IMPROVED INVENTORY CONTROL AT BOART HARDMETALS (PTY) LTD

BY: M Jagoe

IMPROVED INVENTORY CONTROL AT BOART HARDMETALS (PTY) LIMITED

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ABSTRACT

This work covers the use of exponential smoothing in calculating order points. Various exponential models are tested and based on an inventory simulation, a model is chosen that will reduce the total inventory holsing. Rules are developed for re.ordering inventory; A-B-C analysis of the inventory is used to highlight those items requiring tight control and a furthe' analysis by by customer is used to indicate demand vulnerability. Savings of at least 28% of the inventory costs are expected.

DECLARATION

I hereby declare that this is
my own, unaided work

M Jagoe

For reasons of confidentiality, the following alterations have been made to this report:

1) All part numbers have been deleted. Reference numbers have been given to the six items specifically dealt with in the report.

2) All rand values for inventory and sales listings have been deleted.

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1. SUMMARY

1.1 Scope of the Report

This report covers the use of time series analysis techniques for inventory demand.

An inventory simulation is carried out, using the forecasted demand, and it is shown that inventory can be reduced by 20%.

1.2 Findings

1.2.1 An ABC analysis of the sales and associated demand for some items is performed. Only items 7% of the total demand for these items were considered. Less or more customers, or products in the analysis, can lead to redundant stock.

1.2.2 The forecasting system needs to have pertinent marketing information.

1.2.3 The inventory simulation shows the distinct advantage of regular monitoring of demand. An inventory saving of R84 500 was possible in the period April 1980 to January 1981.

1.2.4 These savings can be obtained by using an exponential smoothing model, with the tracking signal used as a control parameter. The R84 500 saving can be increased to R114 000 by better matching of the forecasting model to individual demand data.

1.3 Conclusions

1.3.1 The current inventory ordering system is inadequate. The re-order point is not recalculated frequently enough nor does it have any statistical basis. The order point should be recalculated monthly as described in this report.

1.3.2 An A-B-C analysis should be carried out regularly (every three months) and cover at least the past six month's sales. This analysis should be used for:

a) Determining demand vulnerability by analysing the 'A' items by customer.

b) Choosing the forecasting model. The exponential smoothing model (using the tracking signal as a control parameter) is suggested for 'A' items. Adaptive smoothing using the Trigg and Leach model, is suggested for 'B' items. 'C' items should be made only on receipt of a customer order.

1.3.3 Inventory should be ordered on the basis of the ordering rules suggested in Section 7.7.6.

1.3.4 Exception reports must be produced monthly for all forecasts that are out of control. The products should be listed in their A-B-C rankings, so that the most important items receive attention first.

1.3.5 Further work should be carried out to determine the optimum distribution of inventory amongst the various branches. The inventory savings calculated in this report are based on the assumption that all demand is satisfied from one central point. The branches could possibly be more economically and efficiently served by special weekly deliveries from the central point. This is particularly attractive as 74% of the sales take place from three branch offices, excluding the central branch.

2. INTRODUCTION

1.1 Why Forecast?

Many forecasts are made in the course of running a business. And they are used for a variety of purposes. Forecasts can be used for setting budgets, planning capital expenditure and for production and inventory control planning.

The need for forecasting most frequently arises because a production or inventory control system consists of a series of decision rules. These rules specify [illegible] size and quantity for any particular item. They are [illegible] on a routine basis to many products.

De Salvia (6) points out that a business firm is operating in an environment of uncertainty, and ultimately the firm has to adjust or adapt to this environment. He notes that, in the manufacturing area, there are only three basic means of adapting to uncertainty:

> "1. The firm may develop flexible means of production - flexible in its ability to alter rates of production and flexible with regard to product changes.
>
> 2. The firm may cushion itself from the effects of uncertainty through inventory policies, particularly in regard to safety stocks.
>
> 3. Finally, the firm may attempt to reduce uncertainty through improved methods, prediction or forecasting."

He notes that these three courses of action are not mutually exclusive. The actual course adopted may be some mixture of the three. Furthermore, each course of action has its own cost [illegible] with it and ideally one should minimise costs. Forecasting is therefore one way in which a firm can try to [illegible] the uncertainty of the future.

Buffa (1) points out that a forecast is essential in [illegible] a valid production schedule. This schedule is an [illegible] document required by the production and inventory control [illegible] in order to plan the factory work load and [illegible] requirements.

Mechanistic forecasting, using a computer model with a monitoring system provides for exception reporting.

A further reason for forecasting is the fact that lead times for raw material and capiral equipment generally far exceed those for production. It is therefore necessary to order the raw material or equipment long before production orders are raised. Forecasting of the correct items and quantities will enable stock reductions to be carried out and customer service to be improved.

3.2 What To Forecast

Orlicky (9) first proposed the independent-dependent demand principle in 1971, in which he states that demand should only be forecast for independent demand items. These are items which he defines as finished goods, or service parts not used in current production, or items where the demand is unrelated to that of others. On the other hand, where demand is dependent, ie related to the demand for other finished goods, it must not be forecasted, but calculated through a bill of material explosion, based on the demand for the finished goods.

It is also necessary to sort the sales items into order of importance. An A-B-C (Pareto) analysis will rank the sales in descending order of sales value. Stratton (11) points out that the A-B-C analysis will prompt the marketing product managers to examine their product lines more closely in order to identify low sales and low profit items. It will also assist management in identifying those items which constitute the bulk of the sales value.

3.3 Forecasting Systems

There are three basic groups of forecasting systems:

a) Qualitative

b) Causal

c) Time series

1.3.1 Qualitative Systems

In this case, all information and judgements related to an item's demand are used to forecast the future demand. It is often used when little evidence is available. The forecasts could also be based on market research studies. It is most suited to the forecasting of demand for a product group rather than for individual items due to the judgemental nature of the forecasting process.

1.3.2 Causal Systems

In this instance, the forecaster attempts to find a relationship between some indicator or index and the demand for an item or product group. A cause and effect relationship is sought. These techniques are also more suited to forecasting the demand of product groups, because of the cost and effort involved in finding a causal relationship.

1.3.3 Time Series Analysis

These techniques rely on a statistical analysis of historical demand to predict future demand. It assumes that underlying trends in the past will be continued into the future. Items which do not fall into this category should not be forecasted using this method. They are better served by techniques mentioned in 1.3.1 and 1.3.2.

It is generally accepted[1] that forecasting based on time series analysis is the most economical method, when the demand for a large number of items has to be forecasted on a routine basis. The method used is basically experimental as the validity of the principle of it. However, one can be encouraged to use the method by the fact that it assumes that the pattern of consumption sales will continue to behave as in the past.

---

[1] (4) p 10
[2] (5) p 31
[3] (5) p 15

3.4 Demand Patterns

Demand patterns must be recognised in order to select the correct forecasting model.

3.4.1 Horizontal Demand Patterns

In this case it is assumed that random fluctuations in the demand occur about a mean level which remains unchanged with the passage of time.

3.4.2 Trend Demand Patterns

In this case the mean level of demand is either rising or falling. Typical examples are the introduction of a new product and the phasing out of an old one.

3.4.3 Seasonal Demand Patterns

In this case demand is varying in a fairly regular manner over a period of time. Such examples include sales of ice cream, heating oil and greetings cards.

3.4.4 Cyclical Demand Patterns

These are demand patterns that are affected by general economic conditions. Sales of consumer durables such as cars and washing machines are affected by the general state of the economy. Long range forecasts are an aid to good economic planning. Techniques like Box-Jenkins are useful in isolating cyclical trend due to the increased size of the standard deviation.

3.5 Demand Distribution

The following assumptions are made about the demand distribution in order that the time series analysis techniques can be applied:

a) The demand distribution is symmetrical

b) The demand distribution is unimodal

c) The fluctuations about the mean are due to random influences.

4. REVIEW OF THE LITERATURE ON TIME SERIES ANALYSIS

4.1 Introduction

The literature on forecasting is so voluminous that I have drawn on previous surveys by Lewis (7) and Oduardo (8). The authors [Brown (2)] point out that for cost effective control it is essential that the forecasting model should:

1) Require the minimum of historical data.

2) Be able to introduce the latest demand information as quickly as possible.

3) Be simple to calculate.

The models discussed below (except for moving averages) comply with the above requirements. In addition, interpretation of these models does not require an extensive mathematical background. This is an important point since, as Lewis (7) points out:

> "One of the principle reasons why forecasting techniques have not gained an even more widespread acceptance than they have, has been the very natural antagonism toward the use of mathematics."

4.2 Types Of Models

4.2.1 Stationary Models

These are models to be used where the demand pattern is essentially horizontal, eg

1) Moving averages
2) Exponential smoothing

4.2.2 Growth Models

Where the demand pattern is rising or falling, the models mentioned in 4.2.1 tend to lag behind the demand. When the demand is growing, it is being under-forecasted and when it is falling it is being over-forecasted. In

order to overcome these deficiencies, other models were developed, such as exponential smoothing with a trend adjustment. The trend adjustment term will attempt to reduce the forecast error by anticipating the trend. De Salvia [6] covers this model in detail.

4.2.3 Seasonal Models

Brown [IV] developed a model [illegible] seasonality [illegible] factors. As all seasonal fluctuations have been noticed in the demand pattern under consideration, this type of model has not been included in future work.

4.2.4 Adaptive Control Models

Adaptive models have been developed because of the length of time it takes the conventional exponentially smoothed model to react to changes in demand levels. In these models, the smoothing factor is adjusted automatically to allow the model to respond quickly to [illegible] changes in demand. When the model has adjusted to the new level, the smoothing factor is reset to its [illegible] value.

4.3 [illegible] Techniques

4.3.1 [illegible] Average Model

[illegible] average model utilizes a constant for the next period in calculating the [illegible] average of the [illegible] the number of periods included in the moving [illegible]. In a six month moving average it was used to find [illegible]'s sales [illegible] by taking a six-[illegible] average would be used as a forecast for the next [illegible]. A month later, [illegible] sales figure is obtained, [illegible] is included and a new six month moving average is [illegible].

$$\bar{x}(n)_6 = \sum_{i=n-5}^{n} (x_i)/6 \qquad (10)$$

and in the next period

$$\bar{x}(n+1)_6 = \sum_{i=n-4}^{n+1} (x_i)/6$$

This method places an equal weight (or importance) on all the past data. If there is a trend increasing or falling present reflected in the latest data, the forecast will be very slow to respond to it. From a computational point of view, the amount of data that has to be carried in order to compute the moving average is a definite disadvantage.

4.3.2. Exponential Smoothing

4.3.2.1 The Exponential Smoothing Equation

Exponential smoothing was first developed by Brown (2) (3) and this method has the advantage that the minimum amount of information has to be stored for each item.
The equation is

$$NF = \alpha ND + (1-\alpha)OF \quad \text{——— (1)}$$

Where NF = new forecast
ND = new demand information
OF = previous forecast
α = smoothing coefficient = alpha

Alpha (also known as the smoothing factor) is [illegible] between the values zero to plus one. [illegible] to 0,2 (20%) one can [illegible] ...

"[illegible] of the latest demand
[illegible] of the old forecast
to generate the forecast for the
next period."

Thus in each period, only 20% of the latest demand information is fed into the forecast. This has the effect of considerably dampening fluctuations in demand level from month to month.

Brown (2) has shown that equation 1 is equivalent to a linear combination of all past demands, where the weight given to each past demand decreases geometrically with age. The exponential smoothing system is quite flexible:
When alpha is very small, the forecast function behaves like an average with a great deal of past data (its response to change is very slow). When alpha is large, the forecast function responds rapidly to change.

4.3.2.2 Selecting A Smoothing Factor

The smoothing factor used, produces an average in which the weight for past observations decreases geometrically, whereas the moving average weights the N most recent observations each with 1/N. Table 1 from Brown (2) shows the relationship between the smoothing factor and the equivalent number of observations in a moving average.
The relationship is given by:

$$\alpha = \frac{2}{N + 1}$$

TABLE 1

RELATIONSHIP BETWEEN NUMBER OF OBSERVATIONS IN A MOVING AVERAGE AND THE SMOOTHING FACTOR

N	Alpha
3.0	0.5
4.0	0.4
5.0	0.33
5.78	0.3
6.0	0.286
9.0	0.2
12.0	0.154
18.0	0.105
19.0	0.1
39.0	0.05

[illegible] (2) points out that if a trial run on actual data indicates that alpha should exceed 0.5, then the data should be examined as it might exhibit a significant trend or seasonal [illegible] In this instance, the use of a [illegible]

[illegible]

In order to evaluate the forecasting model it is necessary to compare the forecasted sales to the actual sales. The forecasting error is defined as:

$$E_t = D_t - F_t \qquad \text{(1)}$$

Where E_t = forecast error in period t
D_t = Actual demand in period t
F_t = Forecasted sales in period t made in period t-1

By making use of equation 1, the average error can be efficiently calculated in each period, using the minimum of data. In this case a smoothing factor - gamma - is used ($0 < \text{gamma} < 1$). Note that gamma could be equal to alpha but this is not necessary.

$$\bar{E}_t = \gamma(E_t) + (1 - \gamma)\bar{E}_{t-1} \quad \text{——— (3)}$$

Where $\bar{E}_t$ = smoothed average error in period t

$\bar{E}_{t-1}$ = smoothed average error in period t-1

Similarly, the smoothed mean absolute error can be calculated:

$$\overline{MAD}_t = \gamma(\ /E_t/\ ) + (1 - \gamma)\overline{MAD}_{t-1} \quad \text{——— (4)}$$

Where $\overline{MAD}_t$ = smoothed mean absolute error in period t

$/E_t/$ = absolute error in period t

$\overline{MAD}_{t-1}$ = smoothed mean absolute error in period t-1

The trend in the forecast is defined as:

$$T_t = F_t - F_{t-1}$$

The smoothed average trend can be calculated in a similar manner:

$$\bar{T}_t = \gamma(T_t) + (1 - \gamma)\bar{T}_{t-1} \quad \text{——— (5)}$$

Where T_t = current trend in period t

$\bar{T}_t$ = smoothed average trend in period t

$\bar{T}_{t-1}$ = smoothed average trend in period t-1

4.3.2.4 Tracking Signals

Tracking signals were developed to monitor the performance of the forecasting models. They are used to alert when the forecasting model is out of control. A number of tracking signals have been proposed, but the one first proposed by Trigg (13) has received considerable attention.

$$\frac{\quad}{\quad} \quad (6)$$

This tracking signal will fluctuate between plus and minus unity. When the forecasting system is under control, it will fluctuate about zero. It will move towards plus or minus unity, according to the direction of the bias in the forecasting errors.

4.3.3 Adaptive Smoothing - Trigg and Leach Method

One of the disadvantages of the models discussed above is the fact that their parameters have to be monitored, and modified manually, when the forecasts go out of control. In a situation where the demand for thousands of items is being forecasted, the number of exception messages and amount of manual intervention required to keep the system going, could be enormous. Some authors, therefore, started developing models whereby the smoothing factor alpha, is varied automatically to allow the model to respond to changes.

The Trigg and Leach (14) model proposed that alpha be varied in proportion to the amount of bias being obtained in the forecasts. This results in the model having the following characteristics:

a) Forecast bias low — then alpha small
— model stable with slow response to changes in demand

b) Forecast bias high — then alpha large
— model has rapid response to changes in demand

This model makes use of the tracking signal defined in equation 6 in 4.3.2.4.
Since the absolute value of the tracking signal fluctuates between zero and unity, and it tends towards unity when the forecast errors are large, Trigg and Leach proposed a model where

$$\alpha_t = |TS|$$

Trigg and Leach (16) point out that the rate at which the system will repond to changes is affected by the value of gamma, where gamma is used for smoothing the average error and mean absolute deviation. The value of gamma between 0,05 and 0,1 is recommended; higher values leading to instability.

Dennis (5) proposed a model using the exponential smoothing equation, but controlling it on the basis of "Runs" of errors. The model counts the number of consecutive times a positive or negative forecasting error is obtained, and compares this against a preset parameter. If the length of the run exceeds the value of the preset parameter, alpha is adjusted upwards. An error of either zero or opposite sign is used to indicate the end of a run and the value of alpha is then immediately reset to its base value.
Dennis (5) reports on a test comparing this model to one proposed by Whybark (15) (a model where the forecast error is compared with the standard deviation of the forecast error, and alpha is adjusted on the basis of

this comparison). He shows that the run based model performed better than the Whybark model. He points out that the model is computationally efficient and easy to understand.

[illegible] A Forecasting Model

[illegible] Forecasting Models

[illegible]ing of a forecasting model is necessary in order to detect real changes in demand. When a real change happens the signal must indicate this change to the person in charge of forecasting. A new model might be required, or alpha might have to be reset to a higher value for a few periods to allow the model to adjust rapidly to the new situation.

Trigg's (13) tracking signal is widely used to indicate when a real change occurs and Batty (1) produced a table of cumulative probabilities for use with the tracking signal. An observer may then determine the statistical confidence in his hypothesis that a significant change has taken place in the mean level of demand.

TABLE 2 [1]

SINGLE EXPONENTIAL SMOOTHING

CUMULATIVE PROBABILITY TABLE FOR VARIOUS VALUES OF ALPHA

CUMULATIVE PROBABILITY	TRACKING SIGNAL			
	$\alpha = 0,1$	$\alpha = 0,2$	$\alpha = 0,3$	$\alpha = 0,4$
[illegible]	0,24	0,33	0,44	0,53
[illegible]	0,29	0,40	0,52	0,62
0,85	0,32	0,45	0,57	0,67
0,9	0,35	0,50	0,63	0,72
0,95	0,42	0,58	0,71	0,8
0,96	0,43	0,60	0,73	0,82
0,97	0,45	0,62	0,76	0,84
0,98	0,48	0,66	0,79	0,87
0,99	0,53	0,71	0,82	0,92

[1] Source : Batty (1)

Thus if one requires a confidence level of [illegible] that the forecasting system is under control the tracking signal must not exceed [illegible] for alpha = 0.1.

4.4.2 Adaptive Forecasting Models

Batty [1] points out that the limits in Table [illegible] cannot be used to monitor an adaptive forecasting system. The only indication of trouble in an adaptive model is when the tracking signal moves away from zero [illegible]. An arbitrary cut-off value on the tracking signal can be used to which the [illegible] [illegible] [illegible] of about [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] monitoring.

4.5 Demand Filtering

Filtering of the demand data is necessary [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible].

The following method is due to Brown [2] and can be used as a [illegible] to automatically filter the demand data.

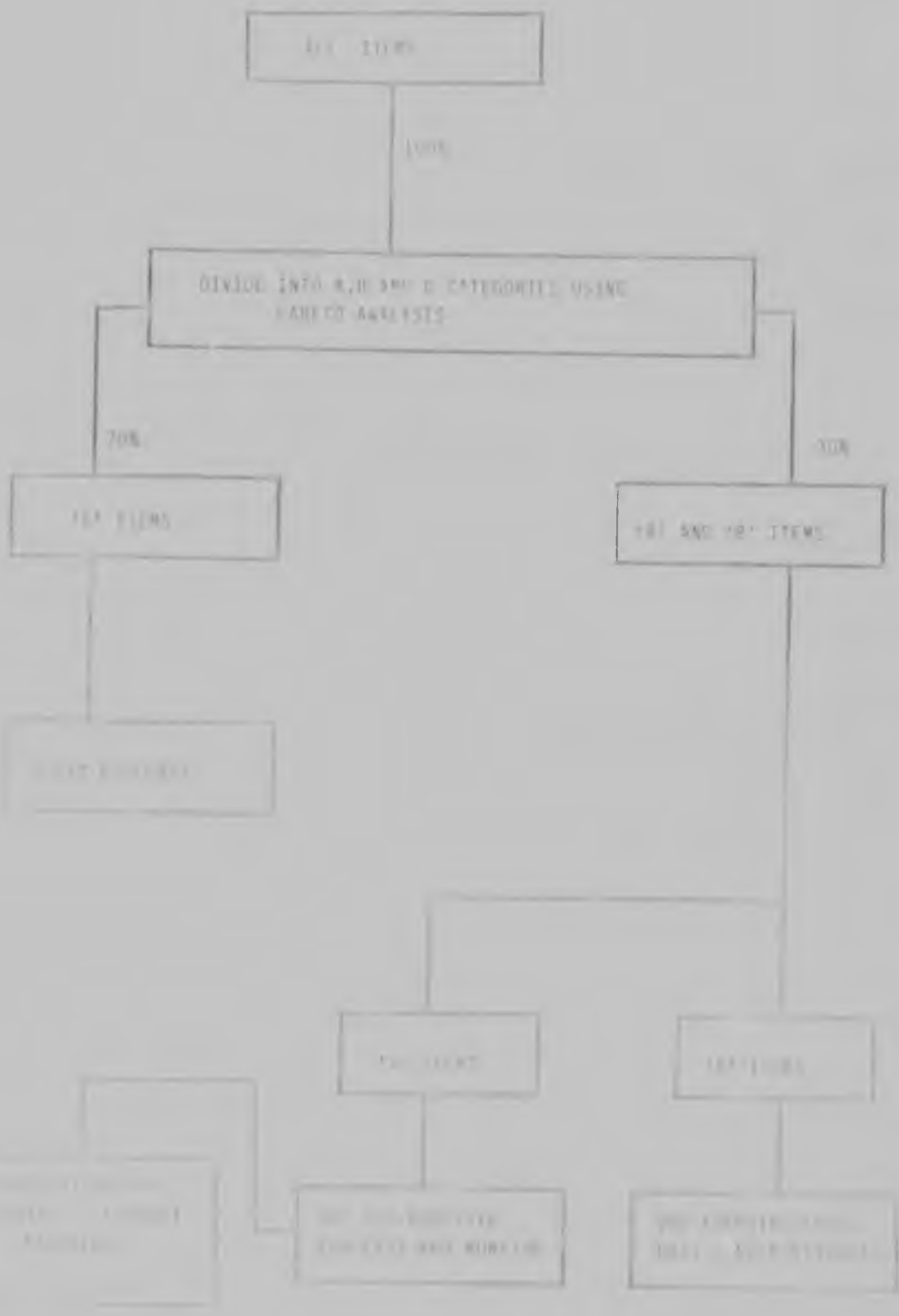

FIGURE 1

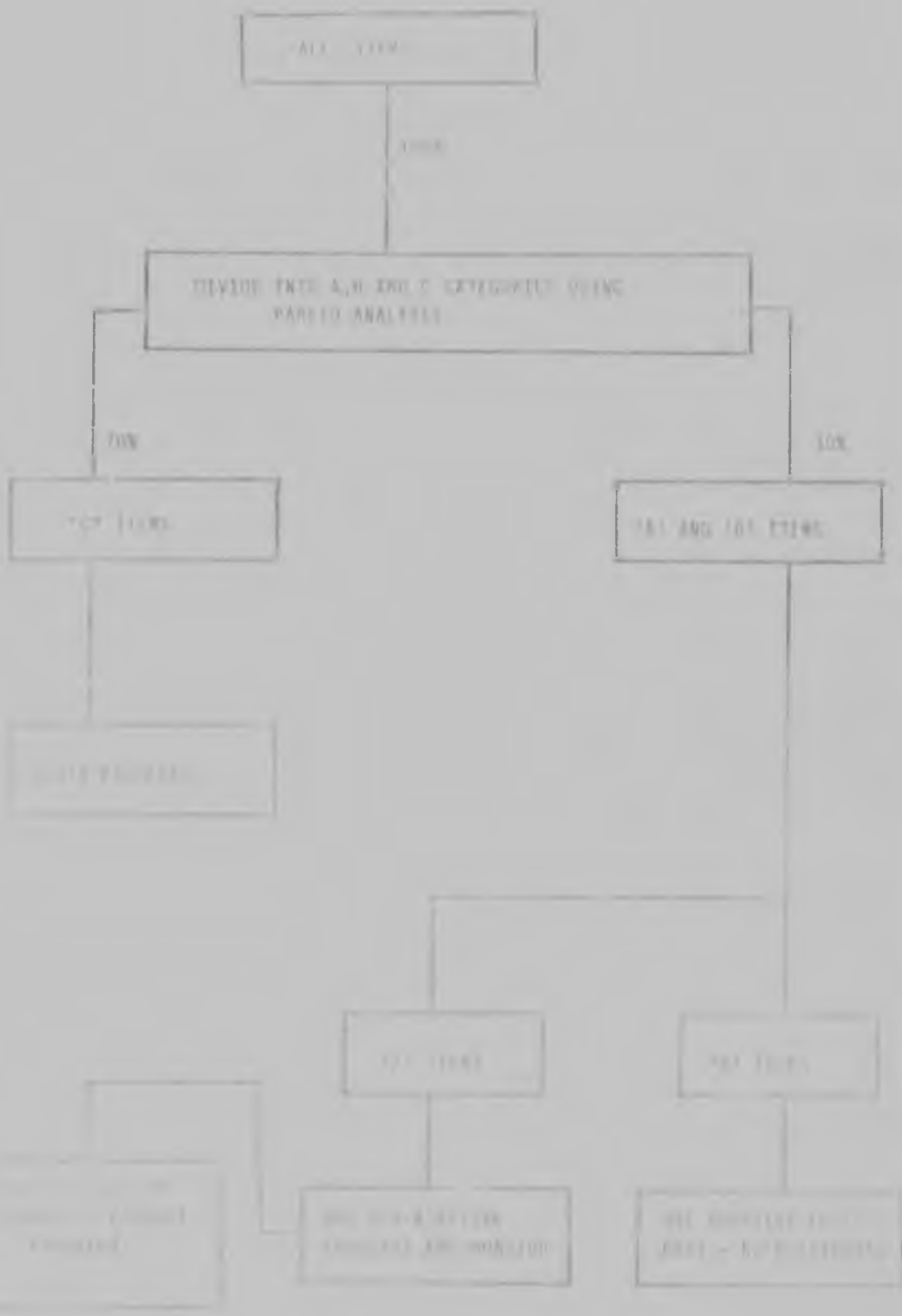

FIGURE 1

Brown calculates

$$K = \frac{D_t - F_t}{S.D.}$$

Where D_t = demand in period t
F_t = forecast of demand for period t
S.D. = standard deviation of forecast error

Brown shows that when $K > 3,5$ (for tight control) the value D_t can be treated as an outlier. In this case D_t can be filtered and reset as follows:

$$\text{Filtered } D_t = F_t \pm 3 \text{ (S.D.)}$$

The sign in the above equation will depend on whether

$$D_t > F_t \quad \text{or} \quad D_t < F_t$$

4.6 Order Point And Order Quantities

Classical inventory control is based on using an order point/ order quantity system for ordering independent demand items (see section 3.2 for the definition of independent demand). This theory has been well developed and is summarised below.

$$OP = DDLT + SS$$

Where OP = order point
DDLT = demand during lead time
SS = safety stock

The order point can be recalculated as frequently as required and the advantages of frequent recalculation will be shown in section 7.

Every time the stock-on-hand plus stock-on-order drops below the order point, one order quantity is ordered from the factory. The safety stock is calculated from the mean absolute deviation of the demand. The details are given in section 4.7.

This system is based on a set of rules to define the workings of the model. These rules must define:

a) How to calculate DDLT
b) What quantity to order

Proposed rules are developed in section 7.

Service Level and Safety Stock

A number of definitions of service level exist. One used by BOART is:

$$\text{S.L.} = \frac{\text{N° of orders delivered from stock}}{\text{N° of orders received}}$$

The target service level is set at
Safety stock is held as a buffer against variations in
a) Lead time from the factory
b) Demand from the customer

The amount of safety stock held is dependent on:
a) Demand variability as measured by mean absolute deviation;
b) Service level;
c) Ratio of lead time period to demand interval period

Extract of the tables of safety stock factors and a sample calculation are shown in Appendix 5.
Table 3 overleaf indicates the safety stock required for the six top 'A' items (note that the safety stock forms only part of the actual stock holding). These results are strictly only true for demand distributions that are symmetrical and therefore the safety stocks calculated for the first two products (where demand is changing rapidly) are not applicable. A management decision must be made on the stocking policy to be followed. This could be based on a contract with the customer, in the case of the first product, where one customer accounts for 86% of the demand.
In the case of the second product, account must be taken of the various customers demand and stock levels determined accordingly.

TABLE 3

SAFETY STOCK REQUIREMENTS

Item #	M.A.D.	Lead Time Adjustment Factor	Safety Stock Factor	Safety Stock	24 Month Average Sales
11	466	1.63	1.60	1215	6411
12	379	1.63	1.60	988	4978
13	110	1.63	1.60	287	1511
14	121	1.63	1.60	316	2316
15	36	1.63	1.60	100	1154
16	20	1.63	1.60	52	612
TOTAL ITEMS 1-16	1132	1.63	1.60	1443	17022

5. REVIEW OF THE TEST DATA

5.1 Extraction of the data

For the purpose of this dissertation, the sales data for one product group was chosen. This product group represents approximately 85.9 million sales records per month. Production planning and inventory control staff experience numerous problems with this group, so changes are in urgent need for determining corrective action.

The monthly sales records were transferred from a Digital Equipment VAX 11/780 computer, on which the data is held, to an IBM 3081 on the existing network.

Figure 2 gives an overview of the system used.

The following programs were used:

a) The program 'Extract' was written to extract the required product group sales history for the last nine months. This data is stored into a sequential file number one.

b) The program 'Customer' was written to read the data, selecting sales only for active customers (customers not officially de-registered from the system). (This rule proved to be inadequate because some customers were still active).

c) The program 'ABC' was written to produce an 'ABC' listing for any period selected from the sequential file number one data. Sample reports are shown in Appendix 2.
The A-B-C listing was used to isolate broken down lines awaiting withdrawal. The customers are kept at the 'A' and 'B' lines.

d) The program 'Cust' produces a ranking of the customers by account value. (See Appendix 3)

e) The program 'Sort' produces a twenty four month listing of all the sales in the product group in descending order of sales value.

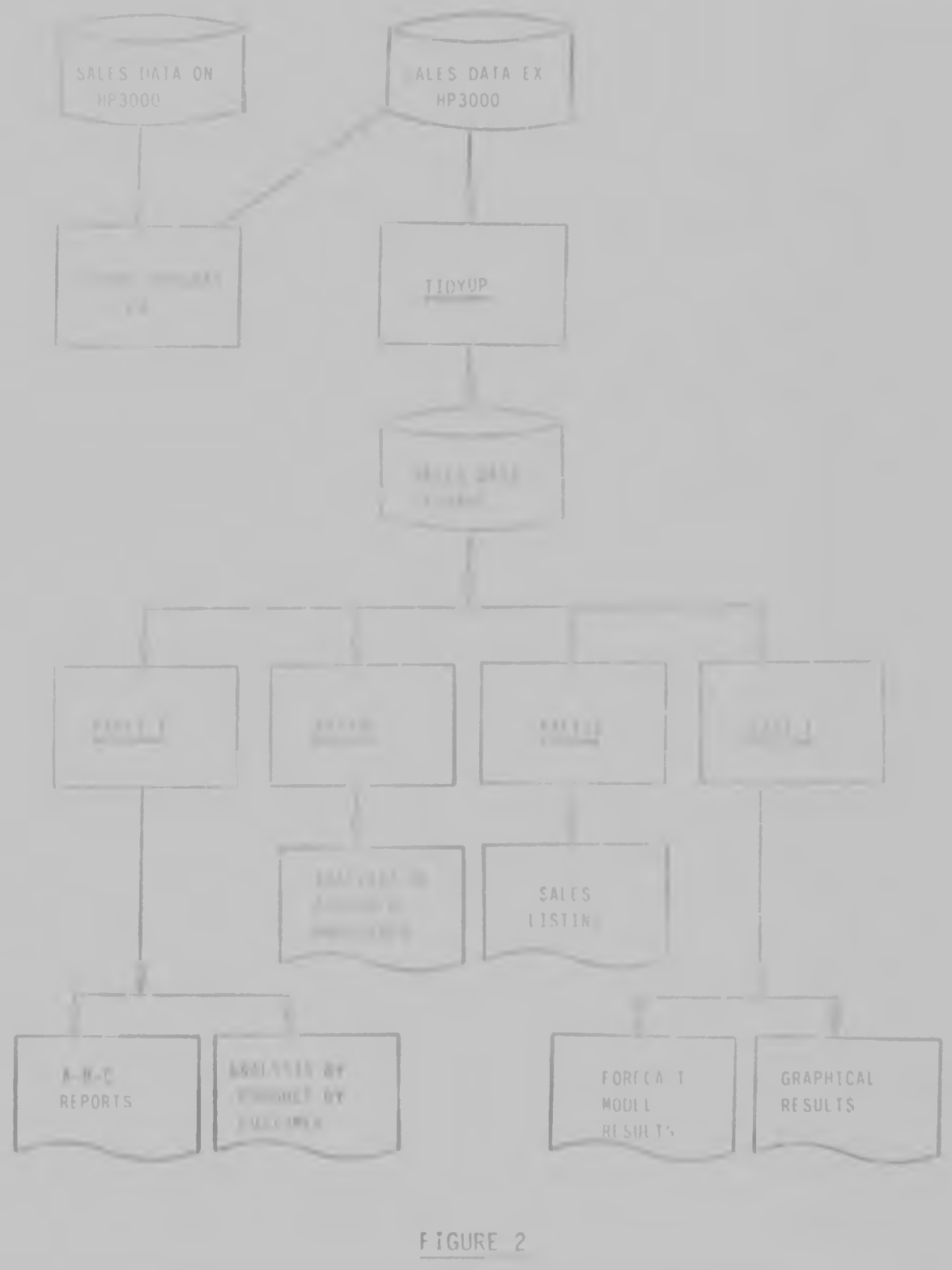

FIGURE 2

DATA EXTRACTION AND ANALYSIS SYSTEM FLOW CHART

f) The program 'FCAST 1' enables any of the four forecasting models listed in Appendix 7 to be tested on any of the product's sales data. All parameters in the model can be varied. Graphical and tabular results are [illegible] (Appendices 7 and 8).

[illegible] A-B-C Classification of Sales Data

Appendices 2, 3 and 4 contain A-B-C classifications of the sales [illegible] discussion of the features of the data. The following two points are particularly pertinent:

i) The A-B-C classification [illegible] of the line items that account for [illegible] of the sales, thus allowing the [illegible] to control the important items closely.

ii) When the classification is split to a customer level, it [illegible] a high degree of demand [illegible]. [illegible] of the [illegible] more than [illegible] of their demand [illegible] customer.

The A-B-C classification [illegible] the [illegible] policies to suit the individual products. [illegible] also necessary to [illegible] classify [illegible] on a regular [illegible]. Table [illegible] the results of A-B-C classifications [illegible] products. The products are [illegible] on the basis [illegible] and [illegible] are given for each [illegible] period. This table shows clearly the [illegible] the first product [illegible] from the [illegible] of the [illegible] in the [illegible] months. [illegible] increasing in [illegible] an increase in importance. [illegible] from [illegible]. The [illegible] products are very [illegible] with [illegible] from A-B-C [illegible]

TABLE 4

A-B-C RANKING COMPARISON

PRODUCT	Aug '80 To Jan '81	May '80 To Oct '80	Feb '80 To Jul '80	Nov '80 To Apr '80	Aug '79 To Jan '80	May '79 To Oct '79
P2	A1	A1	A4	B2	A12	A10
P3	A2	A2	A1	A2	A4	A3
P4	A3	A5	A3	A3	A2	A2
	A4	A6	A9	A13	B5	B2
	A5	A7	A6	A8	A13	B5
	A6	A9	A11	A12	A10	A12
P1	A7	A3	A2	A7	A1	A1
	A8	A10	A10	A9	A7	A6
P6	A9	A8	A7	A7	A6	A7
	A10	A11	A13	A16	B1	B3
	A11	A4	A5	-	B6	A15
	A12	A14	A12	A4	A5	A5
	A13	A13	A16	A5	A3	A4
	A14	B6	-	-	-	-
P5	A15	A15	A8	A6	B4	B1
	B1	A12	A15	A11	A9	A13
	B2	B7	B1	A10	A8	A8
	B3	B4	A17	A14	A11	A14
	B4	A16	B7	B14	-	-
	B5	B12	B9	B10	-	B12
	B6	-	-	-	B7	-
	B7	B9	B8	B1	B9	B8
	B8	B10	B4	B6	-	-
	B9	B5	B6	B13	B14	-
	B10	-	-	-	-	-
	B11	B14	B17	B8	B13	B6
	B12	B3	B5	B20	-	-
	B13	B15	B14	B19	B15	-
	B14	-	-	-	-	-

Appendix 1 contains a graphical representation of the sales history for each of the 'A' items, the 'B' item and for the product group as a whole. The following points should be noted:

a) The demands for P1 and P2 both exhibit significant changes over the time series analysis forecasting models can provide.

b) Most products have a similar sensitivity to their demand. These items will require increased levels of stock must be held to provide a stock service level.

c) Note that since January, sales of both P1 and P2 have been the highest in the 24 months of data. Demand should be monitored for the continuation of this trend. Table 5 summarises the average forecasting errors and standard deviations for a range of models. Due to the high variability in the demand data, none of the models can provide accurate forecasts. This is evident from the high standard deviations for the errors. Of the models, the exponential smoothing models produce the smallest errors.

d) The large standard deviations of forecasting errors serve to emphasise the importance of safety stocks.

e) A stock control system which relies only upon forecasting will result in stock-outs.

5.4 Summary

5.4.1 Ranking of Inventory

The ranking of the inventory item items in decreasing order of sales value (Section 4.1) enables the inventory manager to concentrate his attention on the important inventory items. It can also serve to highlight high stockholding/low movement items in order that arrange-

TABLE 5

DEMAND CHARACTERISTICS

	[illegible]	[illegible]	P3	P4	P5	P6	GRAND TOTAL SALES
DEMAND VARIABILITY[1] [illegible]	/	X	X	X		X	X
NUMBER OF CUSTOMERS ACCOUNTING >75% OF DEMAND [2]	1	3	4	6	5	1	27
LUMPY DEMAND [3]	X	X					
DEMAND VARIABILITY HIGH	X	X				X	
DEMAND VARIABILITY MEDIUM			X	X	X		X

[1] Extracted from Appendix 2
[2] Extracted from Appendix 3

ment> can be made to [illegible]

The rankings show th[illegible] the items are fairly s[illegible] table provides an indication of the [illegible] from A to A category [illegible] holding policies might be [illegible]

5.4.2 Demand Vulnerability

Appendix 3 indicates that [illegible] than 75% of their demand [illegible] This means that:

a) Stockholding policies [illegible] take account.

b) Demand forecasting must [illegible] of discovering additional [illegible]

Generally, items going out [illegible] are [illegible] from stock as quickly as they are [illegible] to be subject to [illegible] understock situations.

Buvet is generally vulnerable [illegible] shares. Its very strength is in fact a potential weakness.

5.4.3 Major Demand Changes

Any major change in demand must be predicted manually. It is impossible for a forecasting system based on past history to do this. When major changes occur, the manual forecast, or a combination of manual and exponential smoothed forecast should be used.

This is clearly evident in Figures 3 and 4 in Appendix 1.

6. TIME SERIES ANALYSIS

A series of monthly forecasts were produced for the top six 'A' items. The results of the various runs have been summarised in Tables 37 to 39 with the final complete model being fitted below each table. Appendix 7 contains a description of each of the four models used and a graph of the forecast results plotted against the fitted demand data.

Appendix 8 illustrates that in each case models 2 and 4 were rejected at the 5% level of significance and at the 2.5% level in the case of model 3, the majority of the significant partial errors were evenly distributed about zero (see Section 3.5 for explanation). It was not possible, however, to determine whether the remaining significant errors were due to missing signal terms or the random noise component and were little effect on the final forecasts.

Appendix 9 contains a summary of the test results obtained. It is clear that the first two items are not suited to forecasting using time series techniques. Attempting to forecast the order pattern purely using the demand data would be a pointless exercise. Furthermore, should an unusual demand occur within the forecast period it will distort the forecasts.

Figure 6 and 6 (Appendix 1.3) shows forecasts using the demand data only. This cannot be recommended.

In the real life situation, the demand is caused by an item shown on the bill of materials, information generated by marketing/sales departments. This enables a provision to be made for the peaks. The forecaster has the following options:

6.1 New level of dem_nd,

a) Alter the model parameters to allow a rapid adjustment, or

b) Select a new model.

TABLE 6
RESULTS FROM THE SELECTED FORECASTING MODELS

PRODUCT	Model	Alpha	P*	% Forecast Error	Tracking Signal	Demand Variability %
P1	2	0,1	N/A	7,1	0,05	86
P2	6	0,2	2	-17,0	-0,48	94
P3	6	0,2	2	-0,14	0,27	36
P4	2	0,2	N/A	0,1	-0,02	44
P5	5		N/A	0,19	0,5	59
P6	2	0,2	N/A	1,3	0,01	47

*P is the number of allowable periods of consecutively signed forecast errors.

6.2 Demand Spike.

a) Manually filter the demand figures to reduce their effect on the model, and

b) Place factory orders for the spike based on marketing information.

7. INVENTORY SIMULATION

7.1 Introduction

In order to test the effectiveness of the forecasting techniques, a simulation was carried out on the data. The theoretical stock was calculated at the end of January 1981, starting with the stock figures for April 1980, and the sales figures for May 1980 to January 1981.
This theoretical stock was compared to the actual stock to measure the improvement.

7.1.1 Existing Ordering Procedure

The existing ordering procedure is as follows:

a) An order point is determined periodically (every three to six months) and is set equal to three times the past six month's average sales).

b) Factory orders are determined by:

Factory orders = order point - (stock on hand + stock on order)

The factory order is rounded to the nearest fifty or one hundred units, depending on the item.

c) In addition, some carton sizes are rounded based on box size limitations.

Figure 7.1 shows the actual inventory of the stock and use of the simulation program.

7.1.2 Improved Ordering Policy

The existing ordering procedure is a crude one. It does not take into consideration the variability of sales, and the order point is not frequently reviewed. A better ordering policy would be based on time series analysis.

From the information presented in sect i ons 4.6 and 4.7, the order point will be calculated as follows:

OP = DDLT + SS

Where OP = Order point
DDLT = Dem nd du ing lead ti
SS = Safety stock

7.2.1 Assu otions

a) Lead time is eight

b) A service lev l of 9(is requir

c) The r l interval i four

d) The fa y order qua tity will a' y l a multiple of one month's forecast d d nd rounded

a) One order quantity will be rai d whenever the stock-o h nd plus s -on ord d ops below the order p t.

b) The order point will be re months an be b sed on the p t six mor h's data. Appendix 2.2 contains hly a rage sales, ar mean absolute d v , c lc lated at three month intervals.

c) The aver s les will d as a forecast.

d) The m an al sol will be used to calculate the saf ty sto .

e) The initial ord nt in pr il 1980 is based on th past twelve months' (Appendix 2.3).

7.2.3 Results

Appendix 9.1, Tables 9.1.1 to 9.1.6 give the results of this exercise. Table 7.10 compares the results of this simulation with the actual stock in January 1981.

a) The total value of stock listed in Table 7 represents the holding in January 1981.

b) A possible saving of [illegible] shown.

c) In the case of the [illegible] the simulated stock level [illegible] because of the rapid increase [illegible]. In the real life situation, additional stock would be [illegible].

Table 7

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1973	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	7[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	891	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				[illegible]		[illegible]

7.3 [illegible] Review Of The Order Point

In this case, the [illegible] from section 6 will be used to continuously update the order point.

7.3.1 Assumptions

a) Lead time is eight weeks.

b) A service level of 90% is required.

c) The demand interval is four weeks.

Appendix 9.1, Tables 25.1 to 25.6 give the results of this exercise. Table 7 below compares the results of this simulation with the actual stock in January 1981.

a) The total value of the 'A' items listed in Table 7 represents 60% of the inventory in January 1981.

b) A possible saving of £[illegible] shown.

c) In the case of [illegible] the simulated stock would go to the opposite extreme of the ranking theoretical demand. Obviously, in the real life situation, ordering would be related to the factory - possibly on a monthly or quarterly lead order.

[illegible]

[illegible] 12 of the items [illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P1	1[illegible]1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P2	8x1	1	[illegible]	[illegible]	1	—
P3	881	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P5	600	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P6	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				[illegible]		[illegible]

7.4 [illegible] Review of the Order Level

In this case, the selected [illegible] model from section 6 will be used to [illegible] within the same period.

7.4.1 Assumptions

a) Lead time is eight weeks.

b) A service level of 90% is required.

c) The demand interval is four weeks.

d, The factory order quantity will always be a multiple of one month's forecasted demand rounded to the nearest fifty units.

7.3.2 Ordering Rules

a) One order quantity will be raised whenever the stock-on-hand plus stock-on-order drops below the order point.

b) The order point will be recalculated every month and be based on the forecasted demand. Appendix 8.1, Table 17.2 shows a sample of the monthly forecast and mean absolute deviations used to recalculate the order points in Table 26.1.

c) The mean absolute deviation will be used to calculate the safety stock.

TABLE 8

STOCK STATUS AT END OF SIMULATION RUN

PRODUCT	Forecast	Safety Stock	Simulated Stock	Simulated Stock On Order	Months Stock On Hand	Months Stock On Hand and On Order
P1	260	743	1360	-	5,3	5,3
P2	982	805	(430)	3600	-	3,2
P3	291	234	634	350	2,2	3,4
P4	256	254	437	550	1,7	3,85
P5	53	151	301	100	5,6	7,5
P6	41	57	75	100	1,8	3,4

7.3.3 Results

The detailing results are shown in Appendix 9.2; Tables 26.1 to [illegible].6 and are summarised in Table 9 (overleaf). The results from Table 7 have been included for comparison purposes. There is substantial reduction in inventory using the continuous review of the order point. Inventory has dropped by 38,7%. Table 8 shows the stock status at the end of the simulated run. Despite the 38,7% drop in inventory, the stock status is acceptable.

7.4 Selection Of One Forecasting Model

Table 8 shows that best results selected from the various forecasting runs using different models (Refer to Appendix 8). In the real life situation, it would be preferable to have one model in use, rather than the three used, to derive the results in Table 8. The principle advantage will be simplicity and ease of understanding, by all concerned, of how the forecasting model operates. Overall, the [illegible] in Table 9 were obtained with models [illegible] six [illegible] principle difference between the two models is in the method of control.

7.4.1 [illegible]

[illegible] by monitoring the tracking signal. [illegible] tracking signal [illegible] allowed to [illegible] critical value (for a 9[illegible] confidence level - [illegible] consecutive periods. In the [illegible] period, alpha is reset to 0,8, and held at [illegible] the tracking signal dropped below the [illegible] level. The method can therefore be made more, or less sensitive by increasing, or decreasing the number of periods allowed before alpha is reset.

PRODUCT	Actual Sales (Rs. Lacs)	Stock Value (Rs.Lacs)	PRESENT ACTIVITY			CONTINUOUS REVIEW		
			Theoretical Closing Stock (Rs. Lacs)	Stock Deviation (Increase)	Value of Deviation (Increase)	Simulated Closing Stock (Rs. Lacs)	Stock Reduction (Increase)	Value Of Reduction (Increase)
P1	1746	14335	2575	(1519)	(10633)	2380	(984)	(7712)
P2	12	205	(1430)	-	-	(1302)	-	-
P3	1705	11041	984	722	11911	834	1072	25711
P4	808	13745	581	421	8547	437	121	2005
P5	431	1015	111	220	2219	121	111	1611
P6	27	221	118	1011	12000	90	21	2511
P7	1	1	1	1	1	1	1	1

Model Six

model six (which uses the same forecasting equation as model two - equation 1, section 4.3.2.1), is controlled simply on the basis of the number of consecutively signed forecast errors. Thus, two consecutive forecast errors of the same sign can be used to indicate that the forecast is out of control. In the various results used in this work, tests using two, three and four periods of consecutive, similarly signed forecast errors were tried. In general, as the number of periods increase, this model becomes less and less responsive to change.

Model Selected

Table 10 shows a comparison between the optimum results detailed in Table 9 and the results obtained using model six for all items.

The table shows that there is a small loss of optimization, particularly for item P3 where the simulated stock has increased by two hundred units (a cost increase of R4 812). The results for item P5 are exactly the same. The stock of item P1 has increased by three hundred and fifty units (R4 640) although, in the real life situation it would be hoped that the end of the demand spike would be foreseen and the model adjusted (by manually resetting alpha to say 0,8 for a few periods or by overriding the order quantity calculation). Note that in fact this fall off in stock is not as serious as the actual stock was only 1 096 units in January 1981.

The opposite situation occurs for item P2 where the simulated stocks are negative (ie unfilled demand). In the real life situation, this would be indicating that sufficient factory capacity is not planned to cover customer demand.

TABLE 10

COMPARISON OF THE BEST SIMULATED STOCK RESULTS

WITH ONE COMMON MODEL

Product	Model	Alpha	Control Period	Simulated Stock	Simulated Stock for Orders
P1	2	0,1	-	1380	-
P1	2	0,7	-	1735	-
P2	6	0,2	2	(430)	3600
P2	2	0,2	-	(1030)	4060
P3	6	0,2	2	634	350
P3	2	0,2	-	834	350
P4	2	0,2	-	437	550
P5	5	-	-	301	200
P5	2	0,2	-	301	100
P6	2	0,2	-	175	100

This could only have been done on either customer orders received or information from marketing. In either case they would signal to the forecaster that the model will require adjustment to reflect the new level of demand. The fact that the simulated stock goes negative is important in that it indicates clearly that a forecasting system cannot operate in isolation. Marketing information is an essential part of the total forecasting system.

The selection of model two using alpha = 0,2 appears to be a good starting point for the data tested. It would have produced a 28,7% reduction in inventory from April 1981 to January 1983.

Model Two

The model has two user:

a) the smoothing factor - alpha

b) the allowable limits for the tracking signal (from Table 2)

c) The number of consecutive periods in which the tracking signal is allowed to exceed the limits. (Determined from Table 2).

d) The value of the smoothing factor used when the tracking signal has exceeded the allowed limits for the specified number of periods.

e) The smoothing factor for the forecast errors (generally set at 0,1).

The following test data was used:

a) Alpha = 0,1; 0,2 or 0,3.

b) 95% confidence limits for the factor alpha from Table 2.

c) The tracking signal was allowed to go out of control for two consecutive periods before alpha was reset.

d) Alpha was reset to 0,8 in all cases.

e) Gamma was set at 0,1.

The following points should be noted:

a) The principle method of monitoring the performance of the model should be by means of the tracking signal. The closer the tracking signal is to zero, the better the model is following actual sales data.

b) Where demand spikes occur, judgement must be used in determining if the smoothing factor must be increased or if it should be held low and special orders placed to cover the spike only. This can only be determined from marketing information.

c) A graph of both the forecast versus actual demand and the tracking signal should be maintained for all 'A' items. This will enable the forecaster to fit his model to what is actually happening.

d) Exception reports must be produced every time the tracking signal indicates that the forecast errors are unacceptable. These reports should be referred to the product managers/ marketing for investigation.

The reasons should be clearly determined so that the outliers in the demand data can be discarded.

e) The exception reports should show the items ranked in their A-B-C rankings to that the most important items are investigated first.

7.6 Forecasting Of 'B' and 'C' Items

A sample 'B' item was chosen and the forecasting results are shown in Appendix 9.4; Tables 28.1 and 28.2. There is very little difference between the models. The inventory simulations show that in all cases the same ending inventory is produced. This is mainly due to the large order quantity of fifty units, which is accepcted as being the minimum factory order quantity desirable. [Altering the order quantity to the forecast quantity, rounded to the nearest ten units, reduces the final inventory (using model five) to seventy five units. This results in a reduction in inventory of ten units - refer to Table 28.2].

For 'B' itmes, the adaptive forecasting model of Trigg and Leach (model five) has distinct advantages. For these less important items, the use of an adaptive model allows more freedom for the forecaster to spend time on 'A' items. As suggested by Lewis (7), 'B' items can be forecasted in this manner and the only monitoring that is done is to set an arbitrary limit on the value of the tracking signal. Exception reports are then prepared for 'B' items whose tracking signals exceed this value.

The demand for 'C' items is highly erratic and it is suggested that these are handled strictly on a 'make to order' basis. No stock of 'C' items should ever be held.

7.7 Summary

7.7.1 A saving of between 24 and 38% of the inventory value at the end of January 1981 could have been achieved by the introduction of a forecasting system and the use of classical order point/order quantity techniques in April 1980.

7.7.2 The introduction of continuous review of the order point is likewise recommended. The saving drops from 38.7% to 8.3% if the same orders are reviewed every three months.

7.7.3 It is assumed that the pay as you order for the test data results in a true loss of any correction. It is thought that there is considerable stock of this type of item and it will be easier to understand.

7.7.4 The procedure for monitoring the performance of the model for each product is explained. Exception reports can be produced and should show the items ranked by their A-B-C classification.

7.7.5 It is proposed that all 'B' items be forecast using model five - the adaptive forecasting model, with monitoring done by limiting the value of the tracking signal. Exception reports should be generated on all items whose tracking signal exceeds the pre-set limit.

7.7.6 The inventory reorder rules are listed below:

7.7.6.1 'A' Items

a) Calculate a new order point each month based on the latest forecast and smoothed mean absolute deviation.

b) When stock-on-hand plus stock-on-order drops below the order point, order one order quantity.

c) The order quantity is defined as the latest forecast rounded to the nearest fifty units.

d) If one order quantity is insufficient to raise stock-on-hand plus stock-on-order to the order point level, place an order for another order quantity. (even if stock-on-hand plus stock-on-order is only just below the order point.)

7.7.6.2 'B' Items

Use the same system, except that the order quantity is rounded to the nearest ten units.

7.7.6.3 'C' Items

Make for firm orders only.

8. CONCLUSIONS

It is shown in this work that it is possible to improve the inventory situation by using a more sophisticated stock control/ordering system than the one presently in use.

8.1 It is suggested that an exponential forecasting model, controlled by a tracking signal as described in Appendix 7.1.2 be used to forecast demand and recalculate the order point every month for each 'A' item.

8.2 It is suggested that all 'B' items be forecasted by an adaptive smoothing model as described in Appendix 7.1.3. A limit should be set on the value of the tracking signal and exception reports must be produced if the tracking signal exceeds this value.

8.3 It is suggested that at least a 28,7% saving of the January 1981 inventory levels is possible, ie R84 518. These savings are based on a customer service level of 90%.

8.4 Exception reports must be generated of all forecasts that are out of control. It is clearly demonstrated that the forecasting system cannot operate in isolation. Marketing information must be combined with the calculated forecast. This is necessary to:

a) Avoid shortages when demand suddenly rises beyond previous fluctuations.

b) Avoid stock increases when demand falls below previous fluctuations.

8.5 Since for a number of Rand products it is easy to be unreliable, these products are heavily customer dependent (Type 3) and cannot be strictly confined to such restrictive rules. A customer analysis of the 'A' items as shown in Figure 7 providing immediate notification of this fact is

8.6 Changes in customer demand from one item to another cause large spikes in the demand patterns. These spikes are not conducive to good stock control. Every effort should be made to track down the reasons for the spikes and, through customer liaison, to try to minimise them. The amount of safety stock carried is directly dependent on the variability in the sales data.

8.7 Regular A-B-C analysis should be carried out to determine when the forecasting policy should change.

8.8 The definition of a 'standard' product should be based on some cut off point in the A, B, C classification. Certainly all 'A' items should be considered as standard products. 'B' items up to 90% of the sales revenue could also be considered as standard.

8.9 'C' items should be handled on a 'make to order' basis only.

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[illegible]

GRA IED [illegible] ES I ATA I [illegible]

TWENTY FI IR MO' [illegible] L [illegible] INC [illegible] Y 1981

APPENDIX 1.1

GRAPHED SALES DATA

APPENDIX 1.1

GRAPHED SALES DATA

The sales history for the top six 'A' items, and one 'B' item have been graphed. The selection of these items comes from the A-B-C analysis in Appendix 2.1.

1.1 Demand For P1

This product exhibits an exceptionally high peak in one period (five times the twenty four month average demand) and 86% of the demand comes from one customer. The distribution is highly skewed with more than 50% of the periods experiencing a demand of less than two hundred and fifty units. Clearly, from the graphed sales figures in this appendix, history provides no indication of the sudden rise in demand and time series analysis cannot forecast this increase. Forecasting models can be chosen that will try to follow the trend rapidly but some outside decision making is required to:

a) Forecast the rise in demand subjectively.

b) Decide if it is a real change of demand level, or purely a 'spike'.

c) Decide if the forecasting model must be changed.

Demand vulnerability is extremely high because of:

a) High demand variability and skew distribution, (ie very few periods with high demand).

b) Customer dependency.

Stock policies must therefore be determined taking these facts into account.

1.2 Demand For P2

This product shows a rapidly rising demand towards the end of the twenty four month period under review. Time series forecasting cannot be used to predict the rise in demand, it can only try to follow the trend. Demand vulnerability is fairly

high because of the low number of customers and high variability in demand.

1.3 Demand For P3

This product is a good candidate for forecasting by time series analysis. Demand is essentially horizontal with fluctuations about a mean level. There is a slight shift in the mean during the second twelve month period. Demand variability is low and variability is lower than for the previous items as four customers account for most of the demand.

1.4 Demand For P4

Generally exhibits the same characteristics as those discussed in 1.3 above, although demand is more variable.

1.5 Demand For P5

Demand for this product is falling continuously through the twenty four month period. Further investigation might reveal that one customer's consumption was changing or being phased out, causing the drop in sales. Time series analysis cannot predict the start or end of the drop, but can attempt to follow it.

1.6 Demand For P6

A horizontal demand pattern is apparent for this product. Forecasting of demand should be possible using time series analysis. Demand vulnerability is extremely high as one customer accounts for 94% of the demand for this item. Stock holding policies must take this into account.

APPENDIX I.1

CODED SALES DATA

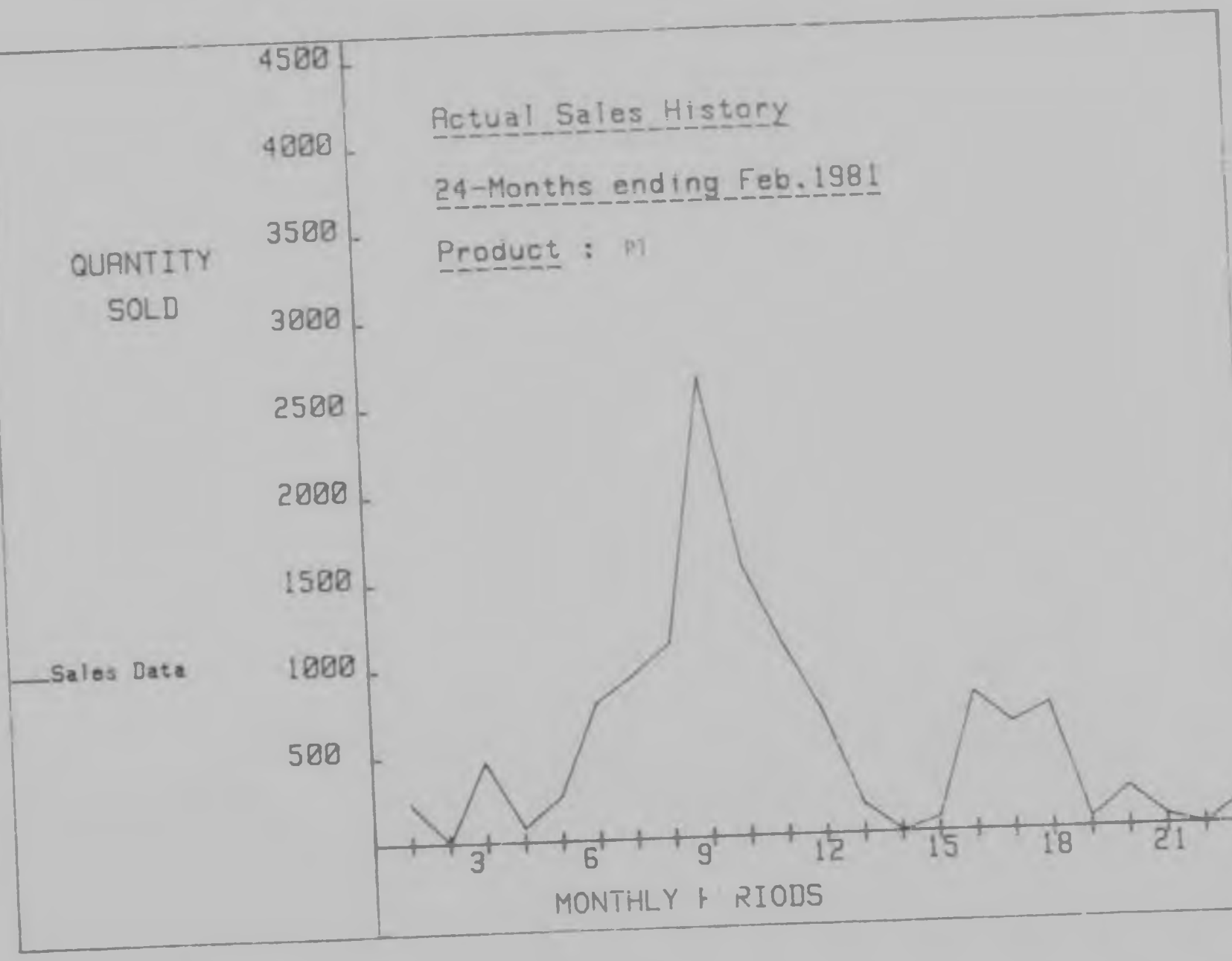

Actual Sales History
24-Months ending Feb.1981
Product : P1
QUANTITY SOLD
4500
4000
3500
3000
2500
2000
1500
1000
500
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 3

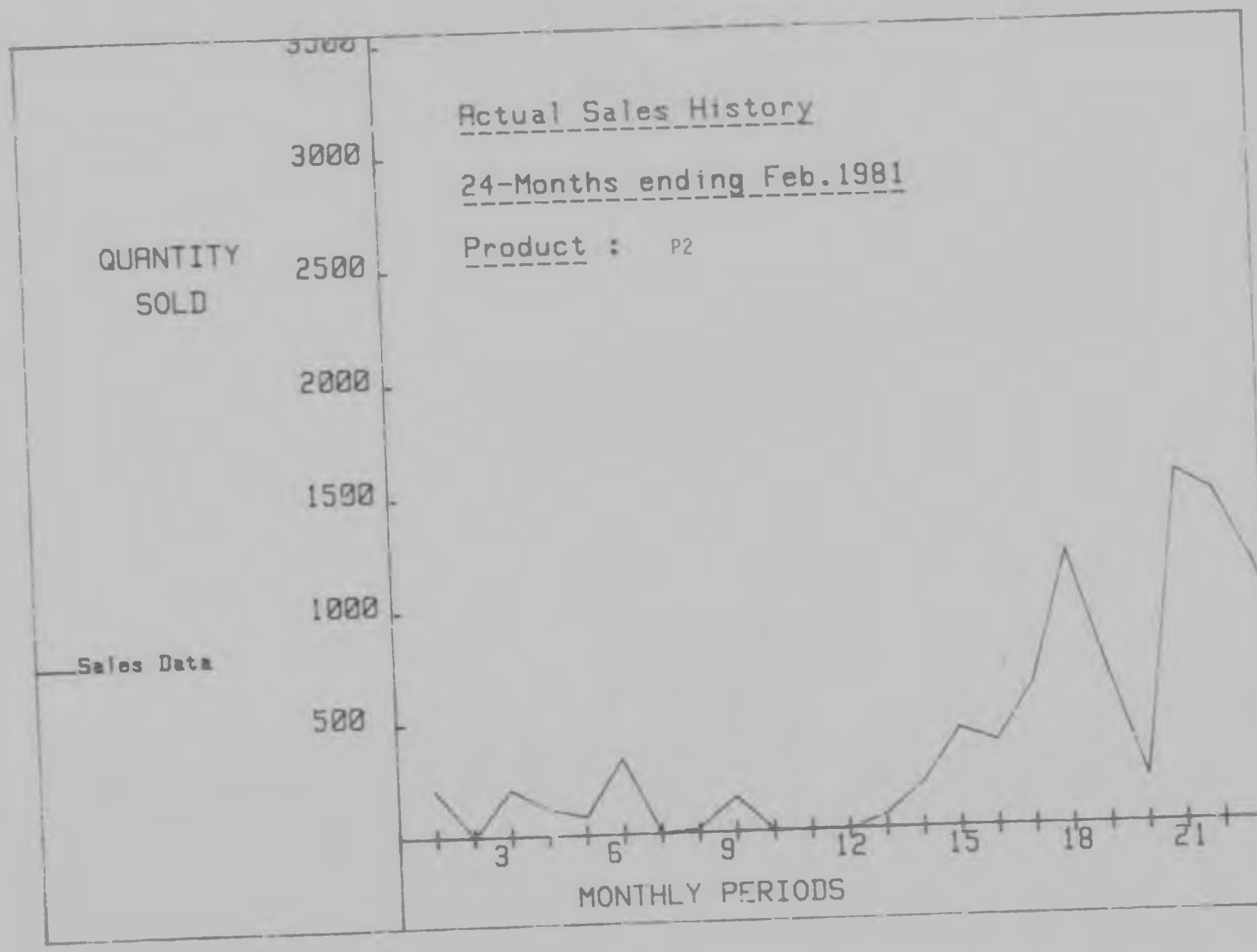

Actual Sales History
24-Months ending Feb.1981
Product : P2
QUANTITY SOLD
3500
3000
2500
2000
1500
1000
500
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 4

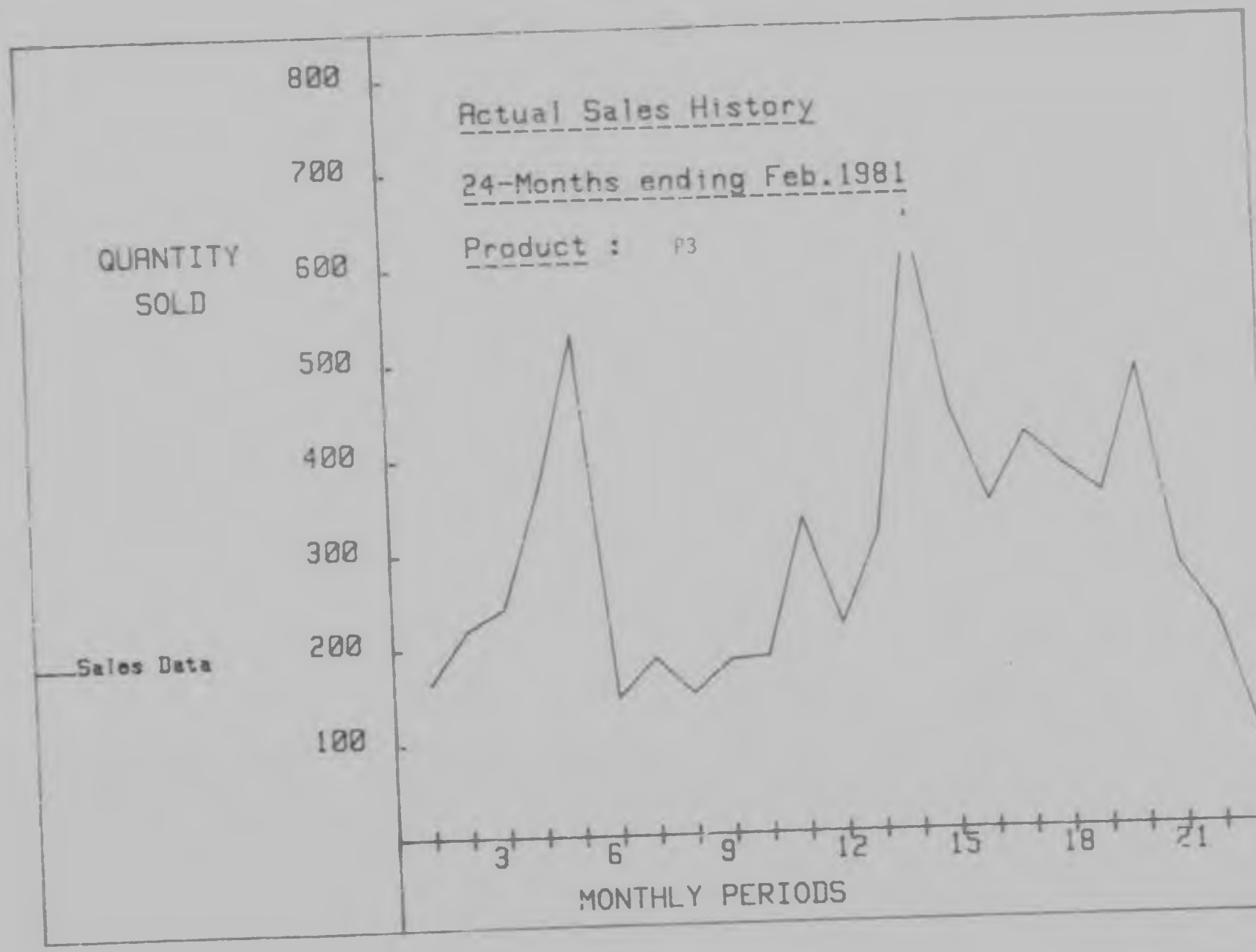

Actual Sales History
24-Months ending Feb.1981
Product : P3
QUANTITY SOLD
800
700
600
500
400
300
200
100
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 5

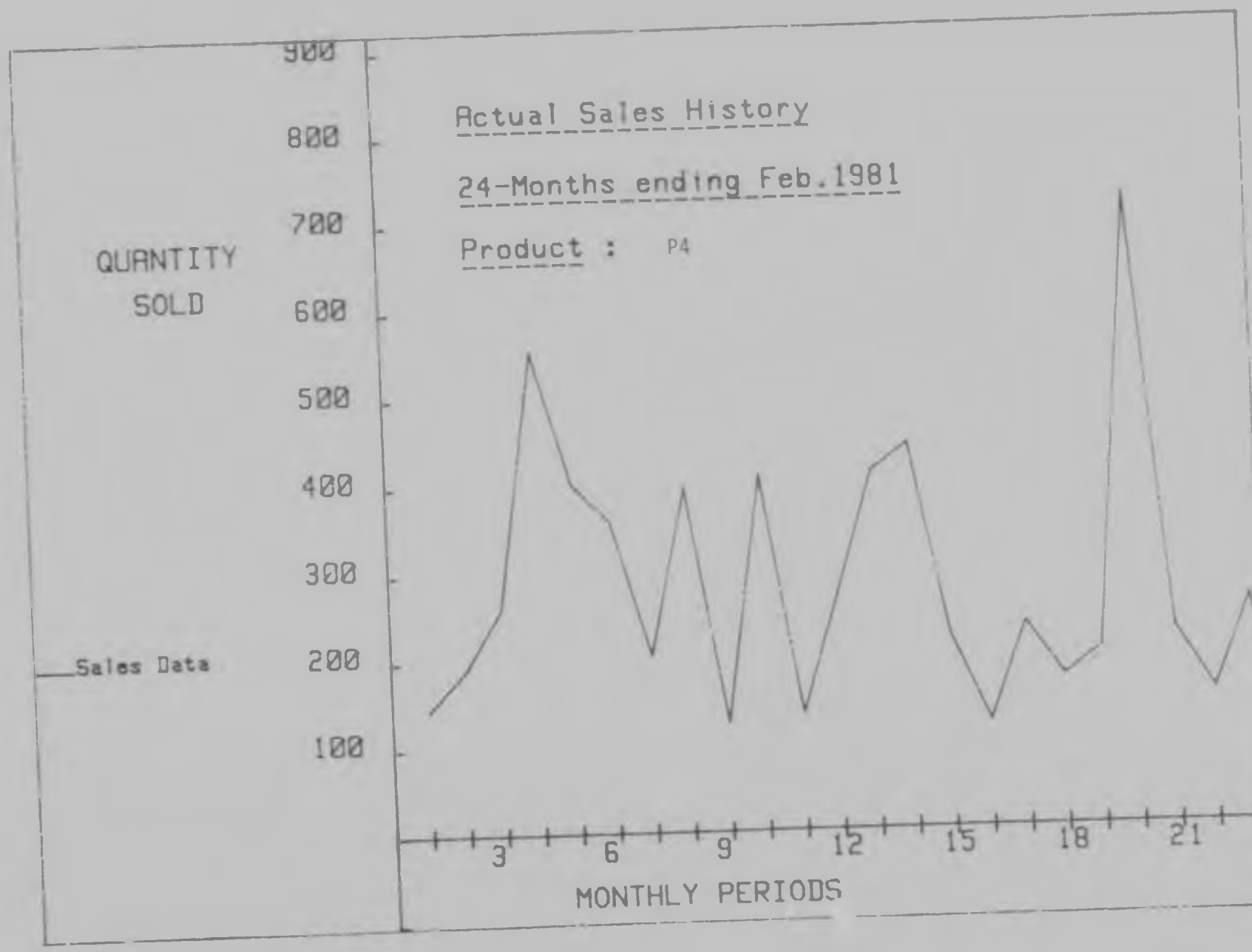

Actual Sales History
24-Months ending Feb.1981
Product : P4
QUANTITY SOLD
900
800
700
600
500
400
300
200
100
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 5

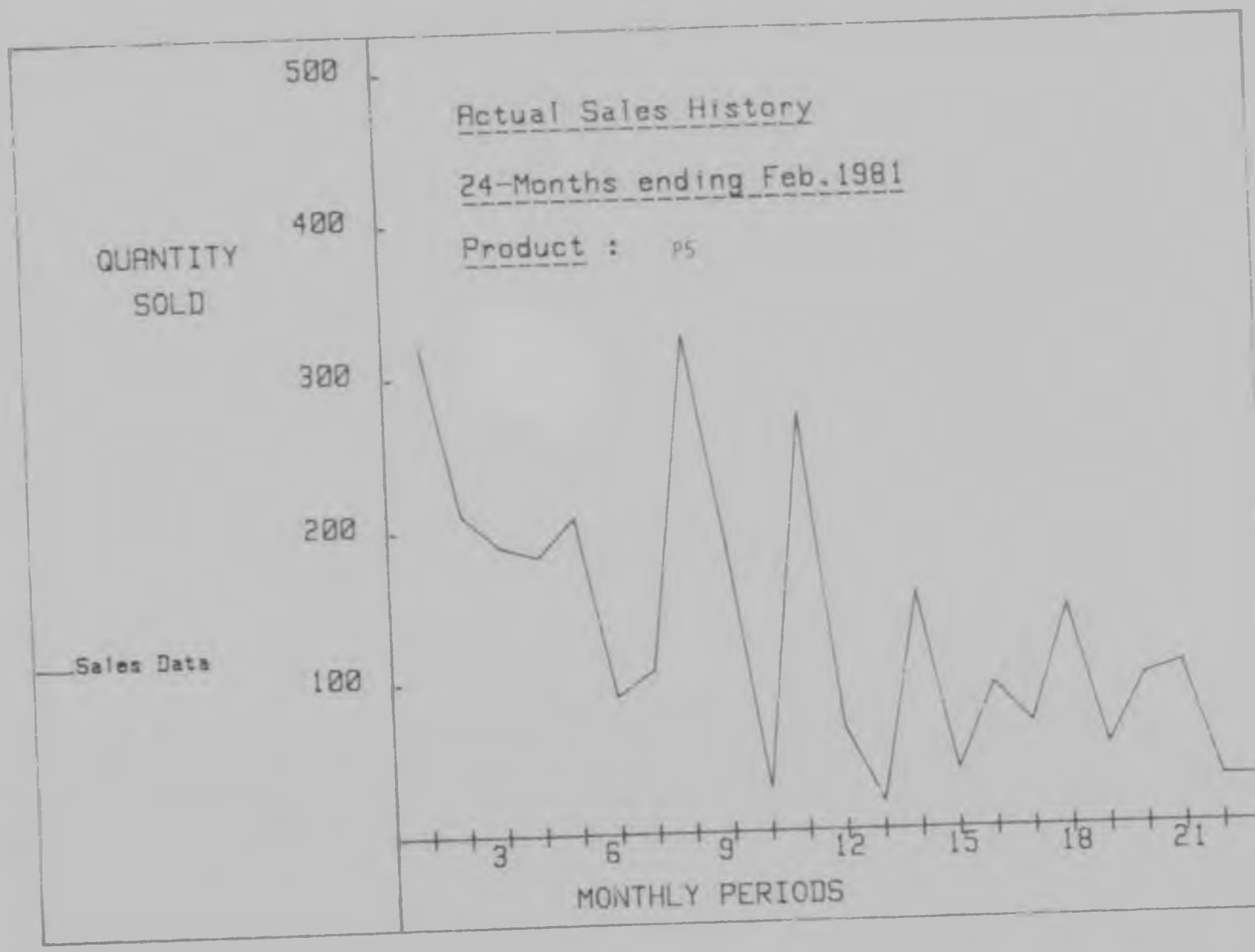

Actual Sales History
24-Months ending Feb.1981
Product : P5
QUANTITY SOLD
500
400
300
200
100
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 7

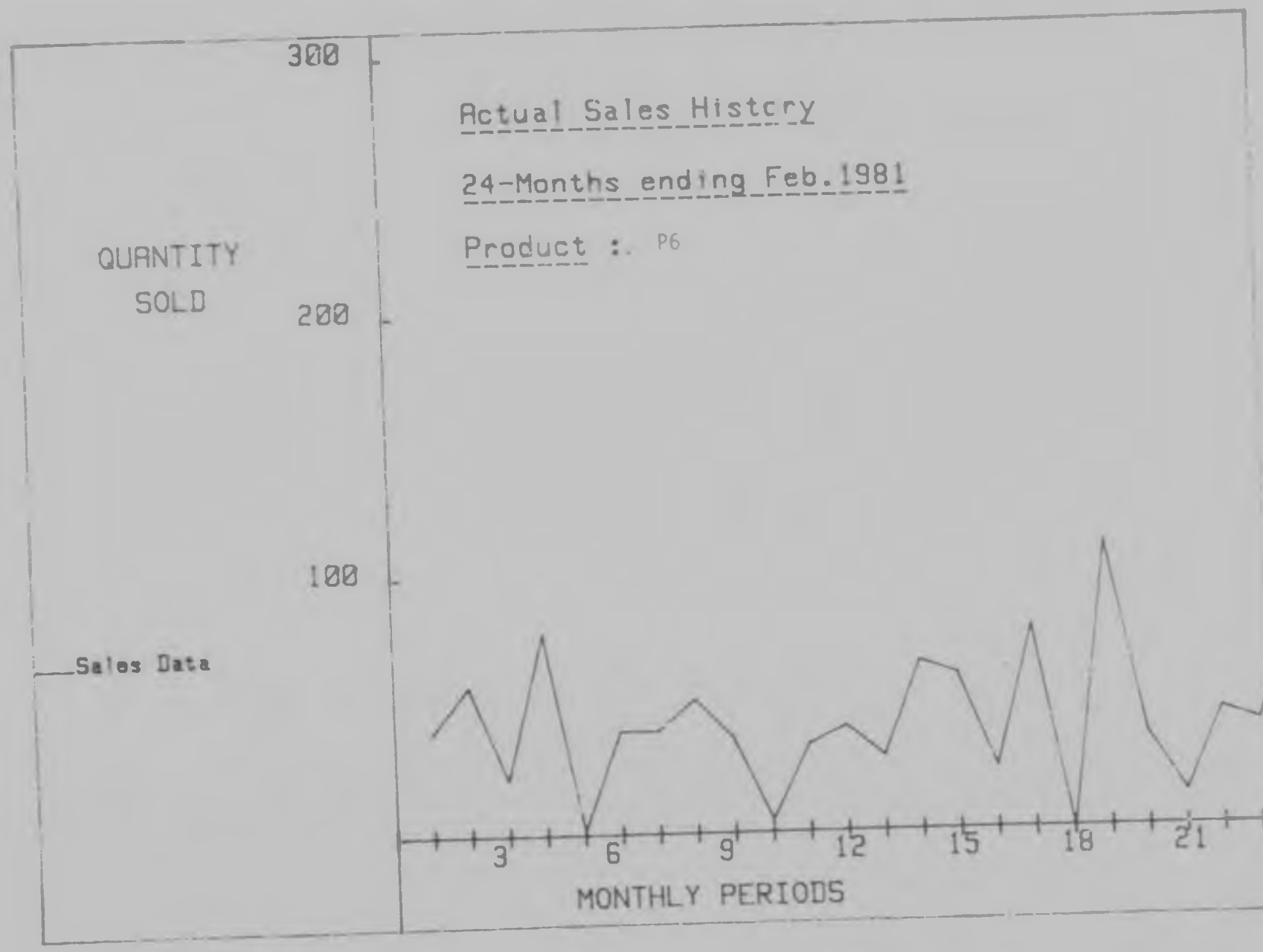

Actual Sales History
24-Months ending Feb.1981
Product : P6
QUANTITY SOLD
300
200
100
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 8

APPENDIX 1.2

SAMPLE OF CTN SALES DATA

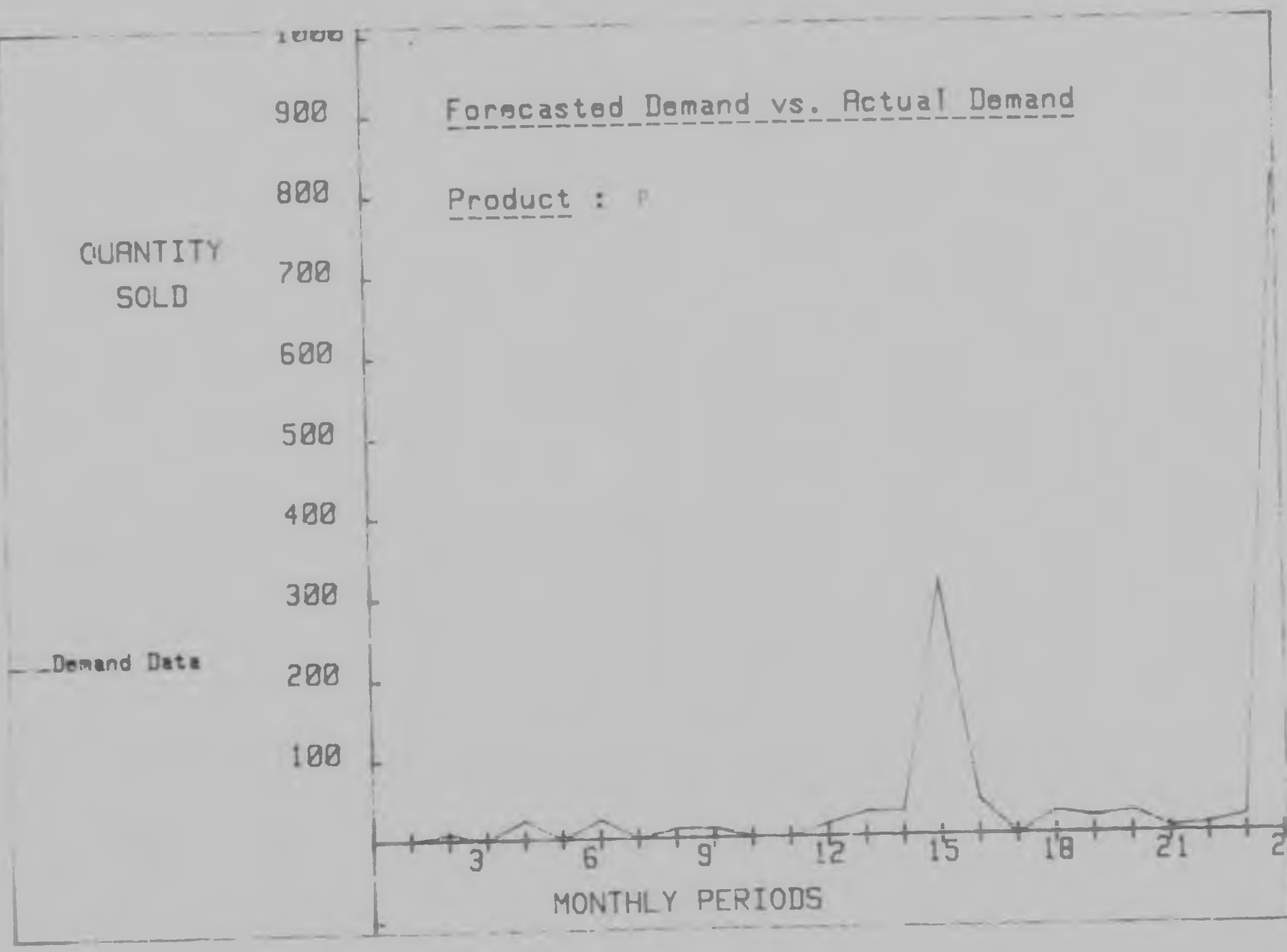

Forecasted Demand vs. Actual Demand
Product : P
QUANTITY SOLD
1000
900
800
700
600
500
400
300
200
100
Demand Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 9

APPENDIX 1.3

GRAND TOTAL SALES FOR TWENTY FOUR MONTHS
ENDING FEBRUARY 1981

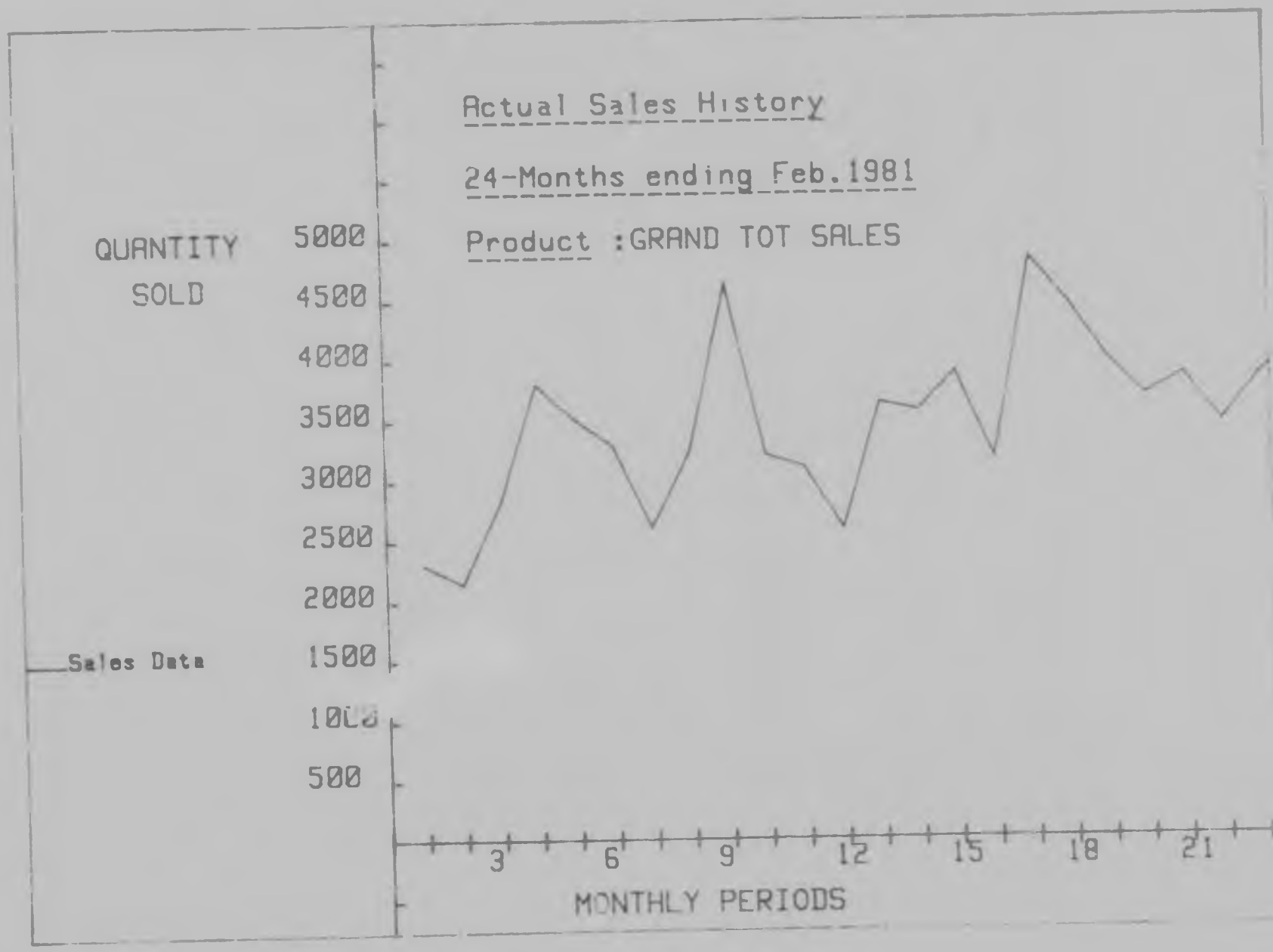

Actual Sales History
24-Months ending Feb.1981
Product :GRAND TOT SALES
QUANTITY SOLD
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Sales Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 10

APPENDIX 2.1

TABLE 2.1.1 : CONSTRUCTION OF SALES DATA

A-B-C ANALYSIS FOR TWENTY FOUR MONTH PERIOD

The results of the A-B C analysis for the twenty four month period are shown in Table 11.

In this analysis the 'A' level was set at 80% of the sales value and the 'A' and 'B' level at 95%. The report shows that just seventeen out of ninety seven line items account for 80% of the sales value. This report shows both the arithmetic average of the sales over the twenty four month period as well as the mean absolute deviation. The variability in demand is determined by the ratio of mean absolute deviation to the arithmetic average.

From Brown's definition of lumpiness (section 3.4.1.) any item with a variability factor exceeding 80% can be considered to have lumpy demand.

In this case both the top two 'A' items have lumpy demand. The nature of this lumpy demand can clearly be seen in the graphs in Appendix 1-1.

This analysis is the first step in determining which items are important and should by forecast. Note that the 'C' items account for 50.88 in monetary value and only 1 950 units per annum.

TABLE 11

A B-C ANALYSIS

SALES: MARCH '79 TO FEBRUARY '81

LIM	DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (4 MON)	AVE.QTY (MON)	MAD.	VAR %	CUM % (TOT.
A	P1			542	466.3	85.97	11.48
A	P2	9691		404	379.4	93.96	21.50
A	P3	7200		300	110.1	36.69	30.11
A	P4	6670		278	121.8	43.79	37.07
A	P5			130	76.1	58.56	41.6
A	P6			43	20.2	46.97	45.79
A				142	102.9	72.21	49.00
A				171	89.1	52.20	53.7
A				136	76.9	56.51	57.5
A				131	67.1	51.29	61.11
A				59	26.4	44.94	64.41
A		1409		118	134.4	113.91	67.4
A				68	37.6	55.35	69.8
A		1631		92	63.4	69.10	72.31
A				44	14.7	33.21	74.64
A				30	16.2	53.89	76.8
A				51	23.5	45.98	78.79
A		1228		73	80.7	109.98	80.47
B		1761		70	95.0	135.81	82.02
B		1678		60	83.9	140 05	82.4
B		1437		17	16.9	98.01	84.47
B				28	23.2	105.77	85.43
B		667		39	62.3	158.33	86.4
B				40	37.5	93.75	87.2
B				20	16.8	83.33	87.95
B				25	32.3	126.79	88.9
B				32	39.6	123.73	89.
B				17	16.2	95.10	90.04
B		408		20	22.7	113.04	90.6
B				25	32.9	134.18	91.2
B				10	13.2	128.37	91.
B				9	5.2	55.94	92.2
B		223		13	14.0	109.31	92.69
B				16	23.5	151.88	93.1
B		372		11	9.5	90.08	93.5
B		252		31	46.2	150.88	93.94
B		735		5	6.2	130.70	94.2
B		114		13	22.1	176.02	94.8
B		301		9	11.8	133.18	94.97
B		212					

TOTAL QUANTITY: [illegible]
TOTAL VALUE:£ [illegible]

APPENDIX 2.7

SIX NORTHS A-B-C CLASSIFICATIONS

Table 12.1 August 1980 to January 1981

Table 12.2 May 1980 to October 1980

Table 12.3 February 1980 to July 1980

Table 12.4 November 1979 to April 1980

Table 12.5 August 1979 to January 1980

Table 12.6 May 1979 to October 1979

TABLE 12.1

PARETO REPORT FOR SALES AUGUST 19[illegible]

A-B-C ANALYSIS

SALES: AUGUST '80 TO JANUARY 81

LIN	DRAWING NO.	TOT.QTY (6 MON)	TOT.VAL (6 MON)	[illegible] (MON)	MAD	VAR %	CUM % (TOT.VAL
A	P2	6245		1041	399.2	38.36	22.82
A	P3	1804		[illegible]	105.7	[illegible]	30.71
A	P4	1728		288	141.0	50.00	37.18
A		1481		[illegible]	60.2	24.40	43.42
A		1251		209	59.0	28.30	48.54
A		522		87	38.3	44.06	52.92
A	P1	1220		203	181.4	89.23	56.60
A		529		155	66.8	43.13	60.63
A	P6	244		41	24.6	60.38	64.15
A		585		98	40.0	41.03	67.46
A		765		128	97.7	76.60	70.07
A		67[illegible]		113	50.0	44.44	72.54
A	P5	459		77	38.8	50.76	74.94
A		498		[illegible]	32.0	38.55	77.01
A		470		[illegible]	44.1	56.31	78.87
A		230		[illegible]	24.8	64.64	80.69
B		129		22	13.8	64.34	82.13
B		238		40	34.1	85.99	83.48
B		[illegible]		27	23.2	87.08	84.75
B		174		[illegible]	19.0	65.52	85.71
B		250		[illegible]	55.6	133.33	86.60
B		220		[illegible]	48.9	133.33	87.43
B		175		[illegible]	32.3	110.67	88.25
B		249		42	33.7	81.12	89.05
B		61		10	6.8	67.21	89.70
B		184		31	29.6	96.38	90.30
B		104		17	11.7	67.31	90.89
B		65		11	9.2	84.62	91.41
B		84		14	11.3	80.95	91.88
B		250		[illegible]	69.4	[illegible]	92.33
B		100		17	27.8	166.67	92.76
B		111		19	7.0	37.84	93.19
B		81		14	19.8	146.91	93.60
B		98		16	21.8	133.33	94.00
B		60		10	7.0	70.00	94.41
B		[illegible]		21	27.3	133.33	94.80

TOTAL QUANTITY: 22201
TOTAL VALUE:R 1113004.89

TABLE 12.2

PARETO REPORT FOR SALES FEBRUARY 1980 TO OCTOBER 1980

A-B-C ANALYSIS

SALES MAY '80 TO OCTOBER '80

CLASS	PRODUCT NO.	TOT. QTY (6 MON)	TOT. VAL (€ MON)	AVG. QTY (MON)	%	CUM %	CUM % TOT. VAL
A	F2	3527		588	27.12	27.12	16.05
A	F3	2127		405	16.35	43.47	32.44
A	F1	2507		418	19.28	62.75	48.11
A		1048		262	20.17	82.91	58.42
A	F4	1671		278	12.85	95.76	67.51
A		1451		242	11.16	106.92	77.71
A		1172		195	9.01	115.93	86.49
A	F6	388		97	3.00	118.93	87.49
A		922		87	6.71	125.64	91.70
A		518		152	3.98	129.62	93.68
A		671		144	5.16	134.78	96.84
A		347		58	2.67	137.45	98.51
A		474		82	3.64	141.09	100.15
B	F5	603		101	4.64	145.73	104.79
B		540		90	4.15	149.88	108.94
B		216		36	1.66	151.54	110.60
B		477		68	3.67	155.21	114.27
B		431		72	3.32	158.53	117.59
B		249		50	1.92	160.45	119.51
B		245		41	1.89	162.34	121.40
B		456		76	3.51	165.85	124.91
B		298		48	2.29	168.14	127.20
B		84		16	.65	168.79	127.85
B		331		55	2.55	171.34	130.40
B		228		37	1.75	173.09	132.15
B		157		26	1.21	174.30	133.36
B		116		20	.89	175.19	134.25
B		119		19	.92	176.11	135.17
B		82		14	.63	176.74	135.80
B		149		25	1.15	177.89	136.95
B		56		9	.43	178.32	137.38
B		84		14	.65	178.97	138.03

TOTAL QUANTITY: 23052

TOTAL VALUE:£ 1140114.03

TABLE 12.3

PARETO ANALYSIS FOR SALES FEBRUARY 1980 TO JULY 1980

P I C ANALYSIS

SALES: FEBRUARY '80 TO JULY '80

LIM	DRAWING NO.	TOT.QTY (6 MON)	TOT.VAL 6 MON)	AVE.QTY MON)	MAP	VAR %	CUM % (TOT.VAL)
A	P3	2391		399	165.5	26.47	10.2
A	P1	1961		398	311.3	78.29	13.4
A	P4	1699		283	94.9	33.51	25.70
A	P2	1679		260	196.2	70.10	33.40
A		1430		238	309.1	129.70	39.49
A		1212		202	38.3	18.98	42.93
A	P6	911		50	18.2	36.70	43.57
A		967		161	175.3	108.90	51.63
A		899		150	54.2	36.15	53.93
A		764		127	67.3	52.88	56.81
A		348		58	32.3	55.75	58.30
A		830		138	61.7	44.58	61.95
A		494		82	38.9	47.23	63.75
A		814		136	145.9	107.53	71.17
A	P5	479		80	36.1	45.23	73.89
A		291		49	11.0	22.68	76.41
A		345		58	15.3	26.67	78.46
A		154		26	8.3	32.47	80.28
B		435		73	80.8	111.49	81.30
B		415		69	71.9	104.02	83.21
B		274		46	21.3	46.72	84.57
B		202		34	21.3	63.37	85.84
B		393		66	63.5	96.95	87.10
B		117		20	10.2	52.14	88.16
B		275		46	76.4	166.67	89.20
B		179		30	23.2	77.65	90.18
B		123		21	11.8	57.72	90.97
B		59		10	12.7	129.38	91.61
B		100		17	16.7	100.00	92.23
B		154		26	24.2	94.37	92.77
B		80		13	13.3	100.00	93.29
B		55		9	5.5	60.00	93.70
B		80		13	5.1	38.33	94.21
B		102		17	21.0	123.53	94.81

TOTAL QUANTITY: 21716
TOTAL VALUE:R 1017363.94

TABLE 12.4

PARETO REPORT FOR SALES NOVE[illegible]

A-B-C ANALYSIS

SALES: NOVEMBER 79 TO APRIL 80

LIM	DRAWING NO.	TOT.QTY (6 MON)	TOT.VAL (6 MON)	[illegible] (MON)	MAD	VAR %	CUM % (TOT.VAL)
A	P1	6186		10[illegible]	[illegible]	71.45	22.77
A	P3	1886		314	117.	37.47	32.05
A	P4	1793		297	12[illegible]	40.44	39.99
A	P5	769		128	[illegible]3.8	65.41	44.59
A		1150		1[illegible]	75.0	39.13	49.16
A		879		147	180.2	122.98	53.23
A		211		[illegible]	12.5	35.55	56.74
A	P6	735		123	71.5	58.37	60.24
A		594		99	85.7	86.53	63.04
A		195		[illegible]	10.0	[illegible].77	65.56
A		271		45	9.9	21.89	68.01
A		238		[illegible]	24.6	61.90	70.32
A		492		[illegible]	42.7	[illegible]2.03	72.62
A		337		56	18.6	33.04	74.83
A		535		[illegible]	136.9	153.58	77.01
A		318		53	20.7	38.99	[illegible]
A		425		[illegible]	94.4	133.33	80.90
B		401		67	69.1	103.41	82.56
B	P2	155		[illegible]	23.2	89.68	83.58
B		239		40	34.8	87.45	84.48
B		73		12	12.2	100.46	85.39
B		147		25	26.0	106.12	86.27
B		128		21	12.0	56.25	87.12
B		155		26	27.8	107.53	87.96
B		200		33	33.3	100.00	88.78
B		145		24	32.2	133.33	89.54
B		93		16	12.5	80.65	90.26
B		104		17	16.8	96.79	90.90
B		152		25	16.4	64.91	91.48
B		58		10	6.7	60.97	92.05
B		130		22	22.9	105.64	92.58
B		80		13	17.1	128.33	93.12
B		218		36	43.2	118.96	93.55
B		62		10	6.4	62.37	93.96
B		44		[illegible]	2.1	[illegible]8.79	94.37
B		63		11	10.5	100.00	94.77

TOTAL QUANTITY: 20801
TOTAL VALUE:R 919313.[illegible]5

TABLE 12.5

PARETO REPORT FOR SALES AUGUST 1979 TO JANUARY 1980

A I - ANALYSIS

SALES: AUGUST '79 TO JANUARY [illegible]

LIM	DRAWING NO.	TOT.QTY (6 MON	TOT.VAL (6 MON)	AVE.QTY (MON)	MAD	VAR %	CUM % (TOT.VAL
A	P1	8166		1361	[illegible]	36.27	31.64
A	P4	1629		272	115.8	42.66	39.17
A	P5	1060		177	93.8	53.11	45.92
A	P3	1187		198	44.7	22.61	51.87
A		1150		192	61.1	31.88	56.71
A	P6	208		35	10.1	29.17	60.35
A		657		110	62.8	57.38	63.63
A		205		34	11.8	34.47	66.41
A		277		46	9.2	19.98	69.02
A		257		43	9.8	22.96	71.63
A		368		61	17.0	27.72	74.14
A		347		58	29.6	51.20	76.45
A	P2	500		83	104.4	125.33	78.59
B		406		68	34.7	51.23	80.60
B		282		47	21.7	46.10	82.58
B		326		54	43.3	79.75	84.35
B		288		48	27.7	57.64	85.76
B		254		42	39.8	93.96	86.99
B		279		47	42.3	91.04	88.11
B		249		42	27.7	66.67	89.20
B		190		32	52.8	166.67	90.14
B		150		25	41.7	166.67	90.80
B		9[illegible]		16	19.1	120.70	91.41
B		76		13	11.2	88.60	92.02
B		28[illegible]		47	56.9	121.90	92.61
B		[illegible]		23	25.8	113.73	93.15
B		119		20	13.2	66.67	93.64
B		48		8	2.0	25.00	94.11
B		10[illegible]		18	23.6	133.33	94.57

TOTAL QUANTITY: 201[illegible]

TOTAL VALUE:£ [illegible]

TABLE 12.6

PARETO REPORT FOR SALES MAY 1979 TO [illegible] 1979

A-B-C ANALYSIS

SALES: MAY '79 TO OCTOBER '79

CLASS	WORKING NO.	TOT.QTY (6 MONTHS)	TOT.VAL (6 MONTHS)	ITEMS (%)	VALUE (%)	VAR %	CUM % (TOT.VALUE)
A	P1	3669		[illegible]	[illegible]	56.86	14.25
A	P4	2174		[illegible]	[illegible]	34.28	24.00
A	P5	1624		[illegible]	115.0	53.42	32.47
A	P8	1149		[illegible]	[illegible]	84.37	39.66
A		1068		[illegible]	88.5	53.26	41.24
A		889		[illegible]	[illegible]	84.17	46.59
A		231		[illegible]	[illegible]	46.15	52.53
A	P6	255		[illegible]	[illegible]	85.49	58.86
A		743		[illegible]	[illegible]	66.01	64.31
A		736		[illegible]	[illegible]	77.-	69.43
A	P2	736		[illegible]	174.1	128.1	75.21
B		275		[illegible]	[illegible]	29.70	76.11
B		287		[illegible]	6.1	16.96	78.85
B		407		[illegible]	39.0	[illegible]	79.42
B		262		[illegible]	12.7	72.65	80.93
B		529		[illegible]	65.2	72.91	82.13
B		421		[illegible]	[illegible]	47.27	83.18
B		430		[illegible]	78.4	195.88	84.19
B		216		[illegible]	24.7	[illegible]	85.68
B		298		[illegible]	84.3	137.93	86.14
B		284		[illegible]	37.1	78.48	86.55
B		318		[illegible]	[illegible]	144.36	87.91
B		227		[illegible]	35.1	92.30	89.14
C		361		[illegible]	[illegible]	166.67	90.92
C		112		[illegible]	27.1	145.24	91.45
C		151		[illegible]	[illegible]	55.15	92.20
C		267		[illegible]	[illegible]	128.84	92.82
C		94		[illegible]	11.3	28.91	93.42
C		97		[illegible]	14.0	36.55	93.99
C		89		[illegible]	4.1	39.83	94.55

TOTAL QUANTITY 19329
TOTAL VALUE 661114.47

APPENDIX 2.3

A-B-C CLASSIFICATIONS

Table 12.7 May 1979 to end April 1980

Table 12.8 January 1980 to end January 1981

These two A-B-C classifications were combined for ranking the stock at the end of each period. The stock listings at the end of April 1980 and January 1981 are shown in Appendix 6.

TABLE 12.7

F[illegible] TO REPL[illegible] FOR SALES MAY 1979 TO APRIL 1980

A B C ANALYSIS

SALES: MAY [illegible]79 TO APRIL [illegible]80

LIM	DRAWING NO.	TOT.QTY (1 [illegible])	TOT.VAL (12 MON)	AVE.QTY (MON)	MAD	VAR %	CUM % (TOT.VAL)
A	F1	9855		[illegible]	544.6	66.32	18.66
A	P3	[illegible]		293	121.9	41.68	27.45
A	P4	[illegible]		331	109.0	32.97	[illegible]0.20
A	P5	1018		160	75.3	47.08	[illegible]
A		2210		184	77.5	42.09	46.78
A	P6	445		[illegible]7	15.6	42.02	[illegible]3.59
A		[illegible]		124	79.7	64.45	54.10
A		[illegible]		108	98.1	90.51	57.1[illegible]
A		[illegible]		38	15.0	40.00	60.1[illegible]
A		[illegible]		47	9.0	[illegible]	62.74
A		55[illegible]		43	18.5	43.37	65.29
A		513		106	148.7	140.40	67.87
A		1271		85	63.6	74.86	70.30
A		[illegible]		58	16.5	28.25	72.6[illegible]
A		699		95	84.5	89.23	75.01
A	P2	1137		77	60.3	78.45	77.17
A		922		79	66.8	85.07	79.17
A		943		45	23.8	53.37	80.99
B		[illegible]		47	34.6	73.84	82.75
B		[illegible]		60	30.6	150.60	84.[illegible]4
B		[illegible]		50	51.9	104.76	85.44
B		[illegible]		48	56.3	117.07	86.56
B		577		31	34.2	110.22	87.[illegible]5
B		[illegible]		17	19.3	112.85	[illegible]
B		[illegible]		20	17.9	89.89	[illegible]8.[illegible]1
B		[illegible]		24	40.3	166.67	89.92
B		[illegible]		16	15.4	96.68	90.52
B		191		9	9.2	101.85	91.0[illegible]
B		108		[illegible]	14.7	65.92	91.5[illegible]
B		[illegible]		40	51.0	126.0[illegible]	92.11
B		[illegible]		7	7.9	119.1[illegible]	92.6[illegible]
B		[illegible]		18	14.7	83.33	93.1[illegible]
B		211		8	3.2	38.38	93.6[illegible]
B		[illegible]		11	12.3	11[illegible].95	94.05
B		130		13	18.2	140.86	94.48
B		155		8	6.2	77.08	94.83
B		[illegible]					

TOTAL QUANTITY: [illegible]6140

TOTAL VALUE:£ [illegible].42

TABLE 12.8

PARETO REPORT FOR SALES JANUARY 1980 TO JANUARY 1981

ANALYSIS

SALES: JANUARY 80 TO JANUARY 81

LIM	DRAWING NO.	TOT.QTY (13 MTH)	TOT.VAL (13 MTH)	AVG.QTY (MTH)	MAD	VAR %	CUM % (TOT.VAL)
A	P2	7904		618	463.5	76.04	14.05
A	P3	4547		148	98.7	28.35	23.43
A	P1	4706		362	329.7	91.08	30.57
A	P4	3562		274	115.2	42.06	37.07
A		2510		193	77.9	40.36	42.18
A		2513		193	54.3	28.11	47.18
A	P6	575		44	21.1	47.60	51.19
A		2225		171	195.0	113.92	55.00
A		908		70	35.2	50.46	58.71
A		1733		133	66.8	50.10	62.17
A		1855		143	72.1	50.55	65.36
A		1159		89	37.9	42.54	68.52
A		1211		93	50.5	54.18	71.57
A	P5	1477		114	101.8	89.61	74.39
A		574		44	17.4	39.45	76.57
A		333		26	13.4	52.21	78.36
A		627		48	26.1	54.18	80.05
B		885		68	88.4	129.89	81.48
B		581		45	41.2	92.10	82.65
B		281		22	16.0	73.97	83.77
B		459		35	28.6	80.95	84.80
B		687		53	43.6	82.57	85.83
B		371		29	20.3	71.03	86.78
B		546		42	42.3	100.73	87.67
B		316		24	18.2	74.78	88.55
B		495		38	58.6	153.85	89.43
B		558		43	47.0	109.43	90.28
B		400		31	42.6	138.46	90.97
B		338		26	26.2	100.59	91.50
B		183		14	9.8	69.53	92.03
B		127		10	7.0	71.47	92.52
B		161		12	12.2	98.23	92.94
B		149		11	12.3	106.97	93.35
B		140		11	11.6	108.08	93.73
B		75		6	6.6	113.85	94.12
B		68		5	5.6	106.11	94.47
B		132		10	12.9	126.57	94.82

TOTAL QUANTITY: 48019

TOTAL VALUE: N 2269390.07

APPENDIX 3

Table 13 Analysis of 'A' items sales by customer

ANALYSIS OF 'A' ITEMS SALES BY CUSTOMER

Table II breaks the 'A' item sales down to customer level. This report indicates where demand is heavily dependent on a limited number of customers. It indicates that six of the 'A' items have more than 75% of their demand originating from one customer.

In one case [illegible] 98% of the demand originates from one customer. These facts have to be taken into account when production and forecasting policies are decided upon. It was decided that Customer Liaison is the best method of forecasting demand for these items. Certainly the inventory savings that are a result of the perfection of demand that is expected are substantial.

TABLE 13

ANALYSIS OF A ITEMS BY CUSTOMER

SALES: MARCH 79 TO FEBRUARY '81

DRAWIN NO.	CUST	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	CUM % TOT.VAL	CUM. ITEM
P1	682	11259		469	492.9	102.74	9.90	86.25
	685	4.0		18	28.3	161.30	10.28	89.53
	749	325		14	22.6	166.67	10.57	92.02
	365	269		11	18.2	162.21	10.81	94.14
	1185	261		11	18.1	166.67	11.05	96.24
	199	120		5	8.3	166.67	11.16	97.22	
	912	120		5	7.9	158.33	11.27	98.19
	254	[illegible]		4	6.7	166.67	11.35	98.88
	819	45		2	3.4	183.33	11.39	99.21
	729	[illegible]		1	2.4	191.67	11.42	99.44
	875	18		1	1.4	191.67	11.43	99.59
	40	12		1	0.9	183.33	11.44	99.68
	1135	10		0	0.8	191.67	11.45	99.76
	343	6		0	0.5	191.67	11.46	99.81
	1638	[illegible]		0	0.4	191.67	11.46	99.84
	299	4		0	[illegible]	191.67	11.47	99.88
	1058	3		0	[illegible]	191.67	11.47	99.90
	1103	3		0	[illegible]	191.67	11.47	99.92
	1287	2		0	0.2	191.67	11.48	99.94
	567	2		0	0.2	191.67	11.48	99.96
	995	2		0	0.2	191.67	11.48	99.97
	1426	2		0	0.1	191.67	11.48	99.98
	1136	1		0	0.1	191.67	11.48	99.99
	1289	1		0	0.1	191.67	11.48	100.00
P2	756	4901		204	[illegible]	[illegible]	16.64	51.48
	296	[illegible]		66	[illegible]	[illegible]	18.36	68.73
	682	[illegible]		43	[illegible]	[illegible]	[illegible]	78.34
	754	807		34	[illegible]	175.00	20.18	86.82
	880	595		[illegible]	[illegible]	175.00	20.70	92.05
	1179	348		[illegible]	[illegible]	166.67	21.08	95.81
	752	[illegible]		4	[illegible]	191.67	21.18	96.88
	758	100		4	[illegible]	191.67	21.29	97.94
	254	65		3	4.7	175.00	21.35	98.56
	904	[illegible]		2	3.8	183.33	21.40	99.05
	295	24		1	1.8	183.33	21.43	99.31
	84	24		1	1.9	191.67	21.45	99.54
	310	22		1	1.7	183.33	21.47	99.74
	465	10		0	0.8	191.67	21.48	99.84
	2104	7		0	0.5	183.33	21.49	99.91
	1313	5		0	0.4	183.33	21.49	99.97
	73	3		0	[illegible]	191.67	21.50	100.00
P3	1361	2760		115	71.3	62.03	24.89	39.35
	332	1999		83	35.9	43.10	27.09	64.33

TABLE 19 (Continued)

DRAWING NO.	CU-I	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	CUM % TOT.VAL	CUM. ITEM
	[illegible]	1999		[illegible]	25.9	43.10	29.29	90.51
	474	550		23	32.5	141.67	30.00	98.[illegible]
	685	500		21	26.3	126.33	30.65	100.30
	431	271		11	7.2	63.44	31.00	110.35
	[illegible]	270		11	20.6	183.33	31.27	113.[illegible]
	1473	166		7	6.1	87.65	31.45	115.[illegible]
	75[illegible]	125		5	8.7	166.67	31.62	117.48
	[illegible]	105		4	7.7	175.00	31.74	118.92
	1951	[illegible]		[illegible]	4.2	166.67	31.82	119.[illegible]
	1162	40		[illegible]	2.5	150.00	31.87	120.46
	75[illegible]	[illegible]		[illegible]	3.1	183.33	31.93	121.07
	2192	[illegible]		2	3.0	158.33	31.98	121.66
	930	[illegible]		[illegible]	2.6	175.00	32.02	122.15
	[illegible]	[illegible]		1	2.2	175.00	32.06	122.61
	59	[illegible]		1	2.4	191.67	32.10	123.04
	1925	24		1	1.8	183.33	32.13	123.42
	702	24		1	1.9	191.67	32.16	123.7[illegible]
	[illegible]	[illegible]		1	1.6	175.00	32.19	124.11
	[illegible]	15		1	1.2	191.67	32.21	124.[illegible]3
	1103	13		1	1.0	183.33	32.22	124.53
	1[illegible]3	12		1	1.0	191.67	32.24	124.71
	2259	10		0	0.8	191.67	32.25	12[illegible].85
	997	9		0	0.7	183.33	32.26	12[illegible].[illegible]
	1474	10		0	0.8	191.67	32.27	125.11
	[illegible]	[illegible]		0	0.6	191.67	32.29	125.[illegible]3
	2190	6		0	0.5	191.67	32.29	125.[illegible]
	634	6		0	0.5	191.67	32.30	125.41
	967	6		0	0.5	191.67	32.31	125.49
	1773	5		0	0.4	183.33	32.31	125.55
	1318	1		0	0.1	191.67	32.31	125.57
	919	1		0	0.1	191.67	32.32	125.58
P4	1474	2487		104	73.0	70.44	34.73	34.68
	685	1061		44	29.8	67.36	35.93	51.94
	471	600		25	19.1	76.33	36.60	61.54
	712	596		[illegible]	37.7	151.[illegible]2	37.20	70.16
	295	471		20	22.5	114.54	37.74	77.95
	1426	350		15	26.7	183.33	38.04	82.22
	758	210		9	12.4	141.67	38.28	85.63
	254	150		6	9.5	151.67	38.43	87.87
	2335	[illegible]		5	8.8	191.67	38.56	89.66
	421	80		3	5.6	166.67	38.65	91.02
	1473	89		4	4.1	111.[illegible]2	38.74	92.27
	2254	80		3	5.6	166.67	38.82	93.47
	1135	[illegible]0		2	3.6	175.00	38.88	94.30

TABLE 13 (Continued)

DRAWING NO.	CUST	TOT.QTY <24 MON	TOT.VAL <24 MON	AVE. QTY	MAD	VAR	CUM % TOT.VAL	CUM. ITEM
	685	1061		[illegible]	[illegible].8	67.36	40.08	111.58
	471	600		[illegible]	19.1	76.33	40.75	121.16
	712	596		[illegible]5	[illegible]7.7	151.62	41.35	129.78
	295	471		[illegible]	22.5	114.54	41.89	137.57
	1426	350		15	26.7	183.33	42.19	141.84
	75[illegible]	210		[illegible]	12.4	141.67	42.43	145.25
	254	150		[illegible]	9.5	151.67	42.58	147.49
	2335	110		5	8.8	191.67	42.71	149.28
	431	80		[illegible]	5.6	166.67	42.80	150.64
	1473	89		4	4.1	111.52	42.89	151.89
	2259	80		[illegible]	5.6	166.67	42.97	153.09
	1135	50		[illegible]	3.6	175.00	43.03	153.92
	1196	50		[illegible]	4.0	191.67	[illegible]	154.69
	1510	33		[illegible]	2.4	175.00	43.12	155.24
	280	30		[illegible]	2.3	183.33	43.16	155.74
	183	[illegible]		[illegible]	2.4	[illegible]1.67	43.19	156.23
	1094	24		[illegible]	1.8	183.33	43.22	156.65
	2190	22		[illegible]	[illegible]	183.33	43.25	157.03
	922	20		[illegible]	1.6	191.67	43.27	157.38
	634	19		[illegible]	1.3	166.67	43.29	157.70
	752	15		[illegible]	1.2	191.67	43.31	157.96
	135	11		0	0.9	191.67	43.32	158.13
	930	10		0	0.9	191.67	43.34	158.31
	1668	10		0	[illegible]	191.67	43.35	158.48
	1947	10		0	0.8	191.67	43.36	158.64
	666	10		0	0.8	191.67	43.37	158.81
	2192	10		0	0.[illegible]	191.67	43.38	158.95
	366	8		0	0.[illegible]	175.00	43.39	159.09
	997	6		0	0.5	191.67	43.40	159.20
	514	6		[illegible]	0.5	191.67	43.41	159.30
	245	6		[illegible]	0.5	191.67	43.41	159.39
	2334	5		0	0.4	191.67	43.42	159.47
	571	4		0	0.3	183.33	43.42	159.54
	1103	4		0	0.3	191.67	43.4[illegible]	159.60
	953	1		0	0.1	191 67	43.43	159.62
P5	2259	1505		63	53.7	85.57	45.56	46.80
	2012	428		18	20.8	116.67	46.18	60.56
	2114	282		12	16.2	137.94	46.59	69.59
	567	159		7	[illegible].8	102.04	46.84	75.15
	142[illegible]	158		[illegible]	9.9	150.00	47.04	79.56
	842	121		5	4.6	91.87	47.24	83.79
	326	80		3	5.3	158.33	47.36	86.43
	486	[illegible]2		[illegible]	4.0	133.33	47.47	88.91
	726	36		2	2.6	175.00	47.52	90.11

TABLE 13 (Continued)

	CUST	TOT.QTY (24 MON)	TOT.VAL (24 MON)	[illegible] .QTY (MON)	MAD	VAR %	CUM % TOT.VAL	CUM. ITEM
	2012	428		18	[illegible]	116.67	48.15	103.86
	2114	282		12	1[illegible].2	137.94	48.56	112.90
	567	159		7	6.8	102.04	48.81	118.46
	1426	158		7	[illegible]	150.[illegible]	49.01	122.87
	842	121		5	4.6	91.67	49.21	[illegible]
	326	80		3	[illegible]	1[illegible].33	49.33	129.74
	486	72		3	4.0	133.[illegible]	49.41	132.22
	726	36		2	[illegible]	175.0[illegible]	49.45	133.42
	295	30		1	2.2	175.0[illegible]	[illegible]	134.51
	1214	28		1	1.9	166.6[illegible]	49.59	135.58
	[illegible]	24		1	1.9	191.6[illegible]	49.63	136.49
	424	23		1	1.1	116.6[illegible]	49.67	137.34
	1118	21		1	1.5	166.67	49.71	138.10
	1053	20		1	1.3	158.33	49.74	138.81
	1357	20		1	1.6	191.67	49.77	139.49
	1487	20		1	1.5	183.33	49.80	140.17
	1156	20		1	1.6	191.67	49.83	140.83
	873	14		1	1.1	191.67	49.85	141.33
	863	13		1	1.0	183.33	49.87	141.74
	1043	11		0	0.8	183.3[illegible]	49.89	142.13
	1272	10		0	0.8	191.67	49.91	142.48
	1196	10		0	0.8	191.67	49.92	142.82
	254	8		0	0.6	191.67	49.93	143.06
	48	5		0	0.4	191.67	49.94	143.23
	1308	1		0	0.1	191.67	49.94	143.27
	1235	1		0	0.1	191.67	49.94	143.31
PE	703	374		41	19.2	47.42	53.83	94.29
	350	24		1	1.8	183.33	53.92	96.58
	245	16		1	1.2	175.00	53.99	98.16
	1271	7		0	0.5	183.33	54.02	98.87
	2259	5		0	0.4	183.33	54.04	99.30
	1322	4		0	0.3	191.67	54.05	99.[illegible]0
	32	3		0	0.2	191.67	54.07	100.00
P	685	1067		44	51.0	114.68	55.37	[illegible]
	1961	911		38	33.5	88.13	56.41	58.33
	758	480		20	26.7	133.33	56.99	72.92
	474	348		15	24.2	166.67	57.41	83.34
	1474	223		9	10.8	116.67	57.64	89.06
	1473	90		4	4.7	125.56	57.73	91.40
	59	70		3	5.3	183.33	57.81	93.49
	219[illegible]	64		3	4.2	158.33	57.88	95.13
	514	56		2	4.3	183.33	57.95	96.80

TABLE 13 (Continued)

DRAWING NO.	CUST	TOT.QTY (24 MON	TOT.VAL (24 MON	AVE.QTY (MON)	FAC	VAR %	CUM % TOT.VAL	CUM. ITEM
	1961	911			33.5	88.13	58.98	122.60
	758	480			26.7	133.33	59.57	137.18
	474	388			24.2	166.67	59.99	147.61
	1474	223			10.8	116.67	60.21	153.32
	1473	90			4.7	125.56	60.31	155.67
	59	70			5.3	183.33	60.39	157.75
	2192	64				158.33	60.46	159.41
	514	56				183.33	60 52	161.07
	254	45		2		191 67	60.57	162.31
	295	24		1		183.33	60.60	163.06
	332	18			1.4	191.67	60.62	163.55
	2190	10				191.67	60.64	163.86
	1202	8			.6	191.67	60.65	164.11
	207	5		0	.4	191.67	60.65	164.26
	752	1650			68.8	100.00	62.28	41.09
	685	1000		4.	59.0	141.67	63.24	65.49
	756	430		18	20.9	166.67	63.66	76.15
	754	300		13	21.9	175.00	63.96	83.68
	135	290		1	10.0	191.67	64.21	90.04
	735	2			16.0	191.67	64.39	94.59
	681	12		5	9.5	183.33	64.52	97.98
	417	90			7.2	191.67	64.61	100.00
	2335	2750		115	74.6	65.09	67.85	85.87
	295	60			8.8	175.00	67.92	87.79
	685	70			5.3	183.33	68.00	89.70
	1426	80			6.4	191.67	68.06	91.35
	1474	60			4.6	191.67	68.12	92.98
	712	59			4.3	175.00	68.18	94.54
	634	46			2.7	141.67	68.23	95.98
	254	35		1	2.7	183.33	68.27	96.91
	906	24		1	1.9	191.67	68.30	97.66
	2192	24		1	1.9	191.67	68.32	98.31
	1094	16		1	1.3	191.67	68.34	98.82
	2276	10		0	0.8	191.67	68.35	99.10
	2280	10		0	0.8	191.67	68.36	99.36
	280	5		0	0.4	191.67	68.37	99.52
	1058	4		0	0.3	183.33	68.37	99.64
	1126	3		0	0.2	183.33	68.37	99.73
	887	3		0	0.2	191.67	68.38	99.82
	435	2		0	0.2	191.67	68.38	99.89
	967	2		0	0.2	191.67	68.38	99.94
	1259	1		0	0.1	191.67	68.38	99.97
	571	1		0	0.1	191.67	68.38	100.00

TABLE 13 (Continued)

DRAWING NO	CUST	QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	CUM % TOT.VAL	CUM. ITEM
	[illegible]	60		3	4.4	[illegible]	[illegible]	[illegible]
	[illegible]	70		3	5.3	183.33	68.53	[illegible]
	[illegible]	[illegible]		[illegible]	6.4	191.67	68.59	[illegible]
	[illegible]	60		3	4.8	191.67	68.65	107.12
	1474	60		2	4.3	175.00	68.71	[illegible]
	712	[illegible]		2	[illegible]	191.67	68.77	110.11
	[illegible]	[illegible]		1	2.7	183.33	68.80	111.04
	[illegible]	[illegible]		1	1.9	191.67	68.83	111.79
	906	24		1	1.9	191.67	68.85	112.44
	2192	24		1	1.3	191.67	68.87	112.95
	[illegible]	[illegible]		0	0.8	191.67	68.88	113.23
	[illegible]	[illegible]		0	0.8	191.67	68.89	113.49
	366	10		0	0.4	191.67	68.90	113.65
	[illegible]	[illegible]		0	0.3	183.33	68.90	113.77
	1058	4		0	0.2	183.33	68.91	113.86
	1126	3		0	0.2	191.67	68.91	113.95
	887	3		0	0.2	191.67	68.91	114.02
	435	2		0	0.2	191.67	68.92	114.07
	96[illegible]	2		0	0.1	191.67	68.92	114.10
	1259	1		0	0.1	191.67	68.92	114.13
	571	1		0	0.1	191.67	68.92	114.16
P	1925	2984		124	64.3	51.70	72.33	95.25
	685	90		4	7.2	191.67	72.43	98.11
	712	40		2	3.2	191.67	72.47	99.33
	283	20		1	1.6	191.67	72.49	99.87
	2335	4		0	0.3	191.67	72.50	100.00
P	959	861		36	16.3	45.41	74.55	61.59
	756	295		12	17.6	143.22	75.26	82.83
	682	70		3	4.6	158.33	75.41	87.39
	656	50		2	3.8	183.33	75.51	90.55
	754	38		2	2.8	175.00	75.60	93.22
	199	20		1	1.5	183.33	75.65	94.69
	365	20		1	1.5	183.33	75.70	96.08
	2190	12		1	0.9	175.00	75.73	96.96
	295	10		0	0.8	191.67	75.75	97.70
	514	8		0	0.6	191.67	75.77	98.26
	969	8		0	0.6	175.00	75.79	98.77
	1166	6		0	0.5	191.67	75.80	99.11
	1139	5		0	0.4	191.67	75.81	99.58
	1166	2		0	0.2	183.33	75.82	99.73
	[illegible]	2		0	0.2	191.67	75.82	99.86
	958	1		0	0.1	191.67	75.83	99.94
	2211	1		0	0.1	191.67	75.83	100.00
P	[illegible]	1239		52	86.0	166.67	77.14	46.15

DRAWING NO.	CUST	TOT.QTY (24 MON.	TOT.VAL (24 MON.	AVE.QTY (24 MON.	MAD	VAR %	CUM % TOT.VAL	CUM% ITEM
	880	723		30	45.2	150.03	77.78	69.38
	682	510		21	37.2	175.00	78.29	87.61
	310	148		6	8.7	141.67	78.42	92.24
	2104	99		4	7.5	181.31	78.53	96.05
	365	60		3	4.8	191.67	78.59	98.17
	904	20		1	1.6	191.67	78.61	98.87
	971	19		1	1.5	183.33	78.63	99.52
	465	10		0	0.8	191.67	78.64	99.88
	254	4		0	0.3	191.67	78.64	100.00

APPE IX 4

CUSTOMER RANKING IN ORD R OF DEC

CUSTOMERS RANKING IN ORDER OF DECREASING ACCOUNT VALUE AND DETAILS OF PURCHASES

The report shows that only twenty seven customers account for 80% of the sales revenue in this product group. Of these customers, twelve have more than 75% of their account concentrated on one item.

TABLE 14

CUSTOMER RANKING BY ACCOUNT VALUE

SALES: MARCH '79 TO FEBRUARY '81

CUSTOMER: 682 CUM % VALUE: 11.8%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
	11259		469	492.0	182.74	83.7
P1	1036		43	64.8	150.00	8.1
P2	510		21	37.2	175.00	4.3
P	96		4	6.8	170.83	1.3
P	70		3	4.6	158.33	1.3
P	114		5	8.7	183.33	1.0
P	20		1	1.6	191.67	.2
P	10		0	0.8	191.67	.1

CUSTOMER: 756 CUM % VALUE: 21.0%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
	4901		204	209.2	131.84	56.3
F2	1239		52	86.0	166.67	14.4
P	831		35	64.7	186.85	9.6
P	295		12	17.6	143.22	7.7
P	500		21	39.9	191.67	5.3
P	430		18	29.9	166.67	4.6
P	180		8	14.4	191.67	2.0

CUSTOMER: 1961 CUM % VALUE: 26.6%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
	2760		115	74.2	62.93	61.0
P3	911		38	33.5	88.13	18.6
P	770		32	53.0	165.15	12.3
P	110		5	4.9	106.82	3.8

TABLE 14 (Contined)

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	45		2	3.6	191.67	2.4
P	20		1	1.4	166.67	.8
P	24		1	1.8	175.00	.6
P	15		1	1.0	158.33	.5

CUSTOMER: 685 CUM % VALUE: 31.6%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	1067		44	51.0	114.69	25.9
P4	1061		44	29.8	67.36	23.8
P	1000		42	59.0	141.67	19.1
P3	500		21	26.3	126.33	13.0
P1	420		18	28.3	161.90	7.5
P	145		6	10.6	175.00	3.5
P	90		4	7.2	191.67	2.1
P	66		3	5..	191.67	1.7
P	70		3	5.3	183.33	1.4
P	45		2	3.6	191.67	1.2
P	100		4	8.0	191.67	.8

CUSTOMER: 703 CUM % VALUE: 35.6%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QT (MON)	MAD	VAR %	%B VAL
P6	974		41	19.2	47.42	99.3
P	5		0	0.4	191.67	.3
P	5		0	0.4	191.67	.3
P	3		0	0.2	191.67	.1

CUSTOMER: 2259 CUM % VALUE: 39.3%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P5	1505		63	53.7	85.57	57.8
P	305		13	20.0	157.49	11.7
P	184		8	11.6	150.72	7.4
P	123		5	9.0	175.00	7.2

TABLE 14 (Continued)

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
	88		3	5.6	166.67	2.3
P4	50		2	3.8	183.33	1.9
P	21		1	1.5	175.00	1.6
P	20		1	1.6	191.67	1.5
P	37		2	2.8	183.33	1.5
P	40		2	3.2	191.67	1.5
P	38		2	3.0	191.67	1.4
P	20		1	1.6	191.67	.8
P	14		1	1.0	175.00	.8
P	8		0	0.6	191.67	.8
P	5		0	0.4	183.33	.5
P6	5		0	0.4	191.67	.5
P	10		0	0.8	191.67	.4
P	10		0	0.8	191 67	.3
P3	4		0	0.3	191.67	.1
P	1		0	0.1	191.67	.1

CUSTOMER: 1925 CUM % VALUE: 42.7%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
	2984		124	64.3	51.70	98.4
P	24		1	1.8	183.33	.9
P3	12		1	1.0	191.67	.5
P	2		0	0.2	191.67	.2
P						

CUSTOMER: 2385 CUM % VALUE: 46.1%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
	2750		115	74.6	65.09	96.2
P	110		5	8.8	191.67	3.7
P4	4		0	0.3	191.67	.1
P						

CUSTOMER: 1474 CUM % VALUE: 48.9%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P4	2487		104	73.0	70.44	86.9

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	223			10.8	116.67	8.2
P	60			4.8	191.67	2.2
P	14			0.9	158.33	1.0
P	18		1	1.4	191.67	.6
P	10			0.8	191.67	.4
P3	10		0	0.8	191.67	.4
	2			0.2	191.67	.2
P	2			0.2	191.67	.1
P	2			0.2	191.67	.1

CUSTOMER: 959 CUM % VALUE: 51.6%

DRAWING NO	TOT.QTY (24 MON)	TOT.VAL (24 MO	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	861		36	10.2	45.41	25.9
P	521		20	20.3	93.41	22.0
P	50		2	4.0	131.67	2.1

CUSTOMER: 1426 CUM % VALUE: 54.3%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	308		13	15.6	121.65	20.9
P	360		15	23.8	158.33	16.5
P	350		15	26.7	183.33	11.1
P4	270		11	20.6	183.33	10.1
P3	190		8	13.2	166.67	9.4
P	158		7	9.9	150.00	7.5
P5	109		5	7.2	158.33	7.4
P	130		5	9.5	175.00	4.8
P	31		1	2.0	158.33	2.7
P	91		4	7.0	183.33	2.4
P	80		3	6.4	191.67	2.3
P	19		1	1.5	191.67	1.3
P	25		1	2.0	191.67	.9
P	25		1	2.0	191.67	.8
P	18		1	1.4	183.33	.8
P	20		1	1.6	191.67	.8
P	2		0	0.2	191.67	.2

[illegible]

[illegible]	TOT.QTY (24 HOUR)	TOT.VOL (24 HOUR)	AVE.QTY (MONTH)	[illegible]	[illegible]	[illegible]
P1	2		0	0.0	[illegible]	[illegible]

CUSTOMER: [illegible]

[illegible]	TOT.QTY (24 HOUR)	TOT.VOL (24 HOUR)	AVE.QTY (MONTH)	AVE	[illegible]	[illegible]
	1359		83	[illegible]	[illegible]	[illegible]
P1	98		4	[illegible]	[illegible]	[illegible]
P	18		2	[illegible]	[illegible]	[illegible]
P	18		1	[illegible]	[illegible]	[illegible]
P	18		0	[illegible]	[illegible]	[illegible]
P	18					

CUM % VOLUME [illegible]

CUSTOMER: [illegible]

[illegible]	TOT.QTY (24 HOUR)	TOT.VOL (24 HOUR)	AVE.QTY (MONTH)	AVE	[illegible]	[illegible]
	607		34	[illegible]	[illegible]	[illegible]
P1	462		22	[illegible]	[illegible]	[illegible]
P	340		13	[illegible]	[illegible]	[illegible]
P	340		3	[illegible]	[illegible]	[illegible]
P	78		2	[illegible]	[illegible]	[illegible]
P	38					

CUM % VOLUME [illegible]

CUSTOMER: [illegible]

DRAWING NO.	TOT.QTY (24 HOUR)	TOT.VOL (24 HOUR)	AVE.QTY (MONTH)	AVE	[illegible]	[illegible]
	723		29	[illegible]	[illegible]	[illegible]
P	595		23	[illegible]	[illegible]	[illegible]
P2	345		16	[illegible]	[illegible]	[illegible]
P	308		13	[illegible]	[illegible]	[illegible]
P	205		8	[illegible]	[illegible]	[illegible]
P	46		2	[illegible]	[illegible]	[illegible]
P	42		2	[illegible]	[illegible]	[illegible]
P	4		0	[illegible]	[illegible]	[illegible]

CUSTOMER: [illegible]

CUM % VOLUME [illegible]

[illegible]	TOT.QTY (24 HOUR)	TOT.VOL (24 HOUR)	AVE.QTY (MONTH)	AVE	[illegible]	[illegible]
P	1104		50	[illegible]	[illegible]	[illegible]

TABLE I (Continued)

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	3		0	0.2	191.67	.3

CUM % VALUE: 64.0%

CUSTOMER: 177

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	64		27	14.1	52.64	99.7
P3	5		0	0.4	183.33	.3

CUM % VALUE: 66.7%

CUSTOMER: 296

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P2	1594		66	69.8	105.07	89.2
P	150		6	11.5	183.33	7.7
P	40		2	3.1	183.33	2.5
P	10		0	0.8	191.67	.6

CUM % VALUE: 68.7%

CUSTOMER: 752

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	1650		69	68.8	100.00	84.3
P3	125		5	8.7	166.67	6.5
P2	100		4	8.0	191.67	5.5
P4	15		1	1.2	191.67	.9
P	5		0	0.4	191.67	.8
P	1		0	0.1	191.67	.1

CUM % VALUE: 70.3%

CUSTOMER: 365

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	1025		43	64.1	150.00	59.7
P1	269		11	18.2	162.21	14.9
P	147		6	8.7	141.67	10.0
P	46		2	3.5	183.33	4.3
P	60		3	4.8	191.67	3.7

TABLE 14 (Contined)

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	20		1	1.5		2.8
P	40		2	3.2	191.67	2.5
P	20		1	1.6		1.2
P	10		0	0.8	191.67	

CUM % VALUE: 71.7%

CUSTOMER: 1175

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	577		24	15.3		95.4
P	20		1	1.6	191.67	4.6

CUM % VALUE: 73.0%

CUSTOMER: 1175

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	495		21	36.1		40.1
P2	348		15	24.2	166.67	29.4
P	107		4	7.1	158.33	14.2
P	92		4	7.0	183.33	7.7
P	47		2	3.6	183.33	6.4
P	18		1	1.3	150.00	2.3

CUSTOMER: 474

CUM % VALUE: 74.2%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P3	550		23	32.5	141.67	58.4
P	348		15	24.2	166.67	34.7
P	52		2	4.2	191.67	4.9
P	10		0	0.8	191.67	2.0

CUSTOMER: 1105

CUM % VALUE: 75.4%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	689		29	43.1	150.00	53.3
P1	261		11	16.1	166.67	20.4

T [illegible] IS (continued)

DRAWING NO.	TOT.QTY (24 MONTHS)	TOT.VOL (24 MONTHS)	AVE.QTY (MONTH)	AVG.	VOL %	%BY VOL.
F	444		18	10.1	171.48	19.9
F	108		4	3.8	191.67	4.4
F	38		1	3.4	191.67	2.1

CUSTOMER: 756 [illegible] 76.6%

DRAWING NO.	TOT.QTY (24 MONTHS)	TOT.VOL (24 MONTHS)	AVE.QTY (MONTH)	AVG.	VOL %	%BY VOL.
F	350		29	10.7	143.33	49.5
F	212		9	12.4	131.67	20.1
F1	100		4	8.3	131.67	9.8
F2	50		2	3.8	191.67	6.9
F	44		2	3.1	142.33	4.4
F3	46		2	3.3	175.00	4.2
F	46		2	3.3	191.33	3.1
F	12		1	2.2	191.33	2.7
F	38		1	2.1	191.67	2.7
F	6		0	0.4	191.67	1.1

CUSTOMER: 295 [illegible] 77.7%

DRAWING NO.	TOT.QTY (24 MONTHS)	TOT.VOL (24 MONTHS)	AVE.QTY (MONTH)	AVG.	VOL %	%BY VOL.
F4	471		20	12.5	114.54	47.3
F	88		4	7.8	191.67	8.4
F	33		1	1.7	143.00	6.8
F	80		3	4.4	175.00	6.3
F	23		1	1.4	142.83	6.1
F	38		1	.8	175.00	4.1
F3	38		1	.8	175.00	3.5
F3	58		3	1.2	191.67	2.7
F	20		1	1.0	191.33	2.6
F	24		1	1.0	191.33	2.3
F2	24		1	0.8	191.67	2.1
F	10		1	1.5	191.67	2.0
F	30		1	0.5	191.67	1.4
F	10		1	1.0	191.67	1.1
F	12		1	0.5	191.67	.9
F	6		1	0.1	191.67	.7
F	6		1	0.1	191.67	.7

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P			0	0.2	191.67	.6
P			0	0.3	191.67	.4
P	1		0	0.	191.67	.4

CUSTOMER: 631 CUM % VALUE: 78.6%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
P	450		19	34.4	183.33	47.4
P	300		13	22.1	176.67	38.9
P	40		2	3.1	183.33	7.0
P	46		2	3.2	191.67	4.6
P	20		1	1.5	183.33	2.2

CUSTOMER: 2012 CUM % VALUE: 79.4%

DRAWING NO.	TOT.QTY (24 MON)	TOT.VAL (24 MON)	AVE.QTY (MON)	MAD	VAR %	%BY VAL
F5	428		18	20.8	116.67	71.7
P	134		6	8.4	150.00	22.2
P	37		2	3.0	191.67	6.1

APPENDIX 5

SAFETY STOCKS

safety stock factors

and time adjustment factors

Tables 15.1 and 15.2 are used in the following manner:

Suppose:

Demand interval = [illegible] (i.e. sales) [illegible] (measured in months)
Re-stock

Lead time interval = [illegible]

Mean absolute deviation of [illegible] = [illegible]

For 95% service level

Safety factor = 1.6 (from table 15.1)

Units of lead time demand to cover variation = 1.6

Lead time demand = [illegible] = 1.1 (from 10.1a & 15.2)

Therefore:

Safety stock = 1.6 x 1.1 = 1.8

= [illegible]

TABLE 15.1

SAFETY STOCK FACTORS BASED ON MEAN ANNUAL [illegible]

Service Level	Factor
80%	1.05
90%	1.65
95%	2.33
97%	2.58
98%	2.58
99%	3.01

Safety Stock = (Factor) (Mean Absolute Deviation)

TABLE 15.2

[illegible] ADJUSTMENT FACTORS F x SAFETY STOCK

[illegible]	Adjustment Factor
2	1.57
3	2.10
[illegible]	2.64
5	3.09
6	3.51
8	4.29
10	5.01

[illegible] — [illegible] from Table 15.1) (Factor [illegible] Table 15.2) (Mean absolute [illegible])

APPENDIX 6

INVENTORY STATUS

Table 16.1 Inventory status at end of April 1980

Table 16.2 Inventory status at end of January 1981

The inventory status at 04-25-1980 and 01-25-1981 are shown in Tables 16.1 and 16.2 respectively. The products are ranked in decreasing order of importance as determined by an A-B-C analysis over twelve preceeding months (see Appendix 2.3).

The following points can be noted:

a) There are no stockouts recorded in April 1980. Table 16.1.

b) Two 'B' items in Table 16.1 have less than one months stock of average sales on hand.

c) One stockout of a 'B' item is recorded in Table 16.2.

d) Three 'A' items have less than one months stock of average sales on hand stock.

The figures in Table 16.1 were used as a starting point for the inventory simulation exercise in Section 7. This exercise goes through to January 1981 where the results are compared with the actual stock figures shown in Table 16.2.
Inventory savings (or increases) are computed on the basis of the difference between the simulated figures and the actual January 1981 figures.

TABLE 16.1

INVENTORY STATUS AT 25 APRIL 1980

PRODUCT	Ending April '80 12 Month Sales	Sales Ave	M.A.D.	Stock on Hand	Stock Turn-Over in Mths	Cum % Stock Value
P1	9855	821	545	1203	1,47	4,19
P3	3510	293	122	891	3,04	9,70
P4	3967	331	109	1091	3,30	15,80
P5	1831	153	76	460	3,01	19,51
	2210	184	77	477	2,59	21,48
P6	445	37	16	87	2,35	23,02
	1483	124	80	569	4,59	26,20
	1300	108	98	722	6,69	30,23
	450	38	15	106	2,79	31,59
	558	47	9	211	4,49	33,71
	513	43	19	140	3,26	35,06
	1271	106	149	649	6,12	37,73
	1019	85	64	383	4,15	39,87
	699	58	17	244	4,21	41,84
P2	1137	95	85	743	7,82	45,21
	922	77	60	530	6,88	48,28
	943	79	67	108	1,37	48,77

Note: Cumulative percentage of stock value only calculated for 'A' items.

Total number of line items = 76

Total nunmber of units = 13 145

TABLE 16.2

INVENTORY STATUS AT 25 JANUARY 1981

PRODUCT	Ending Jan 1981 12 Month Sales	Sales Ave	M.A.D.	Stock on Hand	Stock Turn-Over in Mths	Cum % Stock Value
P2	7924	610	464	12	0,02	0,06
P3	4527	348	99	1706	4,90	12,61
P1	4706	362	330	1096	3,03	16,99
P4	3562	274	115	808	2,95	22,25
	2510	193	78	547	2,83	25,92
	2513	193	54	533	2,76	29,39
P6	575	44	21	117	2,66	31,91
	2225	171	195	104	0,61	32,47
	908	70	35	155	2,21	34,28
	1733	133	67	105	0,79	34,97
	1855	143	72	563	3,94	37,70
	1159	89	38	345	3,88	40,82
P5	1171	90	50	411	4,57	44,83
	1477	114	102	313	2,75	46,87
	574	44	17	159	3,61	48,84
	333	26	13	63	2,42	49,83

Note: Cumulative percentage pf stock value was only calculated for 'A' items.

Number of items	69
Number of units	13 842

APPENDIX 7

SAMPLE EXPONENTIAL SMOOTHING RESULTS

[illegible] results in Appendices 7, 8 and 9 are based on the following models:

model [illegible]: Exponential smoothing with no trend or seasonality.

model [illegible]: Exponential smoothing with removal of trend by Brown's tracking signal.

[illegible]: Adaptive smoothing by Trigg and Leach method.

[illegible]: Adaptive smoothing by a fan filter method.

7.1 The Exponential Smoothing Models

7.1.1 Model 1 - Exponential Smoothing With No Control

The model is based on equation 1

$$NF = (ND) + (1 - \alpha)OF$$

Where NF = new forecast
ND = new demand information
OF = previous forecast
α = smoothing coefficient = Alpha

This model is included purely for reference purposes. It would not be used in practical applications unless monitored. It forms the basis of models two, five and six.

7.1.2 Model 2 - Exponential Smoothing With Control

This model is based on model 1 but is controlled by means of the tracking signal (refer to section 4.3.2.4).

$$TS = \frac{E_t}{MAD_t}$$

Control is exercised in the following manner:

a) The limit for the tracking signal is determined from Table 2. It depends on the value of the smoothing factor and confidence level required. In this work a confidence level of 95% has been used.

b) When three successive forecasts produce tracking signals that exceed the limit, it is assumed that definite trend has been detected. The next forecast is recalculated with alpha = 0,8 and a new tracking signal is calculated

c) Alpha is maintained at 0,8 until the tracking signal drops below the limit. Alpha is then reset to the original specified value.

d) The selected value of alpha equal to 0,8 can be varied to speed up or slow down the model's response. The allowed number of forecasts, where the tracking signal is out of control, can also be altered.

7.1.3 [illegible]

This method is also based on equation 1 and the tracking signal. In this instance the value of alpha is reset, in each time period, equal to the absolute value of the tracking signal. [illegible] closely following the sales data, the tracking signal will be very small and the forecast will be stable. When large forecast errors occur, the tracking signal will become large and the model will respond quickly to any changes.

7.1.4 Model 6 - Exponential Smoothing - Run Based Model

This model is adequately explained in section 4.3.5.

7.2 Start Up Conditions For All Models

a) Forecast for period two equals demand in period one.

b) Alpha = 0,5 for periods one and two and is then reset to the specified value.

c) Gamma (the smoothing factor for mean absolute deviation equals 0,3 for periods one and two).

APPENDIX B.3

DEMAND VERSUS ACTUAL GAINS

FOR THE FIVE NEW 'A' TYPES

The five item numbers are shown for all four months.

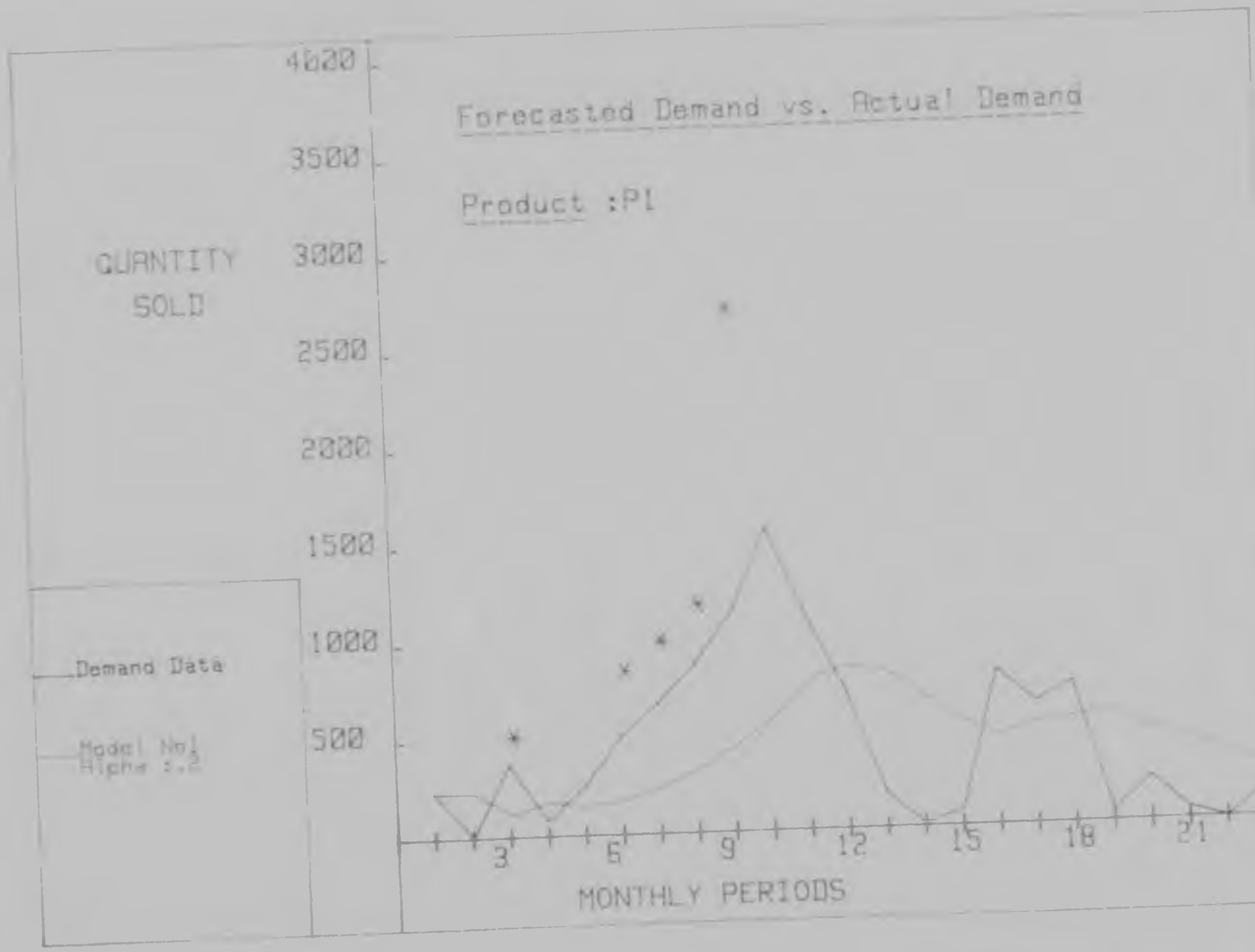

Forecasted Demand vs. Actual Demand
Product :P1
QUANTITY SOLD
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
Model No1
Alpha =.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 11

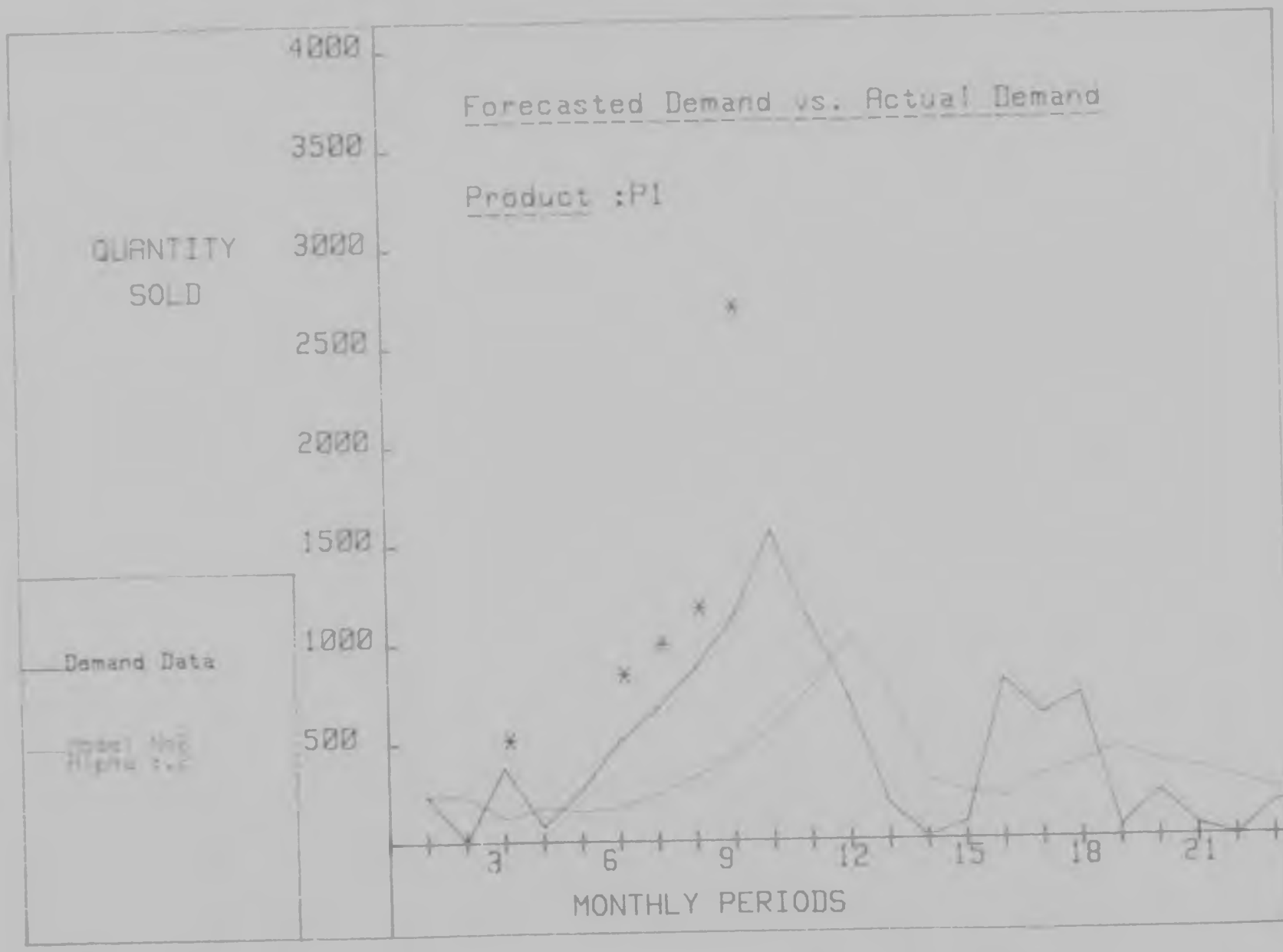

Forecasted Demand vs. Actual Demand
Product :P1
QUANTITY SOLD
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 12

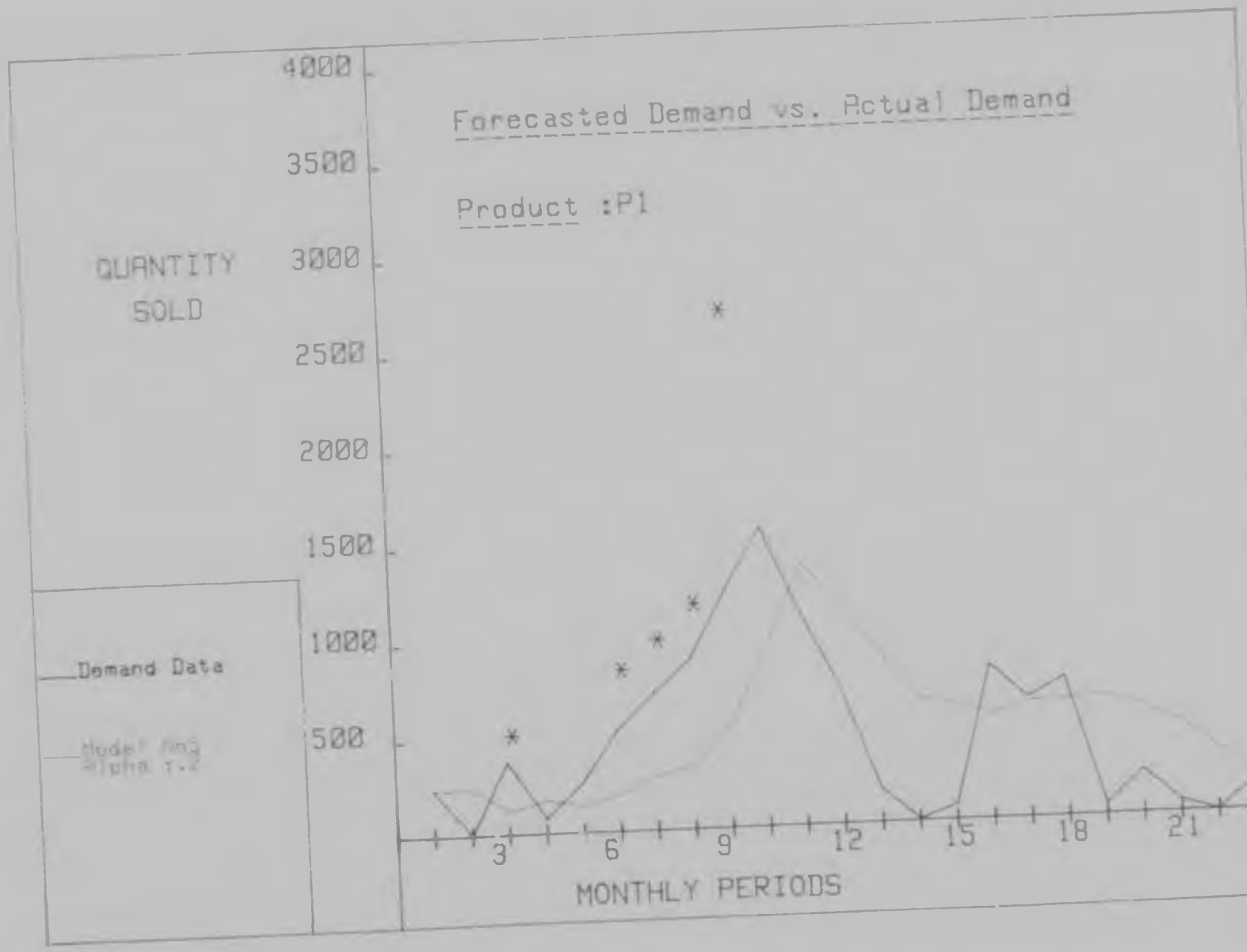

Forecasted Demand vs. Actual Demand
Product :P1
QUANTITY SOLD
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
Model fmg
Alpha 1.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 13

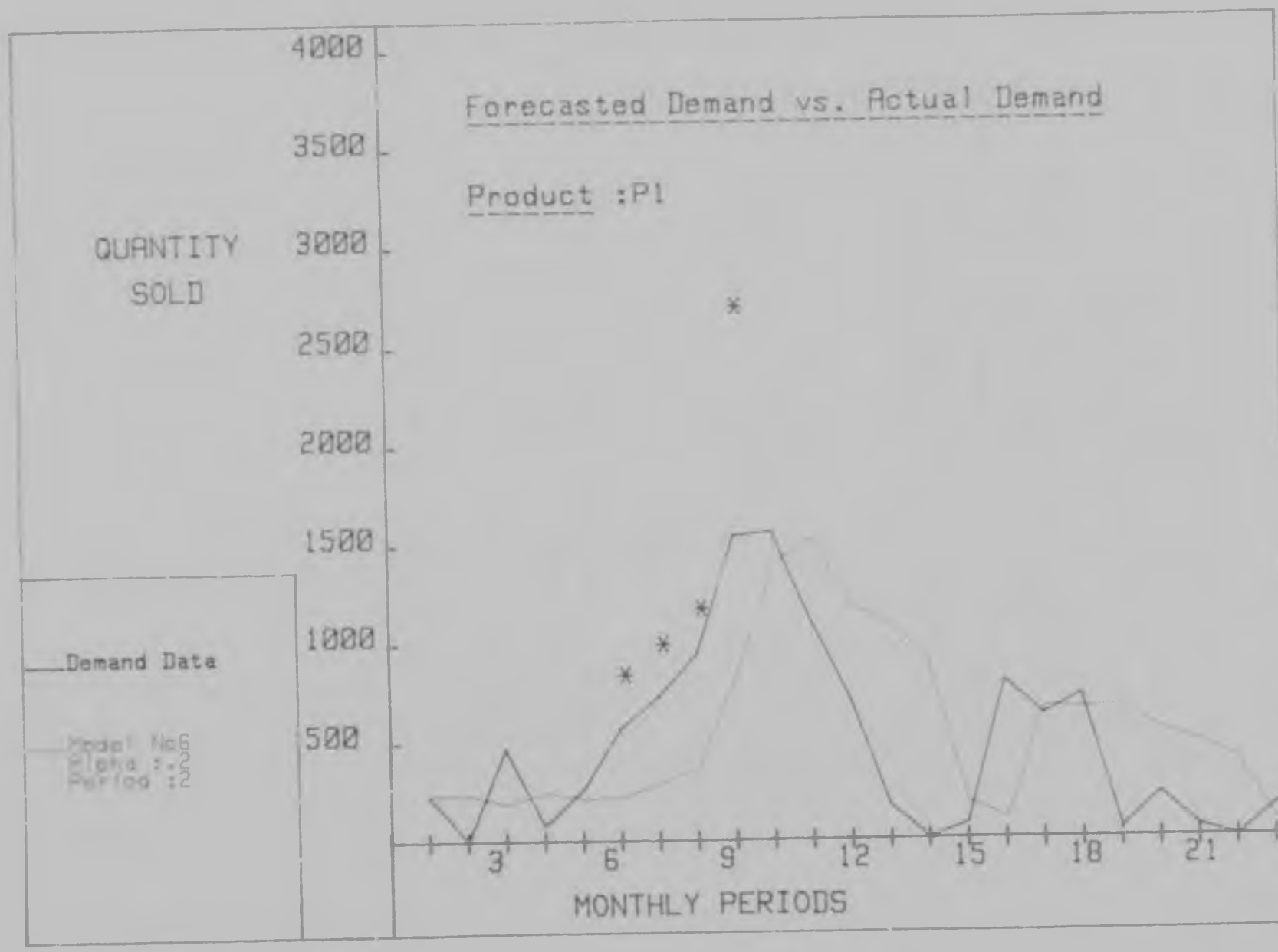

Forecasted Demand vs. Actual Demand
Product :P1
QUANTITY SOLD
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
Model No 6
Alpha :.2
Period :2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 14

7.3.2 Product : PZ

Note the following points:

a) Demand variability is 94% (ref Appendix 2-1) (Table 11)

b) Model 1 produces the smoothest forecast but badly lags the upward trend.

c) Model 6 follows the trend most closely.

d) External, marketing information is required to forecast an increase in demand for this item.

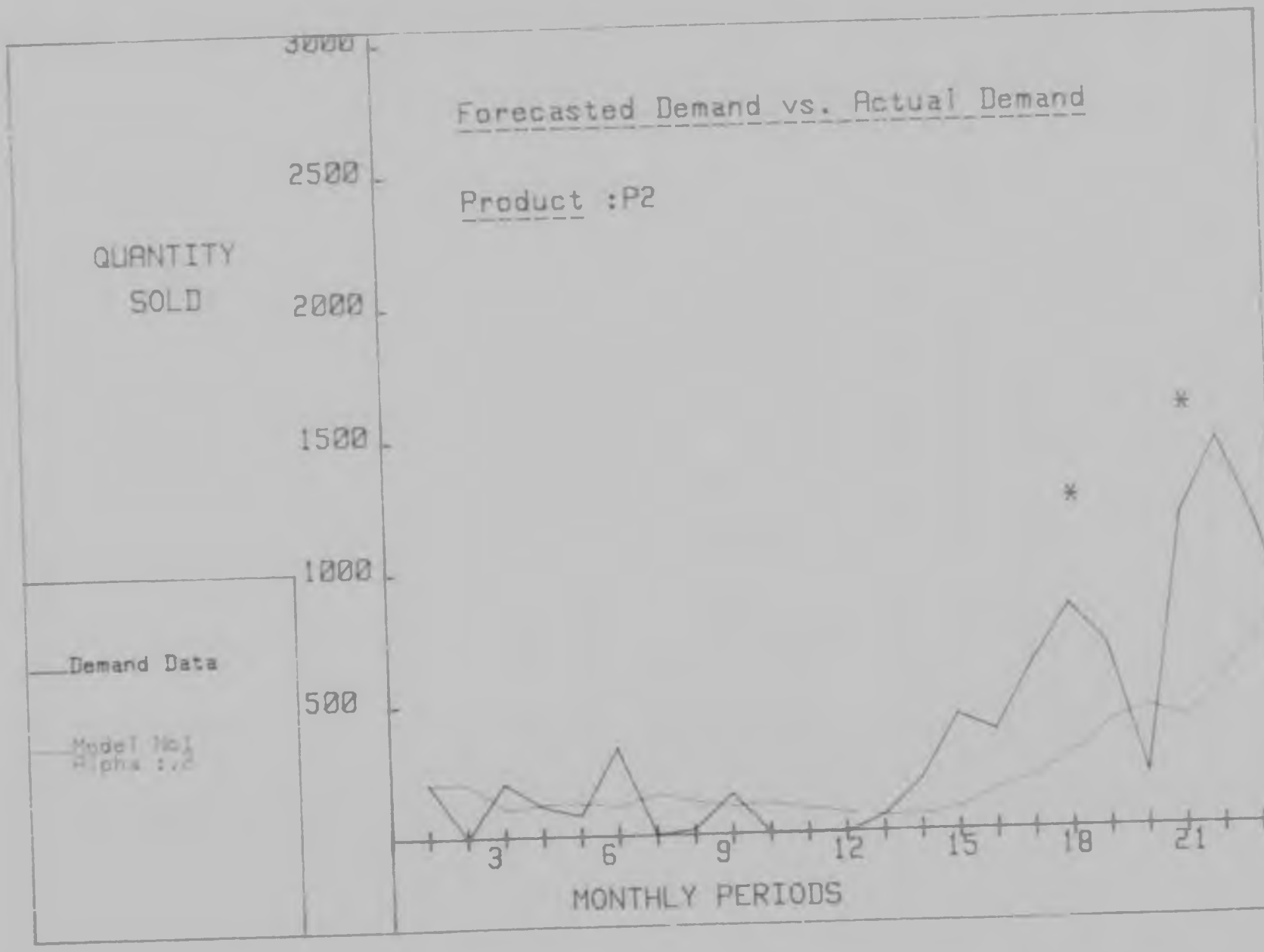

Forecasted Demand vs. Actual Demand
Product :P2
QUANTITY SOLD
3000
2500
2000
1500
1000
500
Demand Data
Model No1
Alpha 1.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 15

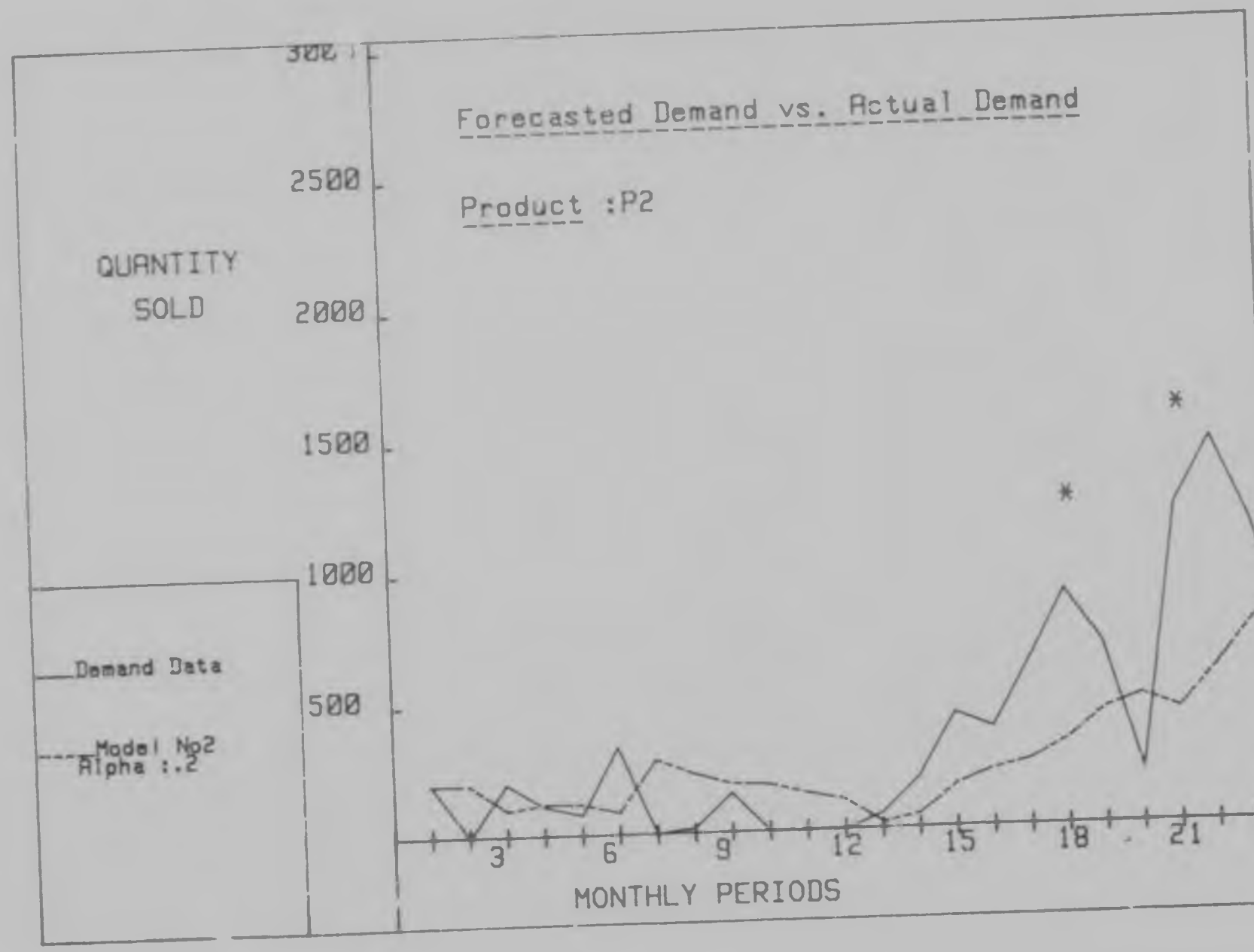

Forecasted Demand vs. Actual Demand
Product :P2
QUANTITY SOLD
3000
2500
2000
1500
1000
500
Demand Data
Model No2
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 16

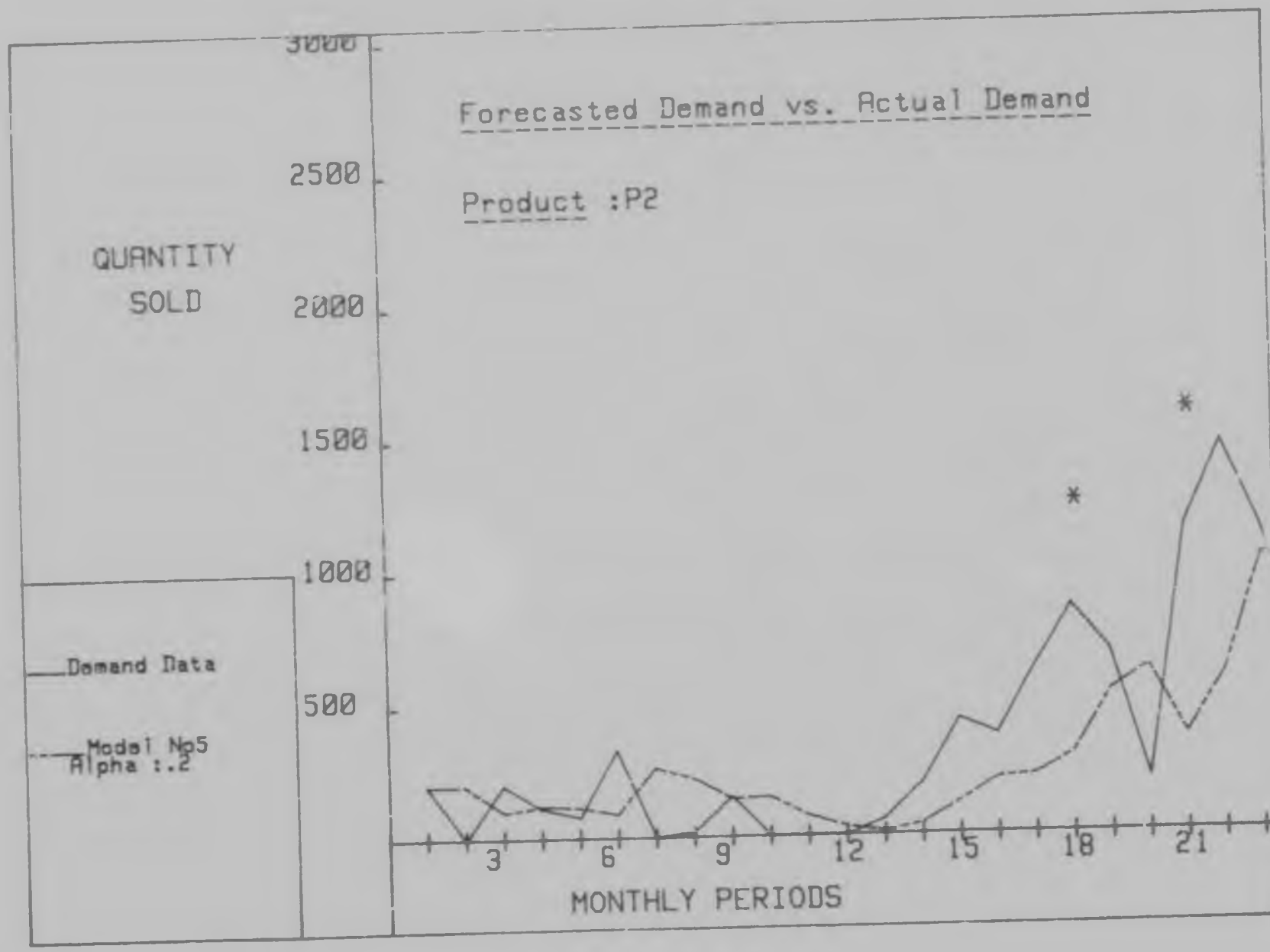

Forecasted Demand vs. Actual Demand
Product :P2
QUANTITY SOLD
3000
2500
2000
1500
1000
500
Demand Data
Model No5
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 17

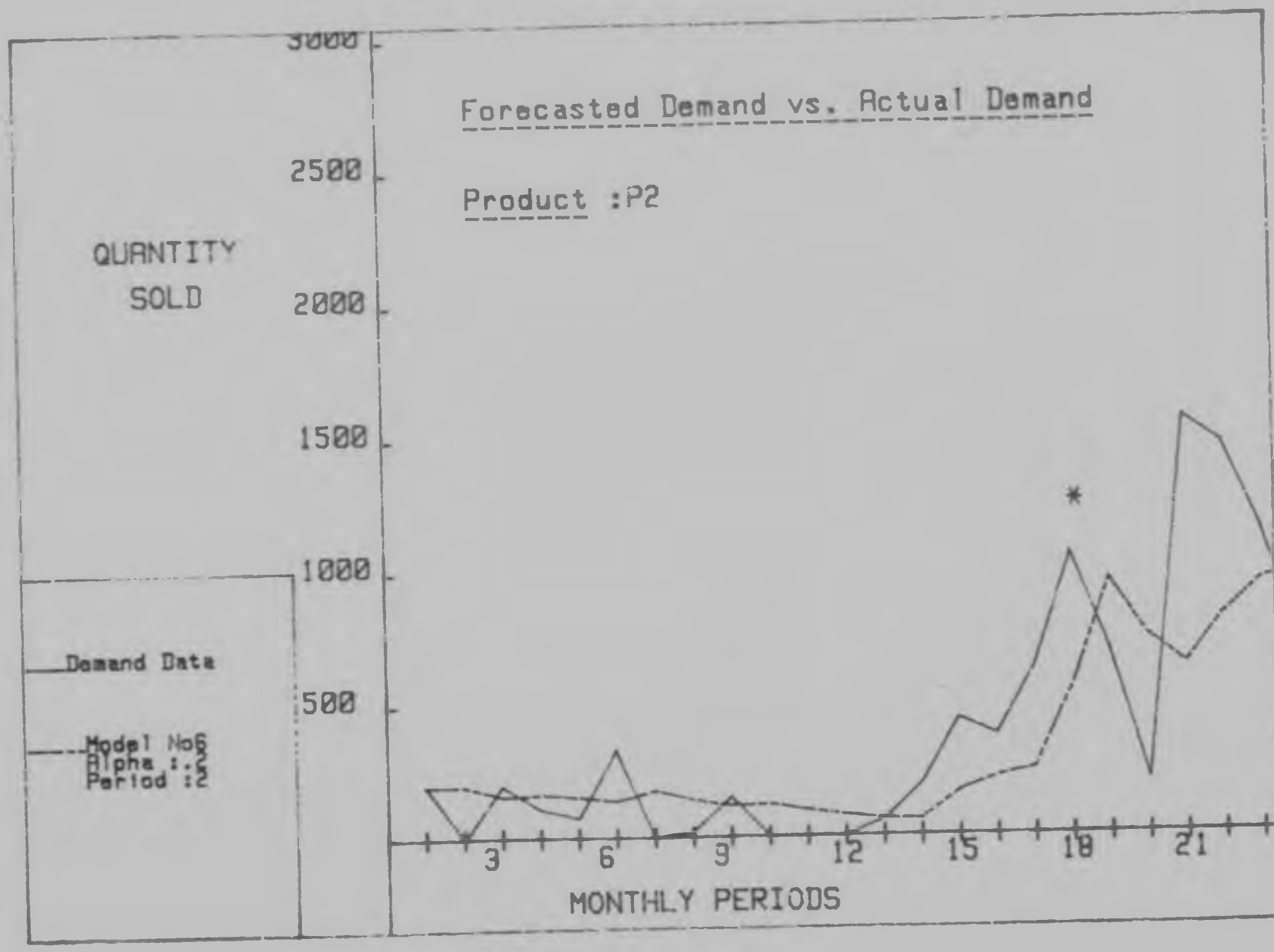

Forecasted Demand vs. Actual Demand
Product :P2
QUANTITY SOLD
3000
2500
2000
1500
1000
500
Demand Data
Model No6
Alpha :.6
Period :2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 18

7.3.3 Product : P3

Note the following points:

a) The demand variability is 37% (Ref Appendix 2.1; Table 11)

b) All models follow the sales data fairly well.

c) Model one's slow response to the change in demand level is clearly evident.

7.3.3 Hydrology [3]

Rate the following parameters:

a) [illegible] variability (see Appendix 2.1; Table 11)

b) All models follow the sales data fairly well.

c) Rapid [illegible] response to the change in demand
(year 1, calendar).

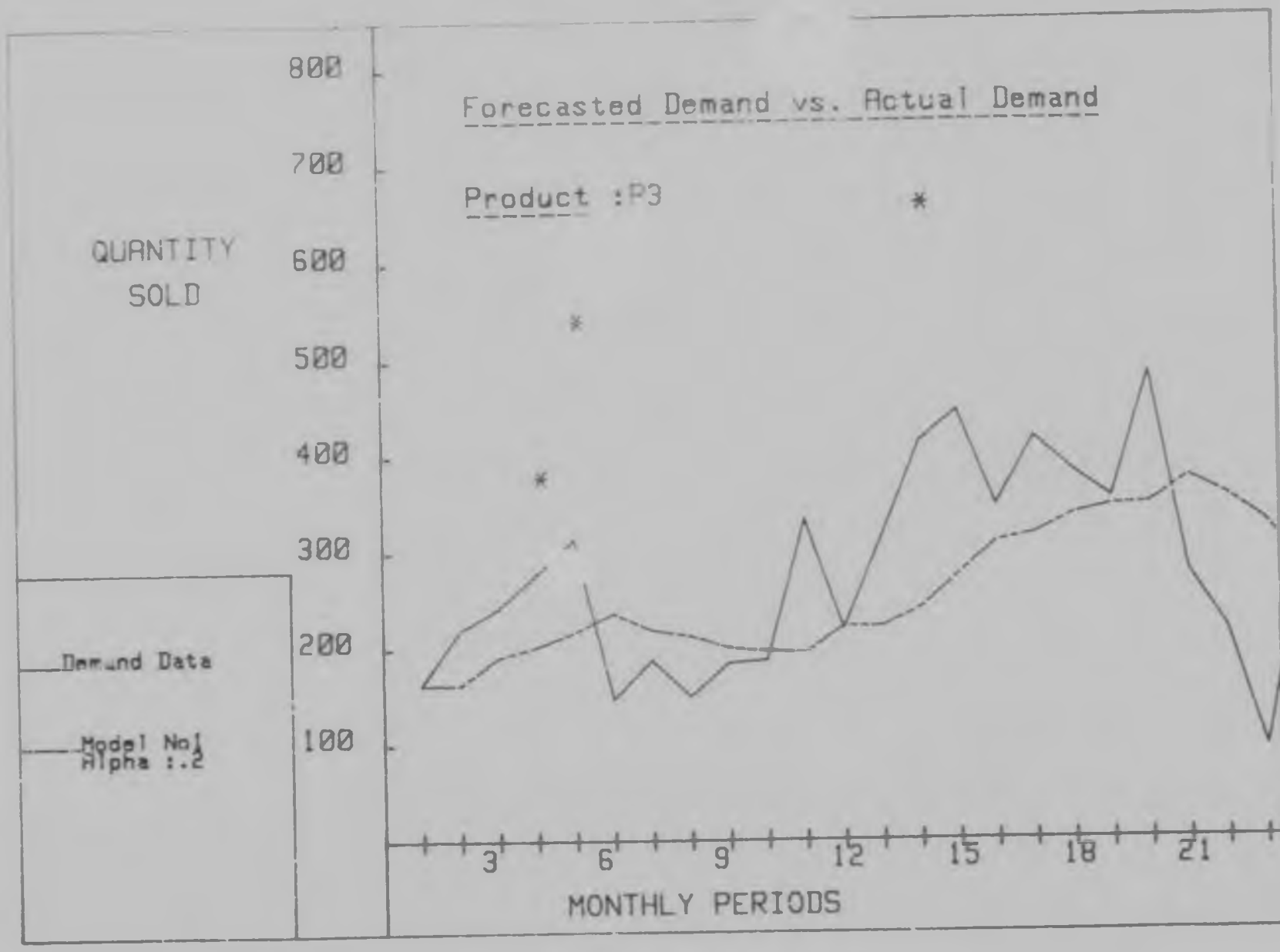

Forecasted Demand vs. Actual Demand
Product :P3
QUANTITY SOLD
800
700
600
500
400
300
200
100
Demand Data
Model No1
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 19

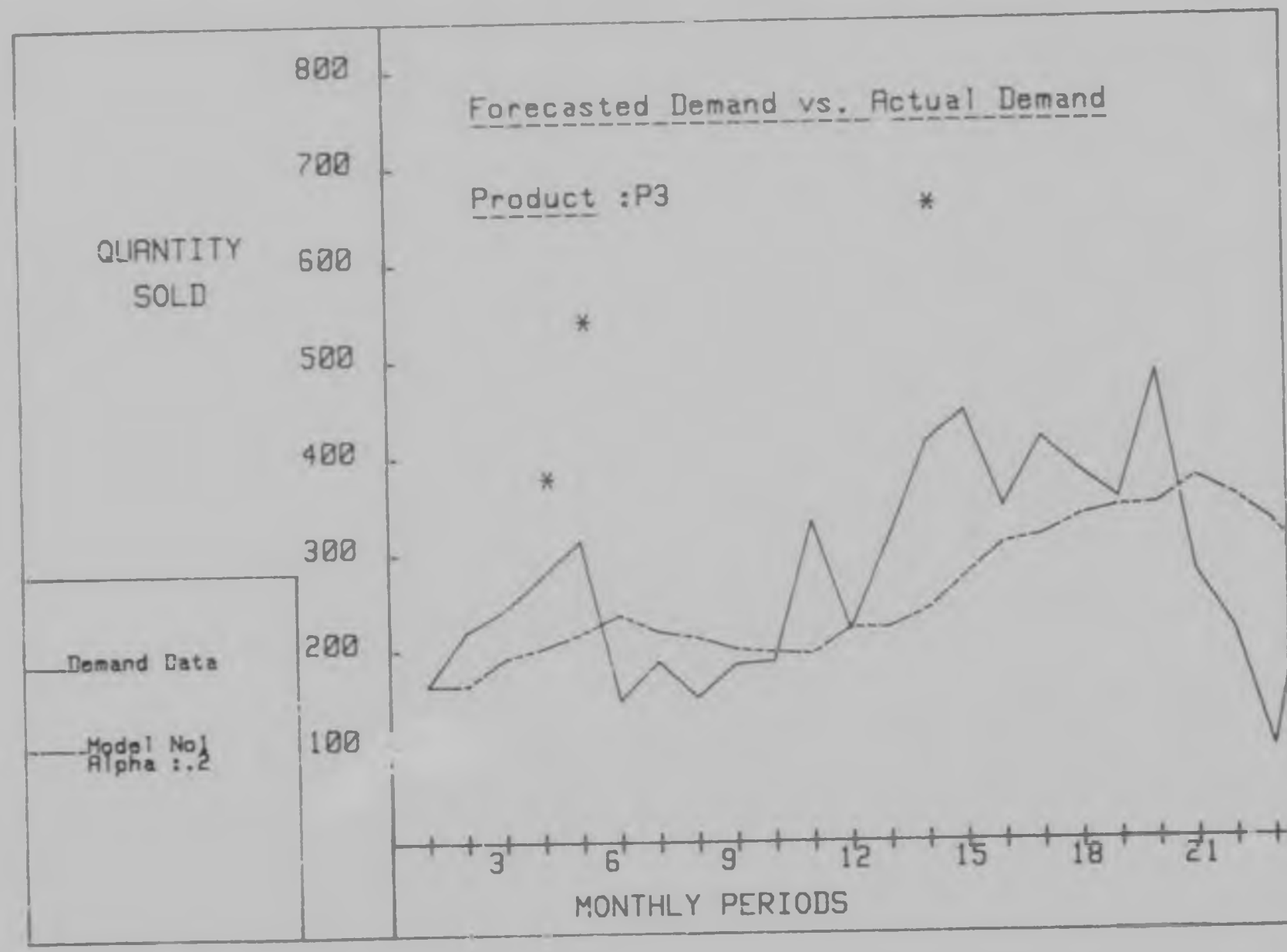

Forecasted Demand vs. Actual Demand
Product :P3
QUANTITY SOLD
800
700
600
500
400
300
200
100
Demand Data
Model No1
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 19

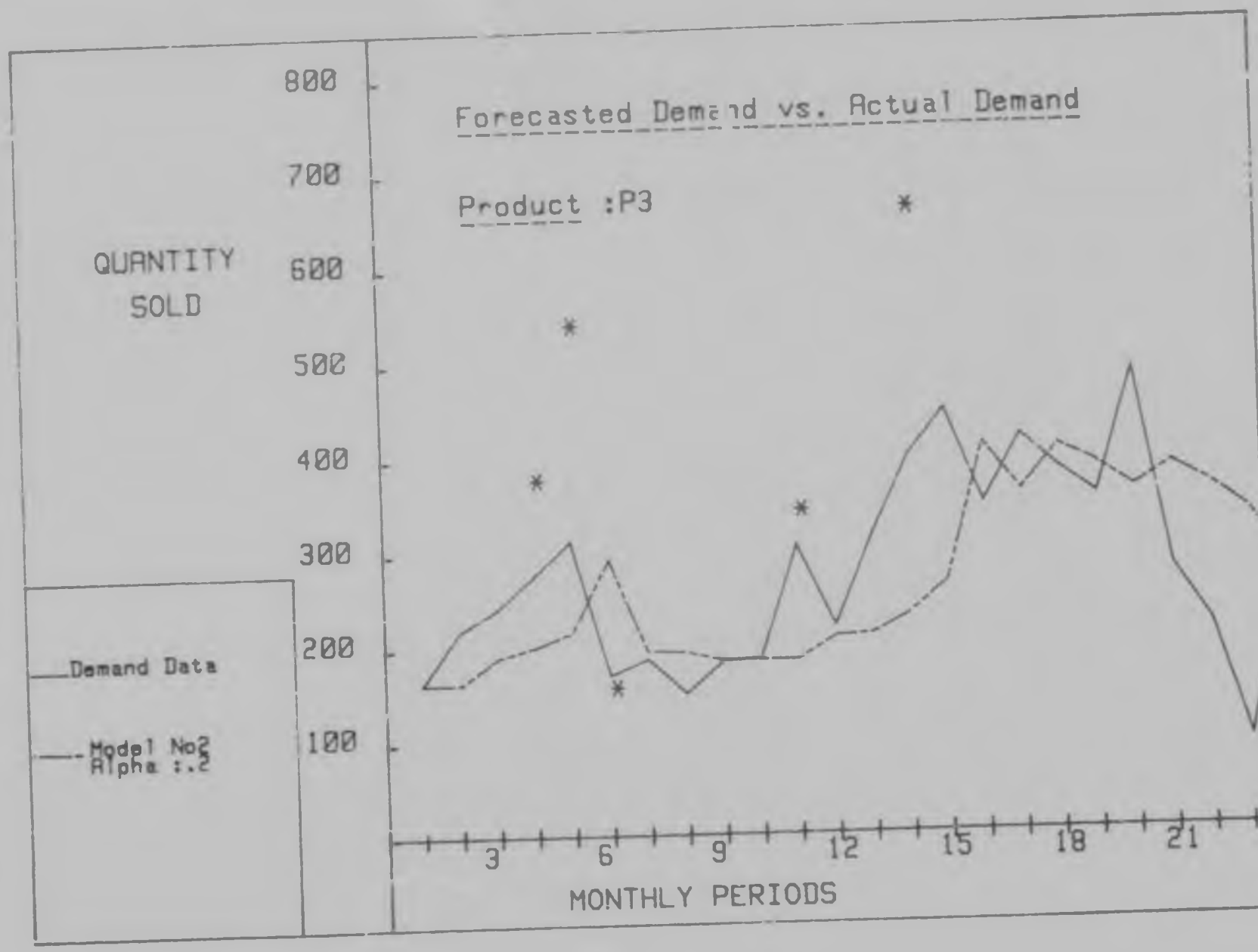

Forecasted Demand vs. Actual Demand
Product :P3
QUANTITY SOLD
800
700
600
500
400
300
200
100
Demand Data
Model No2
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 20

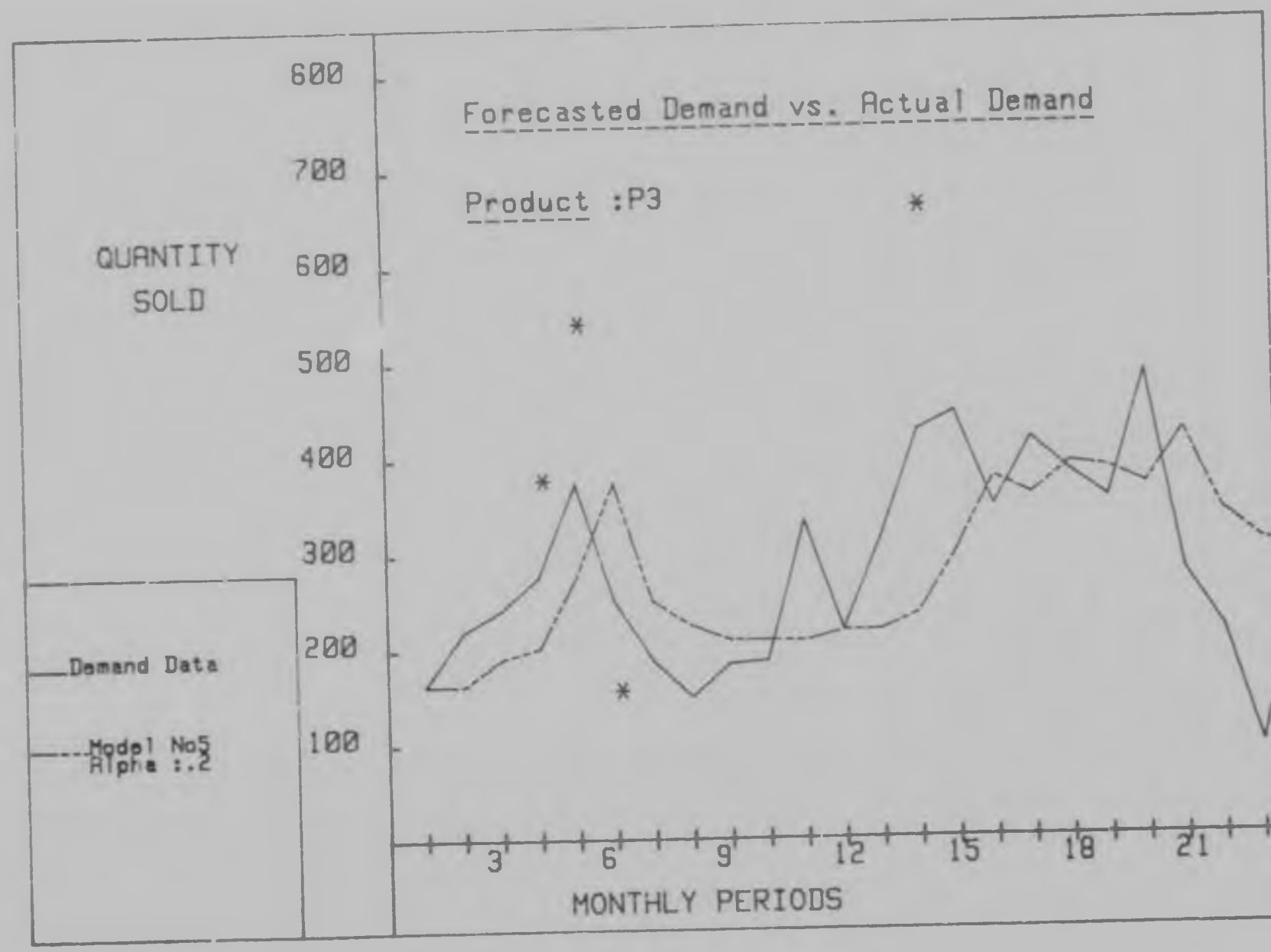

Forecasted Demand vs. Actual Demand
Product :P3
QUANTITY SOLD
600
700
600
500
400
300
200
100
Demand Data
Model No5
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 21

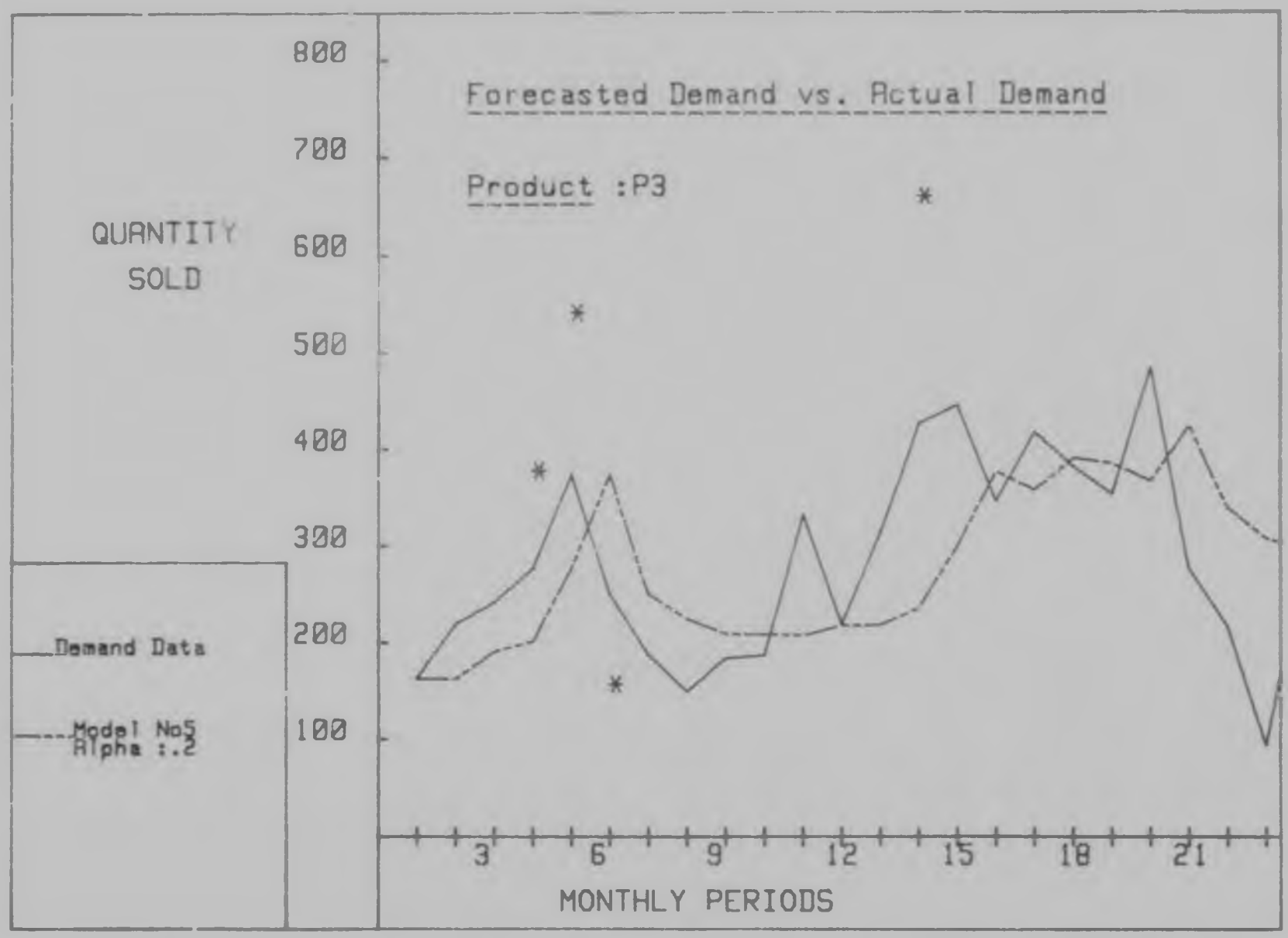

Forecasted Demand vs. Actual Demand
Product :P3
QUANTITY SOLD
800
700
600
500
400
300
200
100
Demand Data
Model No5
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 21

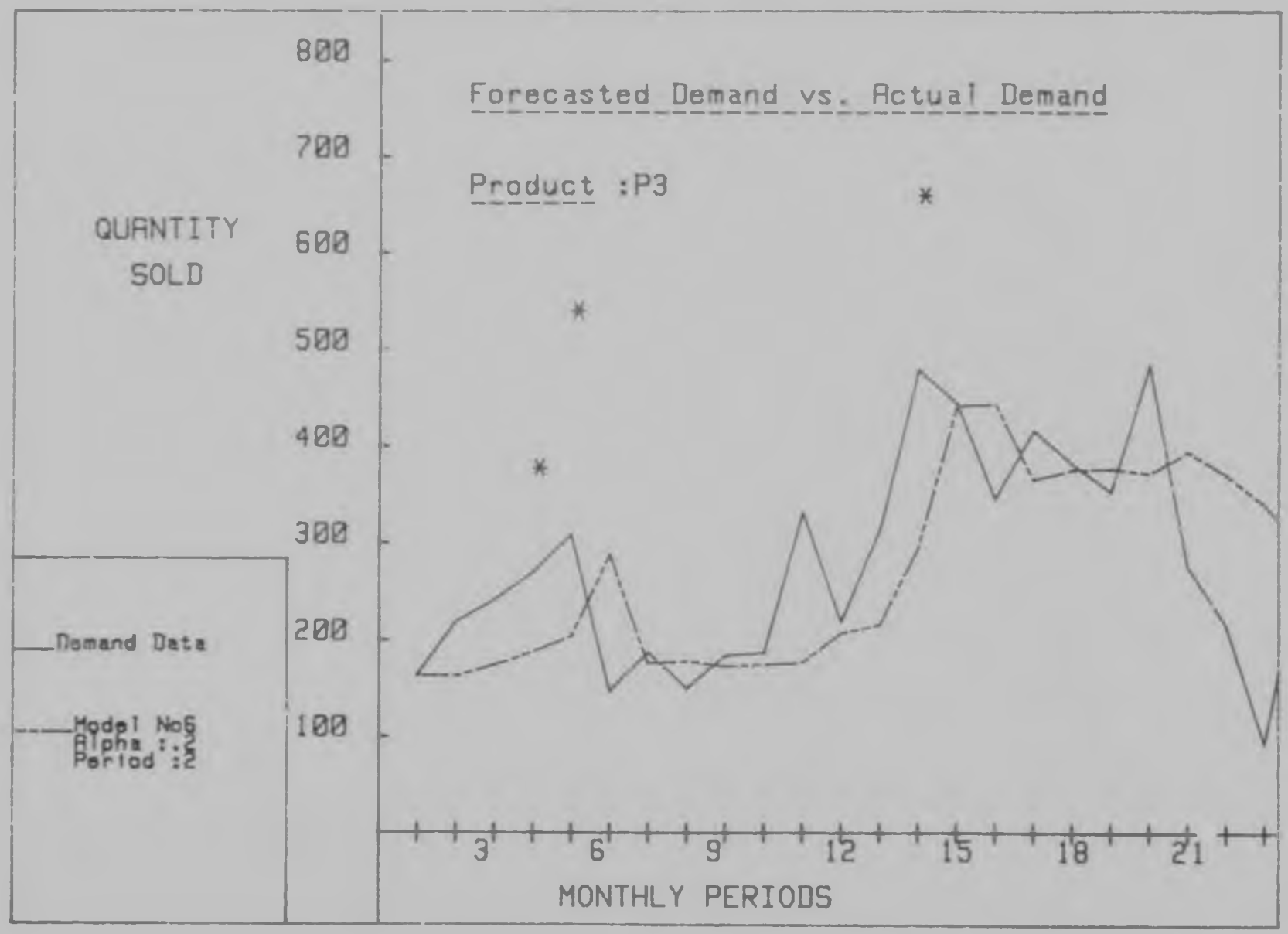

Forecasted Demand vs. Actual Demand
Product :P3
QUANTITY SOLD
800
700
600
500
400
300
200
100
Demand Data
Model No6
Alpha :.2
Period :2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 22

7.3.4 Product 1 P4

Note the following points:

a) The demand variability is 44 (Cf Appendix 2.1; Table 11)

b) All models follow the s[illegible] data well.

c) A lot of filtering of the early demand periods occurs due to the start up conditions of the model.

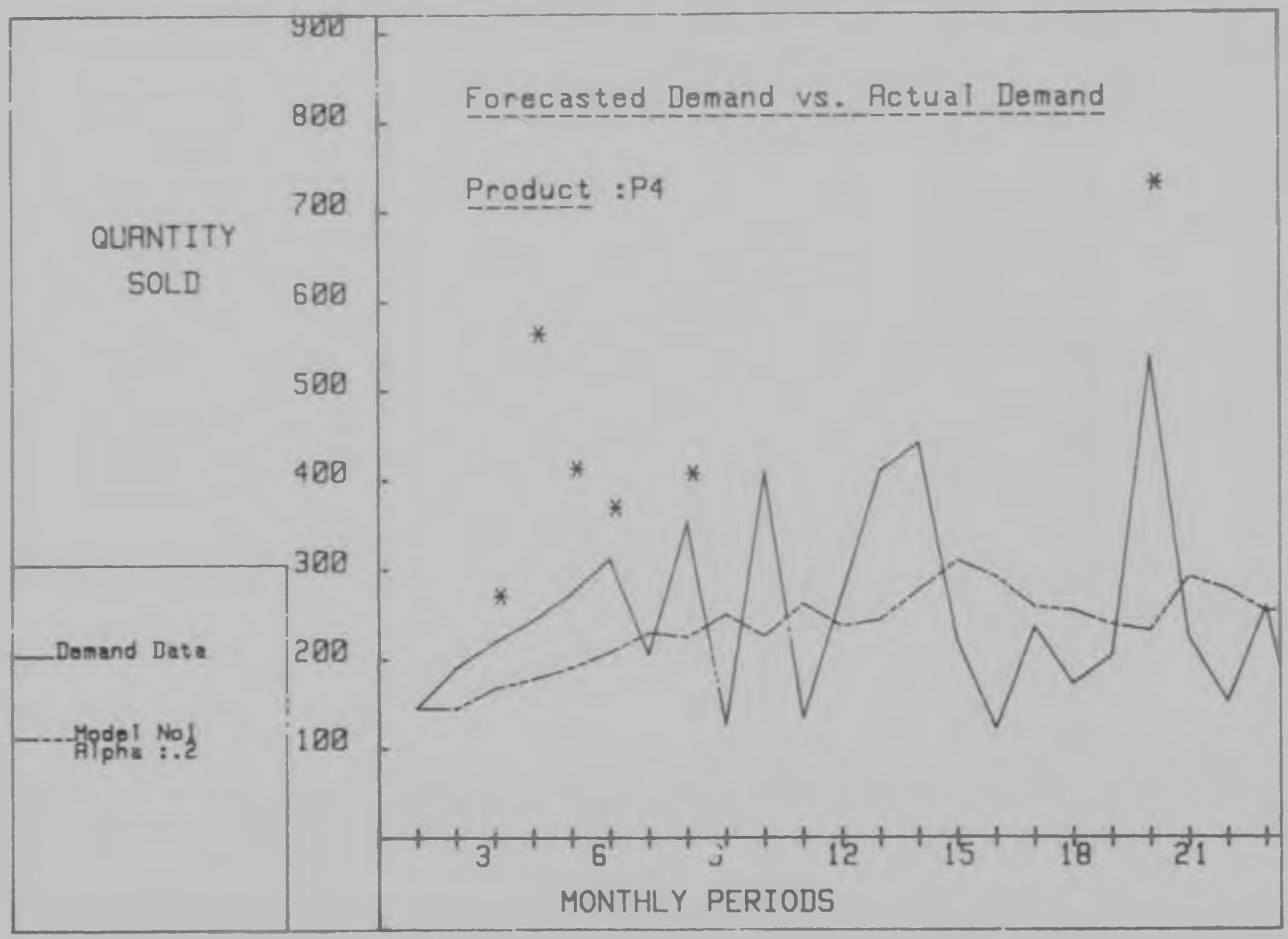

Forecasted Demand vs. Actual Demand
Product :P4
QUANTITY SOLD
900
800
700
600
500
400
300
200
100
Demand Data
Model No1
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 23

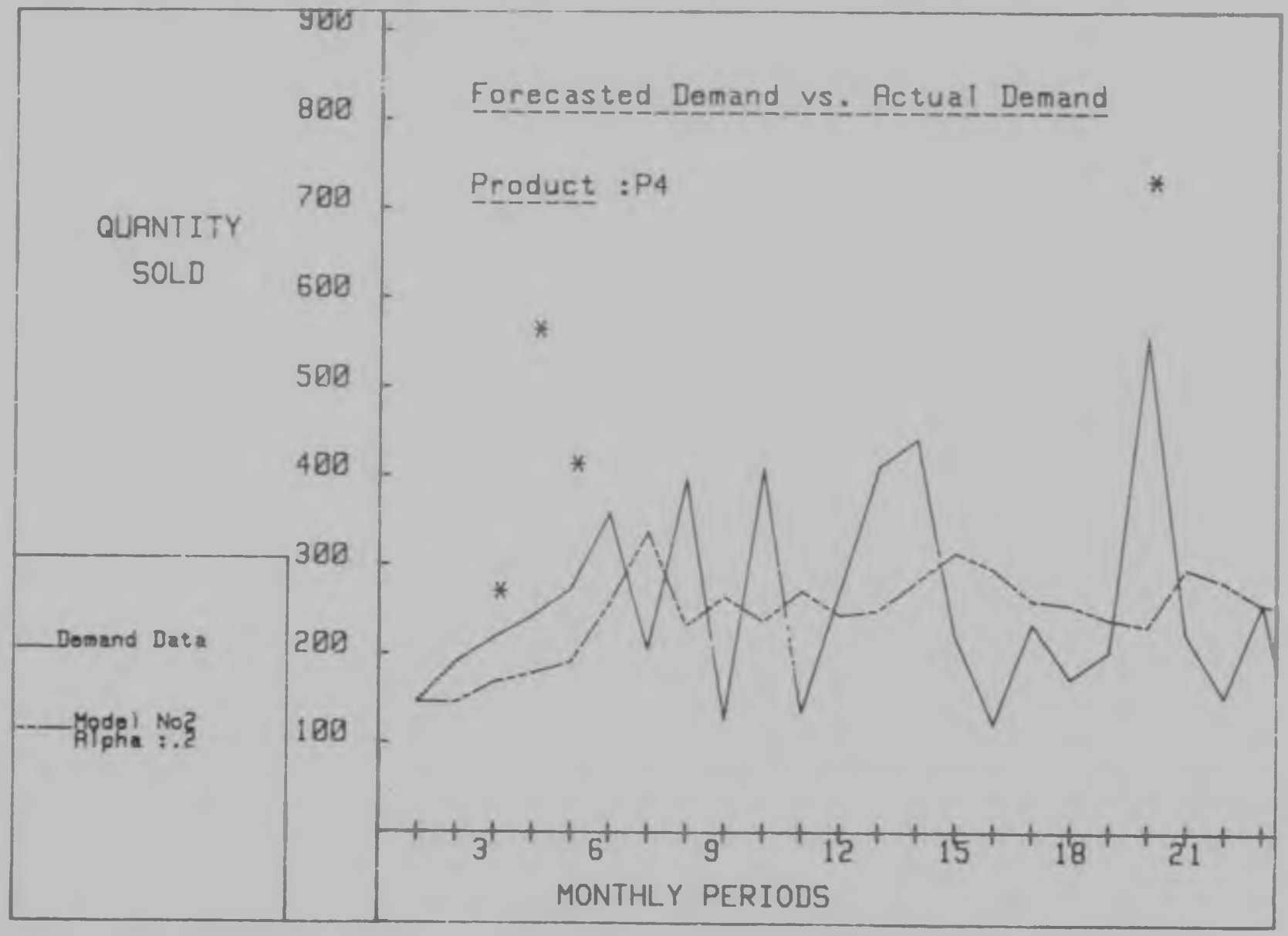

Forecasted Demand vs. Actual Demand
Product :P4
QUANTITY SOLD
900
800
700
600
500
400
300
200
100
3
6
9
12
15
18
21
MONTHLY PERIODS
Demand Data
Model No2
Alpha :.2

FIGURE 24

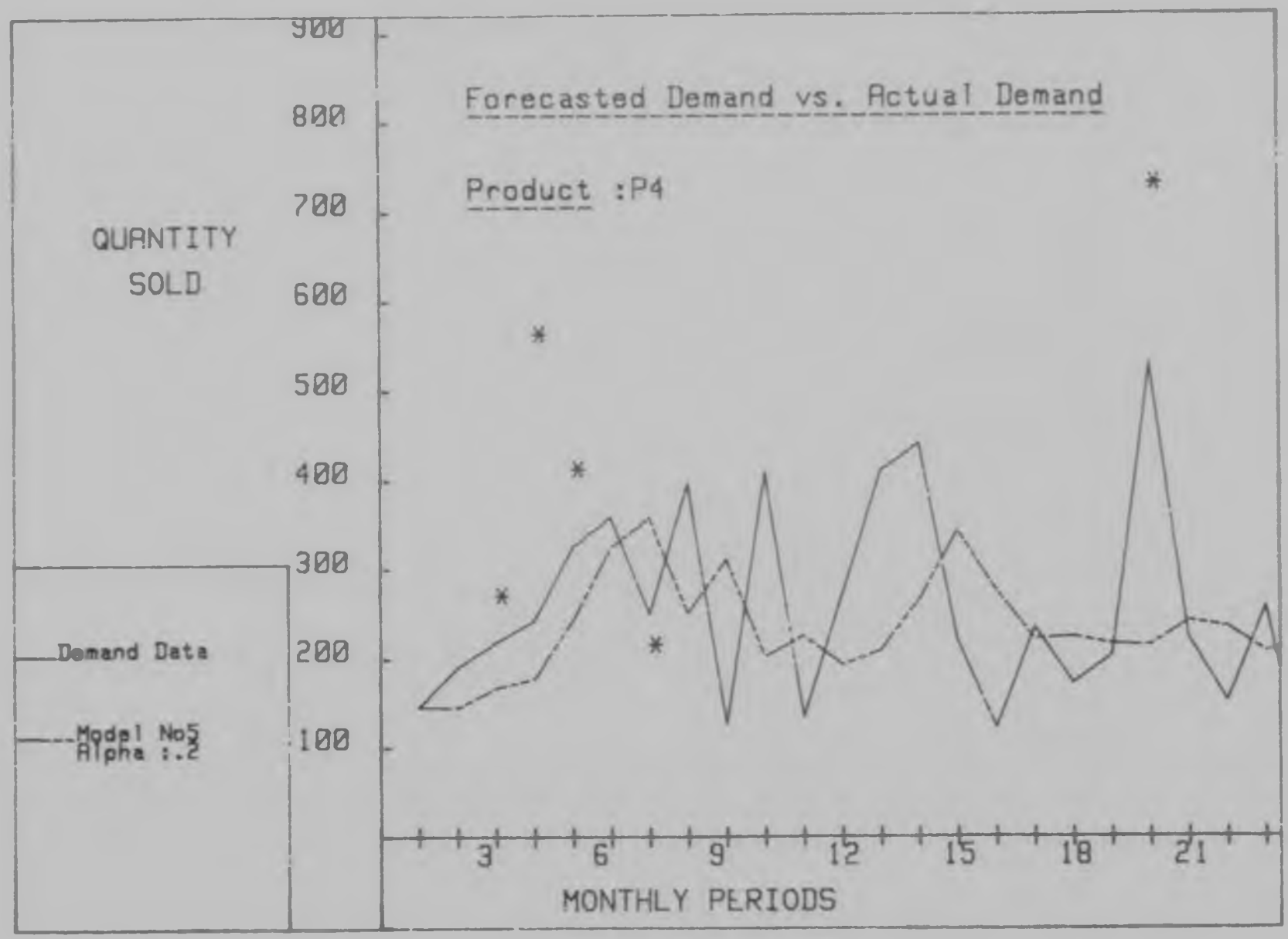

Forecasted Demand vs. Actual Demand
Product :P4
QUANTITY SOLD
900
800
700
600
500
400
300
200
100
Demand Data
Model No5
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 25

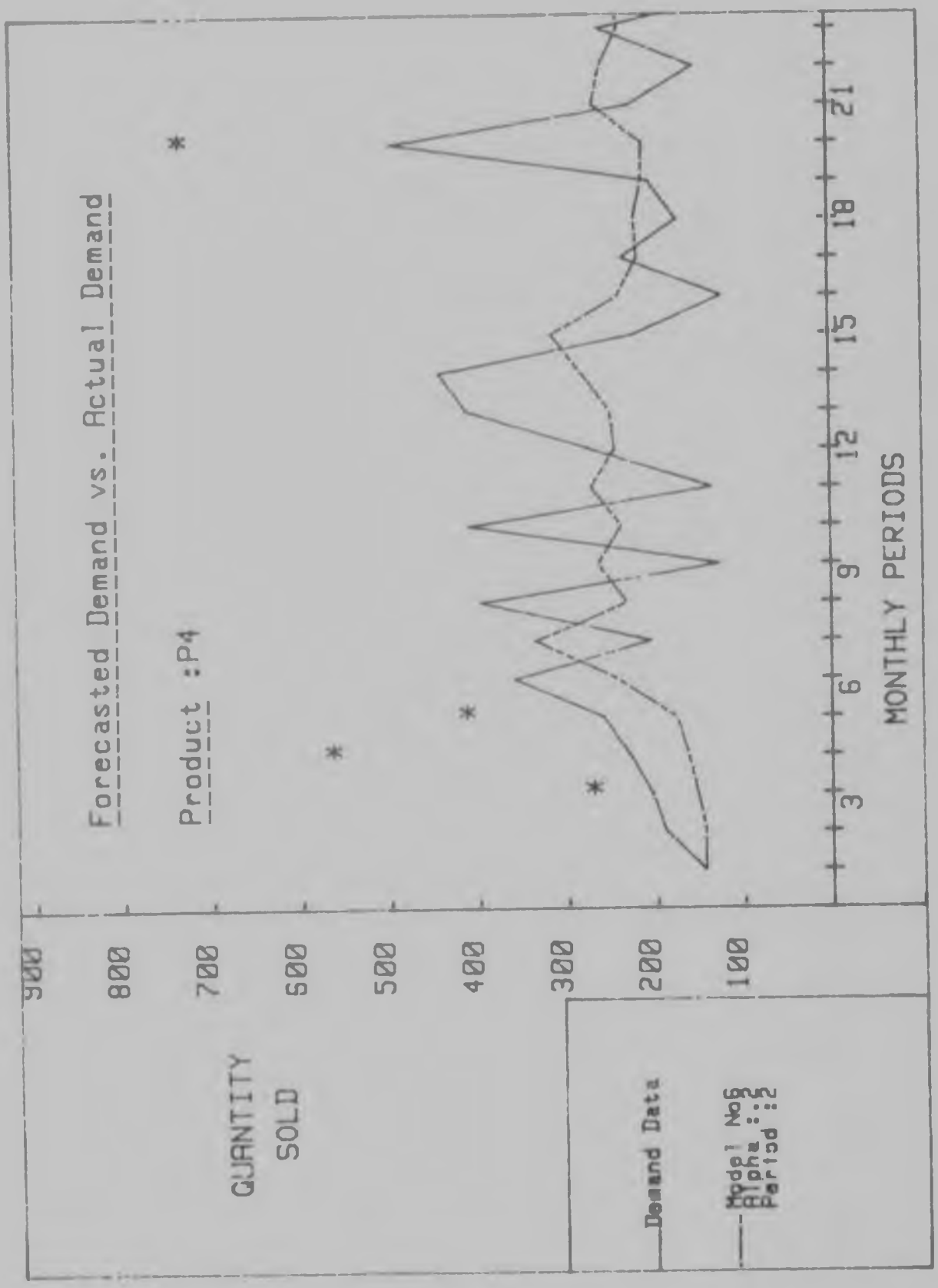

Forecasted Demand vs. Actual Demand
Product :P4
QUANTITY SOLD
900
800
700
600
500
400
300
200
100
3
6
9
12
15
18
21
MONTHLY PERIODS
Demand Data
Model No6
Alpha :.2
Period :2

FIGURE 26

7.3.5 Product : P5

Note the following points:

a) The demand variability is 59% (Ref Appendix-2.1, 1.6.1, (1))

b) The demand is very erratic

c) The forecast tends to lag the demand trend.

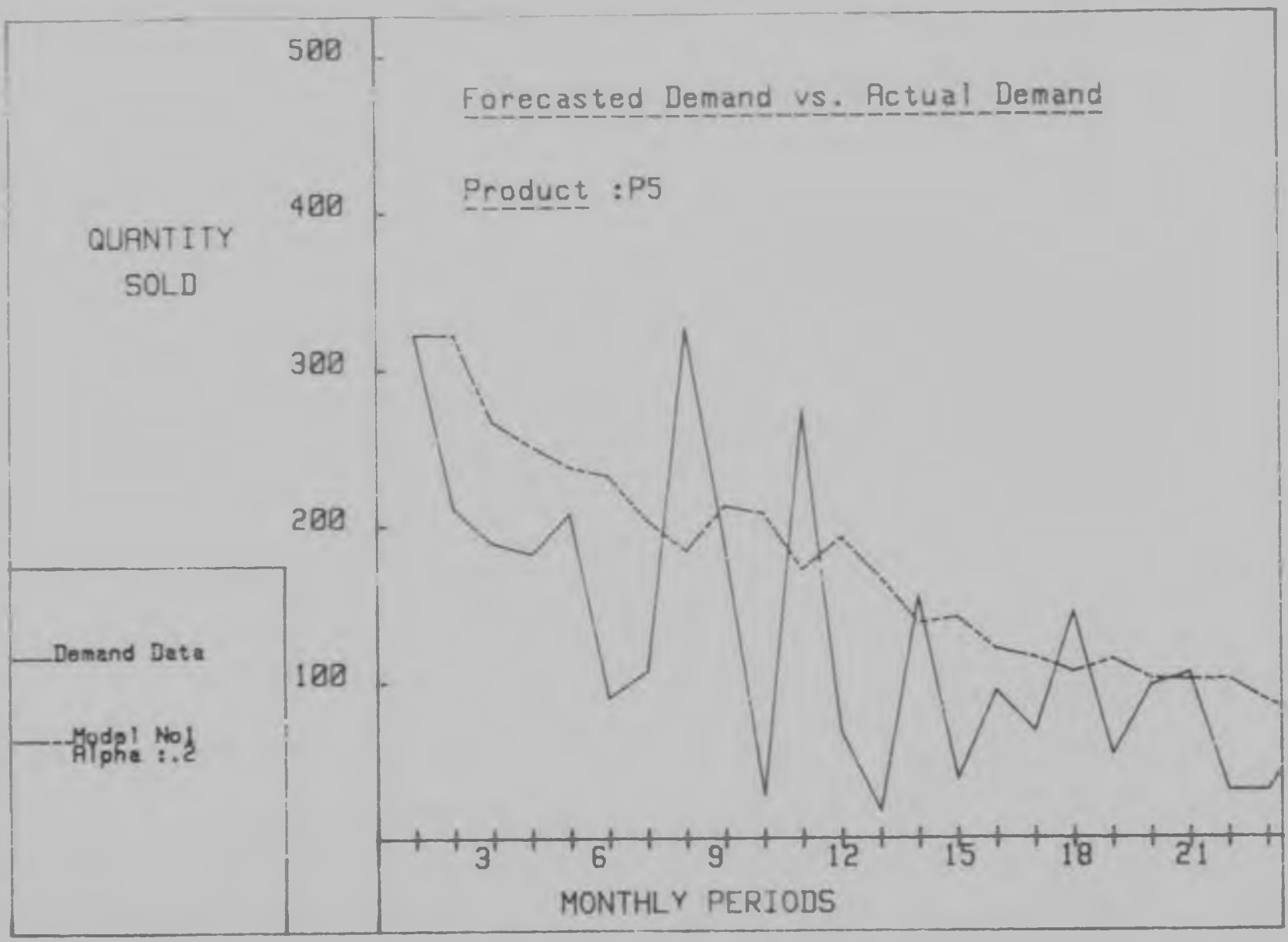

Forecasted Demand vs. Actual Demand
Product :P5
QUANTITY SOLD
500
400
300
200
100
Demand Data
Model No1
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 27

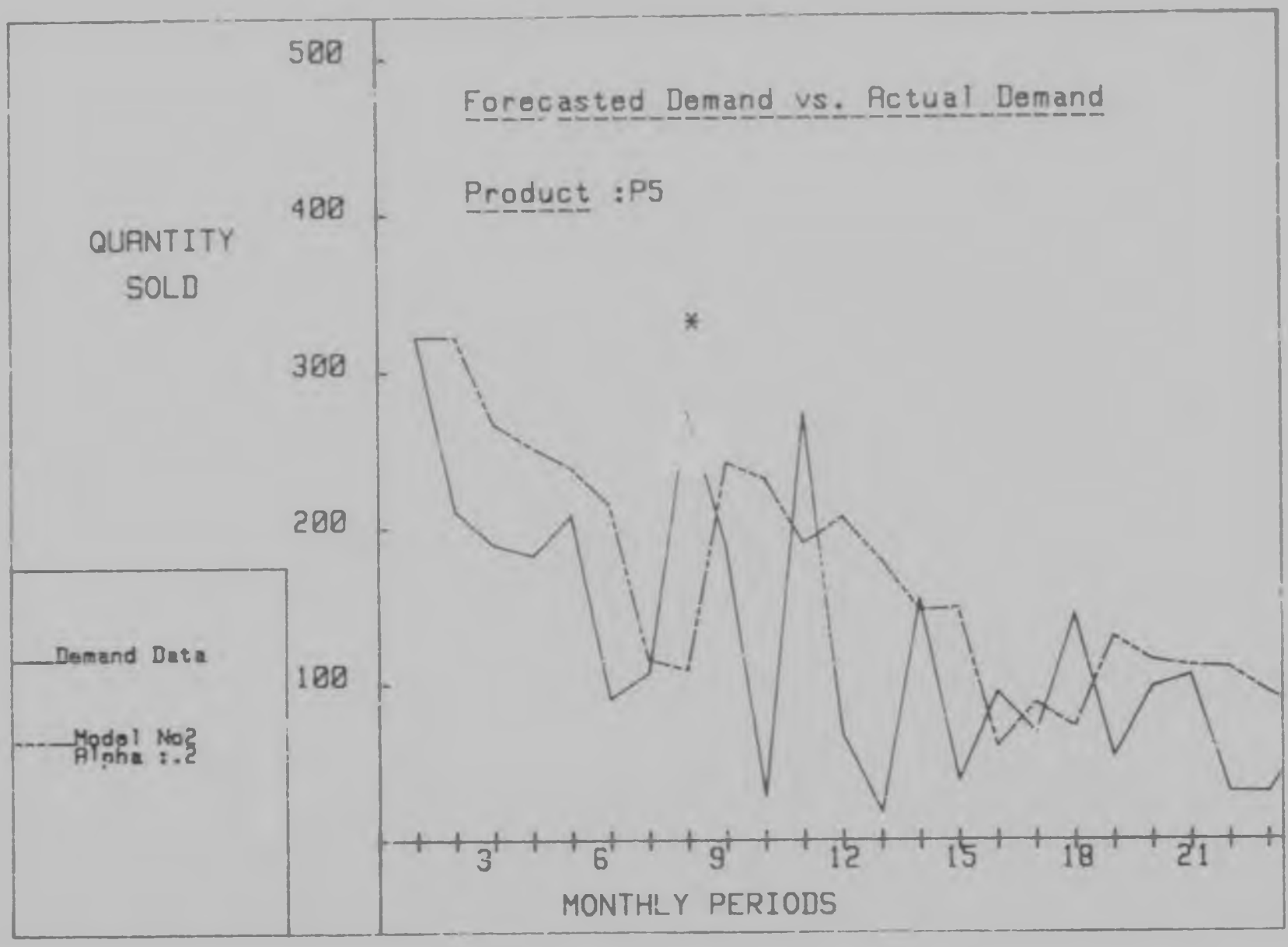

Forecasted Demand vs. Actual Demand
Product :P5
QUANTITY SOLD
500
400
300
200
100
Demand Data
Model No2
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 28

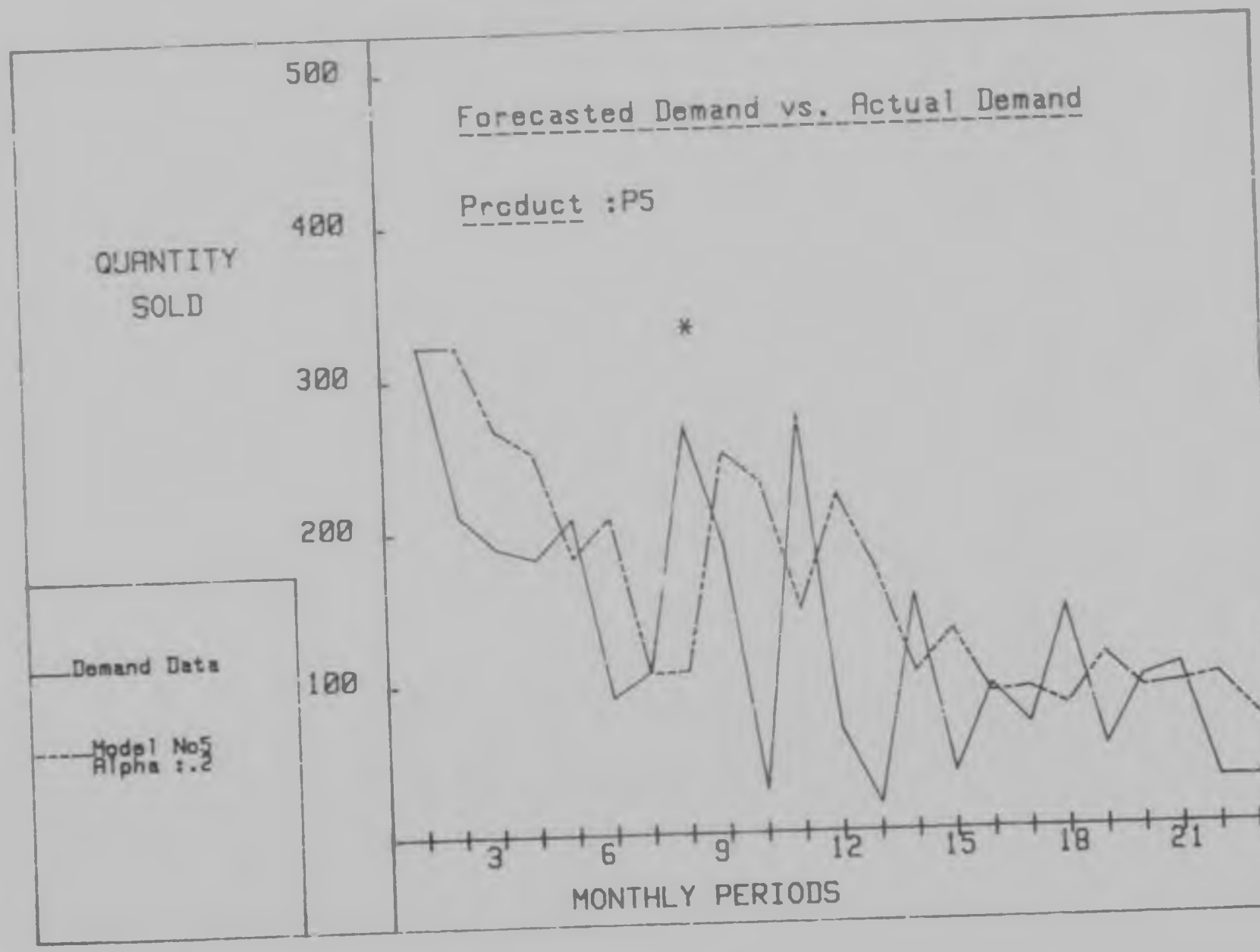

Forecasted Demand vs. Actual Demand
Product :P5
QUANTITY SOLD
500
400
300
200
100
Demand Data
Model No5
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 29

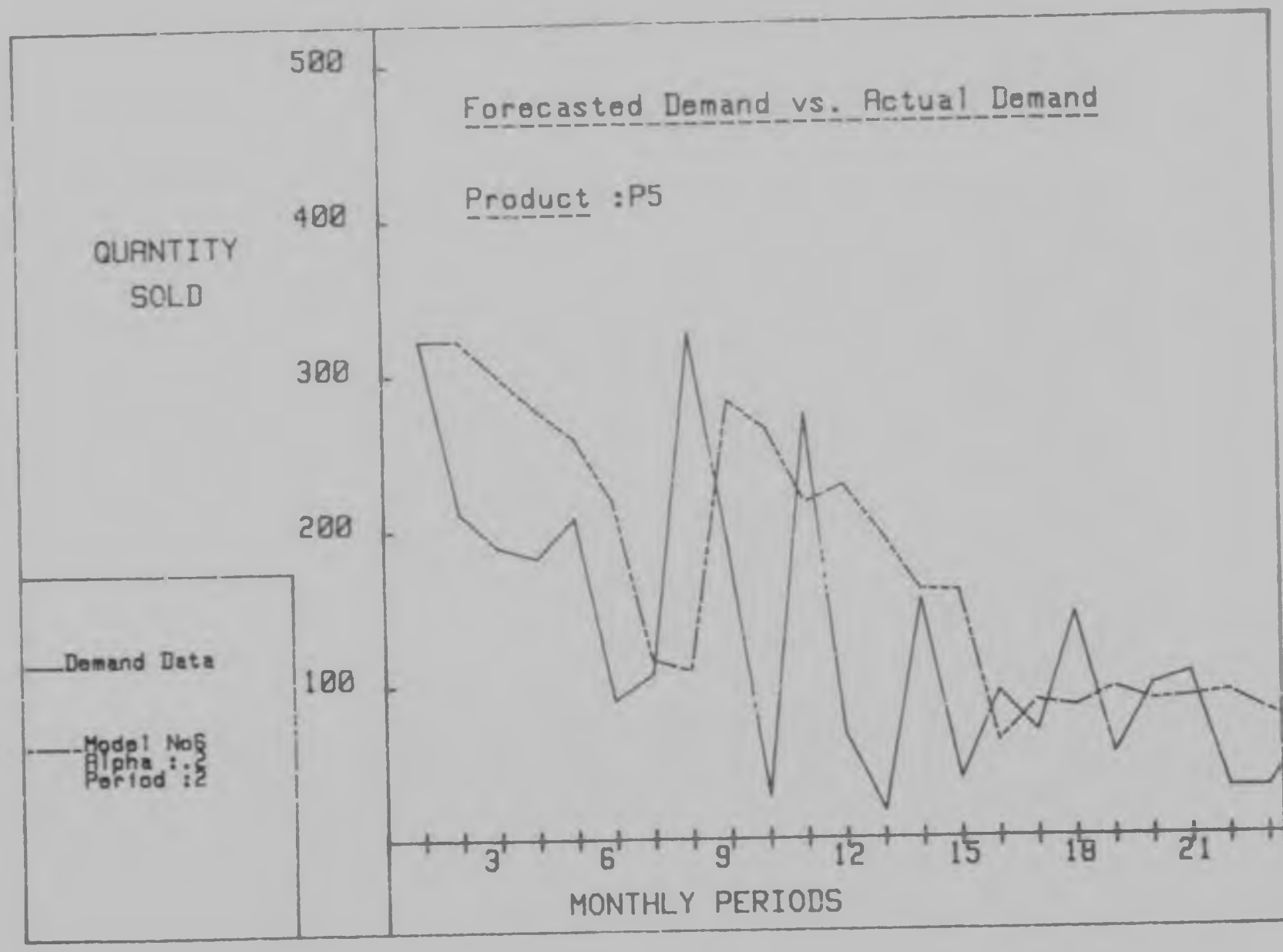

Forecasted Demand vs. Actual Demand
Product :P5
QUANTITY SOLD
500
400
300
200
100
Demand Data
Model No6
Alpha :.2
Period :2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 30

7.3.9 Product : PG

Note the following points:

a) The moisture variability is 47% (Ref Appendix 2.4; Table 11)

b) The control pattern is horizontal.

c) There is very little noticeable difference between the two.

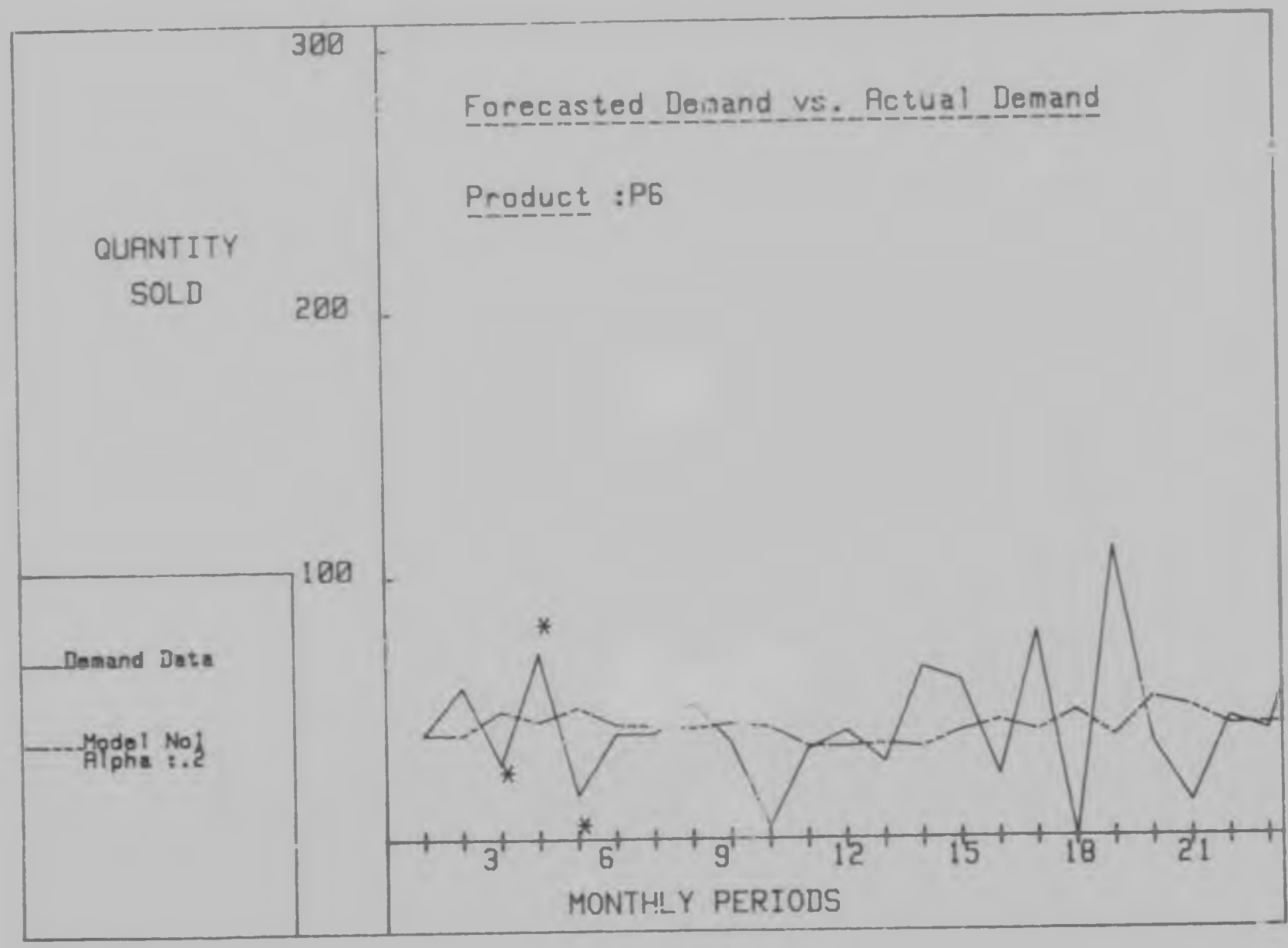

Forecasted Demand vs. Actual Demand
Product :P6
QUANTITY SOLD
300
200
100
Demand Data
Model No1
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 31

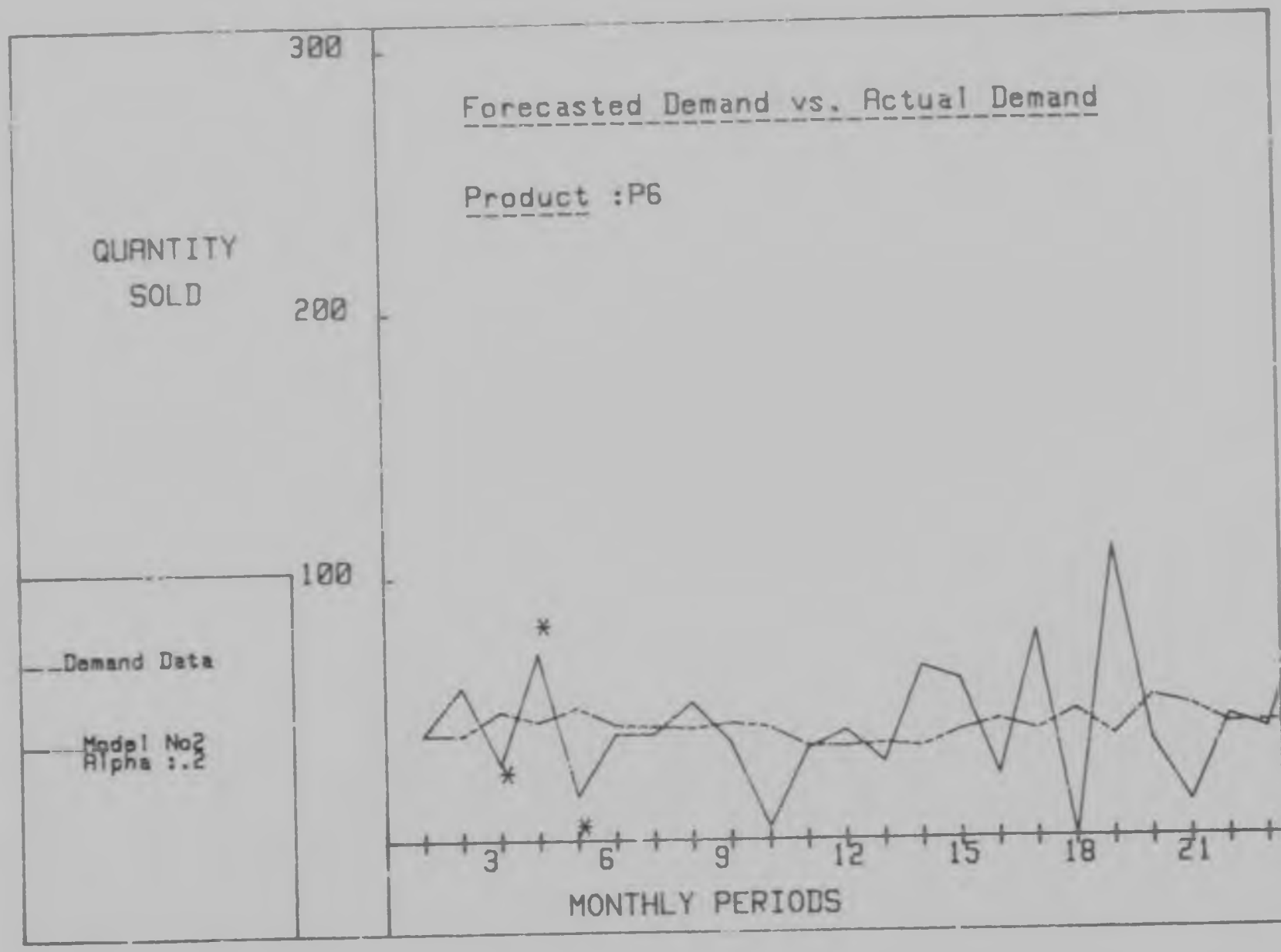

Forecasted Demand vs. Actual Demand
Product :P6
QUANTITY SOLD
300
200
100
Demand Data
Model No2
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 32

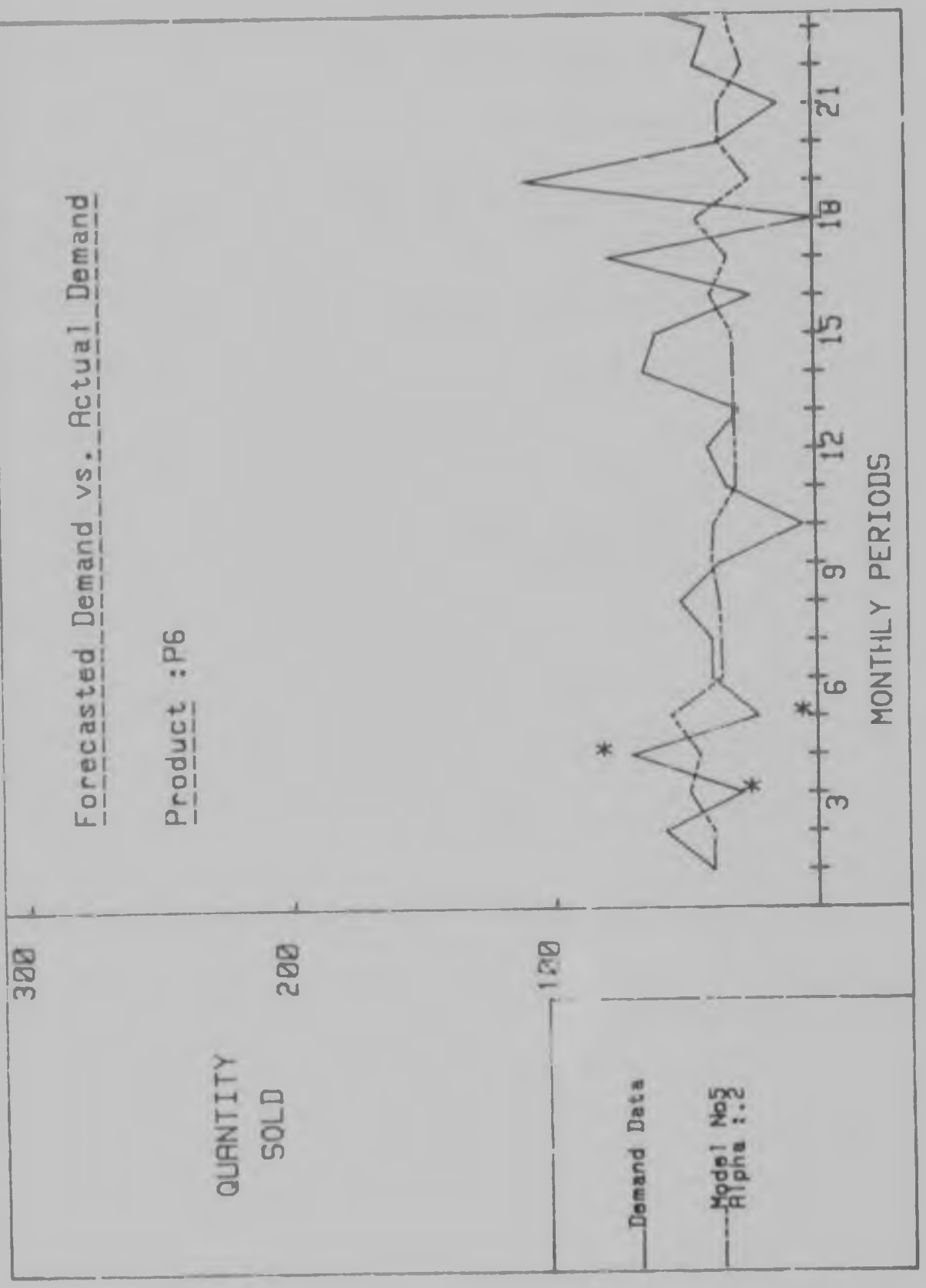

Forecasted Demand vs. Actual Demand
Product :P6
QUANTITY SOLD
300
200
100
Demand Data
Model No5
Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 33

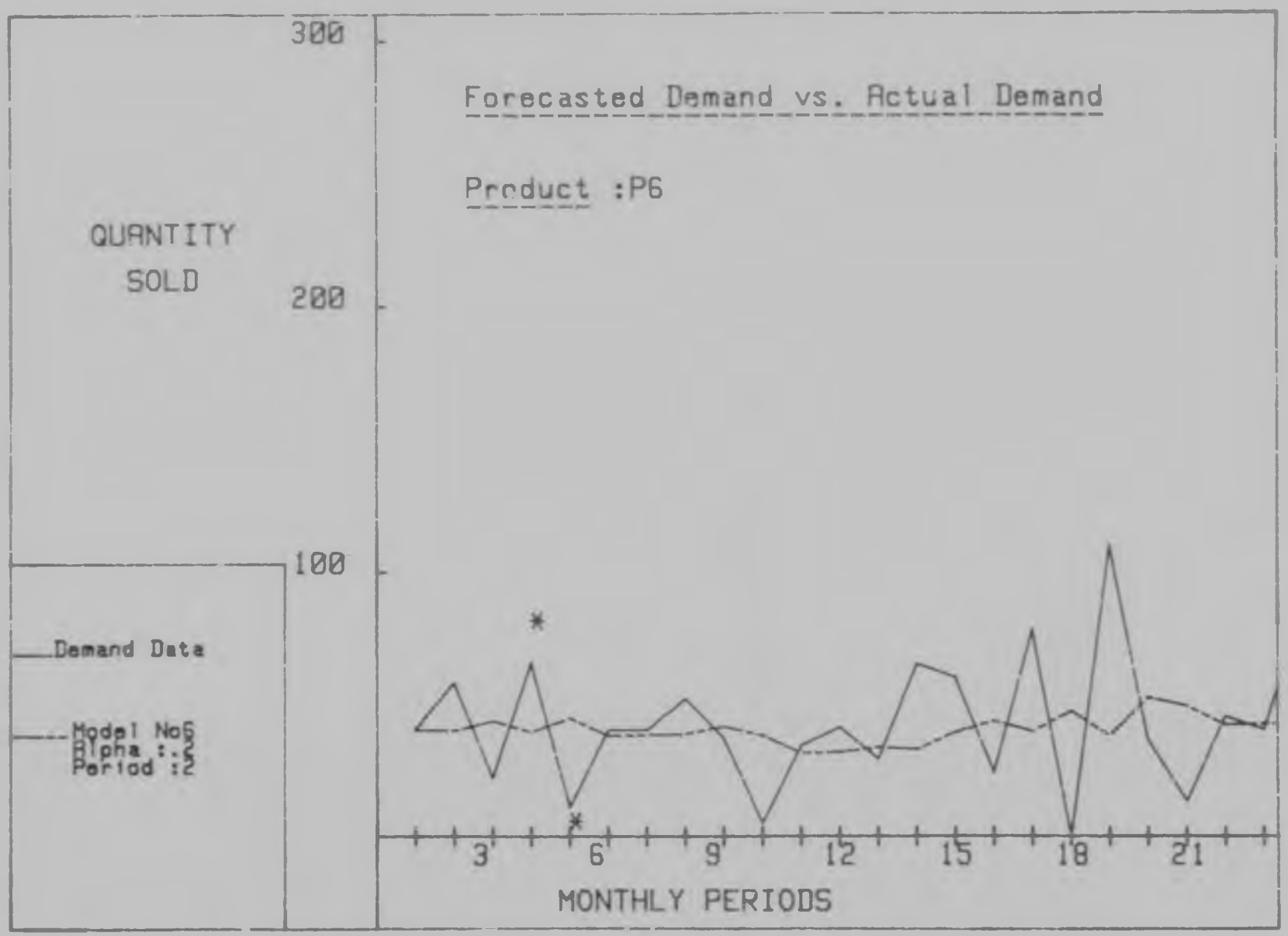

Forecasted Demand vs. Actual Demand
Product :P6
QUANTITY SOLD
300
200
100
Demand Data
Model No6
Alpha :.5
Period :2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 34

APPENDIX B

TABLES AND FIGURES SHOWING RESULTS OF EXPERIMENT
FOR FIRST STEP OF TUNING

For each item two levels were selected for further testing.

APPENDIX B.1

FORECASTING RESULTS FOR P1

TABLE 17.1

FORECASTING RESULTS FOR P1

Models	Alpha	Total Forecast Error	M.A.D.	Forecast Exceeds Total Demand	Tracking Signal at End of Run
1	0,2	-430	170	-3,3	-
2*	0,2	979	294	7,5	0,02
5	-	1198	316	9,2	0,48
6*	0,2 P=2	1661	339	12,7	0,44
1	0,1	932	285	7,1	0,05
2	0,3	43	301	0,3	0,3
6	0,1 P=2	2091	366	16,0	0,49
6	0,3 P-2	1287	315	9,8	0,39
6	0,2 P=3	2184	373	16,7	0,52
6	0.2 P 4	2037	365	15,6	0,52

* [illegible] selected from initial run for further [illegible]

[illegible] is not suited for forecasting by time series [illegible] of the sudden changes in demand. [illegible], over the period considered, model 2 (alpha = 0,1) produced the best results.

TABLE 17.2

FORECASTING RESULTS USING MODEL 2 WITH ALPHA EQUAL .0 0.2

INITIAL VALUE OF SMOOTHING FACTOR	.50
SMOOTHING FACTOR FOR ERROR X-SUB	.10
NO OF PERIODS BEFORE ERRORS ARE SUMED	2.00
ALPHA VALUE WHEN FORECAST IS OUT OF CONTROL	.80
TRACKING SIGNAL MUST NOT EXCEED	.50
AFTER THESE PERIODS, THE FACTORS ARE RESET:	
RESET VALUE OF ALPHA	.20
RESET VALUE OF GAMMA	.10

P1

PERIOD	FILTER DEMAND	ACTUAL DEMAND	NEXT PERIOD FCAST	CUSUM	ERROR	SMOOTH M.A.D	ALPHA	TRACK-SIGNAL
1	232	233	233	0	0	0.0	.50	0.00
2	0	0	233	0	22[illegible]	[illegible]	.50	1.00
3	875	467	175	0	259	86.8	.20	.41
4	69	69	154	81	81	87.4	.20	.47
5	259	259	174	-16	-187	93.1	.20	-.26
6	500	792	241	-350	-334	133.6	.20	-1.05
7	667	934	345	-726	-426	144.9	.20	-1.33
8	869	1167	495	-1320	-594	164.3	.20	-1.54
9	1127	2694	570	-2017	-693	225.6	.20	-1.65
10	1559	1559	778	-2999	-982	310.5	.20	-1.70
11	1188	1188	1038	0	-338	312.5	.80	-1.80
12	785	785	771	0	329	314.2	.80	-1.61
13	178	178	199	681	681	314.2	.20	-1.53
14	0	0	234	1015	293	336.8	.20	-1.22
15	81	81	283	1015	153	340.4	.20	-1.16
16	798	798	322	496	-595	346.0	.20	-1.31
17	629	629	383	139	-302	341.6	.20	-1.37
18	726	726	451	-284	-348	341.9	.20	-1.43
19	53	53	512	199	[illegible]	[illegible]	.20	-1.27
20	225	225	542	546	147	327.3	.20	-1.21
21	55	55	485	626	287	324.[illegible]	.20	-1.30
22	0	0	428	912	285	314.5	.20	-1.46
23	161	161	214	970	47	294.2	.20	-1.62

EVALUATION REPORT

No OF FORECASTS HIGH	10.0
AMOUNT FORECASTED HIGH	2639.0
No OF FORECASTS LOW	10.0
AMOUNT FORECASTED LOW	-4659.0
M.A.D. AT END OF RUN	294.2

TABLE 17.3

FORECASTING RESULTS USING MODEL 2 WITH ALPHA EQUAL TO 0.1

INITIAL VALUE OF SMOOTHING FACTOR	.50
SMOOTHING FACTOR FOR ERROR & MAD	.30
NO OF PERIODS BEFORE ERRORS ARE USED	2.50
ALPHA VALUE WHEN FORECAST IS OUT OF CONTROL	.80
TRACKING SIGNAL MUST NOT EXCEED	.42
	.10
INPUT VALUE OF GAMMA	.10

Pi

PERIOD	FILTE	ACTUAL DEMAND	PERIOD FCAST			SMOOTH		
1	233		233		0	0.0		
2		6	120			66.1		
3	37	467	14		(255	86.0		
	80	80	139		65	84.6		
	209	259	151		-120	88.2		
	401	792	184		-331	112.5		
6		9	226		422	143.4		
7	686	9	288		-530	182.9		
8	764	1127	288		-60	233.2		
9	965	2644	348		-87	297.3		
10	1221	1559	1048		-52	272.8		
11	1180	1100	1090		305	284.8		
12	705	705	702		612	314.3		
13	170	170	292		284	313.5		
14	8	8	264		183	308.5		
15	81	81	246		-552	325.6		
16	790	790	301		-323	325.4		
17	624	624	333		-393	332.1		
18	726	726	372		319	338.9		
19	53	53	441		116	309.3		
20	225	225	329		274	305.9		
21	55	55	302		302	305.4		
22	0	0	271		110	285.9		
23	161	161	268					

EVALUATION REPORT

No OF FORECASTS HIGH	10.0
AMOUNT FORECASTED HIGH	4649.8
No OF FORECASTS LOW	10.0
AMOUNT FORECASTED LOW	4291.7
M.A.D. AT END OF RUN	285.9

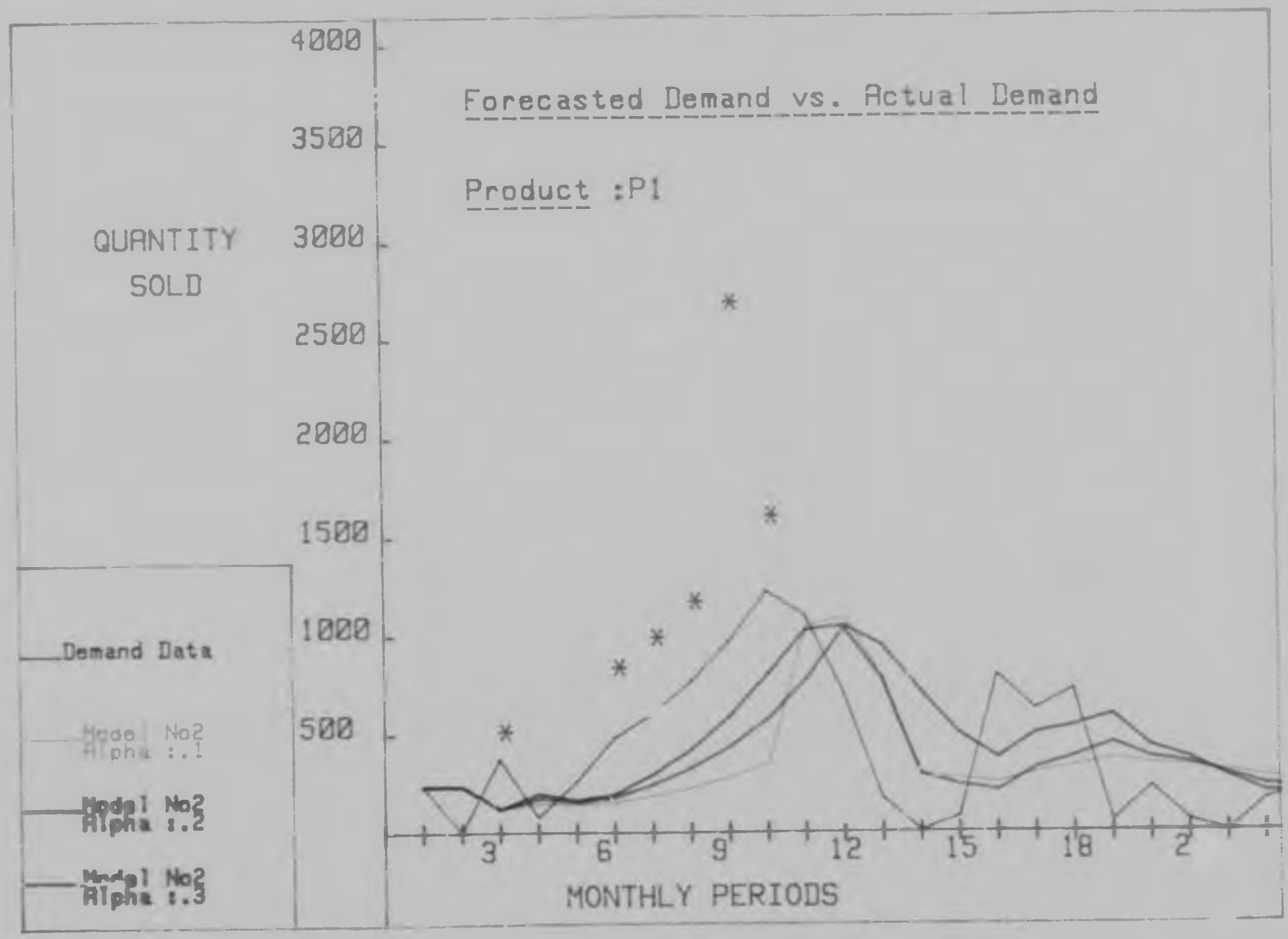

Forecasted Demand vs. Actual Demand
Product :P1
QUANTITY SOLD
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
Model No2 Alpha :.1
Model No2 Alpha :.2
Model No2 Alpha :.3
3
6
9
12
15
18
2
MONTHLY PERIODS

FIGURE 35

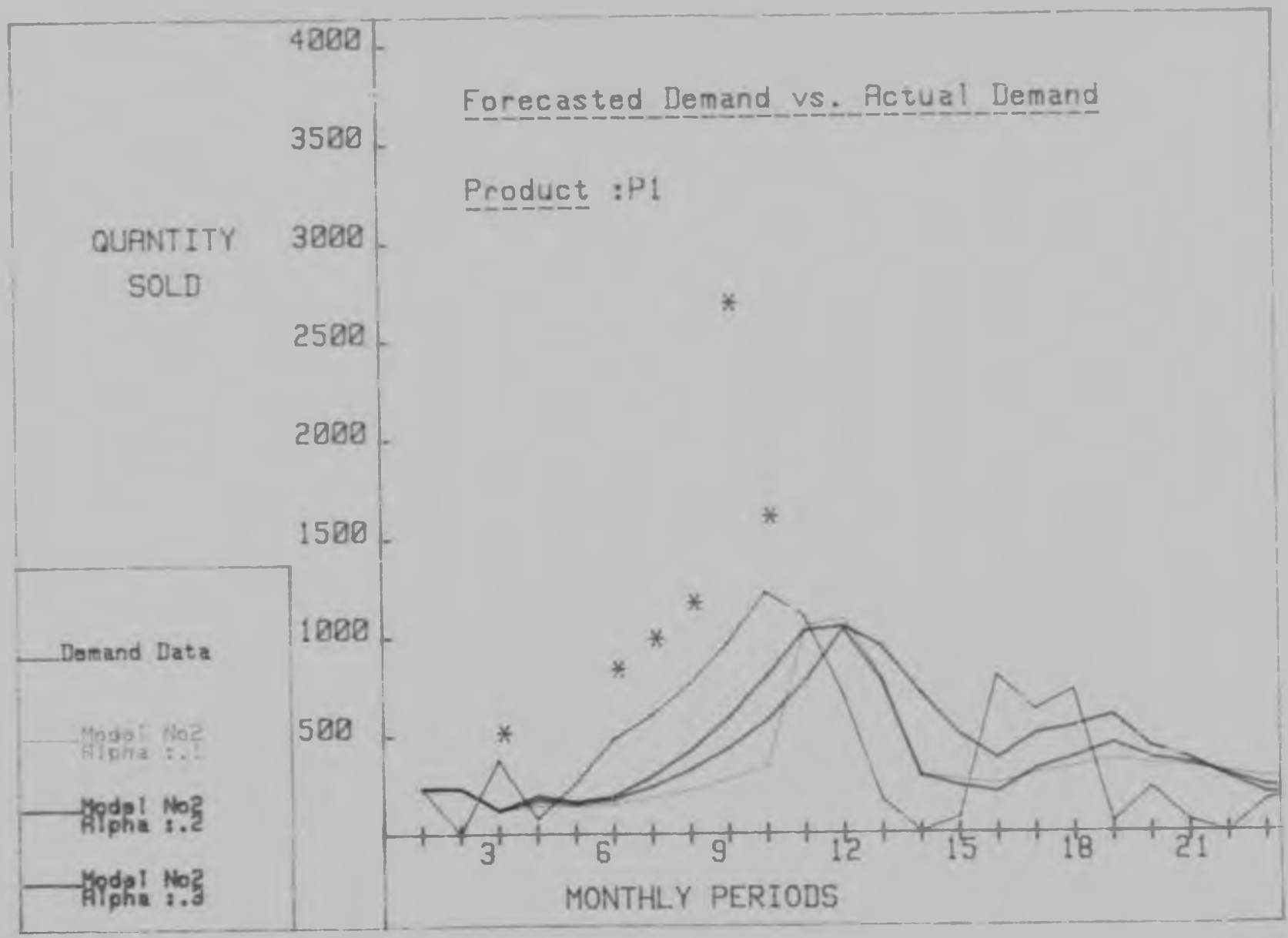

Forecasted Demand vs. Actual Demand
Product :P1
QUANTITY SOLD
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
Model No2 Alpha :.1
Model No2 Alpha :.2
Model No2 Alpha :.3
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 35

APPENDIX 8.2

FORECASTING RESULTS FOR P2

TABLE 18.1

FORECASTING RESULTS FOR 72

Month	Alpha	Total Forecast Error	M.A.D.	% Forecast Exceeds Total Demand	Tracking Signal at End of Run
1	0,2	-3487	333	-36,9	-
2*	0,2	-3494	330	-36,0	-0,69
5	-	-2621	304	-27,9	-0,65
6*	0,2 P=2	-1856	309	-19,0	-0,48
1	0,1	0	396	0	-0,74
2	0,3	-2877	297	-29,0	-0,69
5	0,1 P=2	-1741	330	-18,0	-0,47
6	0,2 P=2	-1803	292	-18,6	-0,45
5	0,2 P=1	-2667	267	-21,9	-0,57
6	0,2 P=1	-3211	309	-33,0	-0,71

* Indicates months selected from initial run for further testing.

(Months 1 and 2 were initially omitted by time series forecasting since the cross-product error over the period).

Alpha = 0,2 and P = 2 was selected as it best follows the trend of recent data.

APPEI X 8.2

FOREC STI P C 1250 302 G10

TABLE 18.3

FORECASTING RESULTS USING MODEL 2 WITH ALPHA EQUAL TO 0.2

INITIAL VALUE OF SMOOTHING FACTOR	.50
SMOOTHING FACTOR FOR ERROR & MAD	.20
NO OF PERIODS BEFORE ERRORS ARE SUMED	2.00
ALPHA VALUE WHEN FORECAST IS OUT OF CONTROL	.80
TRACKING SIGNAL MUST NOT EXCEED	.50
AFTER THESE PERIODS, THE FACTORS ARE RESET=	
RESET VALUE OF ALPHA	.20
RESET VALUE OF GAMMA	.10

P2

PERIOD	FILTER DEMAND	ACTUAL DEMAND	NEXT PERIOD FORCST	CUSUM	ERROR	SMOOTH M.A.D.	ALPHA	TRACK-ING SIGNAL	
1	280	280	280	0	0	0.0	.50	0.00	
2	0	0	168	0	-280	56.0	.50	1.00	
3	280	280	128	0	-168	64.8	.20	.69	
4	118	118	118	10	-10	58.6	.11	.69	
5	76	76	99	0	42	56.9	.00	.72	***
6	338	338	281	-246	-246	77.3	.29	.16	
7	0	0	225	-35	211	86.1	.49	.48	
8	20	20	184	240	205	107.6	.29	.52	
9	158	158	177	278	34	99.0	.20	.53	
10	0	0	142	451	177	107.5	.26	.61	
11	0	0	113	562	142	118.9	.28	.66	
12	0	0	91	0	113	111.2	.68	.78	***
13	60	60	94	0	-37	103.0	.80	.63	***
14	191	191	163	-138	-138	107..	.20	.42	
15	431	431	217	-487	-489	123.4	.20	.11	
16	371	371	248	-561	-154	126.5	.20	-.02	
17	825	825	323	-936	-377	151.5	.20	-.27	
18	1215	1215	437	-1587	-568	193.2	.20	-.48	
19	684	684	486	-1754	-247	198 6	.20	-.55	
20	288	288	429	-1667	-286	207.4	.20	-.59	
21	1287	1553	595	-2245	-778	264.4	.20	-.53	
22	1857	1857	759	-3117	-872	325.2	.20	-.48	
23	1138	1138	894	-3434	-377	330.4	.20	-.49	

EVALUATION REPORT

No OF FORECASTS HIGH	9.0
AMOUNT FORECASTED HIGH	1209.6
No OF FORECASTS LOW	11 0
AMOUNT FORECASTED LOW	-4863.9
M.A.D. AT END OF RUN	330.4

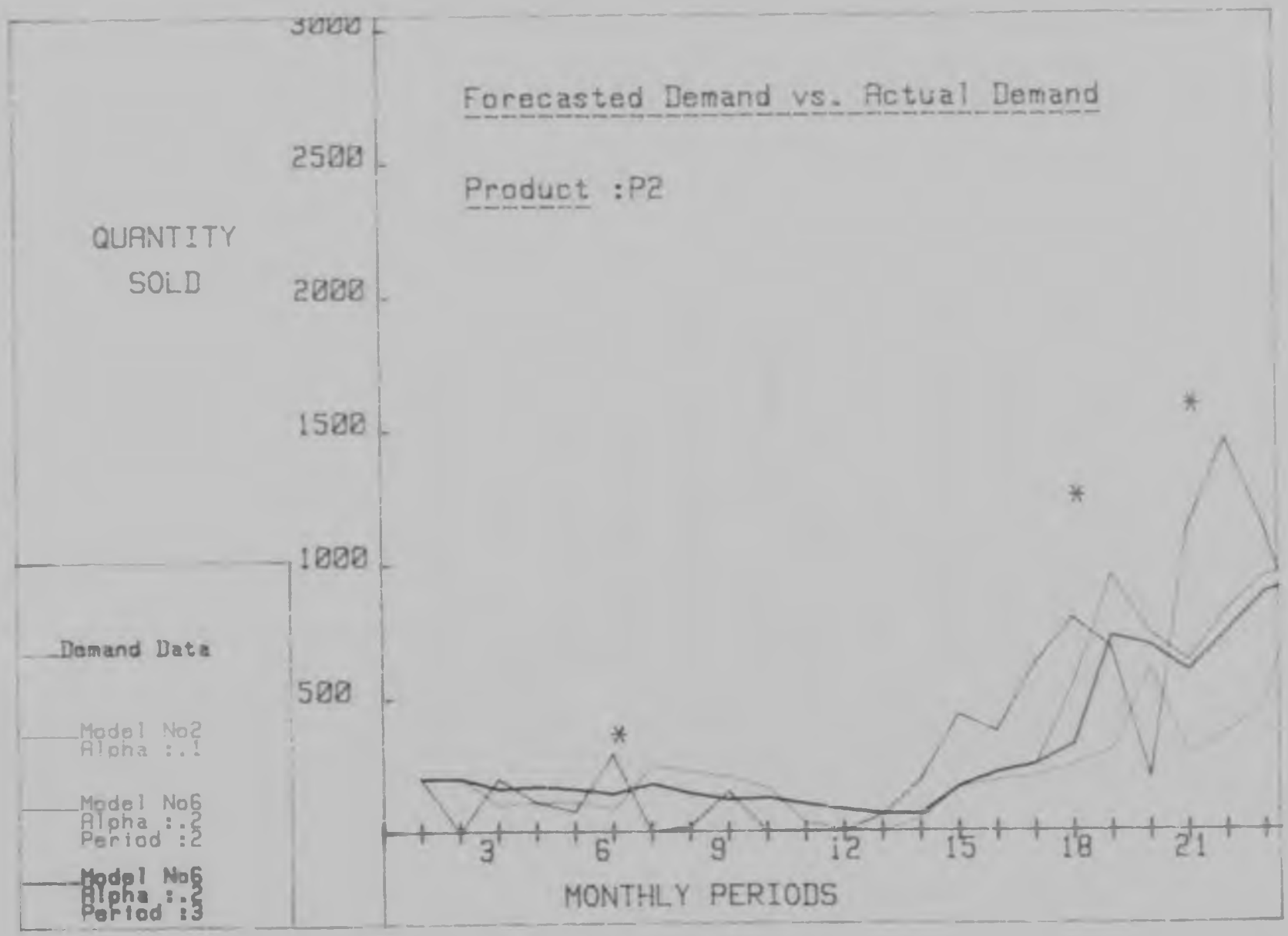

Forecasted Demand vs. Actual Demand
Product :P2
QUANTITY SOLD
3000
2500
2000
1500
1000
500
Demand Data
Model No2
Alpha :.1
Model No6
Alpha :.2
Period :2
Model No6
Alpha :.2
Period :3
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 36

APPENDIX 8.

FORECASTING RESULTS FOR P3

TABLE 19.1

FORECASTING RESULTS FOR P3

Models	Alpha	Total Forecast Error	M.A.D.	Forecast Exceeds Total	Tracking Signal At End of Run
1*	0,2	- 395	94		-
2*	0,2	405	94	5,6	0,18
5	-	- 43	91		0,19
6*	0,2 P-2	- 31	90		0,27
1	0,3	- 151	90	-2,0	-
2	0,1	407	92	5,6	0,26
2	0,2	462	91	6,4	0,2
6	0,1 P=2	- 79	91	-1,0	0,26
6	0,3 P=2	- 159	92	-2,2	0,19
6	0,2 P=3	- 132	90	-1,8	0,25
6	0,2 P=4	- 74	89	-1,0	0,21

* This implies models selected from initial run for further testing.

The mean absolute deviations of all the models are very similar.
Model 6, alpha = 0,2 and P = 2 was selected as it had the lowest total forecast error.

TABLE 19.2

F[illegible]TING RESULTS USING MODEL 2 WITH ALPHA EQUAL TO 0,2

INITIAL VAL[illegible] OF SMOUTHING FACTOR	.50
[illegible]ING [illegible] FAC[illegible] & MAD	.30
[illegible] [illegible] ARE USED	2.5
[illegible] [illegible] OUT OF CONTROL	.00
[illegible] [illegible] USED	.50
[illegible] [illegible] FACTORS [illegible] RESET!	
R[illegible] VALUE OF [illegible]	.10

PERIOD	FILTERED DEMAND	ACTUAL	PERIOD FCEST	[illegible]	[illegible]	SMOOTH M.A.D.	ALPHA	TRACKING SIGNAL
1	[illegible]	[illegible]	[illegible]	0	[illegible]	0.0	[illegible]	[illegible]
2	219	219	181	0	-56	16.8	.50	1.00
3	242	242	231	0	-51	20.2	.20	-1.00
4	[illegible]	368	216	-76	-76	25.[illegible]	.20	-1.00
5	313	538	294	0	-97	32.9	.00	1.00 ***
6	170	147	195	123	123	41.9	.20	-.41
7	187	187	193	131	8	38.5	.20	-.38
8	150	150	185	175	43	39.8	.20	-.23
9	184	184	185	176	1	35.2	.20	-.23
10	187	187	185	173	[illegible]	31.[illegible]	.20	-.23
11	305	332	209	54	-120	40.7	.20	-.46
12	219	219	211	44	-10	37.6	.20	-.47
13	314	3[illegible]4	232	-59	-103	44.2	.20	-.59
14	397	650	265	-225	-166	56.3	.20	-.71
15	445	445	.09	0	-180	68.7	.00	-.79 ***
16	346	346	359	0	63	60.1	.00	-.62 ***
17	419	419	40[illegible]	0	58	67.1	.00	-.66 ***
18	382	8[illegible]	387	0	23	62.0	.00	-.59 ***
19	35[illegible]	353	360	34	34	59.9	.20	-.51
20	484	484	385	-91	-124	66.3	.20	-.60
21	276	276	363	18	109	70.[illegible]	.20	-.35
22	216	216	333	165	147	78.2	.20	-.10
23	93	93	285	405	240	94.4	.20	.10

EVALUATION REPORT

No OF FORECASTS HIGH	10.0
AMOUNT FORECASTED HIGH	791.5
No OF FORECASTS LOW	10.0
AMOUNT FORECASTED LOW	-936.0
M.A.D. AT END OF RUN	94.4

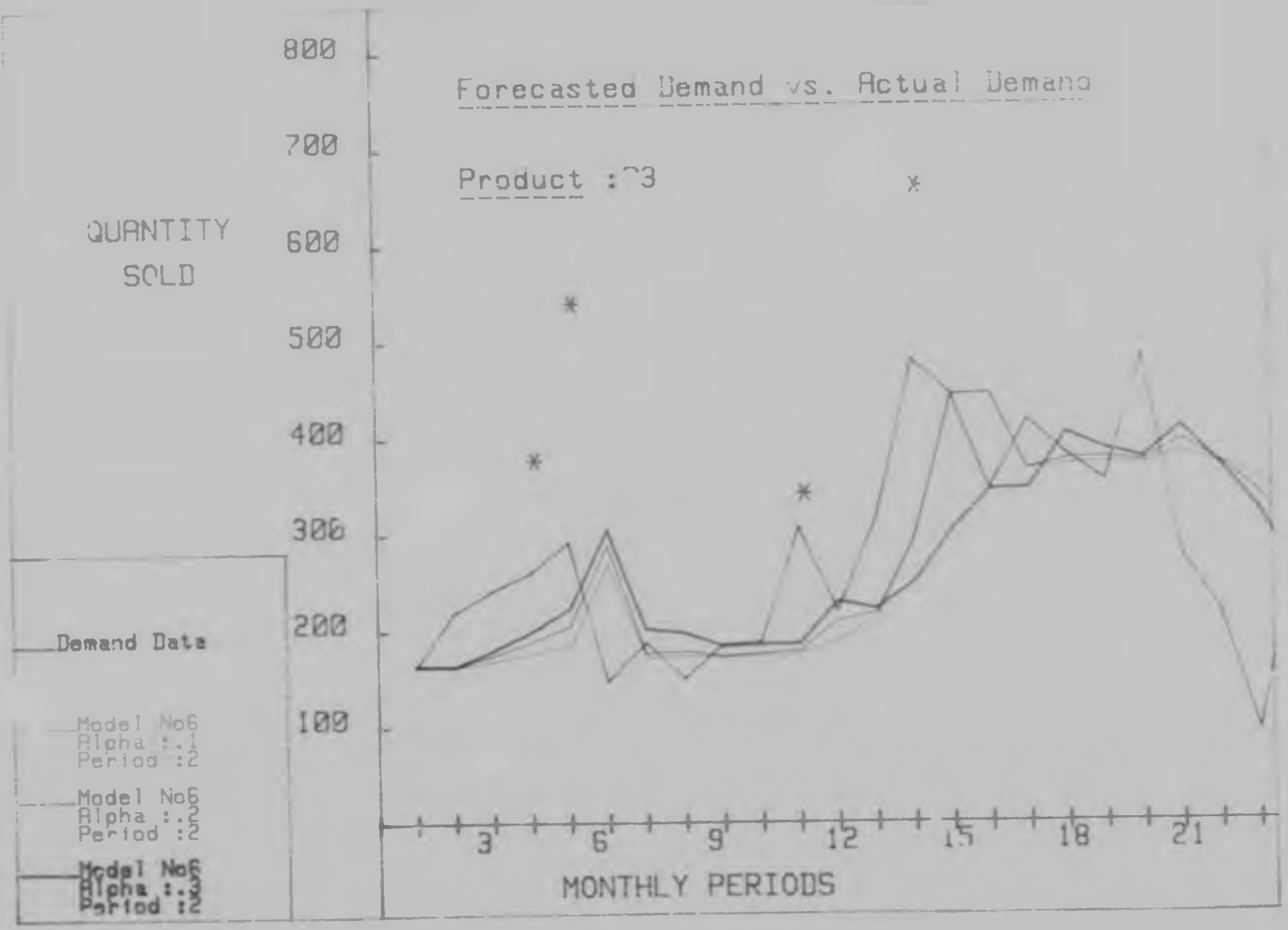

Forecasted Demand vs. Actual Demand
Product :73
QUANTITY SOLD
800
700
600
500
400
300
200
100
3
6
9
12
15
18
21
MONTHLY PERIODS
Demand Data
Model No6
Alpha :.1
Period :2
Model No6
Alpha :.2
Period :2
Model No6
Alpha :.3
Period :2

FIGURE 37

APPENDIX 8.4

FORECASTING RESULTS FOR P4

TABLE 20.1

FORECASTING RESULTS FOR P4

Models	Alpha	Total Forecast Errors	M.A.D.	% Forecast Exceeds Total Demand	Tracking Signal At End Of Run
1	0.2	-380	93	-5.7	-
2*	0.2	10	98	0.1	-0.02
3	-	-645	92	-8.9	[illegible]
4*	0.2 P-2	+458	85	6.8	-5.18
5	0.1	357	119	5.3	-0.2
6	0.3	76	109	1.1	0.0
7	0.1 P-2	-824	80	-9.3	0.23
8	0.3 P-2	-388	91	-5.7	-5.12
9	0.4 P-2	-260	90	-3.9	
10	0.2 P-3	66	131	0.8	0.28
11	0.3 P-3	- 26	130	0.4	0.21

* This implies models selected from initial run for further testing.

Model 2 with alpha = 0.2 was selected as having the lowest total forecast error, mean absolute deviation and tracking signal.

TABLE 20.2

FORECASTING RESULTS USING MODEL 6 WITH ALPHA EQUAL TO 0,2

INITIAL VALUE OF SMOOTHED ERROR .00
SMOOTHING CONSTANT FOR ERROR & MAD .20
NO. OF PERIODS BEFORE TRACKING SIGNAL 2.00
RESET VALUE OF GAMMA .10

ALPHA VALUE WHEN FORECAST IS OUT OF CONTROL .60
LENGTH OF HISTORY BEFORE ALPHA IS RESET 8.00
ALPHA IS RESET TO .20

P4

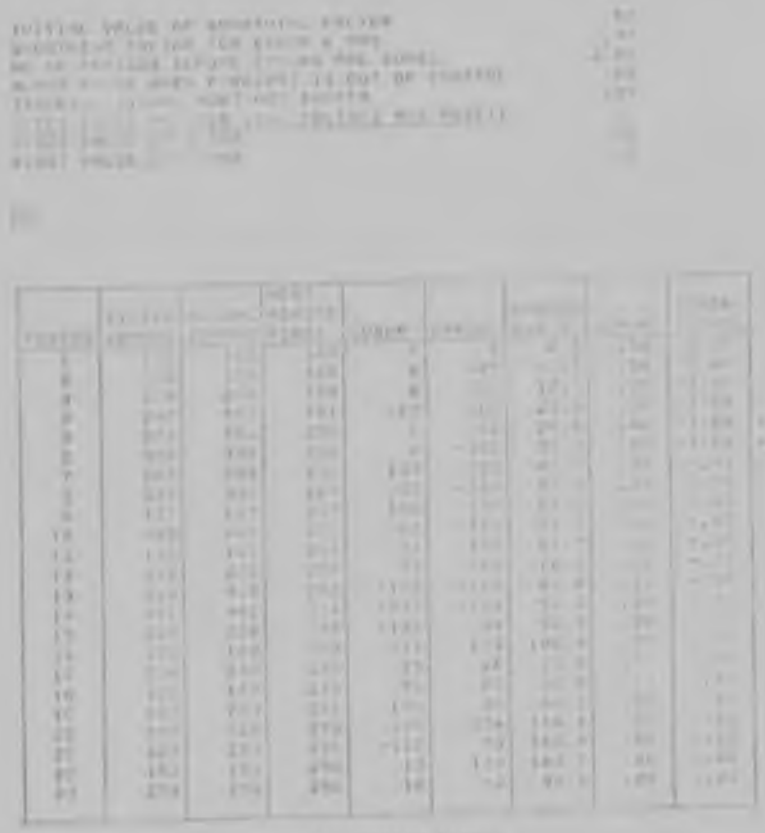
PERIOD	FILTER DEMAND	ACTUAL DEMAND	PERIOD FCAST	ERROR	SMOOTH M.A.D.	ALPHA	TRACK-SIGNAL	
1	150	195	150	0	0	0.0	.20	0.00	
2	150	180	150	0	-5	11.5	.20	-1.00	
3	150	200	150	0	-51	17.2	.20	-1.00	
4	150	170	177	-65	-65	21.9	.20	-1.00	***
5	150	150	197	-147	-92	28.0	.20	-1.00	***
6	150	150	205	-205	-115	36.7	.20	-1.00	***
7	150	140	220	-134	148	46.8	.20	-.44	
8	150	140	184	-297	-165	57.9	.20	-.69	
9	150	140	237	-160	-187	65.8	.20	-.84	
10	150	140	224	-131	-171	73.4	.20	-.93	
11	150	150	204	-74	-135	78.4	.20	-.89	
12	150	150	208	-108	-121	79.9	.20	-.92	
13	150	150	201	-101	-101	85.3	.20	-.97	
14	150	150	207	-154	-160	92.7	.20	-.69	***
15	150	150	210	-114	-92	87.0	.20	-.82	
16	150	150	210	-114	118	95.2	.20	-.17	
17	150	150	210	-114	-43	97.9	.20	-.35	
18	150	150	210	-114	69	91.1	.20	-.13	
19	150	150	210	-114	8	83.1	.20	-.11	
20	150	150	210	-114	-234	96.6	.20	-.91	
21	150	150	210	-114	-42	86.1	.20	-.91	
22	150	150	210	-114	139	92.6	.20	-.19	
23	150	150	210	-114	-19	81.9	.20	-.19	

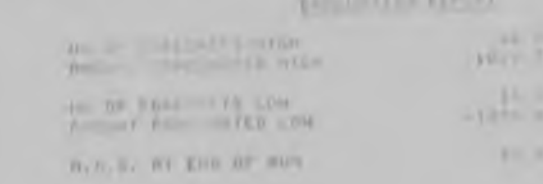
EVALUATION AFTER

NO. OF PERIODS	9.0
AMOUNT FORECAST ERROR	813.6
NO. OF POSITIVE DEVIATIONS	11.0
M.A.D. AT END OF PERIOD	85.5

TABLE 90.3

FORECASTING RESULTS USING MODEL 2 WITH ALPHA EQUAL TO 0.2





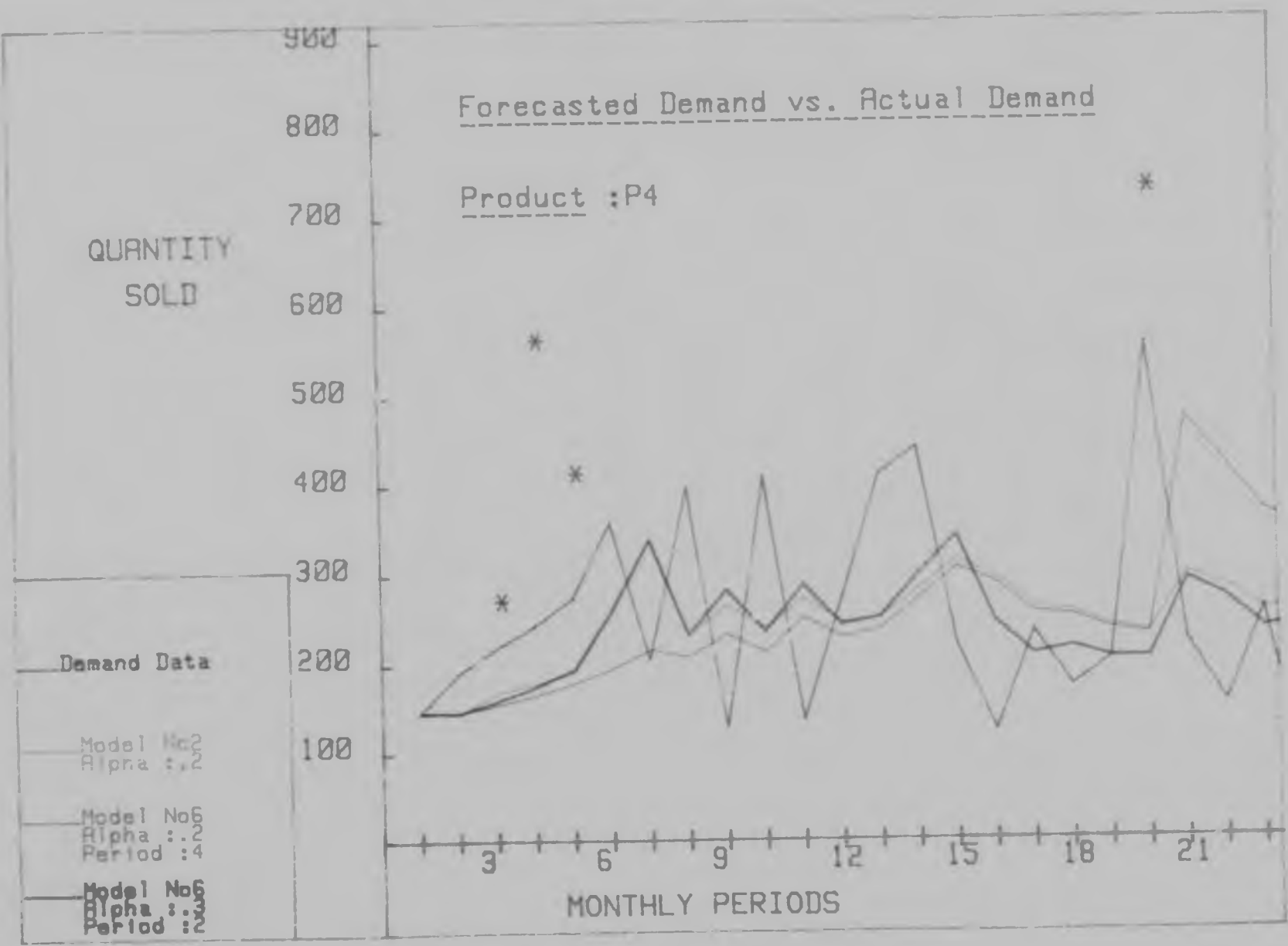

Forecasted Demand vs. Actual Demand
Product :P4
QUANTITY SOLD
900
800
700
600
500
400
300
200
100
3
6
9
12
15
18
21
MONTHLY PERIODS
Demand Data
Model No2
Alpha :.2
Model No6
Alpha :.2
Period :4
Model No6
Alpha :.3
Period :2

FIGURE 38

APPENDIX 8.5

FORECASTING RESULTS FOR P5

TABLE 21.1
FORECASTING RESULTS FOR P5

Models	Alpha	Total Forecast Error	M.A.D.	Forecast Exceeds Total Demand	Tracking Signal At End of Run
1	0,2	57	58	1,8	
2*	0,2	171	62	5,5	0,62
[illegible]	-	590	58	0,19	0,5
6*	0,2	861	62	27,8	0,57
2	0,1	211	69	6,8	[illegible]
2	[illegible].3	418	55	13,5	0,54
[illegible]	0,1 P-2	1136	67	36,0	0,66
[illegible]	0,3 P-2	714	55	23,0	0,6
6	0,3 P=3	861	62	35,0	0,71
6	0,2 P=4	1257	72	40,0	0,74

* This implies models selected from initial run for further testing.

Model 5 was selected having a low total forecast error and mean absolute deviation.

TABLE 2:.1

FORECASTING RESULTS FOR [illegible]

[illegible]Ts	Alpha	Total Forecast Error	M.A.D.	C.F. exceeds Control Limits	Tracking Signal At End of Run
1	0,2	57	58	1,3	
4	0,2	171	62	5,0	0,69
5	-	59	58	0,19	0,5
6*	0,2	861	62	23,0	0,57
2	0,1	211	69	0,0	0,24
3	0,3	818	55	13,5	0,24
7	0,1 P=2	1130	67	36,0	0,4
8	0,3 P=2	714	55	23,0	0,6
9	0,3 P=3	861	62	32,0	0,71
10	0,3 P=4	1297	72	60,0	0,74

* This implies models selected from initial run for further testing.

Model 5 was selected having a low total forecast error and mean absolute deviation.

TABLE 21.2

FORECASTING RESULTS USING MODEL 5 WITH ALPHA EQUAL TO 0.2

INITIAL VALUE OF SMOOTHING FACTOR .50
.30
2.00
.20
.10
OFFSET VALUE U

P5

PERIOD	ACTUA				CUSUM	SMOOTH	SMOOTH M.A.D.	TRACK-	
1					0	45.1	33.20		1.0
2						37.2	37.72		1.00
3		1				40.0	40.85	1.00	1.00
4					63	43	39.36	.07	.07
5					161	42.5	47.23	.98	.98
7		107			148	18.3	94.37		.38
8							55.81	.41	
9							69.66	.50	.50
10					263		75.33		.32
11		2			136		81.18	.44	.46
12		67				48.4	90.17		.94
13						38.6	64.17		.65
14		1					86.93		.91
15						39.1	70.62		.50
16						37.6	73.12	.51	.51
17						27.4	72.82	.38	.38
18		144				30.6	78.98	.43	.43
19		53				26.9	64.57	.42	.42
20	97					24.8	59.30	.39	.39
21	145	145		-12		27.9	60.18	.46	.46
22	39		72	60		28.9	58.33	.50	.50
23			53						

EVALUATION REPORT

HIGH	11.0
FORECASTED HIGH	1842.8
No OF FORECASTS LOW	9.0
AMOUNT FORECASTED LOW	-451.5
AT END OF RUN	58.3

TABLE 21.3

FORECASTING RESULTS USING [illegible] WITH [illegible] EQUAL TO 0.2

[illegible]

[illegible]

[illegible]

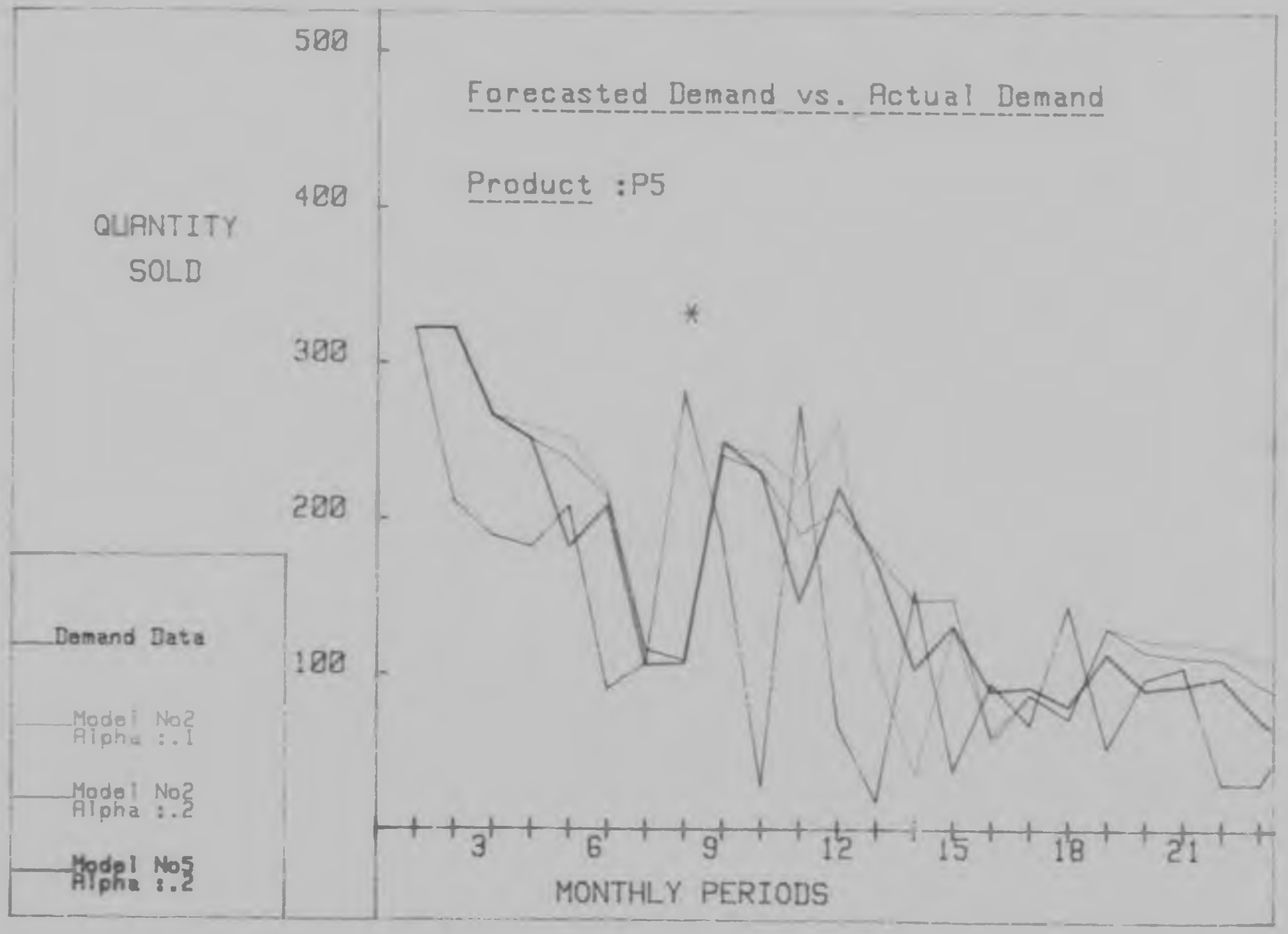

Forecasted Demand vs. Actual Demand
Product :P5
QUANTITY SOLD
500
400
300
200
100
3
6
9
12
15
18
21
MONTHLY PERIODS
Demand Data
Model No2 Alpha :.1
Model No2 Alpha :.2
Model No5 Alpha :.2

FIGURE 39

APPENDIX 6.6

FORECASTING RESULTS FOR P6

TABLE 22.1

FORECASTING RESULTS FOR P6

Quarter	Alpha	Total Forecast Error	M.A.D.	Forecast Error/ Total Demand	Tracking Signal at End of Qtr
1	0.7	3	21	0.1	
2*	0.2	12	21	1.1	0.01
3	-	-8	22	-0.7	0.0
4*	0.7	-26	31	2.5	0.0
2	0.1	91	21	5.8	0.0
3	0.3	8	22	0.5	0.01
4	0.1	-18	22	1.1	-0.01
1	0.3	3	19	0.17	-0.01
2	0.2	-14	21	1.3	0.0
3	0.3	-14	21	1.3	-0.07

* Initially = 0.1 selected from initial run for minimum tracking.

Using a site alpha = 0.7 and P = 2 was selected as having the lowest mean absolute deviation and one of the lowest forecast errors.

TABLE 22.7

FORECASTING WITH EXPONENTIAL MODEL A WITH ALPHA EQUAL TO 0.3

[redacted]

[redacted]

TABLE 22.3

FORECASTING RESULTS USING MODEL 2 WITH ALPHA EQUAL TO 0,2

INITIAL VALUE OF SMOOTHING FACTOR	.50
SMOOTHING FACTOR FOR ERROR & MAD	.30
NO OF PERIODS BEFORE ERRORS ARE SUMED	2.00
ALPHA VALUE WHEN FORECAST IS OUT OF CONTROL	.00
TRACKING SIGNAL MUST NOT EXCEED	.50
AFTER THESE PERIODS, THE FACTORS WILL BE RESET:	
RESET VALUE OF ALPHA	.40
RESET VALUE OF GAMMA	.10

P6

PERIOD	FILTER DEMAND	ACTUAL DEMAND	NEXT PERIOD FCAST	CUSUM	ERROR	SMOOTH M.A.E.	ALPHA	TRACK-SIGNAL
1	42	43	42	0	0	0.0	.50	0.00
2	44	44	43	1	1.00	2.0	.50	1.00
3	44	43	43	0	.00	1.5	.35	.00
4	43	44	43	1	1.00	1.5	.35	1.43
5	44	44	44	2	1.00	1.5	.35	2.00
6	44	44	44	3	.00	1.2	.35	2.50
7	44	44	44	4	.00	1.0	.35	2.86
8	44	44	44	5	.00	.9	.35	3.13
9	44	44	44	6	.00	.8	.35	3.33
10	44	44	44	7	.00	.7	.35	3.50
11	44	44	44	8	.00	.6	.35	3.64
12	44	44	44	9	.00	.6	.35	3.75
13	44	44	44	10	.00	.5	.35	3.85
14	44	44	44	11	.00	.5	.35	3.93
15	44	44	44	12	.00	.5	.35	4.00
16	44	44	44	13	.00	.4	.35	4.06
17	44	44	44	14	.00	.4	.35	4.12
18	44	44	44	15	.00	.4	.35	4.17
19	44	44	44	16	.00	.4	.35	4.21
20	44	44	44	17	.00	.3	.35	4.25
21	44	44	44	18	.00	.3	.35	4.29
22	44	44	44	19	.00	.3	.35	4.32
23	44	44	44	20	.00	.3	.35	4.35

EVALUATION RESULTS

No OF FORECASTS HIGH	12.0
AMOUNT FORECASTED HIGH	217.1
No OF FORECASTS LOW	8.0
AMOUNT FORECASTED LOW	-203.0
M.A.D. AT END OF RUN	1.3

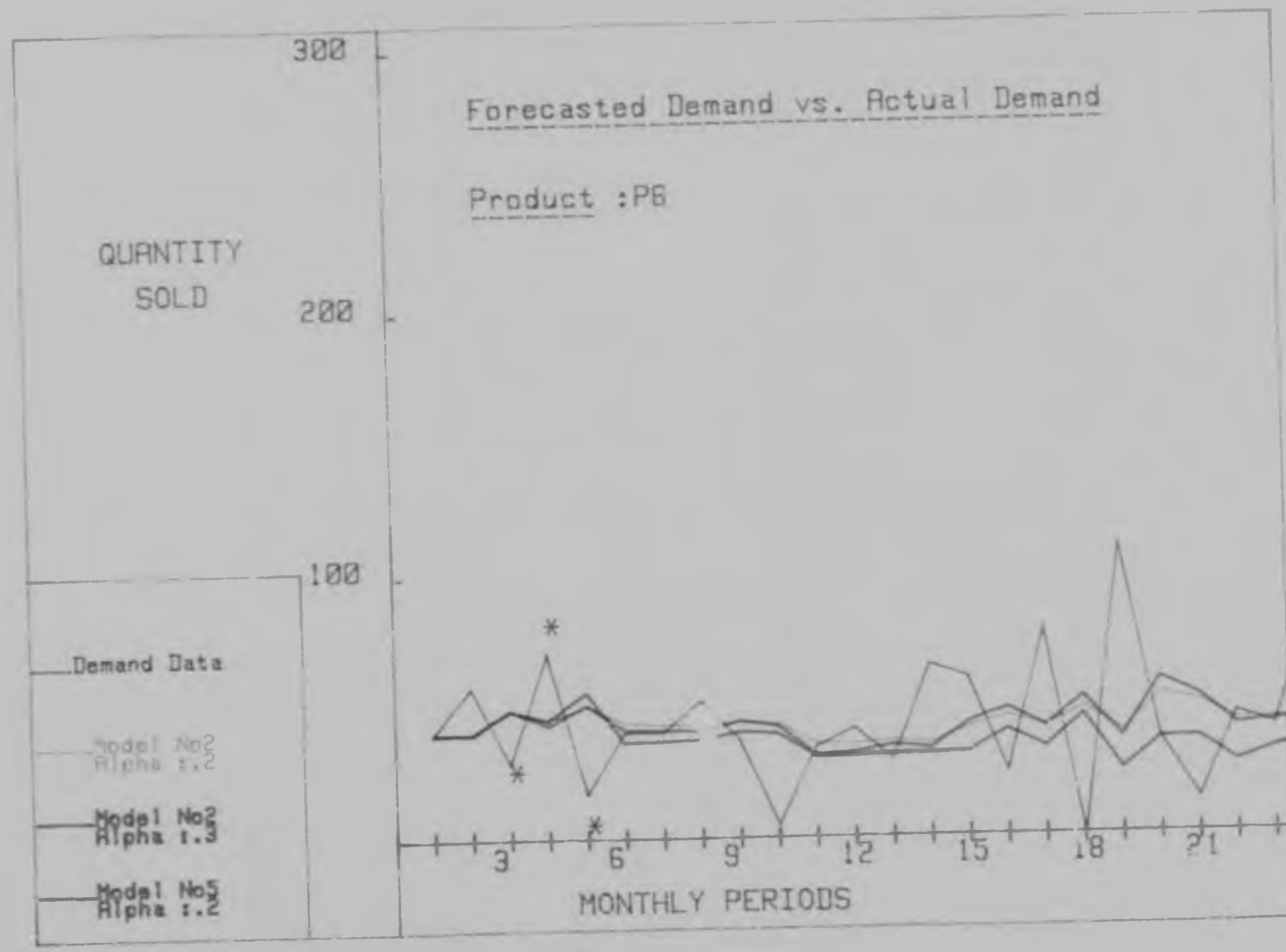

Forecasted Demand vs. Actual Demand
Product :P6
QUANTITY SOLD
300
200
100
Demand Data
Model No2 Alpha :.2
Model No2 Alpha :.3
Model No5 Alpha :.2
3
6
9
12
15
18
21
MONTHLY PERIODS

FIGURE 40

APPENDIX 8.7

FORECASTING RESULTS FOR [illegible]

TABLE 23.1

FORECASTING RESULTS FOR GRAND TOTAL SALES

Models	Alpha	Total Forecast Error	M.A.D.	Forecast Exceeds Total Demand	Tracking Signal At End of Run
1	[illegible]	7265	369	8,6	
2*	0,2	61	440	0,07	-0,55
5	[illegible]	-4038	376	-4,8	0,29
6*	0,2	-7119	384	8,5	-0,74
2	0,1	532	398	0,6	-0,27
2	0,3	357	366	0,4	-0,56
6	0,1 P 2	-4921	488	5,5	-0,21
6	0,3 P-2	[illegible]	367	6,8	-0,58
6	0,2 P 3	[illegible]	[illegible]	5,0	-0,48
6	0,2 P 4	[illegible]	[illegible]	5,3	-0,5

* This implies models selected from initial run for further testing.

Model 2 with alpha 0,1; 0,2 and 0,3 give the lowest forecast error. With alpha 0,2, the smoothest forecast is obtained.

TABLE 23.2

FORECASTING RESULTS USING MODEL 2 WITH ALPHA EQUAL TO 0.2

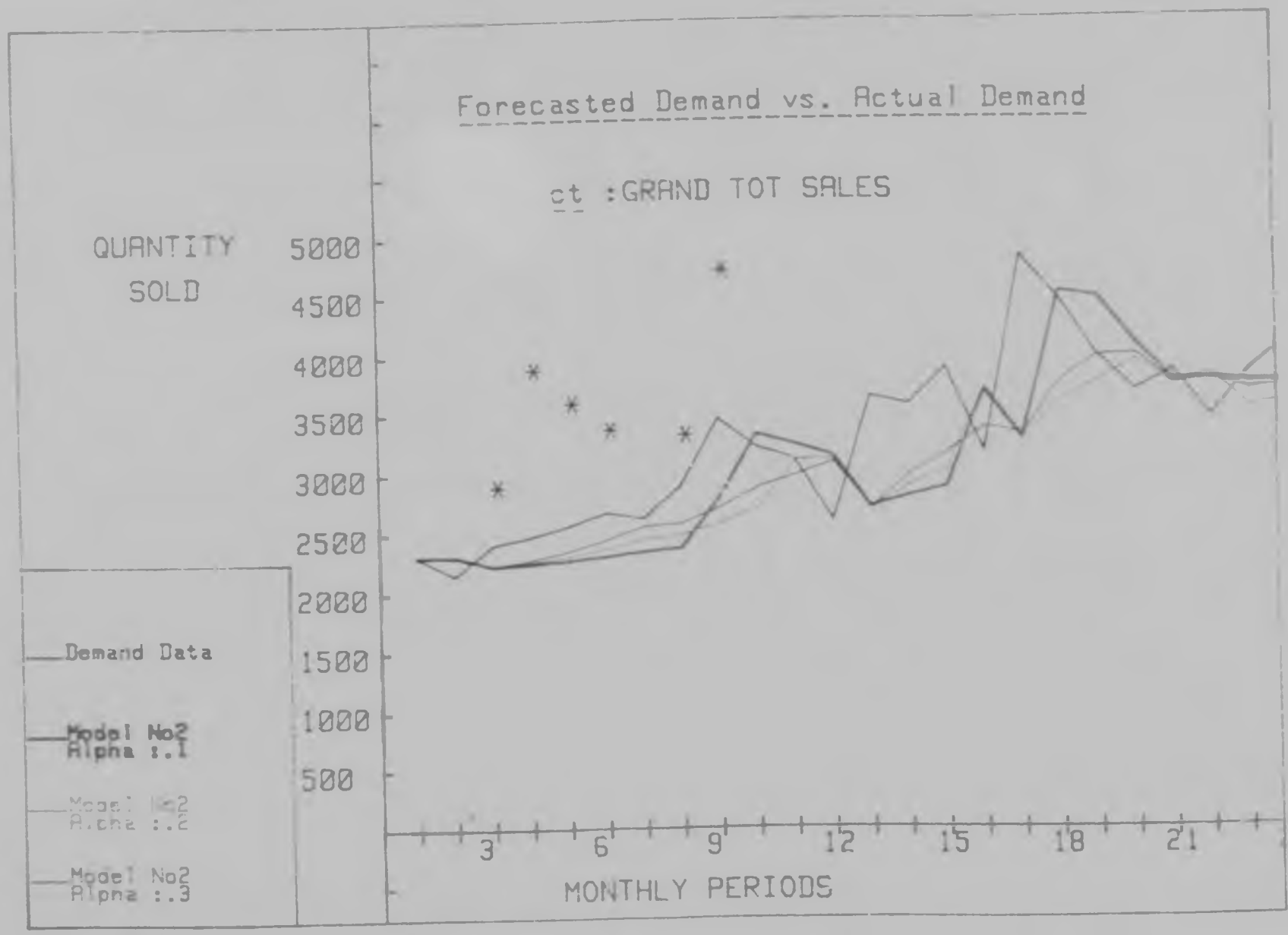
INITIAL VALUE OF SMOOTHING FACTOR	.50
SMOOTHING FACTOR FOR ERROR & MAD	.30
NO OF PERIODS BEFORE ERRORS ARE SUMED	4.00
ALPHA VALUE WHEN FORECAST IS OUT OF CONTROL	.05
TRACKING SIGNAL MUST NOT EXCEED	.50
AFTER THESE PERIODS, THE PREVIOUS ARE RESET:	
RESET VALUE OF ALPHA	.20
RESET VALUE OF GAMMA	.10

GRAND TOT SALES

PERIOD	FILTER DEMAND	ACTUAL DEMAND	NEXT PERIOD FCAST	∑ERROR	ERROR	SMOOTH M.A.D.	ALPHA	TRACK-SIGNAL	
1	[illegible]	[illegible]	[illegible]	0	0	0.0	.50	0.00	
2	2148	2140	[illegible]	0	157	47.1	.50	1.69	
3	[illegible]	[illegible]	[illegible]	0	177	88.6	.39	.41	
4	[illegible]	[illegible]	2387	[illegible]	-435	78.8	.26	-.80	
5	[illegible]	[illegible]	2364	[illegible]	-297	97.6	.28	-.38	
6	2738	3284	2439	-878	-946	111.5	.28	-.58	
7	[illegible]	2818	2472	-1851	-972	129.3	.28	-.57	
8	[illegible]	[illegible]	[illegible]	[illegible]	-489	164.8	.28	-.48	
9	[illegible]	[illegible]	[illegible]	[illegible]	-618	214.1	.28	-.29	
10	3199	3199	[illegible]	0	-906	[illegible]	.30	-.83	***
11	[illegible]	[illegible]	[illegible]	0	[illegible]	216.1	.30	-.83	***
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	245.8	.30	-.45	
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.40	-.61	
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.39	-.66	
15	[illegible]	3767	3814	-1333	[illegible]	[illegible]	.50	-.75	***
16	[illegible]	[illegible]	3784	0	[illegible]	[illegible]	.50	-.53	
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	538.2	.50	-.47	
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.50	-.73	
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	529.7	.50	-.73	***
20	[illegible]	[illegible]	3118	0	[illegible]	[illegible]	.50	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.50	-1.40	***
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.50	-1.41	
23	[illegible]	[illegible]	3518	[illegible]	[illegible]	448.3	.50	-1.01	
24	[illegible]	[illegible]	3579	[illegible]	[illegible]	[illegible]	.50	[illegible]	

EVALUATION RESULTS

NO OF FORECASTS HIGH	[illegible]
AMOUNT FORECASTED HIGH	1[illegible]8.2
NO OF FORECASTS LOW	16
AMOUNT FORECASTED LOW	-8215.0
M.A.D. AT END OF RUN	448.3


Forecasted Demand vs. Actual Demand
ct :GRAND TOT SALES
QUANTITY SOLD
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
Demand Data
Model No2 Alpha :.1
Model No2 Alpha :.2
Model No2 Alpha :.3
3
6
9
12
15
18
21
MONTHLY PERIODS

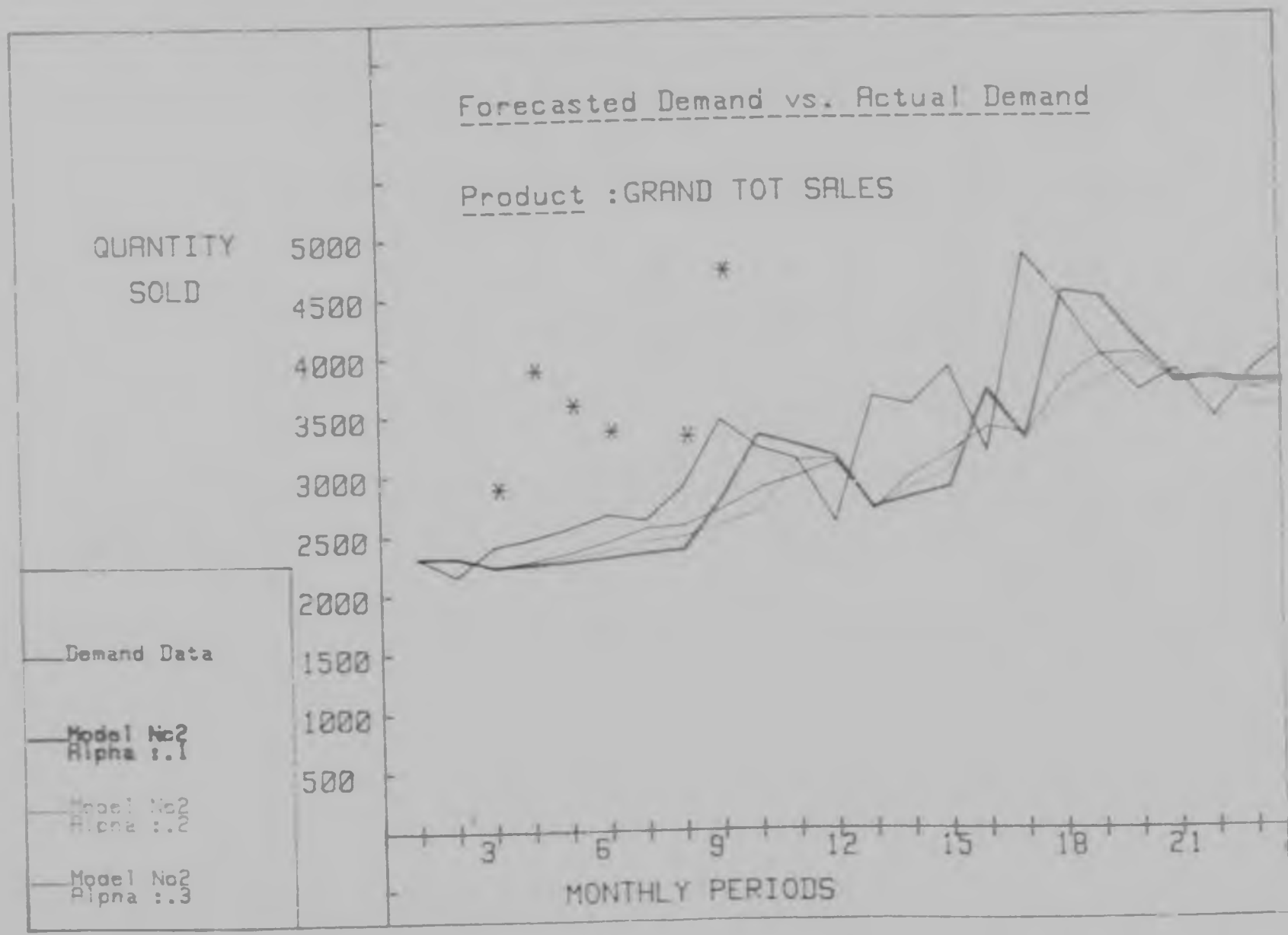

Forecasted Demand vs. Actual Demand
Product :GRAND TOT SALES
QUANTITY SOLD
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
3
6
9
12
15
18
21
MONTHLY PERIODS
Demand Data
Model No2 Alpha :.1
Model No2 Alpha :.2
Model No2 Alpha :.3

Figure 4.1

APPENDIX B.8

RESULTS FOR A SAMPLE 'B' ITEM

TABLE 24

FORECASTING RESULTS FOR P5

Models	Alpha	Total Forecast Error	M.A.D.	Forecast Exceeds Demand	Tracking Signal at End of Run
1	0,2	-65	[illegible]	-22,0	-
2	0,1	-25	8,2	- 8,5	0
2	0,2	-27	8,8	- 9,2	-0,03
2	0,3	-38	9,9	-12,9	-0,05
5	-	-22	8,6	-7,5	0,04
6	0,2 P=2	-34	8,7	-11,6	-0,07

APPENDIX

[illegible] RESULTS

APPENDIX-E/I

INVENTORY SIMULATION

RECALCULATION ORDER POINTS EVERY THREE MONTHS BASED ON

SIX MONTHS MOVING AVERAGE

Notes on the simulation exercise.

1. Lead times. A constant lead time of eight weeks is assumed for each order.

2. Order quantity. The order quantity is set at the sales average (or forecast) level, rounded to the nearest fifty units, ie the order quantity in period two equals the rounded sales average (or forecast) calculated in period one.

3. Multiples of the order quantity are ordered every time the stock on hand plus on order drops below the order point. Sufficient order quantities are ordered so that stock on hand plus on order exceed the order point.

4. Order point. The order point is calculated as described in section 4.6.
Safety stock is based on a 90% service level.

TABLE 25.1

PERIODIC REVIEW, INVENTORY SIMULATION FOR P1

'A' ITEM

MONTH	FORECAST	MAD	DDLT	SS	OP	OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
End April	821	544	1642	1419	3060			1800	1203	
May						1203		800	1122	81
June						1121	1800	800	2124	798
July	398	311			1607	2124	800	-	2300	624
August						2300	800	-	3174	726
September						3174	-	-	3121	53
October	418	298			1611	3121			2896	225
November						2896	-	-	2841	55
December						2841			2841	0
Jan 1981	202	181			878	2841			2575	161

TABLE 25.2

PERIODIC REVIEW, INVENTORY SIMULATION FOR P2

[illegible]	FORECAST	[illegible]	DDLT	SS	OP	OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
[illegible]	95	85			411			[illegible]	734	
May						743		100	311	432
[illegible]						311		400	(60)	371
[illegible]		196			1071	(60)	100	600	(585)	[illegible]
August						(585)	400	1800	(1400)	1215
[illegible]						(1400)	600	800	(1484)	[illegible]
October					1838	(1484)	1800	300	116	[illegible]
[illegible]						116	800	1500	(637)	1553
[illegible]						(637)	300	2000	(1794	145
[illegible]	1041				3122	(1794)	1500		(1430)	113

TABLE 25.3

PERIODIC REVIEW, INVENTORY SIMULATION FOR P3

'A' ITEM

MONTH	FORECAST	MAD	DDLT			OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
End April	293	122	699					300	891	445
May						891		300	4	445
June						446		300	400	346
July	399	106				400		600	283	417
August								400	201	382
September						201	600	400	448	353
October	405	44				448		400	364	484
November							400	400	493	271
December						493	400		677	216
Jan 1981	301	101			878	677	400		984	93

TABLE 25.4

PERIODIC REVIEW, INVENTORY SIMULATION FOR P4

'A' ITEM

MONTH	FORECAST	MAD	DDLT			OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
End April	331	109	880	164	944				1091	
May						1091		300	871	220
June						871			749	122
July	283				814	749	300	300	815	234
August						815			643	172
September						643	300	300	740	203
October	279	147			947	740		600	20	720
November						20	300		91	229
December						91	600	600	691	197
Jan 1981	288	144			951	691		300	1091	258

TABLE 25.6

PERIODIC REVIEW, INVENTORY SIMULATION FOR PS

'A' ITEM

MONTH	FORECAST	RAD	DDLT	SS	OU	OPENING STOCK	ORDERS RECEIVED	SALES	CLOSING STOCK	ORDER
1st April	151	76	300	150	500			150	500	
						500			424	58
						424	100	100	324	94
									418	100
July	73	36			438	418			418	154
August						418	94		324	74
September						318			324	74
October	52	26			240	324			298	57
November						298		80	161	137
December						161		40	141	74
January						141		50	141	50
1st 1981	71	36			288	141	74	50	141	50

TABLE 25.6

PERIODIC REVIEW, INVENTORY SIMULATION FOR PS

'A' ITEM

MONTH	FORECAST	RAD	DDLT	SS	OU	OPENING STOCK	ORDERS RECEIVED	SALES	CLOSING STOCK	ORDER
1st April	51	25	76	12	185			100	87	
						87			87	18
						71	18		147	18
						147		50	97	18
	50	18	100	18	117	97		50	47	0
						47		100	(53)	118
						65	118		(53)	118
	53	27	100	24	193	(53)	118	50	(53)	68
						1771	100	150	118	18
						118	68		118	18
						118	118		118	50
1st 1981	53	27	80	27	147	118	118	50	118	50

APPENDIX 9.2

INVENTORY SIMULATION
RECALCULATING THE ORDER POINT EVERY MONTH BASED ON
EXPONENTIAL SMOOTHING WITH BEST MODEL

TABLE 26.1

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P1

MODEL 2 α = 0,1

MONTH	FORECAST	MAD	DDL1			ENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
End April	264	313	526		1344			250	1203	
May	246	300	492	782	1274	1203			1122	81
June	301	325	602	847	1449	1122	250	900	574	798
July	373	325	666		1513	574		600	(50)	624
August	372	332	744			(50)	900	800	124	726
September	341	330	682		1542	124	600	350	671	53
October	329	390	658		1463	671	800		1246	225
November	302	305	60			1246			1541	55
	271	305	542			1541			1541	0
Jan 1981	260		520			1541			1380	161

TABLE 26 2

CONTINUOUS REVIE , I Y STI ATION FOR P2

MO 6 = P 2

MONTH	FORECAST	MAD				OPENING		QTY ORDERED	CLOSING STOCK	SALES
End April	165		33		549				743	
	218		436		702			400	311	432
	249	107	498		777	311		500	(60)	371
July	550	134	1100		1449	(60)	400	750	(285)	625
	952	170	1904	443		(285)	500	1650	(1000)	1215
September	738	180	1476				750	1900	(934)	684
October	630	216				(934)	1650		516	200
November	815	286	163	745	2375		1900	1300	863	1553
December	943	322	1886					1600	(594)	1457
Jan 1981	982		1964			(5 (	1300	2000	(430)	

TABLE 26.3

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P3

MODEL 6 α = 0,2; P

MONTH	FORECAST	MAD	DDLT		OP	OPENING STOCK	QUANTITY RECEIVED	QTY	CLOSING STOCK	ALES
End April	442	63	884	164	1048			450	891	
May	444	57		148	1036	891			446	445
June	366	61	672	219	891	446			550	346
July	376	60	752	156	908	550			583	417
August	377	55	754	143	897	583			201	382
September	372	52	744	135	879	201			198	353
October	395	58	790	151	941	198			114	484
November	371	64	742	166	908	114			243	271
December	340	73	680	190	870	243	700	350	727	216
Jan 1981	291	90	582	234	816	727		-	634	93

TABLE 26.4

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P4

MODEL 2 α = 0,2

MONTH	FORECAST	MAD	DDLT	SS	OP	OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
End April	314	92	628	240	868			-	1091	-
May	295	92	590	240	830	1091		300	871	220
June	260	100	520	261	781	871		300	749	122
July	255	93	510	243	753	749	300		815	234
August	238	92	476	240	716	815	300		943	172
September	231	86	462	224	686	943			740	203
October	296	110	592	287	879	740		750	20	720
November	281	106	562	276	838	20		300	(203)	223
December	256	109	512	284	796	(203)	750	300	395	152
Jan 1981	256	98	512	254	766	395	300	0	437	258

TABLE 26.5

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P5

MODEL 5

MONTH					OP	OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
			262	224	486			150	460	
May		87	178	227		460		150	422	38
			184		390	422	150		478	94
July				190	350	478	150		560	68
				189	414	560			416	144
		71		185	365	416		100	363	53
	93		186		356	363			266	97
			196	154	350	266	100	100	261	105
						261		100	231	
					257	231	100		301	30

TABLE 26.6

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P6

MODEL 2 AT 0.2

MONTH					OP	OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
					113			50	87	
		13			124	87		50	71	16
					119	71	50			24
					138	97	50	100	69	
					126	69			69	
					171	69	100	100	59	110
		24			161	59			23	
November					149	23	100	50	110	13
December	43				146	110		50	65	45
Jan 1981		21			139	65	50	50	75	40

APPENDIX 9.3

INVENTORY SIMULATION
RECALCULATING THE ORDER POINT MONTHLY
BASED ON EXPONENTIAL SMOOTHING WITH MODEL 2

TABLE 27.1

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P1

MODEL 2 $\alpha = 0,2$

MONTH	FORECAST	MAD				OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALES
End April	234	137						250	1703	
May	203	318				(203)			1122	81
June	322	346						800	574	798
July	38[illegible]	342			1658	574		900	(50)	624
August	451	342						800	24	726
September	372	347				24		450	871	53
October	342	327				871			1446	225
November	285	323				1446			1896	55
December	225								1896	0
Jan 1981	214					1896			1735	161

TABLE 27.2

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P2

MODEL 2 $\alpha = 0,2$

MONTH	FORECAST	MAD	ODLT				RECEIVED	ORDERED	CLOSING STOCK	SALES
End April	163	107							743	
May	217	123						300	311	432
June	248	127						600	(60)	371
July	323	152				( )		750	(385)	675
August	437	193						1500	(1000)	1215
September	486	199			1491			900	(934)	684
October	429	207				(934)	1500	500	366	200
November	585	264				366	900	1350	(287)	1553
December	759	325			2366	(287)	500	1800	(1244)	1457
Jan 1981	834	330			2529	(1244)	1350	2250	(1030)	1136

TABLE 27.3

[illegible] REVIEW, INVENTORY SIMULATION FOR [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	BEGINN. [illegible]	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALE
									[illegible]	
						[illegible]			446	445
						[illegible]			100	346
						[illegible]		350	(67	417
						[illegible]		400	351	[illegible]
						351		400	348	[illegible]
						[illegible]		350	264	484
						264	400	400	393	271
						[illegible]	350		529	216
						529	[illegible]	350	834	93

TABLE 27.4

[illegible] INVENTORY SIMULATION FOR [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	BEGINNING [illegible]	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	SALE
	[illegible]							150	460	
[illegible]	[illegible]	[illegible]			[illegible]	[illegible]			422	[illegible]
[illegible]	[illegible]				[illegible]	[illegible]	150		478	94
					[illegible]	[illegible]			410	68
[illegible]	[illegible]				[illegible]	[illegible]		100	[illegible]	144
[illegible]	[illegible]				[illegible]	266		150	213	[illegible]
[illegible]	111				[illegible]	[illegible]	[illegible]	100	216	[illegible]
November	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	261	[illegible]
[illegible]	94	62			[illegible]	[illegible]	[illegible]		331	[illegible]
	[illegible]	[illegible]			[illegible]	[illegible]		[illegible]	[illegible]	

APPENDIX 2.4

INVENTORY SIMULATION
EVALUATING THE ORDER POINT SYSTEM
FOR A 26 ITEM

TABLE 28.1

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P5

USING MODEL 5 AND ORDER QUANTITY 50 UNITS

		MAD	DDLT			PENIV. STOCK	QUANTITY RECEIVED	QTY ORDERED		IN.	
		2,8			21,3						
May					37,0	39			21		
					57,0	21					
		,1			77,0	(5)		50			
		4,7			74,0	(39)	50	50			
					49,0		50		30		
Octob		7,6			66,0		50		63		
Novem		7,1			63,0	63		50	43		
	16	7,8			52,0	43					
Jan 1981	13	8,6			48,0	35			85		

TABLE 28.2

CONTINUOUS REVIEW, INVENTORY SIMULATION FOR P6

USING MODEL 5 WITH ORDER QUANTITY = NEAREST 10 UNITS TO FORECAST

MONTH	FORECAST	MA	DDLT	SS	OP	OPENING STOCK	QUANTITY RECEIVED	QTY ORDERED	CLOSING STOCK	ALE
End April					21				39	
May	14				37				21	18
June	23				57	21		50	(5)	26
July	32				77	(5)		60	(39)	34
Aug ust	31				74	(39)	50	60		
September	17				49		60		40	
October	23				66	40	60		83	17
November					63	83			63	
December	16				52	63			45	
Jan 1981					48					