.125

Table 9. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 2

Subgroup	X-bar	Range
1	74.375	4.625
2	74.4063	2
3	75.2188	2.125
4	73.6563	1.25
5	75.0938	3.125
6	75.9688	3.5
7	74.0313	2.5
8	72.9375	2.375

Table 10. Control Charts Set-up for Compressed Neutral Corridor 2

8 subgroup, size 4

process mean = 74.4609

process sigma = 1.30525

mean Range = 2.6875

X-bar		Range	
UCL: + 3.0 sigma	= 76.4188	UCL: + 3.0 sigma	= 6.13335
Centerline	= 74.4609	Centerline	= 2.6875
LCL: - 3.0 sigma	= 72.5031	LCL: - 3.0 sigma	= 0
out of limits =0		out of limits = 0	

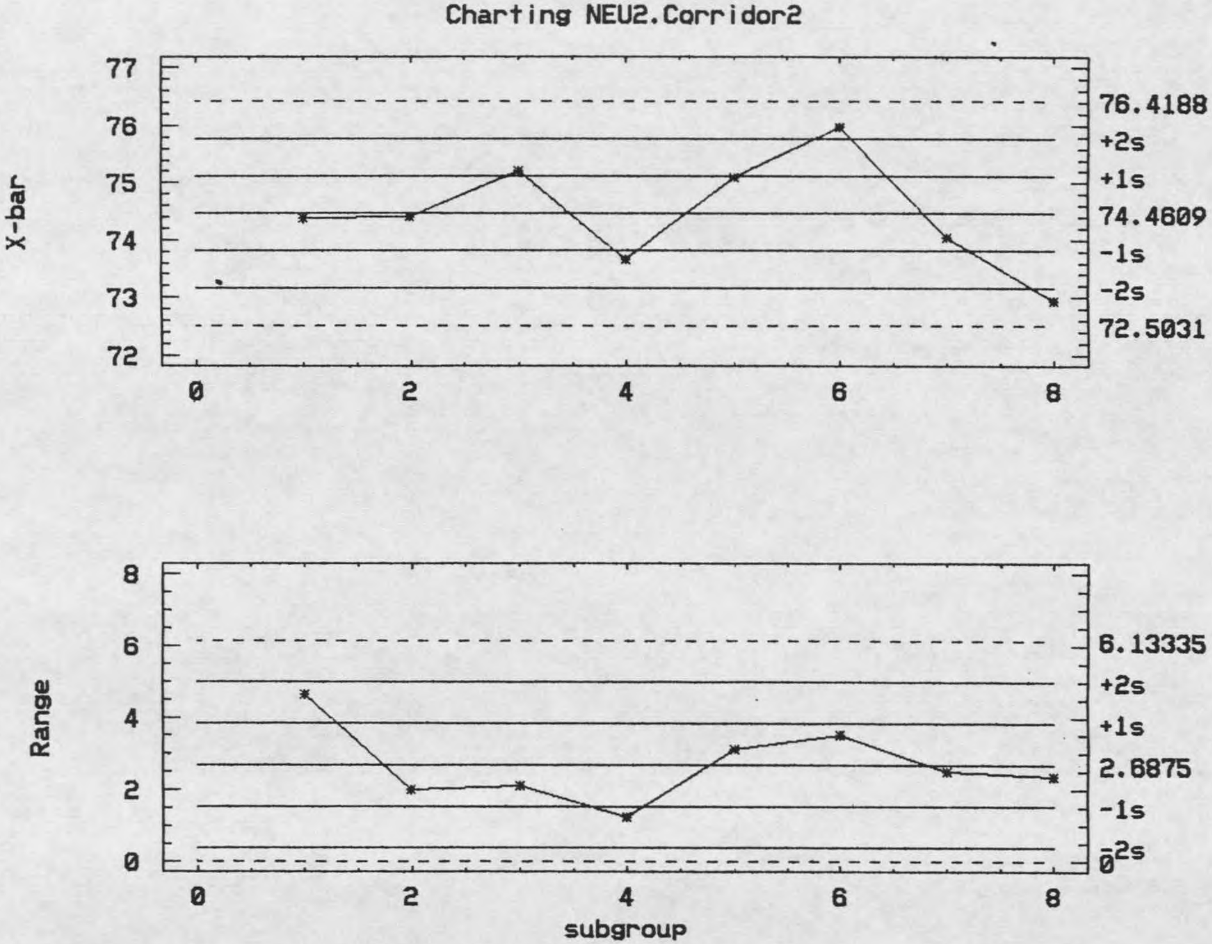

Figure 7. Control Charts Using Data from Compressed Neutral Corridor 2

* Substituting the parameters into the price shift formulas, yielded:

$$\Delta = (1.30525/2)\ (4 + 2 \times 2 + 3 \times 2) + 2.6875/2 = 10.4805$$

and

$$PL = 74.4609 - 10.4805 = 63.980\ .$$

* Compared to the actual value

Actual PL = 65.375

Error = Actual PL - Projected PL = 65.375 - 63.980 = 1.395

This result shows that the projected value was 1.395 less than actual value. Because the security broke out of the down side, the model produced overshoot, and hence, positive error for the projection.

<u>Scenario 2: Break out of the upper boundary</u>

Historical data forming Neutral Corridor 7 was used to test the model:

* Identify a neutral corridor. Refer to Figure 16 in Appendix A.

* Detect the breakout signal out of the neutral corridor using the method in Chapter 3. This time, the security broke from the upper boundary.

* Use MetaStock Compression function to obtain a compressed neutral corridor. Here, 14-period compression was conducted. Refer to Figure 8 for the compressed neutral corridor.

* Record the compressed data. See Table 11 for the data.

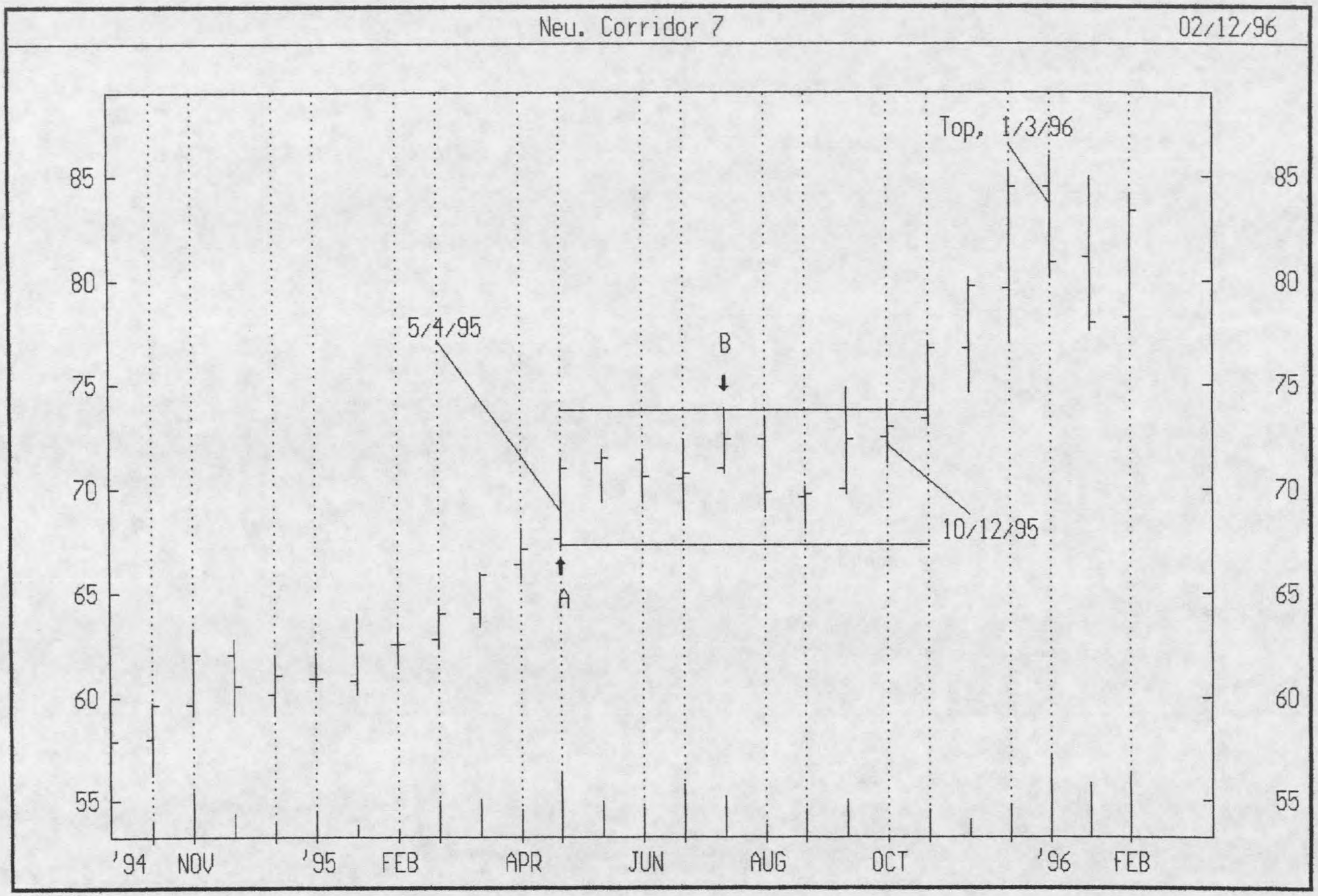

Figure 8. 14-period Compressed Neutral Corridor 7

Table 11. 14-period Compressed data for Neutral Corridor 7.

Date	Open	High	Low	Close
5/4/95	67.625	71.375	67.25	71
5/24/95	71.25	71.875	69.375	71.5
6/14/95	71.375	71.75	69.375	70.625
7/5/95	70.5	72.375	68.5	70.75
7/25/95	71	73.875	70.75	72.375
8/14/95	72.375	73.375	68.875	69.875
9/1/95	69.625	70.125	68.125	69.75
9/22/95	70	74.875	69.75	72.375
10/12/95	72.5	74.25	71.25	73

* Import the data to Statgraphics for further analysis, The results are shown in Table 12 and Table 13.

* Count the number of points appearing in Zones C, B, and A, respectively. See Figure 9.

Zone C: $n_1 = 4$

Zone B: $n_2 = 3$

Zone A: $n_3 = 1$

* Substituting the parameters into the price shift formulas, yielded:

$$\Delta = (1.65264/2)\ (4 + 2 \times 3 + 3 \times 1) + 3.40278/2 = 12.44355$$

$$PU = 70.9618 + 12.44355 = 83.405$$

Table 12. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 7

Subgroup	X-bar	Range
1	69.3125	4.125
2	71	2.5
3	70.7813	2.375
4	70.5313	3.875
5	72	3.125
6	71.125	4.5
7	69.4063	2
8	71.75	5.125
9	72.75	3

Table 13. Control Charts Set-up for Compressed Neutral Corridor 7

9 subgroup, size 4

process mean = 70.9618

process sigma = 1.65264

mean Range = 3.420278

X-bar		Range	
UCL:	+ 3.0 sigma = 73.4408	UCL:	+ 3.0 sigma = 7.76574
Centerline	= 70.9618	Centerline	= 3.40278
LCL:	- 3.0 sigma = 68.4829	LCL:	- 3.0 sigma = 0
	out of limits =0		out of limits = 0

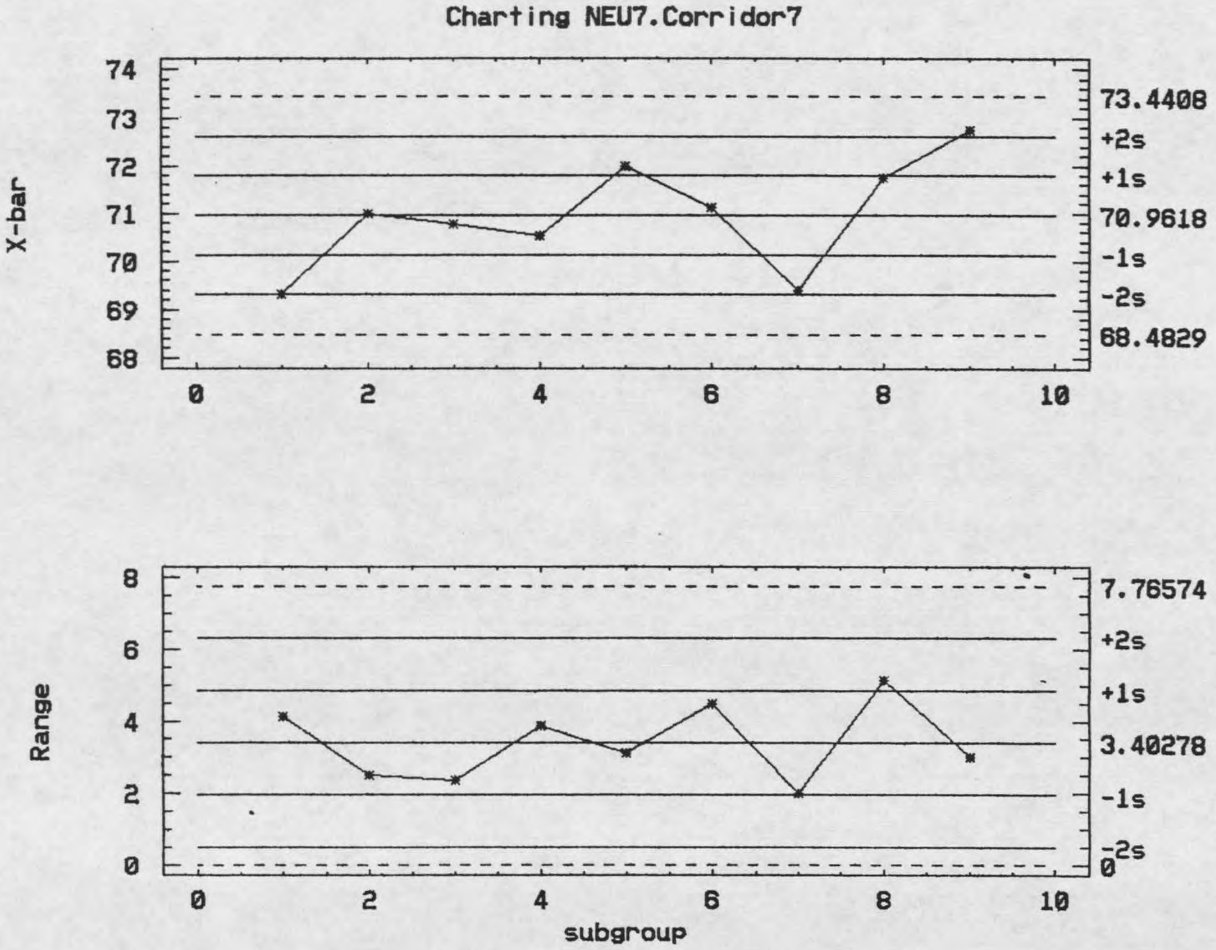

Figure 9. Control Charts Using Data from Compressed Neutral Corridor 7

* Compared with the actual value

On 1/3/95, the Security reached the top,

Actual PU = 86

Error = Actual PU - Projected PU = 86 - 83.405 = 2.595

Because this time, the security broke out of the upside, the model produced undershoot, and hence, negative error for the projection.

Same procedures were conducted for the 26 neutral corridors of the market security. Table 14 shows the results.

Examination of the Residual Errors

The study of residuals is very important to decide the appropriateness of a forecasting model. If the errors are essentially random, then the model may be built right. If the errors show any kind of pattern, then a systematic bias may be existing in the model. Two typical tools for error analyses were used to validate the model.

1. Plot of the Errors for Visual Inspection

The errors for the 26 neutral corridors applied to the projection model were plotted versus their testing order. See Figure 10. From this plot, it can be seen that the errors oscillate around 0 and between ± 4. Because no obvious pattern existed, the residues were considered to be random.

Table 14. Results of Breakout Projection for the 26 Neutral Corridors

Neutr. Corri.	Compr.	NO. of Subgroup	Dire. Of Breakout	Projected Value	Actual Value	Error	% Error
1	15	7	UP	9.59	12.5	-2.91	23.2%
2	9	8	DOWN	63.98	65.375	1.395	2.13%
3	12	9	UP	21.573	22.625	-0.927	4.1%
4	7	7	UP	43.791	46	-2.209	4.8%
5	9	10	UP	37.34	37.25	0.09	0.24%
6	8	9	UP	74.97	76.25	-1.28	1.68%
7	14	9	UP	83.405	86	-2.595	3.02%
8	22	9	DOWN	11.079	11.875	0.796	6.7%
9	10	10	DOWN	12.172	12.25	0.078	0.64%
10	8	8	UP	45.262	44.375	0.887	2%
11	W	9	DOWN	36.6	34.625	1.975	5.7%
12	W	7	DOWN	22.02	21.375	-0.645	3.02%
13	W	8	UP	11.867	12.625	-0.758	6%
14	W	8	DOWN	22.344	21.5	-0.844	3.93%
15	10	9	UP	32.957	36.625	3.668	10%
16	W	9	UP	47.95	47.625	0.325	0.68%
17	24	8	UP	63.186	60.75	2.436	4.01%
18	8	6	UP	79.2	80.25	-1.05	1.3%
19	6	8	UP	115.346	114.625	0.721	0.63%
20	W	5	DOWN	17.606	17.625	0.019	0.167%
21	6	9	UP	8.789	8.125	0.664	8.17%
22	4	10	UP	6.421	6.375	0.046	0.73%
23	4	9	UP	64.044	62	2.044	3.3%
24	10	7	UP	51.024	50.75	0.274	0.54%
25	140	12	UP	133.599	134.25	-0.349	0.26%
26	20	11	UP	58.374	54.75	3.624	6.6%

Note: W=Weekly

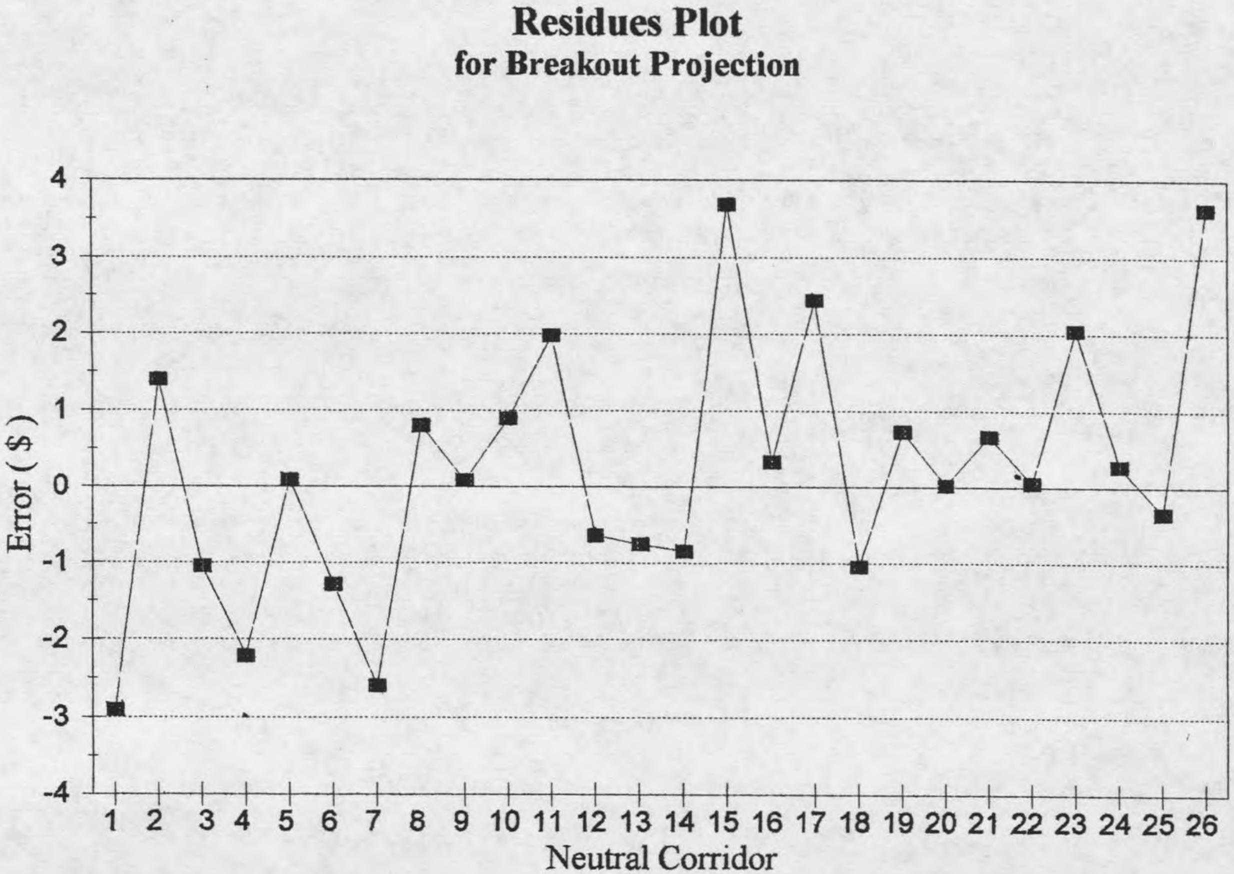

Figure 10. Residues Plot for Breakout Projections of the 26 Neutral Corridors

2. Run Test

A Run Test [4] is a kind of nonparametric test that applies when the normality assumption is not guaranteed.

Given a sequence of two symbols, such as A and B, a run is defined as a succession of identical symbols contained between different symbols or none at all. For example, the sequence

A A B B A A B B B A B B B A A A A

contains 7 runs, as indicated by the underlies. If a sequence contains n_1 symbols of one kind and n_2 of another kind (and neither n_1 nor n_2 is less than 10), the sampling distribution of the total number of runs, u, can be approximated closely by a normal distribution with mean and standard deviation as follows:

$$\mu_u = \frac{2n_1n_2}{n_1+n_2} + 1$$

$$\alpha_u = \sqrt{\frac{2n_1n_2(2n_1n_2-n_1-n_2)}{(n_1+n_2)^2(n_1+n_2-1)}}$$

Thus, test of the null hypothesis that arrangement of the symbols (and, hence, the sample) is random is based on the statistic

$$Z = \frac{u-\mu_u}{\sigma_u} .$$

The run test is used to test the randomness of samples consisting of numerical data by counting runs above and below the median. Denoting an observation exceeding the median of the sample by the letter A and an observation less than the median by the letter B, the resulting sequence of A's and B's can be used to test for randomness. The procedure is shown below:

1. Null hypothesis: Residues are random.

   Alternative hypothesis: Residues are not random

2. Level of significance: $\alpha = 0.01$

3. Criterion: Reject the null hypothesis if $Z < -2.5753$ or $Z > 2.575$.

4. Calculations: The median of the 26 measurements is 0.019, so that yields the following sequence:

   B A B B A B B A A A A B B B A A A B A A A A A A B A

Thus, $n_1 = 10$, $n_2 = 15$, and $u = 12$

$$\mu_u = \frac{2 \cdot 10 \cdot 15}{10+15} + 1 = 13$$

$$\alpha_u = \sqrt{\frac{2\times10\times15(2\times10\times15-10-15)}{(10+15)^2(10+15-1)}} = 2.345$$

$$Z = \frac{12-13}{2.345} = -0.426$$

5. Decision: Because Z = -0.426 > -2.575, the null hypothesis can not be rejected; The residues are random at a significance level of 0.01.

Results

Table 15 summarizes the results of Table 14 .

Table 15. Summary of Results for Breakout Projections of the 26 Neutral Corridors

	% Error within 5%	% Error within 6%	% Error within 7%
No. of Neu. Corr.	19	21	23
% in All Neu. Corr	73.1	80.76	88.5

88.5% of the neutral corridor applied to the model obtained a percent error that was within 7% . This was very promising. The residues for the total 26 projections passed this run test for randomness.

Remarks

The mathematical model developed for the projection of a market security out of a neutral corridor has been validated by 26 neutral corridors formed by historical data. The error was within reasonable limits. The randomness of the residues was also achieved. However, this model needs to be further validated by forecasting future data.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Breakout Detection

- Pattern recognition techniques make it possible to detect quantitatively a significant breakout signal from a neutral corridor by using similarity values. This method is easy to understand and perform. With the help of ModelWare, it has been proved that this technique possesses a high accuracy and brings high confidence for the decision maker.
- Because of the author's limited knowledge of market securities, only seven variables were selected by the author to reflect the behavior of a neutral corridor. There might be some other elements that can be chosen to better present the nature of a neutral corridor so as to enhance this method. Expertise plays a very important role for the element selection.
- The threshold value is empirical, and with more experiments and experience, rules to establish this value can be further elaborated. The determination of the threshold value reflects the confidence level of the analyst.
- It is very important to eliminate the shakeout noise when applying this method. Otherwise, false signals will be obtained.
- Neutral corridors from different types of time series can also be tested to validate this technique.

Breakout Projection

- A simple mathematical model has been developed to project the potential movement of the time series after it breaks out of a neutral corridor. This model reveals the direct cause-and-effect relationship between the consolidation area and its following breakout projection in view of energy accumulation and transferal. The model will provide good benchmarks of the new potential "top" and "bottom" of the time series' movement. However, when the time series reaches the new top or bottom, it is not necessary that a reversal takes place. The time series may keep going or form another consolidation. So this model only tells us at least how far a time series will move after it breaks out with so much consolidation. It does not tell us when the time series will reverse, even though at times it gives the reversal signals.
- The author used A, B, and C zones to stand for 1σ, 2σ and 3σ areas and made corresponding contribution to the breakout projection. Four or more zones may be tried in the future.
- An empirical rule for compression limited the number of subgroups to the range from 5 to 12. Accuracy deteriorates outside of this range, and the reason is not clear. However, future studies concerning relationships between compression and standard deviation estimate for σ, computed using compressed data, may clarify this problem.
- Another adaption is to assign a weight to replace k/2 in the price shift formulas. This weight takes into account that the projection is proportional to the number of

subgroups. But, when k is beyond the range from 5 to 12, this relation is not valid. What weight to use will be another challenge.

- Overall, much room is still left for more exploration. One should realize that the nature of the work presented here is strictly experimental.

APPENDICES

APPENDIX A

BREAKOUT DETECTION FROM NEUTRAL CORRIDORS

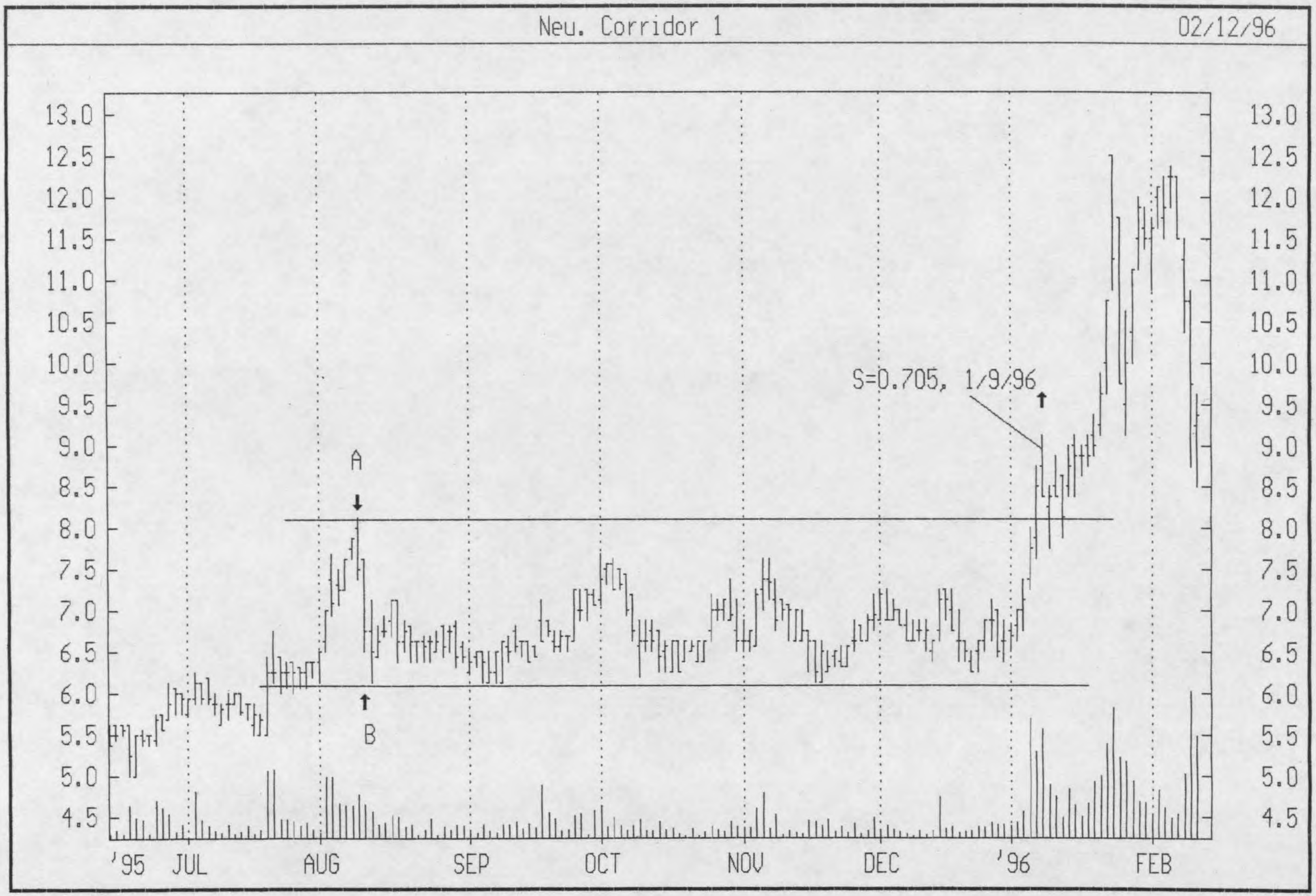

Figure 11. Breakout Detection for Neutral Corridor 1

Figure 12. Breakout Detection for Neutral Corridor 3

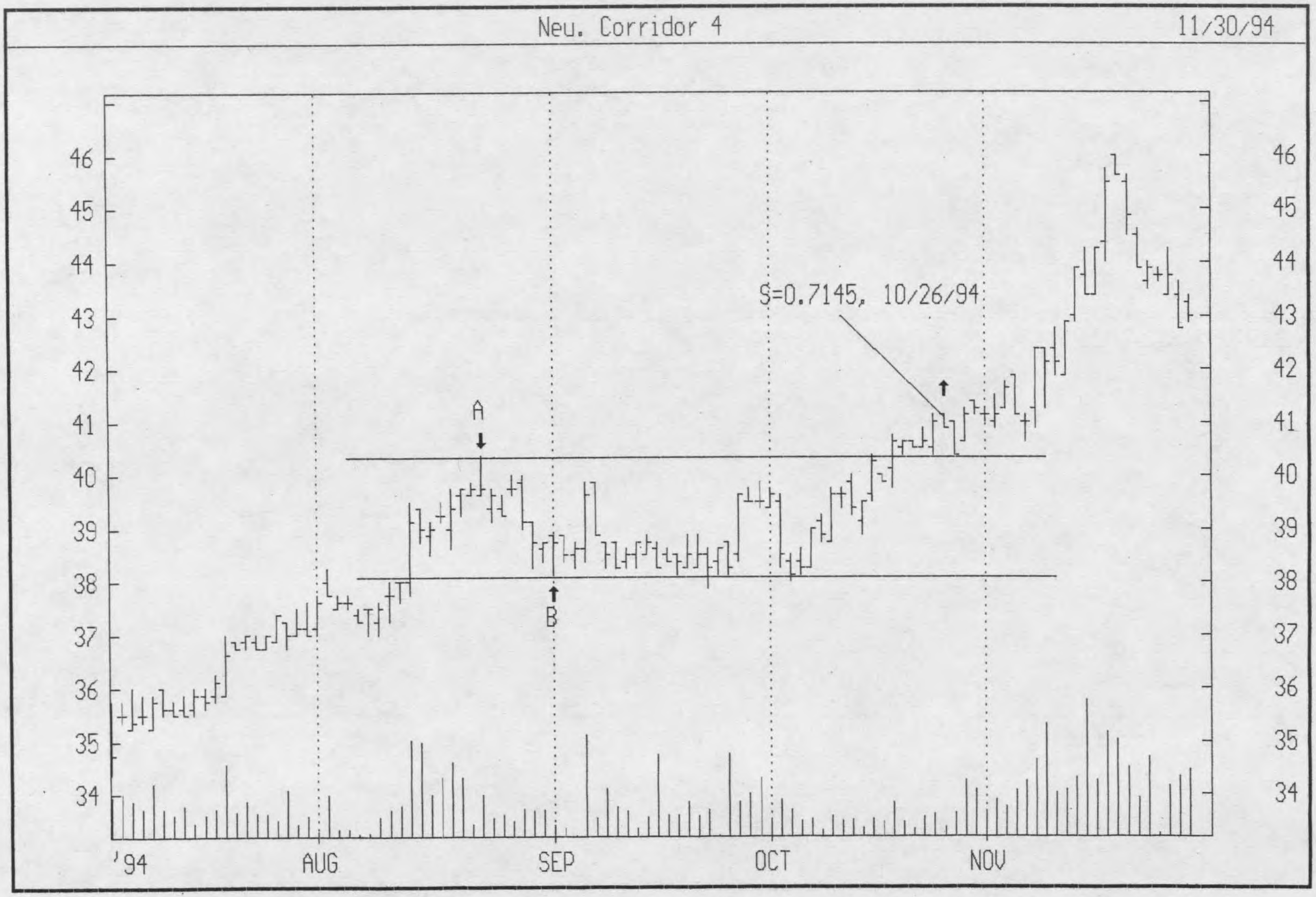

Figure 13. Breakout Detection for Neutral Corridor 4

Figure 14. Breakout Detection for Neutral Corridor 5

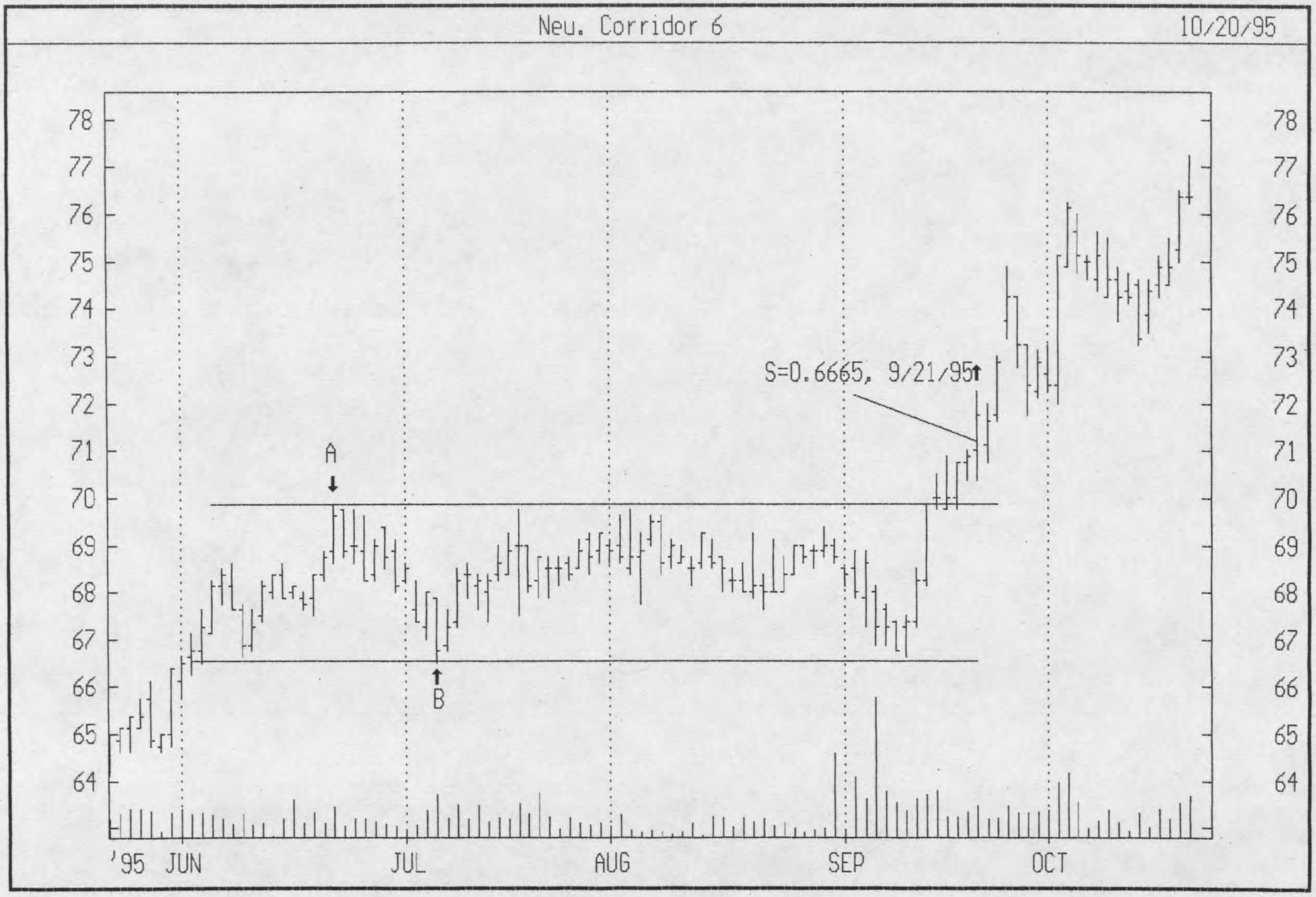

Figure 15. Breakout Detection for Neutral Corridor 6

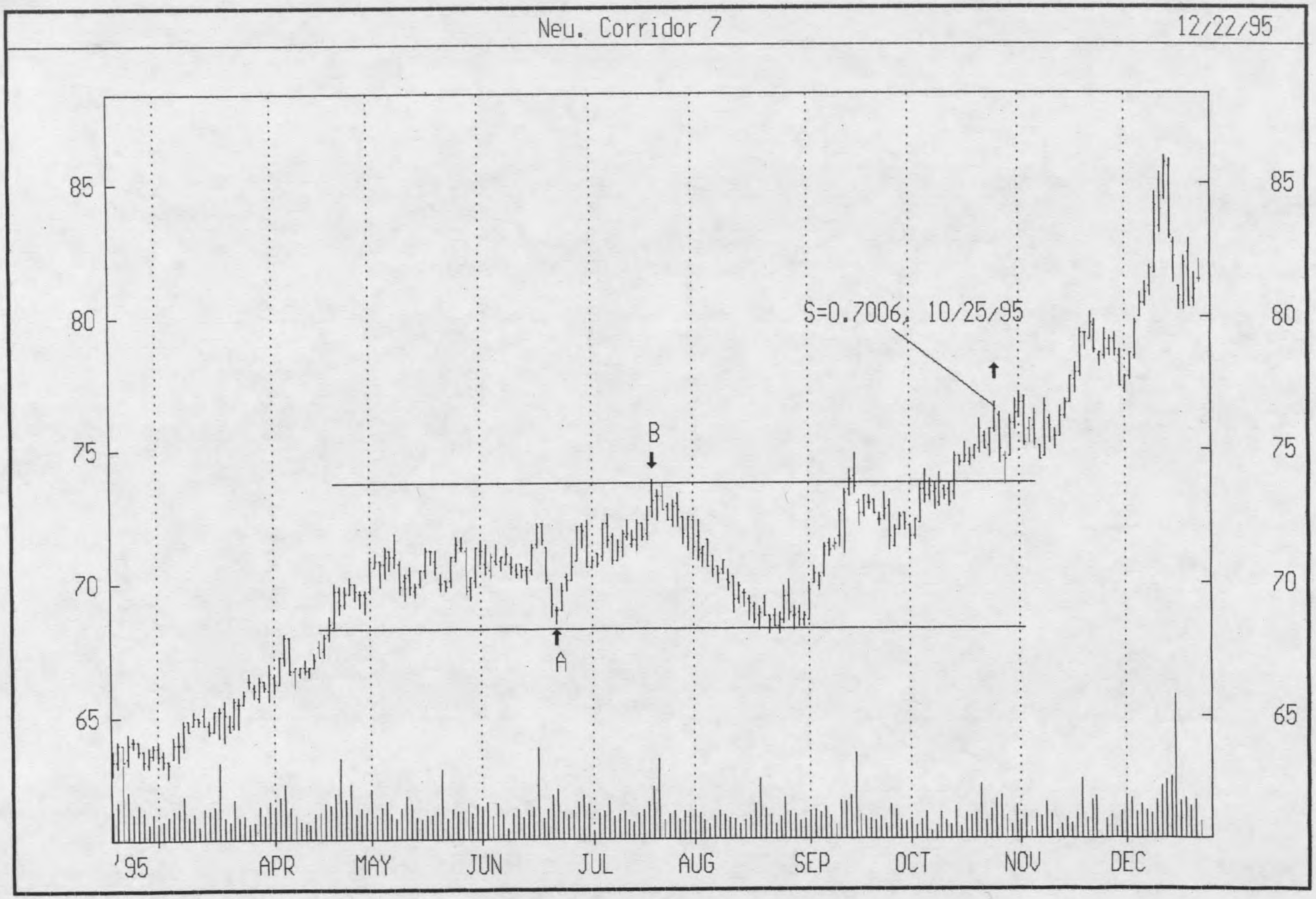

Figure 16. Breakout Detection for Neutral Corridor 7

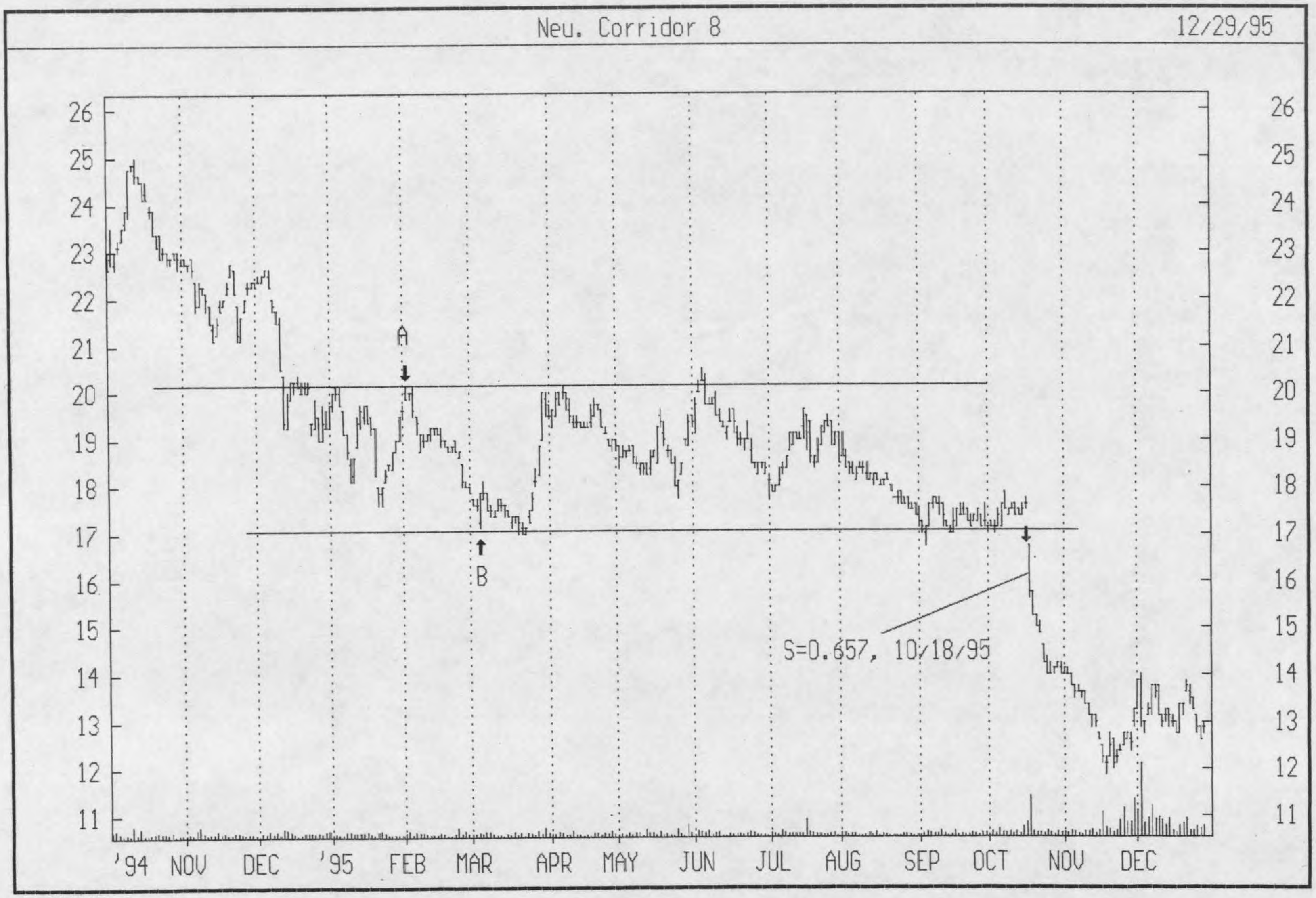

Figure 17. Breakout Detection for Neutral Corridor 8

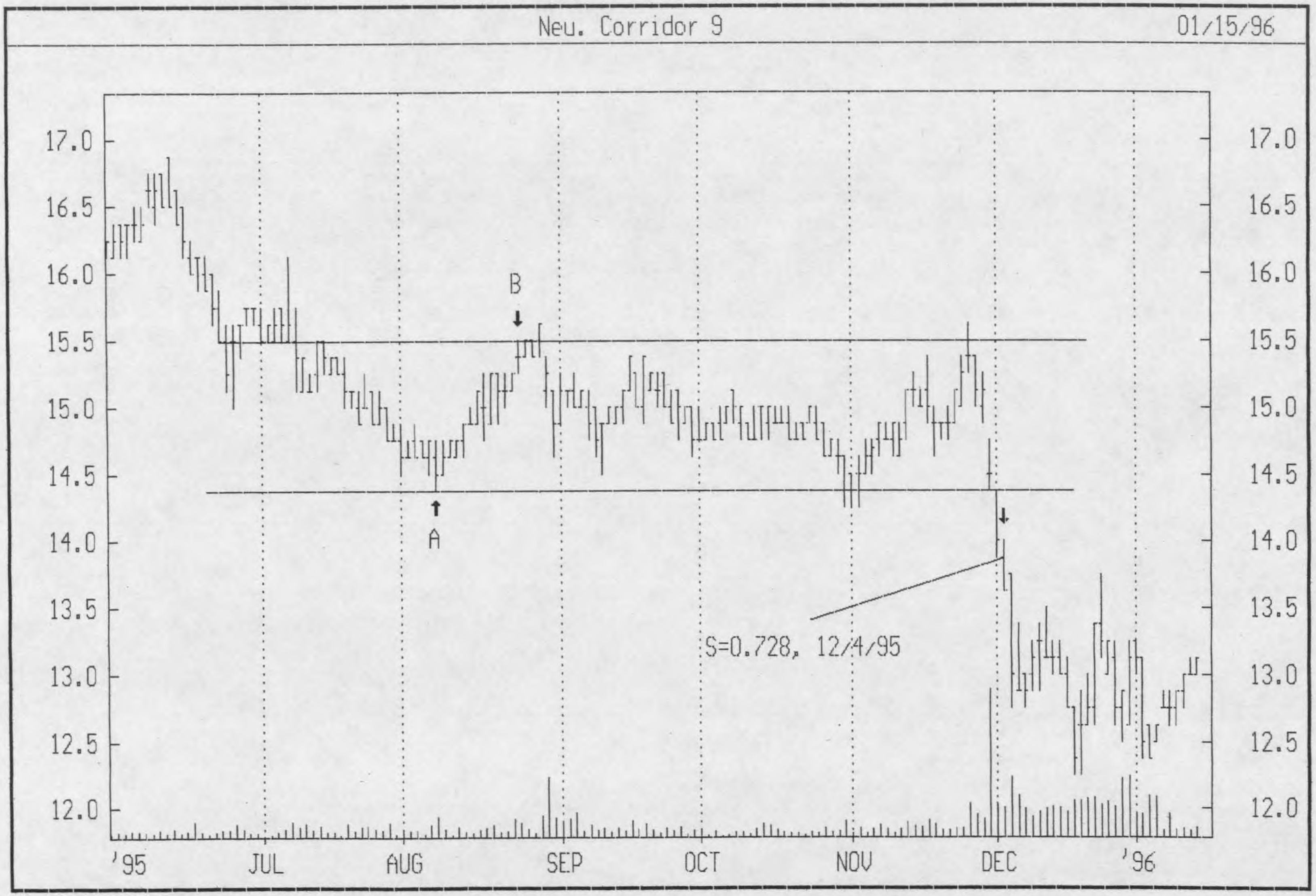

Figure 18. Breakout Detection for Neutral Corridor 9

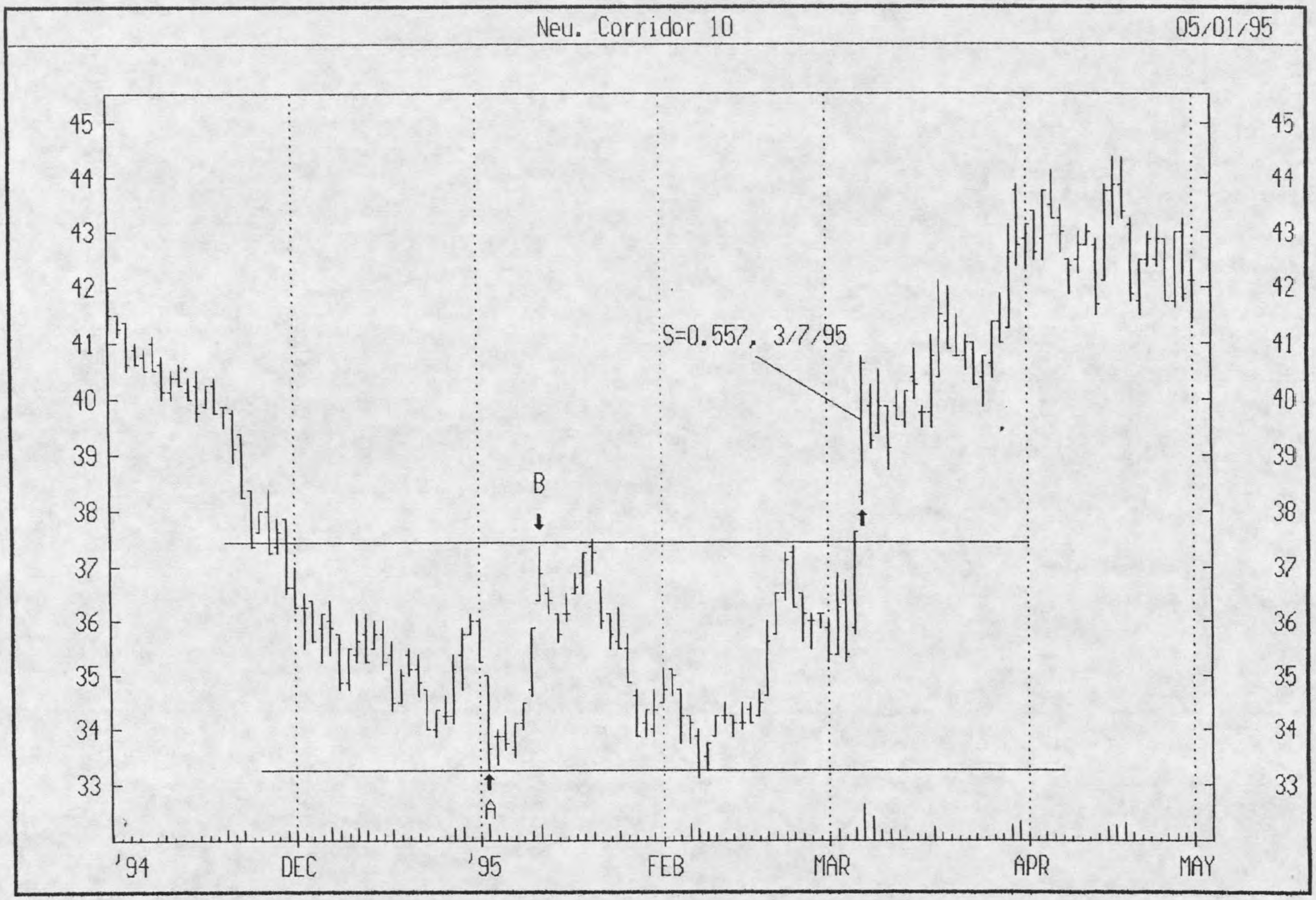

Figure 19. Breakout Detection for Neutral Corridor 10

APPENDIX B

BREAKOUT PROJECTIONS FOR NEUTRAL CORRIDORS

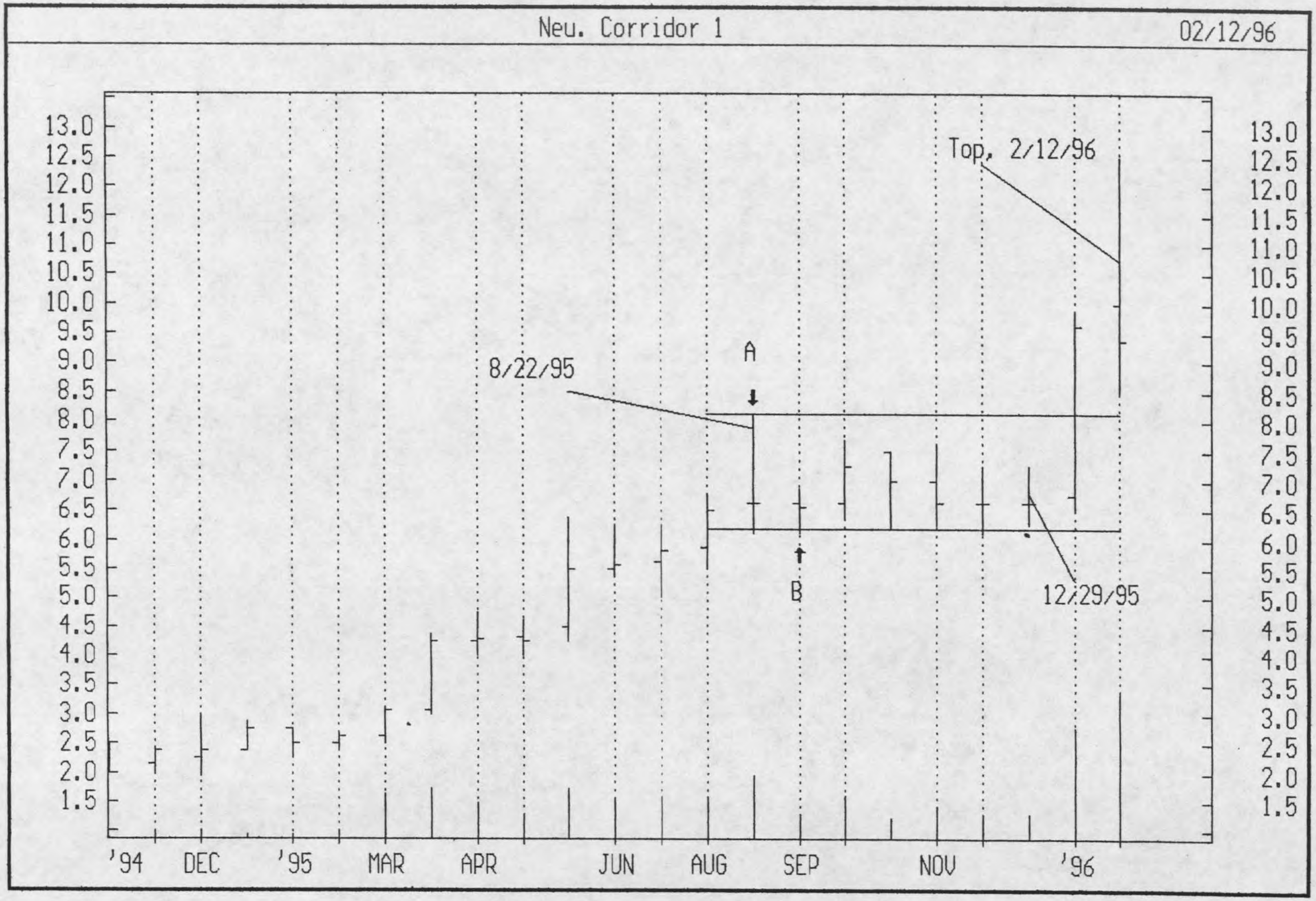

Figure 20. 15-period Compressed Neutral Corridor 1

Table 16. 15-period Compressed Data for Neutral Corridor 1

Date	Open	High	Low	Close
8/22/95	6.625	8.125	6.125	6.625
9/13/95	6.625	6.875	6.125	6.562
10/4/95	6.625	7.687	6.375	7.25
10/25/95	7.5	7.5	6.187	7
11/15/95	7	7.625	6.25	6.625
12/07/95	6.625	7.25	6.125	6.625
12/29/95	6.625	7.25	6.25	6.625

Table 17. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 1

Subgroup	X-bar	Range
1	6.875	2
2	6.54675	0.75
3	6.98425	1.312
4	7.04675	1.313
5	6.875	1.375
6	6.65625	1.125
7	6.6875	1

Table 18. Control Charts Set-up for Compressed Neutral Corridor 1

---

7 subgroup, size 4
process mean = 6.81021
process sigma = 0.615764
mean Range = 1.26786

X-bar		Range	
UCL:	+ 3.0 sigma = 7.73386	UCL:	+ 3.0 sigma = 2.89347
Centerline	= 6.81021	Centerline	=1.26786
LCL:	- 3.0 sigma = 5.88657	LCL:	- 3.0 sigma = 0
	out of limits =0		out of limits = 0

Breakout Direction: Up

Projection Calculation (refer to the following page):

$n_1 = 7$

$n_2 = 0$

$n_3 = 0$

$\Delta = (0.615764/2)\,(7 + 0 + 0) + 1.26786/2 = 2.789$

PU = 6.81021 + 2.789 = 9.59

Actual PU = 12.5

Error= 9.59 - 12.5 = -2.91

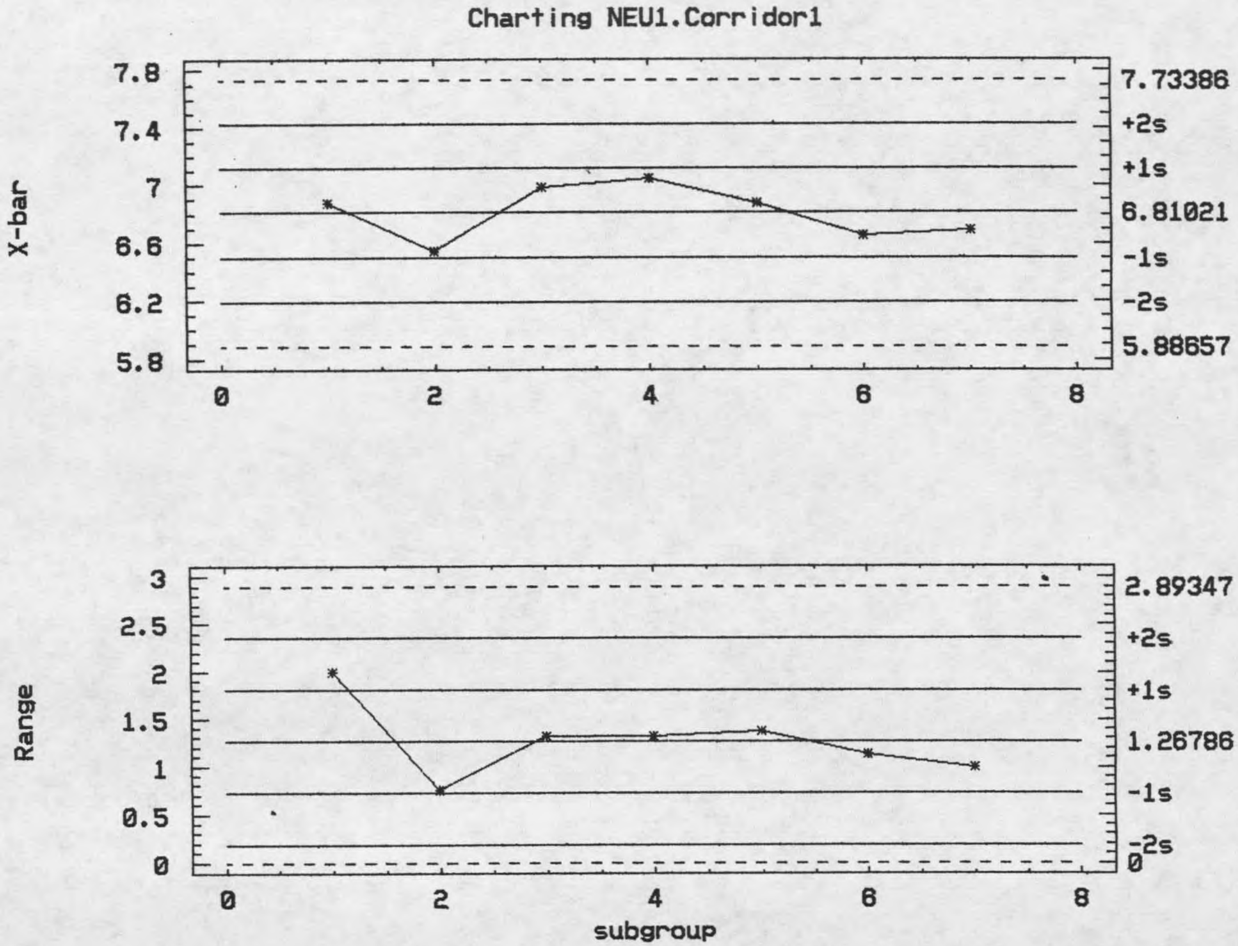

Figure 21. Control Charts Using Data from Compressed Neutral Corridor 1

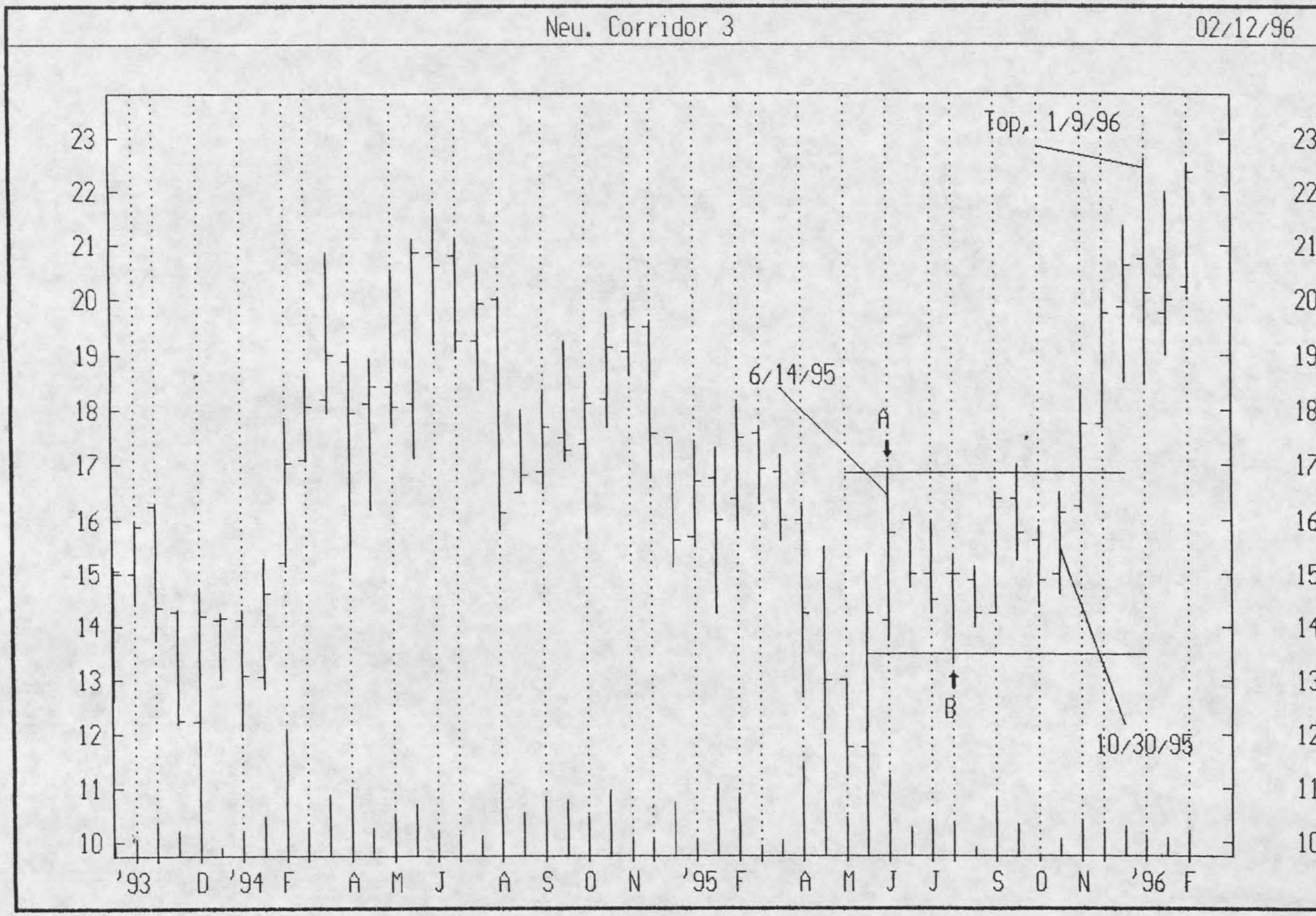

Figure 22. 12-period Compressed Neutral Corridor 3

Table 19. 12-period Compressed Data for Neutral Corridor 3

Date	Open	High	Low	Close
4/5/95	62.75	66.875	62.625	66.125
4/18/95	66	70	66	67
4/28/95	67	68.75	63.25	67.375
5/10/95	67.125	69.375	65.5	67.625
5/22/95	67.625	70	66.375	68.25
6/2/95	68	69.5	65.625	67.75

Table 20. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 3

Subgroup	X-bar	Range
1	15.125	3.125
2	15.4688	1.375
3	14.9375	1.75
4	14.6875	2
5	14.5625	1.125
6	15.3438	2.25
7	15.0938	1.75
8	15.1875	1.5
9	15.5625	1.875

Table 21. Control Charts Set-up for Compressed Neutral Corridor 3

9 subgroup, size 4
process mean = 15.2188
process sigma = 0.903891
mean Range = 1.86111

X-bar		Range	
UCL: + 3.0 sigma	= 16.5746	UCL: + 3.0 sigma	= 4.24738
Centerline	= 15.2188	Centerline	= 1.86111
LCL: - 3.0 sigma	= 13.8629	LCL: - 3.0 sigma	= 0
out of limits	= 0	out of limits	= 0

Breakout Direction: Up

Projection Calculation (refer to the following page):

$n_1 = 6$

$n_2 = 3$

$n_3 = 0$

$\Delta = (0.903891/2)(6+2 \times 3 + 0) + 1.86111/2 = 6.354$

PU = 15.2188 + 6.354 = 21.573

Actual PU = 22.625

Error = 21.573 - 22.5 = -0.927

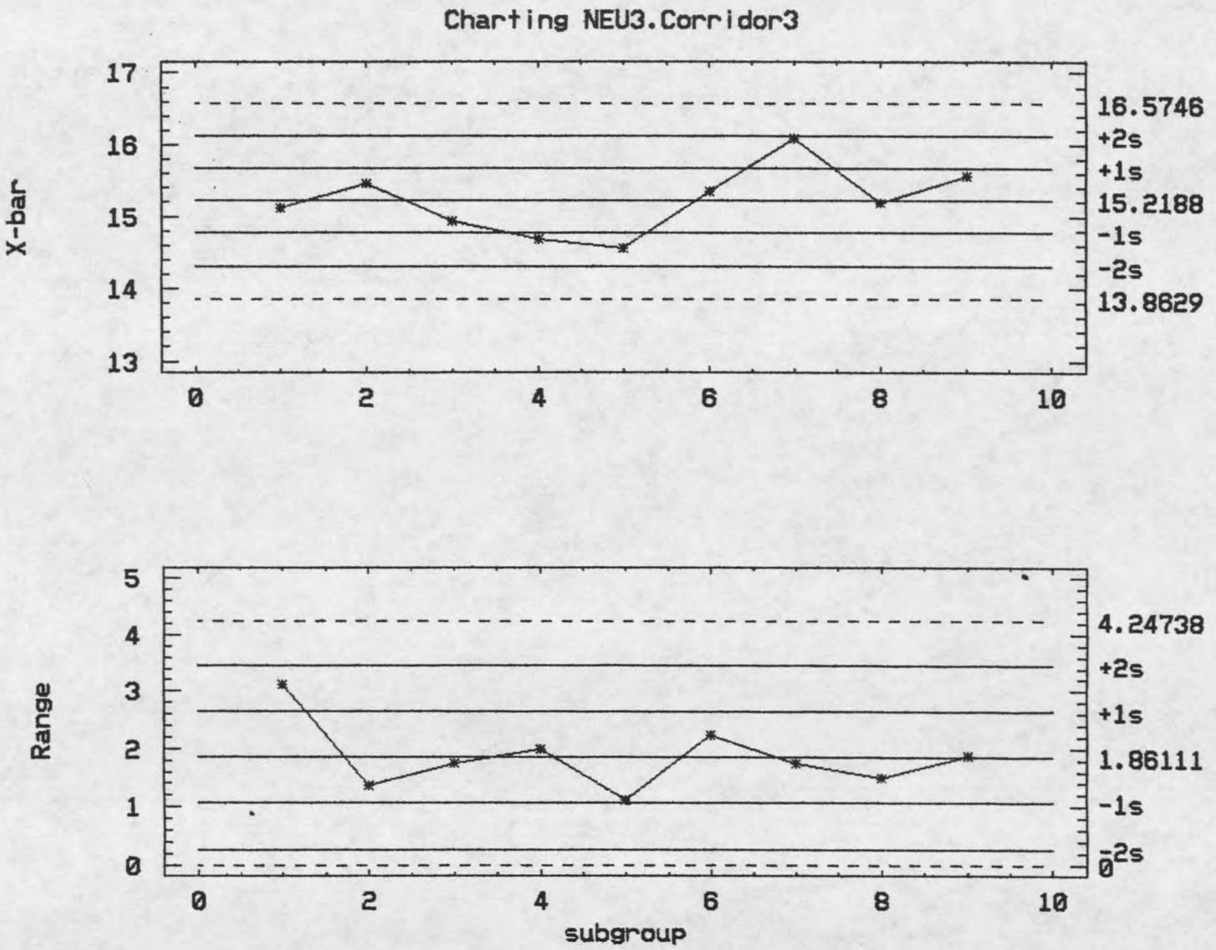

Figure 23. Control Charts Using Data from Compressed Neutral Corridor 3

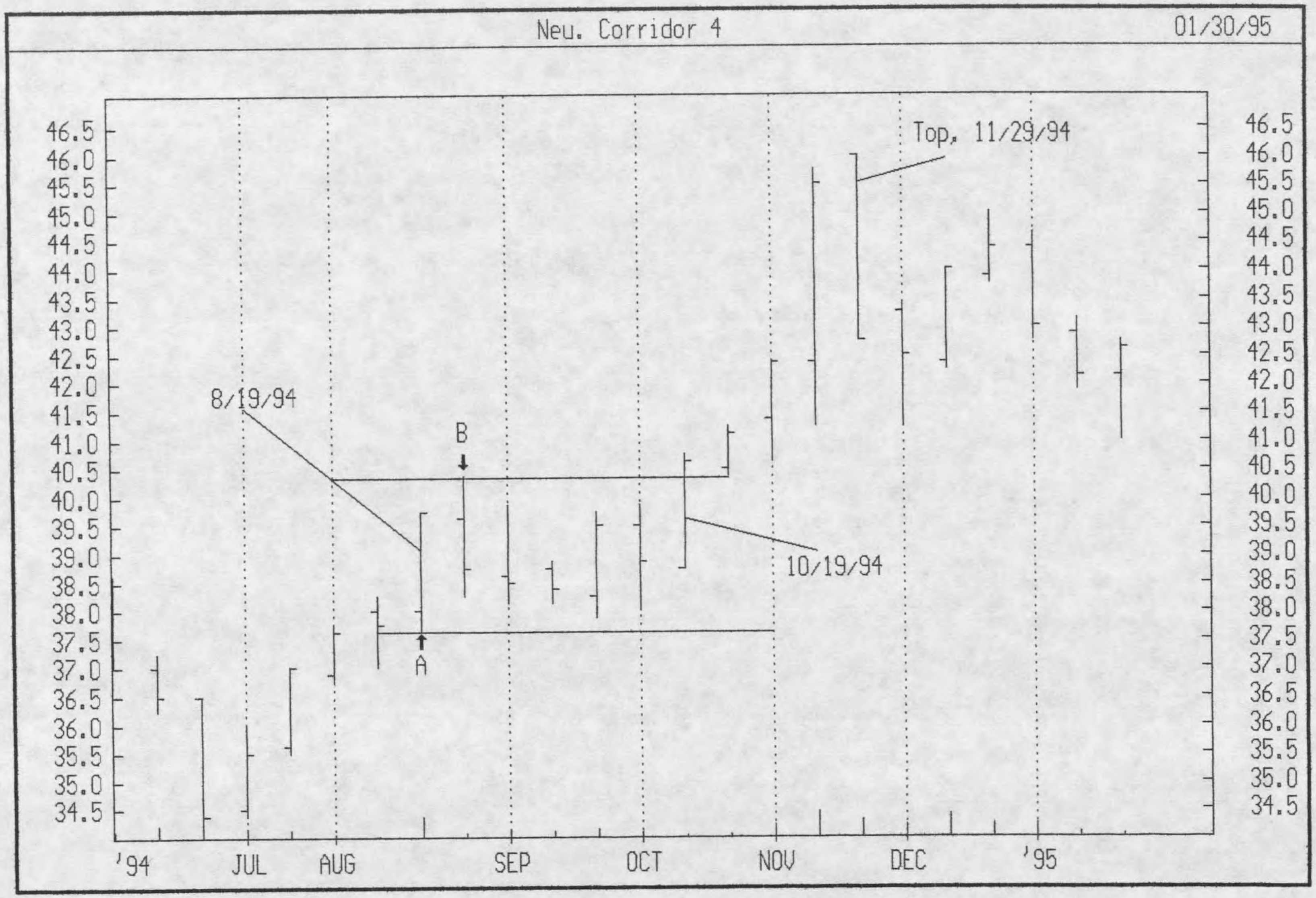

Figure 24. 7-period Compressed Neutral Corridor 4

Table 22. 7-period Compressed Data for Neutral Corridor 4

Date	Open	High	Low	Close
8/19/94	38	39.75	37.625	39.75
8/30/94	39.625	40.375	38.25	38.75
9/9/94	38.625	39.875	38.125	38.5
9/20/94	38.75	38.875	38.125	38.375
9/29/94	37.25	39.75	37.875	39.5
10/10/94	39.5	39.875	38	38.875
10/19/94	38.75	40.75	38.75	40.625

Table 23. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 4

Subgroup	X-bar	Range
1	38.7813	2.125
2	39.25	2.125
3	38.7813	1.75
4	38.531	0.75
5	38.8438	1.875
6	39.0625	1.875
7	39 7188	2

Table 24. Control Charts Set-up for Compressed Neutral Corridor 4

7 subgroup, size 4
process mean = 38.9955
process sigma = 0.867273
mean Range = 1.78571

X-bar		Range	
UCL:	+ 3.0 sigma = 40.2964	UCL:	+ 3.0 sigma = 4.07531
Centerline	=38.99551	Centerline	=1.78571
LCL:	- 3.0 sigma =37.6946	LCL:	- 3.0 sigma = 0
	out of limits =0		out of limits = 0

Breakout Direction: Up

Projection Calculation (refer to the following page):

$n_1 = 5$

$n_2 = 2$

$n_3 = 0$

$\Delta = (0.867273/2)\ (5 + 2 \times 2 + 0) + 1.78571/2 = 4.796$

PU = 38.9955 + 4.796 = 43.791

Actual PU = 46

Error= 43.791 - 46 = -2.209

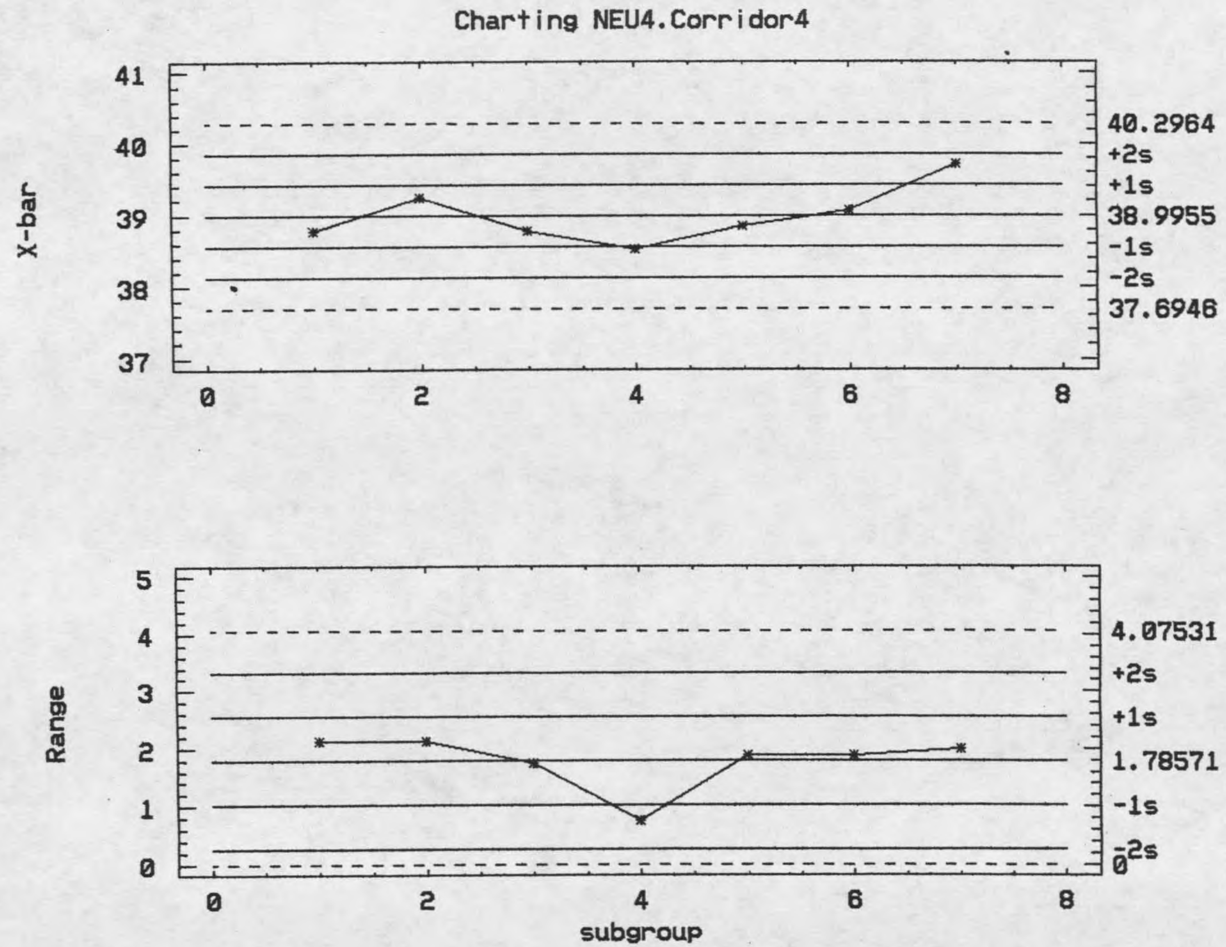

Figure 25. Control Charts Using Data from Compressed Neutral Corridor 4

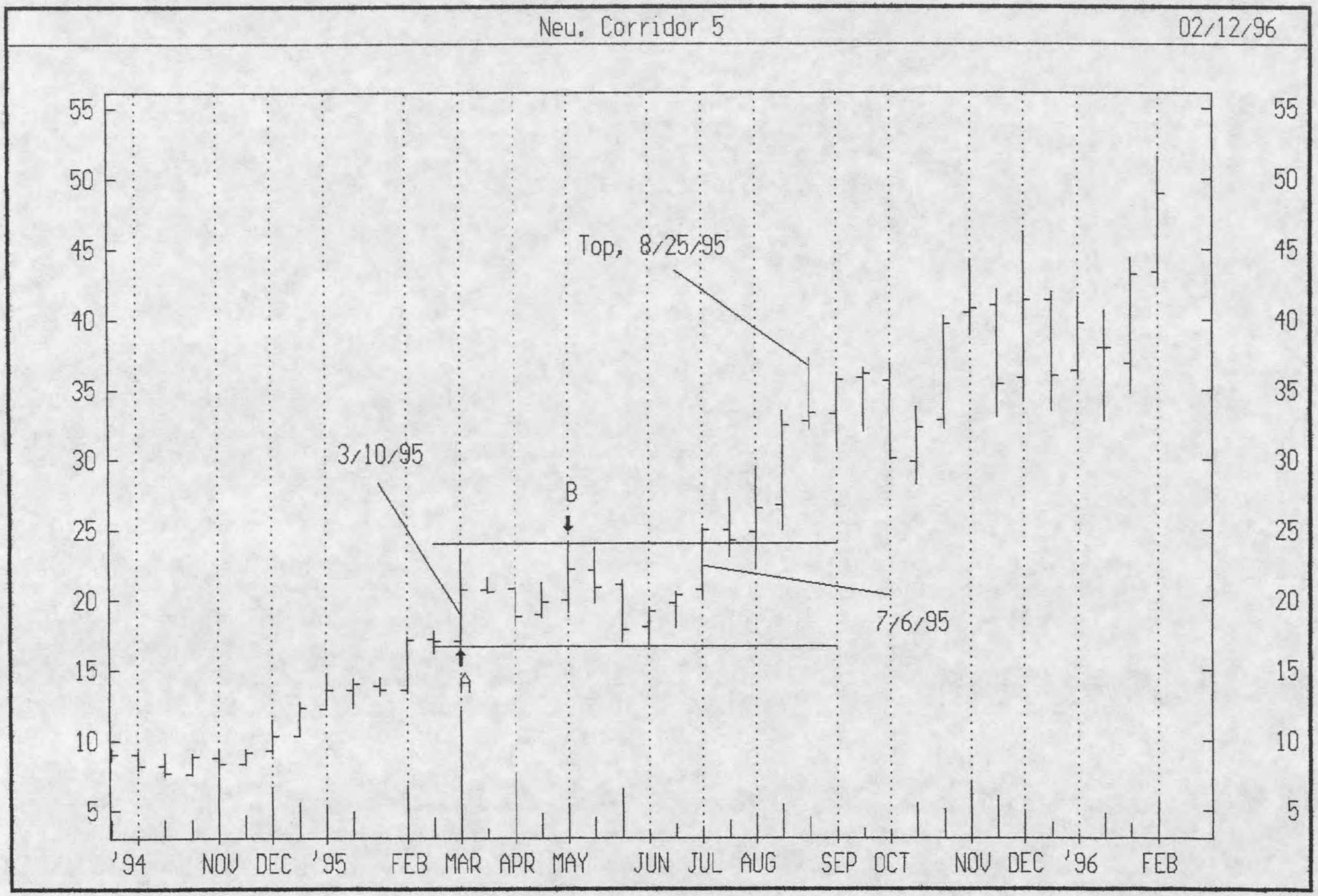

Figure 26. 9-period Compressed Neutral Corridor 5

Table 25. 9-period Compressed Data for Neutral Corridor 5

Date	Open	High	Low	Close
3/10/95	17.062	23.687	16.812	20.718
3/23/95	20.718	21.593	20.5	20.625
4/5/95	20.781	20.875	18.187	18.843
4/19/95	18.937	21.281	18.781	19.875
5/2/95	20	24.062	19.125	22.187
5/15/95	22.125	23.75	19.75	20.875
5/26/95	21.125	21.375	17	17.875
6/9/95	18.062	19.375	16.75	19.187
6/22/95	19.75	20.625	18	20.375
7/6/95	20.75	25.125	20	25

Table 26. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 5

Subgroup	X-bar	Range
1	19.5697	6.87
2	20.859	1.09
3	19.6715	2.68
4	19.7185	2.5
5	21.3435	4.93
6	21.625	4
7	19.3438	4.375
8	19.3435	2.625
9	19.6875	2.625
10	22.7188	5.125

Table 27. Control Charts Set-up for Compressed Corridor 5

10 subgroup, size 4
process mean = 20.2881
process sigma = 1.78936
mean Range = 3.6843

X-bar		Range	
UCL:	+ 3.0 sigma = 22.9721	UCL:	+ 3.0 sigma =8.40822
Centerline	=20.2881	Centerline	=3.6843
LCL:	- 3.0 sigma =17.604	LCL:	- 3.0 sigma = 0
	out of limits =0		out of limits = 0

Breakout Direction: Up

Projection Calculation (refer to the following page):

$n_1 = 5$

$n_2 = 3$

$n_3 = 2$

$\Delta = (1.78936/2)\ (5 + 2 \times 3 + 3 \times 2\ ) + 3.6843/2 = 17.052$

PU = 20.2881 + 17.052 = 37.34

Actual PU = 37.25

Error= 37.25 - 37.34 = 0.09

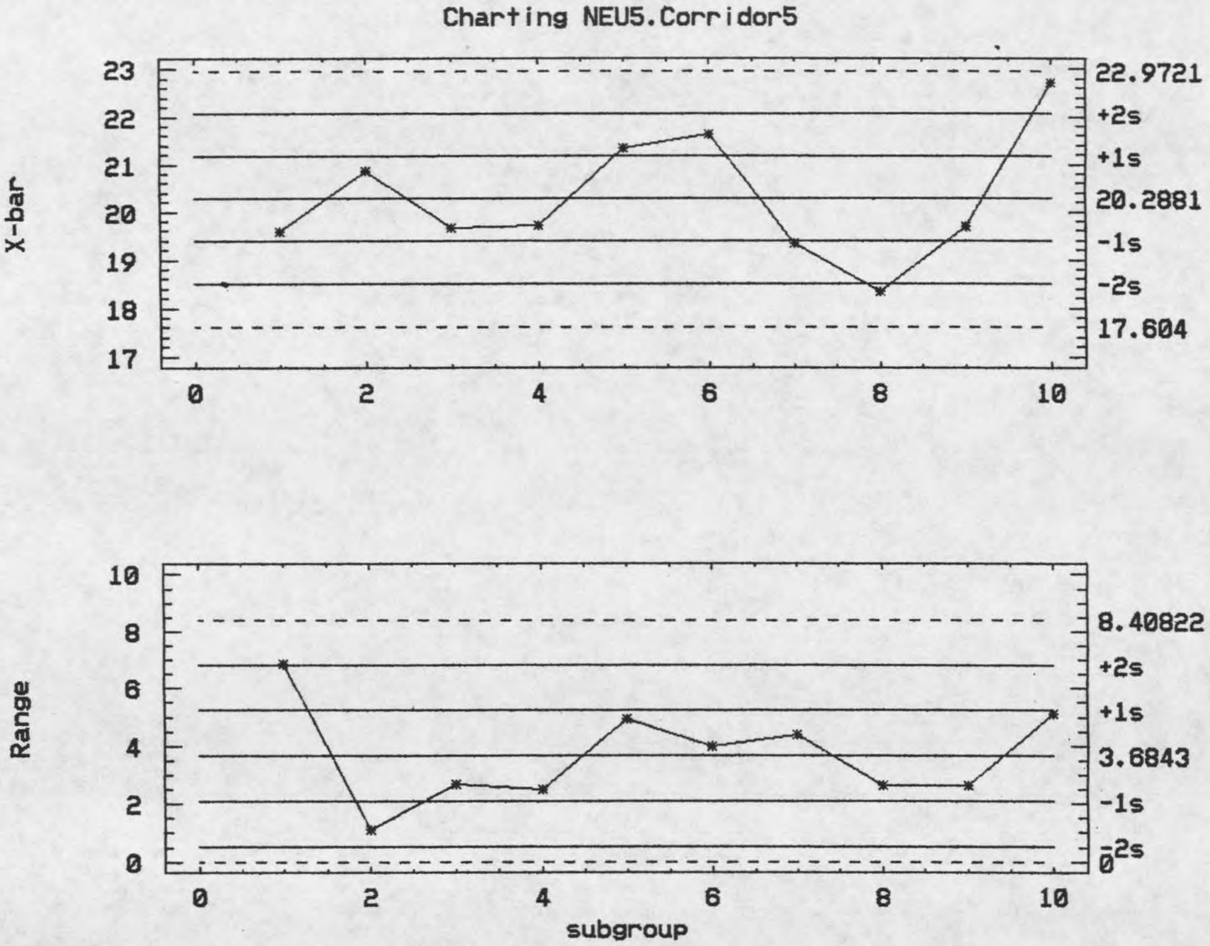

Figure 27. Control Charts Using Data from Compressed Neutral Corridor 5

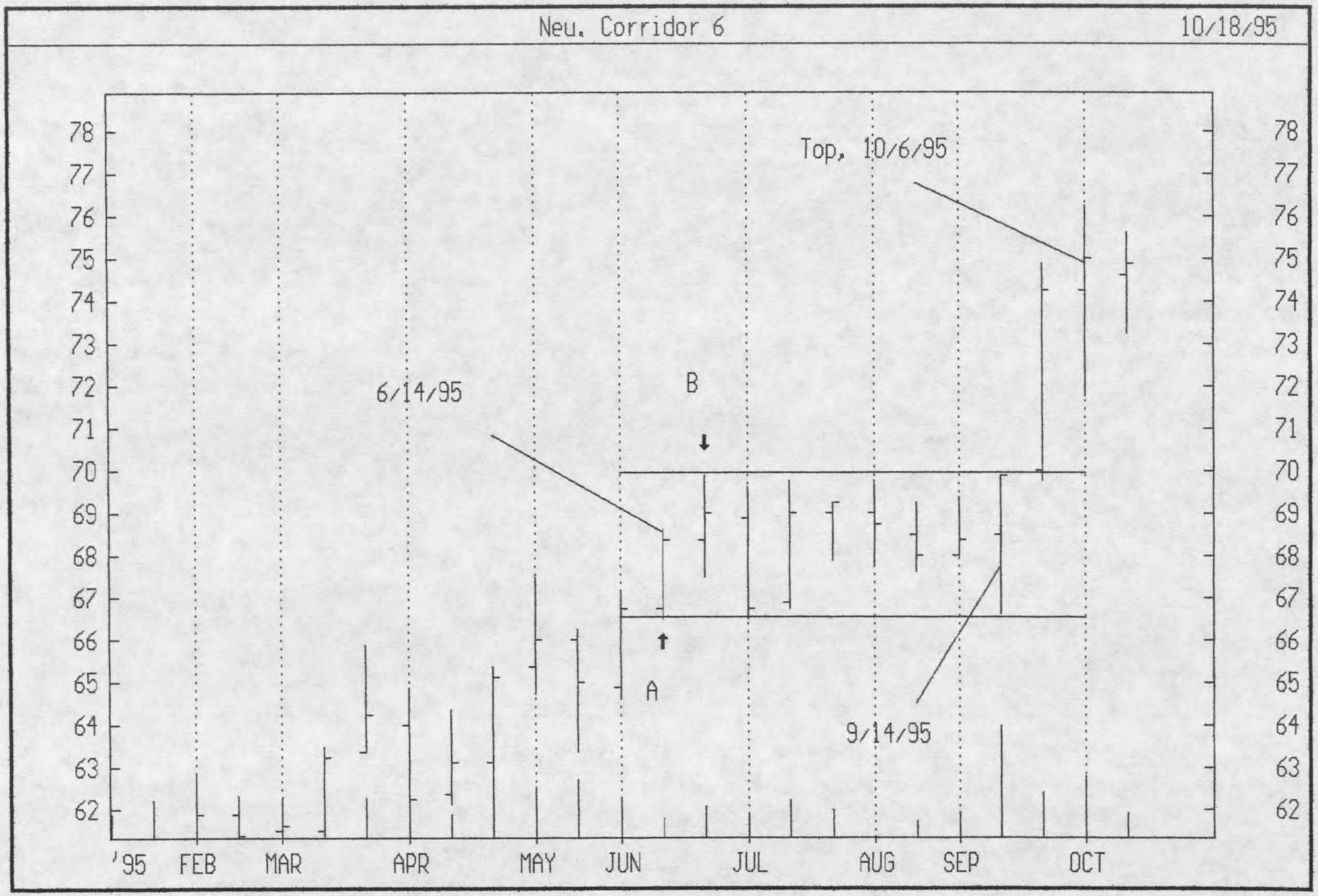

Figure 28. 8-period Compressed Neutral Corridor 6

Table 28. 8-period Compressed Data for Neutral Corridor 6

Date	Open	High	Low	Close
6/14/95	66.75	68.625	66.5	68.375
6/26/95	68.375	69.875	67.5	69
7/7/95	68.875	69.625	66.5	66.75
7/9/95	66.875	69.75	66.75	69
7/31/95	69	69.25	67.875	69.25
8/10/95	69	69.75	67.75	68.75
8/22/95	68.5	69.25	67.625	68
9/1/95	68	69.375	68	68.375
9/14/95	68.5	69.875	66.625	69.875

Table 29. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 6

Subgroup	X-bar	Range
1	67.5625	2.125
2	68.6875	2.375
3	67.9375	3.125
4	68.0938	3
5	68.8438	1.375
6	68.8125	2
7	68.3438	1.625
8	68.4375	1.375
9	68.7188	3.25

Table 30. Control Charts Set-up for Compressed Neutral Corridor 6

9 subgroup, size 4
process mean = 68.3819
process sigma =1.09276
mean Range = 2.25

X-bar		Range	
UCL: + 3.0 sigma	= 70.0211	UCL: + 3.0 sigma	= 5.1349
Centerline	=68.3819	Centerline	=2.25
LCL: - 3.0 sigma	=66.7428	LCL: - 3.0 sigma	= 0
out of limits =0		out of limits = 0	

Breakout Direction: Up

Projection Calculation (refer to the following page):

$n_1 = 8$

$n_2 = 1$

$n_3 = 0$

$\Delta = (1.09276/2)(8+2 \times 1 + 0) + 2.25/2 = 6.5888$

PU = 68.3819 + 6.5888 = 74.971

Actual PU = 76.25

Error = 74.971 - 76.25 = -1.279

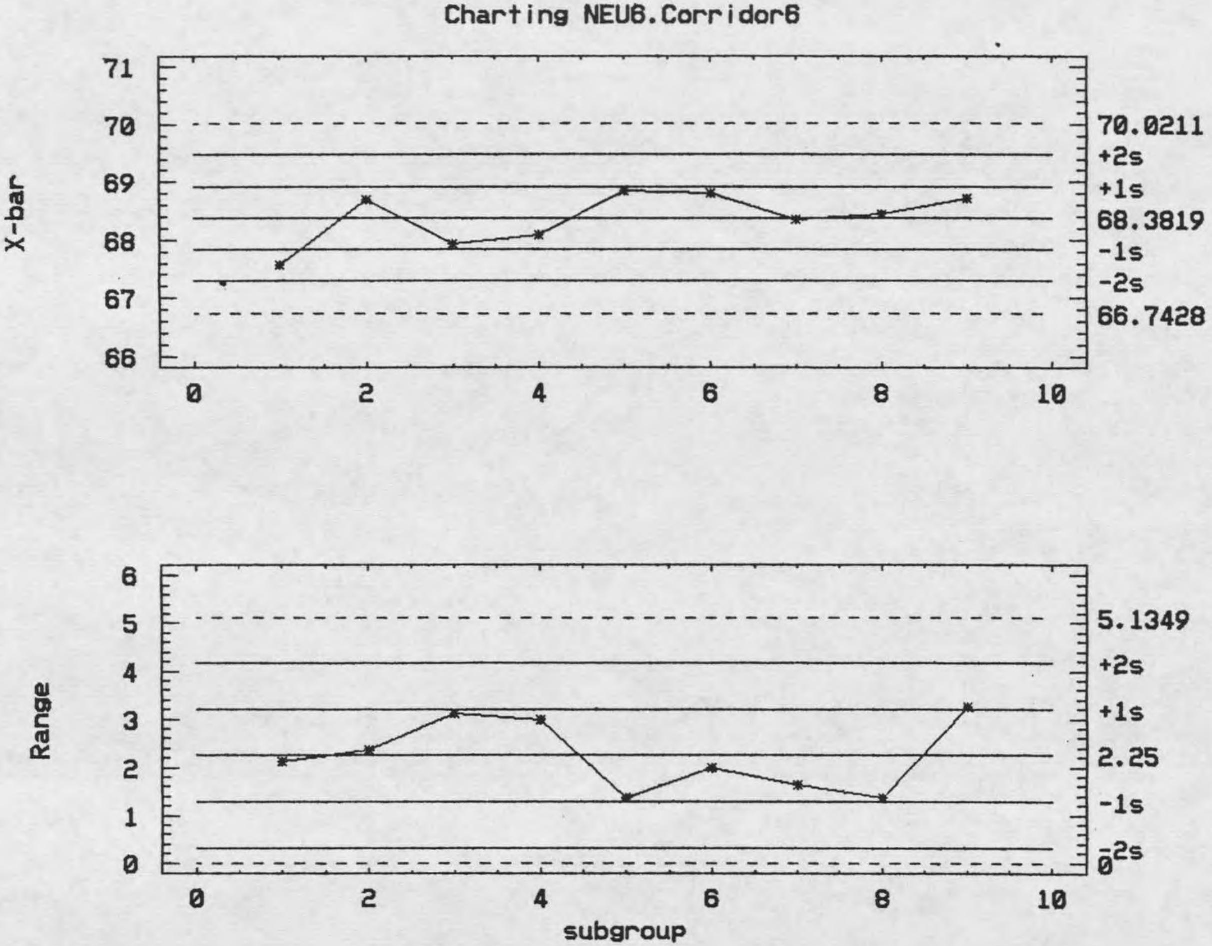

Figure 29. Control Charts Using Data from Compressed Neutral Corridor 6

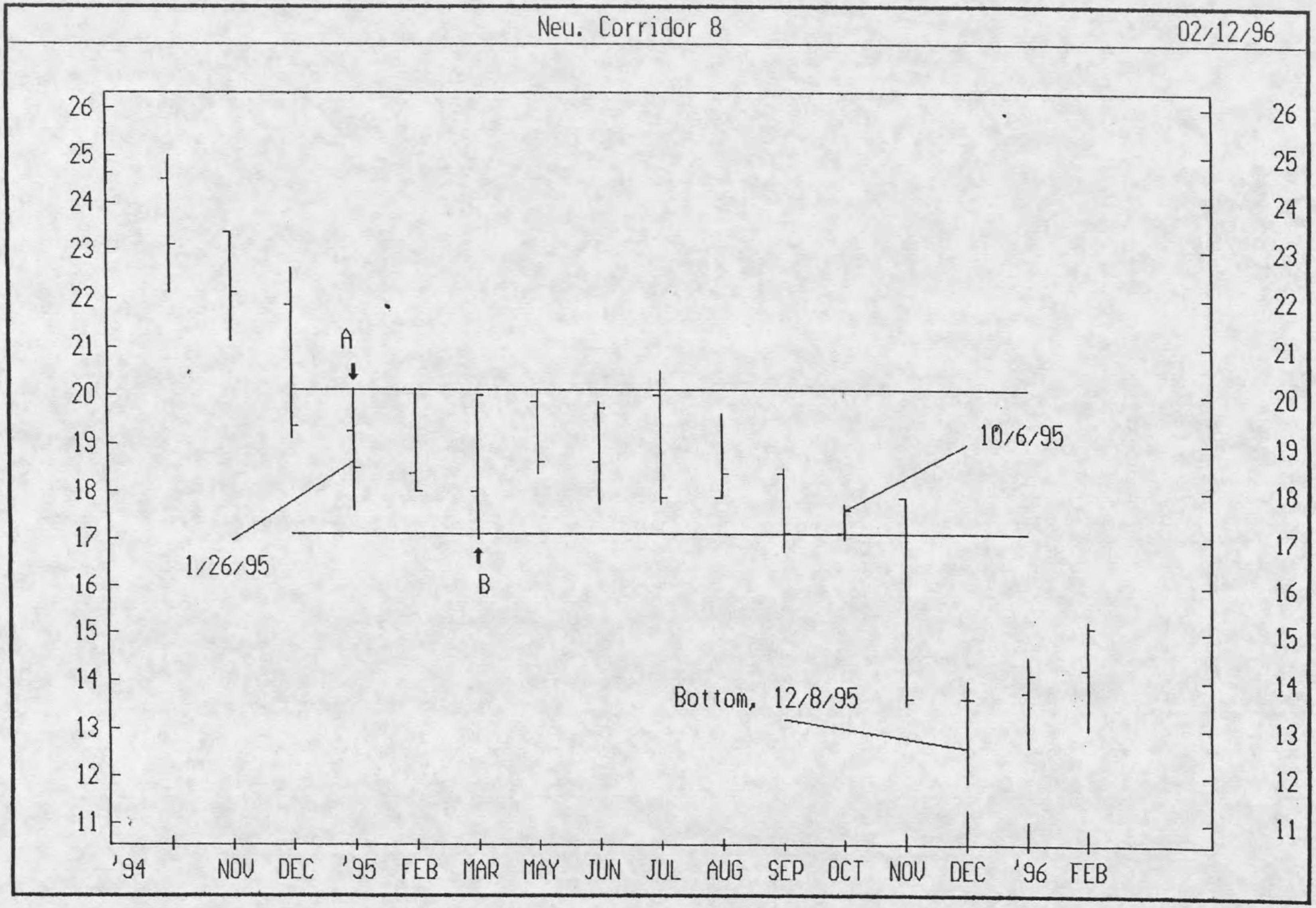

Figure 30. 22-period Compressed Neutral Corridor 8

Table 31. 22-period Compressed Data for Neutral Corridor 8

Date	Open	High	Low	Close
1/26/95	19.25	20.125	17.625	18.5
2/28/95	18.375	20.125	18	18
3/30/95	18	20	17	20
5/2/95	19.875	20.125	18.375	18.625
6/2/95	18.625	19.875	17.75	19.75
7/5/95	20	20.5	17.75	17.875
8/4/95	17.875	19.625	17.875	18.375
9/6/95	18.375	18.5	16.75	17.125
10/6/95	17.125	17.25	17	17.625

Table 32. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 8

Subgroup	X-bar	Range
1	18.875	2.5
2	18.625	2.125
3	18.75	3
4	19.25	1.75
5	19	2.125
6	19.0313	2.75
7	19.4375	1.75
8	17.6875	1.75
9	17.25	0.625

Table 33. Control Charts Set-up for Compressed Neutral Corridor 8

9 subgroup, size 4
process mean = 18.5451
process sigma = 0.991582
mean Range = 2.04167

X-bar		Range	
UCL:	+ 3.0 sigma = 20.0325	UCL:	+ 3.0 sigma = 4.65944
Centerline	=18.5451	Centerline	=2.04167
LCL:	- 3.0 sigma =17.0578	LCL:	- 3.0 sigma = 0
	out of limits =0		out of limits = 0

Breakout Direction: Down

Projection Calculation (refer to the following page):

$n_1 = 6$

$n_2 = 2$

$n_3 = 1$

$\Delta = (0.991582/2)\ (6 + 2 \times 2 + 3 \times 1) + 2.04167/2 = 7.466$

PU = 18.5451 - 7.466 = 11.079

Actual PL = 11.825

Error = 11.825 - 11.079 = 0.796

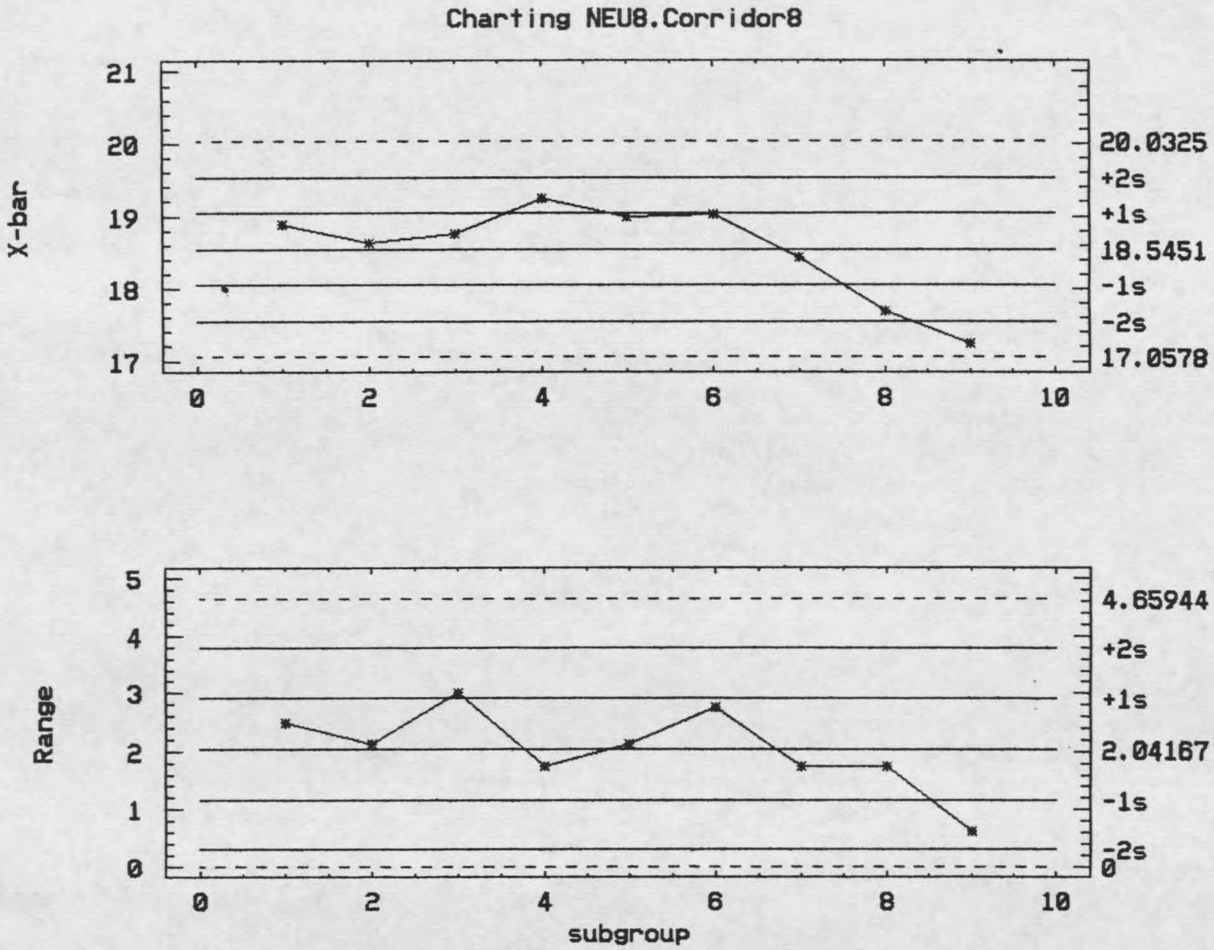

Figure 31. Control Charts Using Data from Compressed Neutral Corridor 8

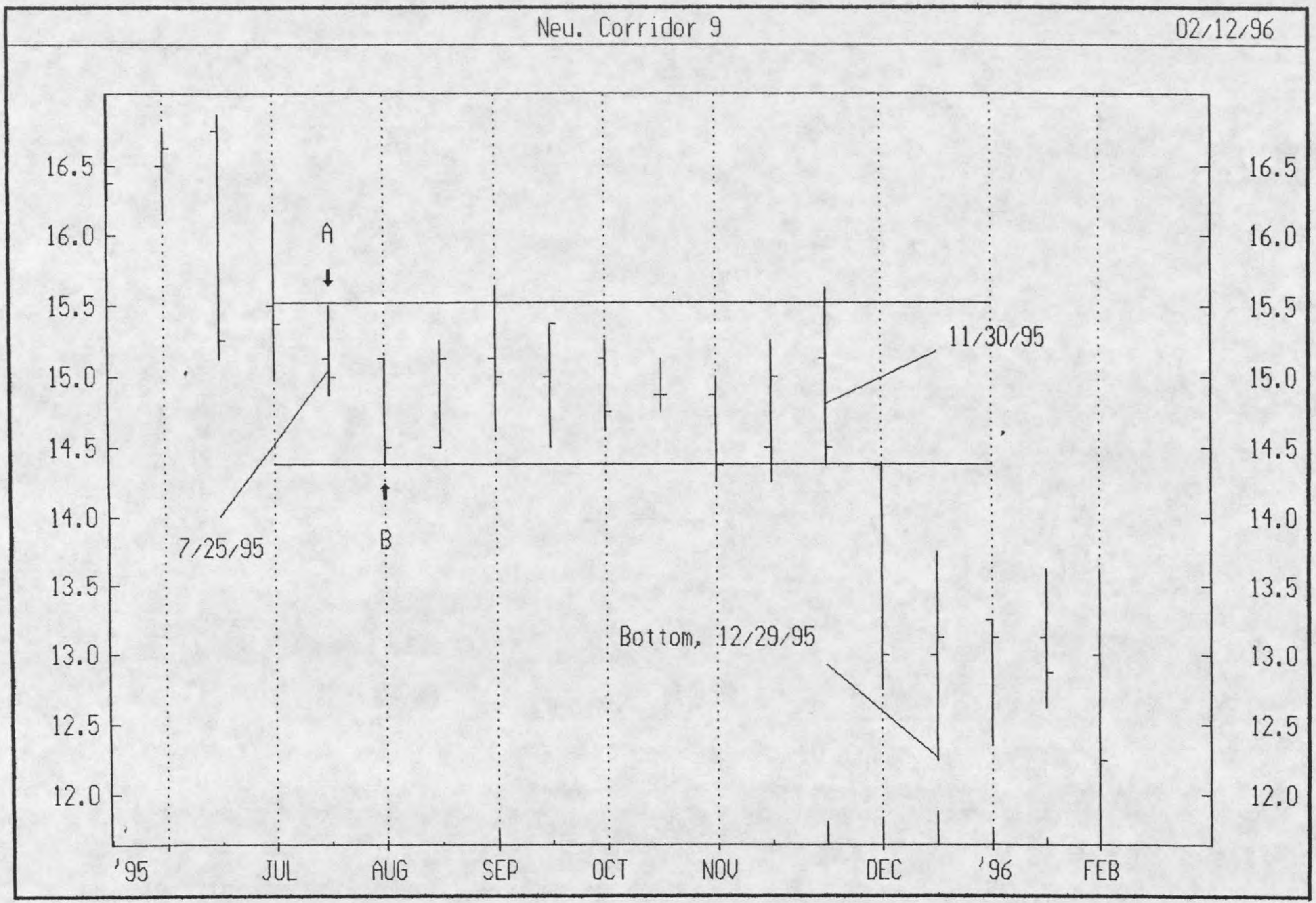

Figure 32. 10-period Compressed Neutral Corridor 9

Table 34. 10-period Compressed Data for Neutral Corridor 9

Date	Open	High	Low	Close
7/25/95	15.125	15.5	14.875	15
8/8/95	15.125	15.125	14.375	14.5
8/22/95	14.5	15.25	14.5	15.125
9/6/95	15.125	15.625	14.625	15
9/20/95	15	15.375	14.5	15.375
10/4/95	15.125	15.25	14.625	14.75
10/895	14.875	15.125	14.75	14.875
11/1/95	14.875	15	14.25	14.375
11/15/95	14.5	15.25	14.25	15
11/30/95	15.125	15.625	14.375	14.5

Table 35. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 9

Subgroup	X-bar	Range
1	15.125	0.625
2	14.7813	0.75
3	14.8438	0.75
4	15.0938	1
5	15.0625	0.875
6	14.9375	0.625
7	14.9063	0.375
8	14.625	0.75
9	14.75	1
10	14.9063	1.25

Table 36. Control Charts Set-up for Compressed Neutral Corridor 9

10 subgroup, size 4
process mean = 14.9031
process sigma =0.388538
mean Range = 0.8

X-bar		Range	
UCL: + 3.0 sigma	= 15.4859	UCL: + 3.0 sigma	= 1.82574
Centerline	=14.9031	Centerline	=0.8
LCL: - 3.0 sigma	=14.3208	LCL: - 3.0 sigma	= 0
out of limits =0		out of limits = 0	

Breakout Direction: Down

Projection Calculation (refer to the following page):

$n_1 = 8$

$n_2 = 2$

$n_3 = 0$

PL = 12.172

$\Delta = (0.388538/2)(8 + 2 \times 2 + 0) + 0.8/2 = 2.731$

PU = 14.9031 - 2.731 = 12.172

Actual PL = 12.25

Error= 12.25 - 12.172 = 0.078

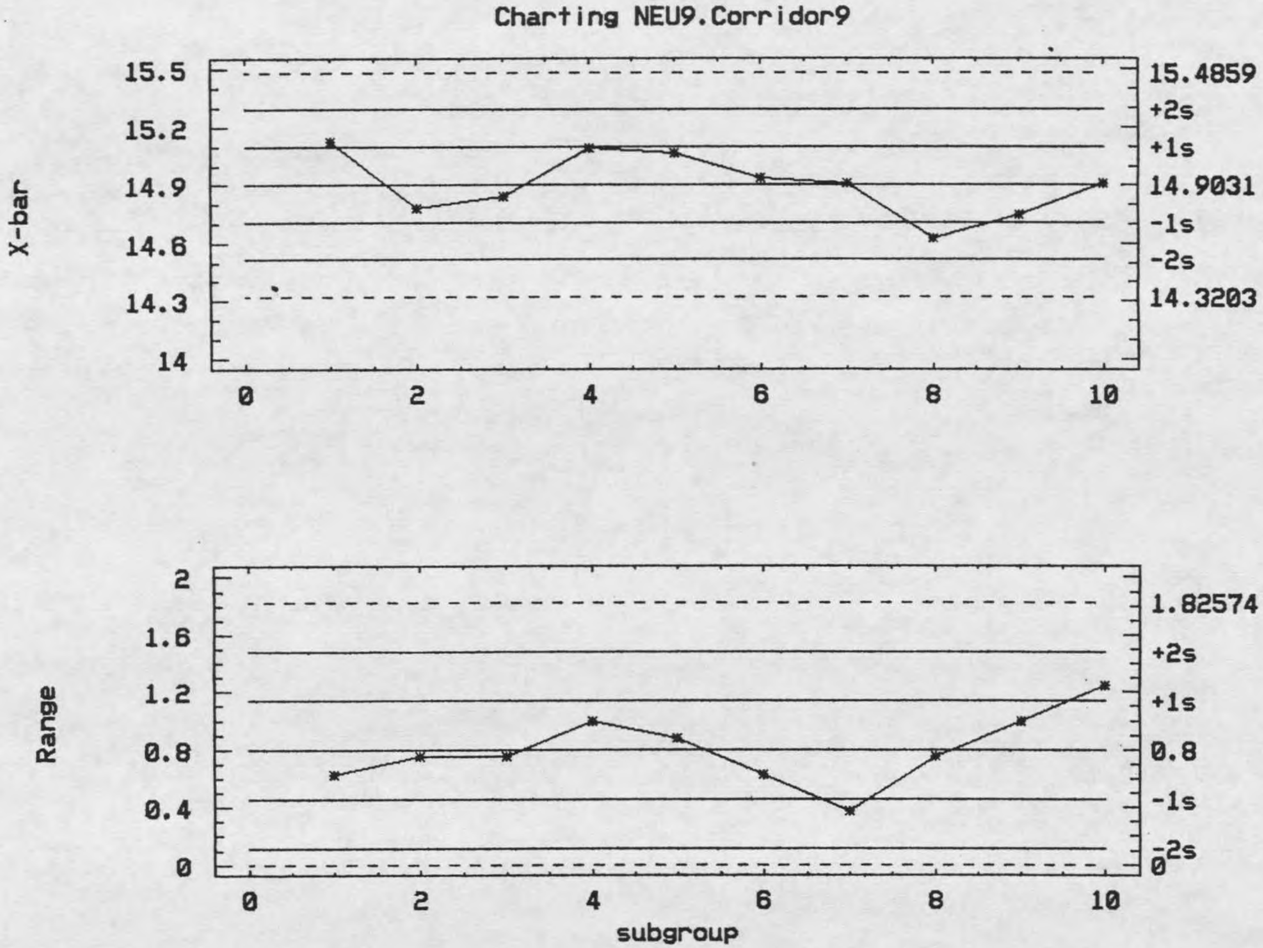

Figure 33. Control Charts Using Data from Compressed Neutral Corridor 9

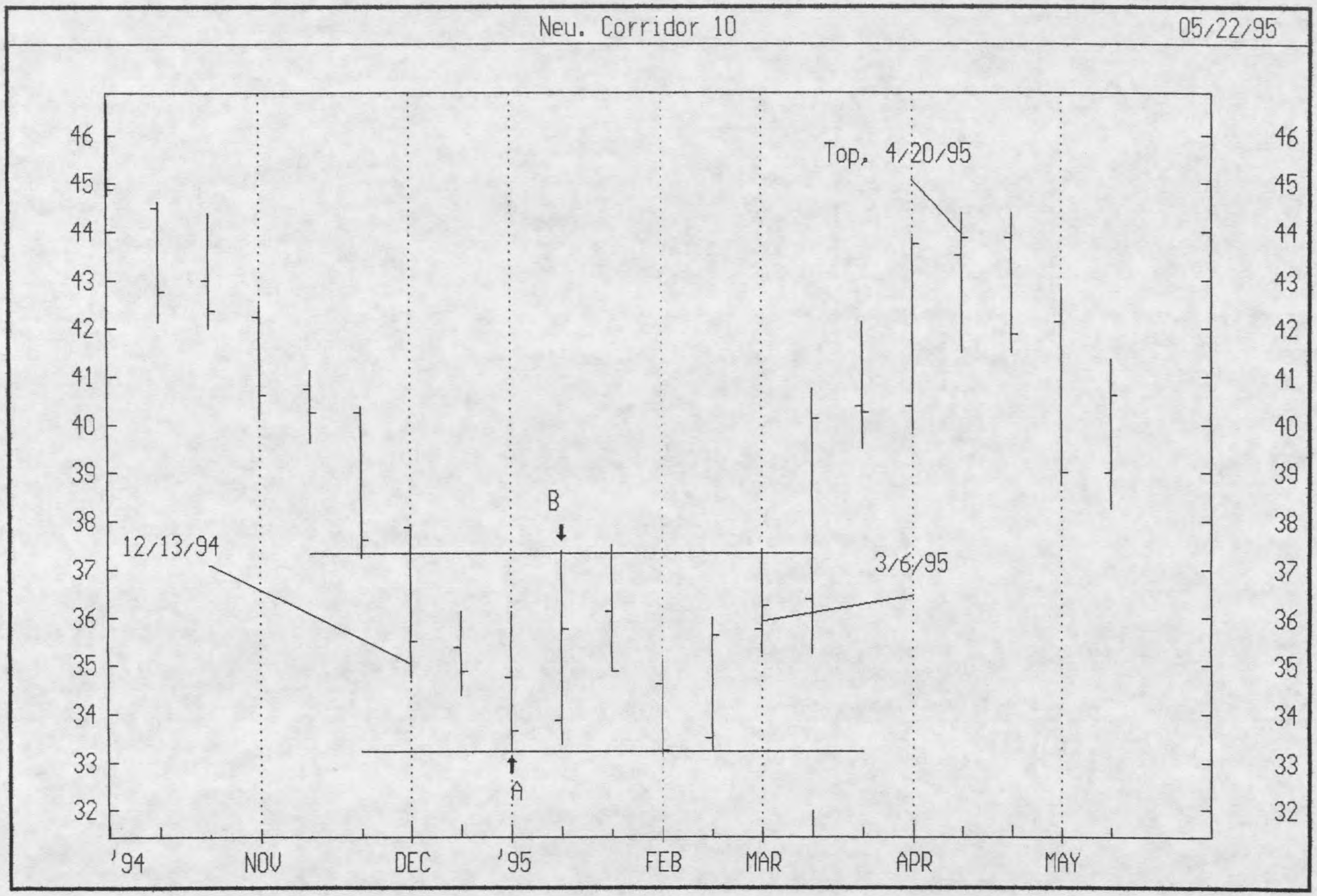

Figure 34. 8-period Compressed Neutral Corridor 10

Table 37. 8-period Compressed Data for Neutral Corridor 10

Date	Open	High	Low	Close
12/9/94	37.875	37.875	34.75	35.5
12/21/94	35.375	36.125	34.375	34.875
1/4/95	34.75	36.125	33.25	33.656
1/16/95	33.875	37.375	33.375	35.75
1/26/95	36.125	37.5	34.875	34.875
2/7/95	34.625	35.125	33.125	33.25
2/17/95	33.5	36	33.25	35.625
3/2/95	35.75	37.375	35.25	36.25

Table 38. X-bar and R Values for Each Subgroup of Compressed Neutral Corridor 10

Subgroup	X-bar	Range
1	36.5	3.125
2	35.1875	1.75
3	34.4453	2.875
4	35.0938	4
5	35.8438	2.625
6	34.0313	2
7	34.8438	3.375
8	36.1563	2.125

Table 39. Control Charts Set-up for Compressed Neutral Corridor 10

8 subgroup, size 4
process mean = 35.2627
process sigma =1.32801
mean Range = 2.73438

X-bar		Range	
UCL: + 3.0 sigma	= 37.2547	UCL: + 3.0 sigma	= 6.24032
Centerline	=35.2627	Centerline	=2.73438
LCL: - 3.0 sigma	=33.2707	LCL: - 3.0 sigma	= 0
out of limits	=0	out of limits	= 0

Breakout Direction: Up

Projection Calculation (refer to the following page):

$n_1 = 3$

$n_2 = 5$

$n_3 = 0$

$\Delta = (1.32801/2)\,(3 + 2 \times 5 + 0) + 2.73438/2 = 9.999$

PU = 35.2627 + 9.999 = 45.262

Actual PU = 44.375

Error= 45.262 - 44.375 = 0.887

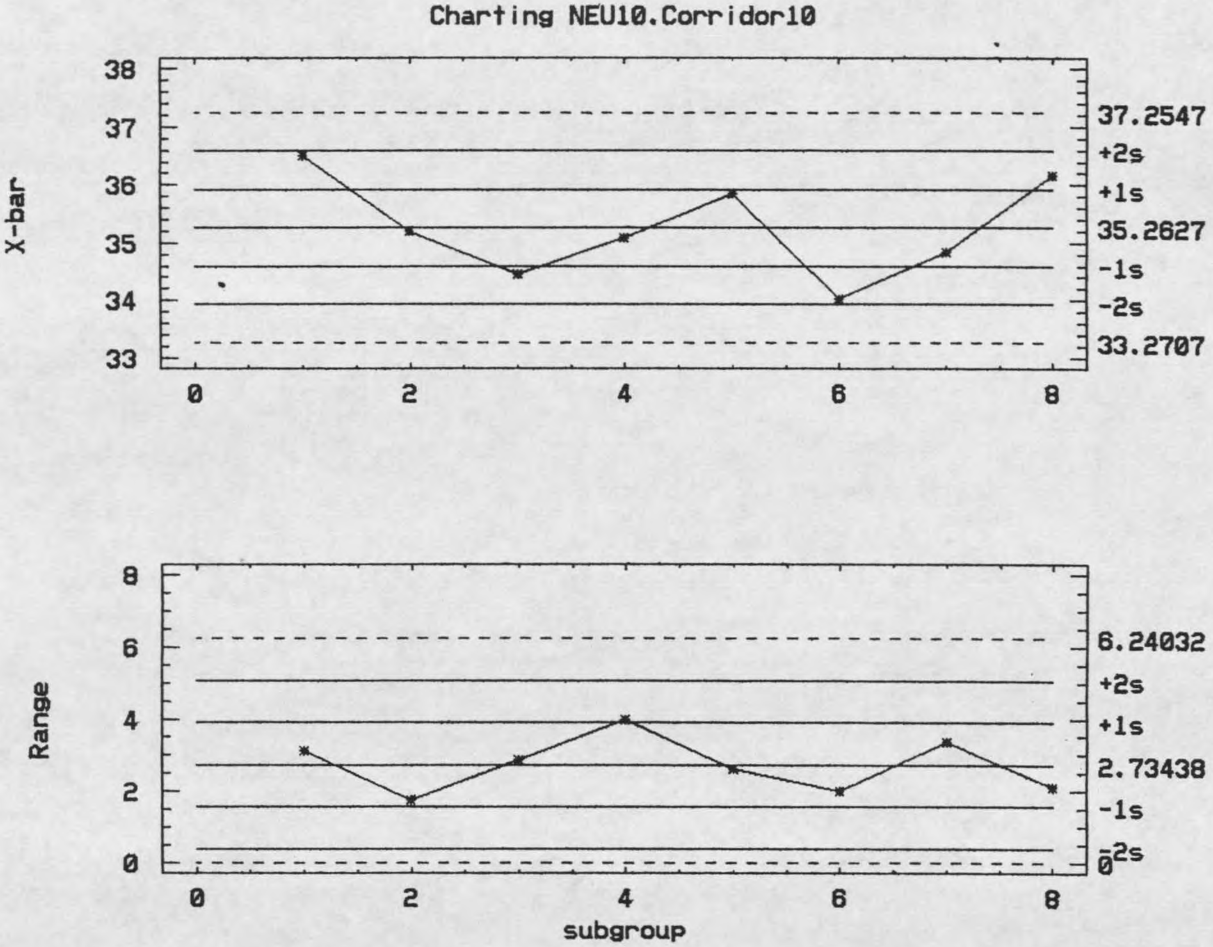

Figure 35. Control Charts Using Data from Compressed Neutral Corridor 10

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