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THE COLLEGE OF AERONAUTICS

(Proposed Cranfield Institute of Technology)

DEPARTMENT OF PRODUCTION ENGINEERING

DESIGN PROJECT 1968

FINAL REPORT OF TECHNICAL SURVEY COMMITTEE

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SUMMARY

A survey has been made to determine the factors influencing the design of a precision turning machine with limited milling facilities.

Seventy six replies were received, have been analysed and histograms plotted and from an analysis of this information a technical specification has been compiled for the machine.

CONTENTS

1. INTRODUCTION

At the commencement of the design project it became apparent that some detailed information would be necessary to establish a basic specification for a precision turning machine with a limited milling facility. Consequently five sub-committees were formed to survey the following industries.

Aircraft and Accessories
Motor Car and Accessories
Electronics and Computing
Machine Tools and Accessories
Precision Equipment and Instruments

As a result of minute 3.0 of the first meeting of the Design Project, the chairmen of the sub-committees formed the Technical Survey Committee. The terms of reference of this committee were to assess the technical requirements for such a machine and to derive the final machine specification. From this assessment, the design project would be aimed at achieving this specification at minimum cost. This in turn implies that the machine must appeal to a wide market, and hence should avoid ever complexity of function.

A questionnaire was compiled to establish the design influencing factors from industry, the questions being such as to provide direct and implied design data.

To reach a wide cross-section of industry, each member of the committee sent out a questionnaire with an accompanying letter, see Appendix, to one hundred firms within the group he was representing. The response to the survey is shown in the following chart.

	Number of returns
Aircraft and Accessories	28
Motor and Accessories	13
Electronics and Computing	10
Machine Tools and Accessories	7
Precision Equipment and Instruments	18
TOTAL	76

It should be borne in mind that some of the firms to whom questionnaires were sent were unable to complete them. The reasons being either, that it was not applicable to their organisation, or that their requirements in this field were very limited. The total number of replies was therefore appreciably greater than the number of returned completed questionnaires.

The information recorded against each question was statistically analysed and as a result histograms were plotted for each question which showed the spread of the information together with the maximum zone at which this information occurred.

From the information on the histograms a machine specification was compiled defining such things as maximum work length and diameter, and the number of tools required per component.

The committee would like to thank all those companies who by contributing information made this technical survey possible.

2. COMMENTS ON THE CONTENT, VALUE, AND VALIDITY OF THE QUESTIONNAIRE

When the questionnaire was being compiled, full use was made of Appendix 2, given in the Final Report of the Market Survey Committee, Drilling System Design Project 1967 (ref. 1).

From the comments on question 1 it was decided to word questions such that they asked for percentage rather than for a tick to be placed in a box. However it was observed during subsequent analysis that this form of answer was in no way related to Company output. Also two different percentages need not mean that the greater percentage was the greater output.

It was assumed therefore that as a large sample had been taken that these errors would average out.

The 1968 questionnaire began with a general question on compnnent accuracy, but in the majority of cases this was not answered. The reasons for this could be that companies did not want to admit that components gave them accuracy problems, or alternatively too long a description or too large a sketch would have had to be given. As a question it gave no insight into the design requirements of the machine.

Question 2 was well answered Part A indicated the desirability of having a milling facility on a turning machine. Part B gave rise to some ambiguity which is best demonstrated by the following interpretations:-

1) Nearly all turned components are made from some sort of bar eg. round, hexagon, square. Therefore the percentage given was in the order of 95%.

2) Some turned components are made direct from bar, as with an automatic or capstain lathe. A sequence of operations is performed on the end of the bar terminating in a parting off operation. This cycle is repeated until all of the bar is used up. In this case the percentage given was in the order of 50%.

The second interpretation was the one required by the survey, but in many instances it appeared from percentages given that the question had been treated as in interpretation 1.

In conclusion question 2 should possibly have been worded:-

"What percentage of your components are manufactured direct from bar, by the automatic or capstan lathe method?"

The aim of question 3 was to determine the maximum length and diameter of the workpiece. It was felt however that the question was too involved just to obtain this information.

Only one company mentioned the omission in question 4 of the $\pm$0.0005 - $\pm$0.001 in. ($\pm$0.012 - $\pm$0.025 mm) tolerance band, which suggests that the results obtained still gave an accurate indication of tolerances. After the results were analysed, and the graphs plotted, the tolerances obtained went directly into the specification.

Question 5, part A showed just how large the percentage is, in this country, of work done on a batch basis. Part B on analysis gave close agreement with the previous years Market Survey results on batch quantities.

In the answers to question 6, cast iron was included frequently under any other metallic materials, and should therefore have been included in the main column.

Question 7 was well answered and therefore gave an accurate indication of the number and type of tools with which the machine should be equipped.

In reply to question 8 asking whether it was considered that a numerically controlled turning machine with a limited milling facility would be suitable for their needs, 2 in 5 gave an affirmative answer. The comments made in answer to question 9 were varied, and useful. A precis of them is given below:-

" . . . accurate quick change tooling, with adjustments .. ."

" . . . fast approach speed, fast retraction . . ."

". . . speed is the criteria for tape control . . ."

" . . . milling usually carried out in fixtures for rigidity, can this be achieved with a turning M/C? . . ."

" . . . this machine could replace two machines . . ."

" . . . no question asked about concentricity, or surface finish . . ."

" . . . a simple milling facility would save a loading and unloading cost . . ."

" . . . a machine that does two functions is rarely as good as two separate machines . . . "

" . . . a plug board controlled automatic machine would be more attractive . . . "

" . . . quick tool change to minimise set up time . . . "

" . . . maintenance must be considered . . . "

" . . . little of milling requires the removal of metal from the circumference of a turned component. It is rather the addition of turning to irregular milled shapes . . . "

". . . profiling would be an advantage . . . "

" . . . there is a need for a limited milling facility from a live toolpost . . . "

" . . . there is a need for N/C turning only at low cost, particularly the control system rather than adding the complexity of a dual purpose machine . . . "

To constructively criticize the questionnaire leads one to the conclusion that it required too much data to fill it in, and as such the number of returns and hence the accuracy suffered.

In any large survey of this nature, it is usual to first survey the market with a pilot questionnaire. This enables essential modifications to be made to the final questionnaire. The pilot survey should produce at least 50 replies; however with the time limitation on the Design Project this was not practicable, and therefore emphasizes the need for considerable care when constructing the questionnaire.

Statistically to ensure a probability of 0.8 that the results are a representative sample, a minimum of 460 replies are required. Based on the percentage returns (40) received to the market survey questionnaire in the previous year, this suggests that at least 1,150 questionnaires should be distributed. It should be realised that a more useful probability is 0.95 which implies that at least 3,000 questionnaires should be distributed.

The results of this survey therefore should only be taken as a general guideline towards the true picture. However it is suggested that they will prove extremely useful, when confirmed as valid by the range of experience of the members of the project team.

3. SPECIFICATION

The specification was chosen so as to include a minimum of 75% of the components surveyed.

The figure of 75% was chosen from an inspection of the shape of the histograms.

1. COMPONENTS

		Percentage included
Maximum Length	8 in	87
Maximum Diameter	4 in	86
Tolerance on Length	±0.001 in (± 0.02 mm)	95
Tolerance on Diameter	±0.001 in (± 0.02 mm)	91
Tolerance on Milling	±0.001 in (± 0.02 mm)	98

2. TOOLING (Magazine requirements)

		Percentage included
Number of Turning Tools	8	100
Number of Drills	4	76
Number of Milling Tools	4	96

4. REFERENCES

1. Powell E. A.
   Boshier G. C.
   "Final Report of Market Survey Committee" Drilling System design project 1967.

2. Hansen
   Hurwitz
   Madour
   "Sample Survey Methods and Theory" (Publisher - J. Wiley) Vol. 1.

5. APPENDICES - Questionnaire and Letter

College of Aeronautics,
Cranfield,
Bedford.

Department of Production Engineering

DESIGN PROJECT 1968.

Questionnaire - Linear Path System

To:- The Technical Director,
Company:- _____

_____

_____

THE COLLEGE OF AERONAUTICS

CRANFIELD, BEDFORD

Tel.: Cranfield 321

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ADMINISTRATION

Professor of Production Engineering:

Head of Department:
Professor : JOHN LOXHAM
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Professor of Industrial Management:
Professor P. G. FORRESTER
M.Sc., F.I.M.

The Technical Director.

Dear Sir,

Questionnaire - Linear Path System

An important feature of the postgraduate course in Production Technology at Cranfield is the study of machine tool automation and design.

In order to make this study realistic, a machine is taken from basic concept through to detailed drawing for manufacture; throughout this project close contact is maintained with manufacturers and users of the machine we are designing.

The study this year is to design an automatic machine tool incorporating a linear path system on one or more axes. Our definition of linear path is - 'A point to point movement with controlled feedrate'. It is envisaged that this sytem will be applied to a precision turning machine with a limited milling facility.

We would greatly appreciate your comments regarding the requirements of such a machine in your particular field of activity. In order to further this objective we have enclosed a questionnaire which we hope you will be able to complete. We would appreciate an early reply so that our technical survey committee can produce a basic specification.

Any information supplied will be treated confidentially and a copy of the report will be sent to you as soon as it becomes available.

Yours faithfully,

M.F. Scarffe.

This questionnaire applies to turned components with a limited amount of milling e.g. splines, keyways, flats, radial holes, etc.

Please answer the following questions. (Note:- Any number which could fall in two columns, should be placed in the smaller of the two).

Q.1.

Do you have a turned component, which also requires some milling, that is giving you accuracy problems? If so, outline briefly :-

Q.2. COMPONENTS

A) What percentage of your turned components require some milling to be done on them?

☐ %

B) What percentage of components are manufactured direct from bar?

☐ %

Q.3. SIZE

State size of components as a percentage of total output.

		LENGTH (IN)						
		0-0.5	0.5-1	1-2	2-4	4-8	8-12	Greater than 12
DIAMETER (IN)	0 - 0.5							
	0.5 - 1							
	1 - 2							
	2 - 4							
	4 - 8							
	Greater than 8							

Q.4. TOLERANCES

Indicate the percentage of components manufactured in the following tolerance ranges.

	Turning		Milling
	length	diameter	
Less than ± 0.000 5"			
± .001" - ± .003"			
± .003" - ± .005"			
± .005" - ± .010"			
Greater than ± .010"			

Q.5. BATCH QUANTITIES

a) What percentage of your production is done on a batch basis?

[ ] %

b) Indicate the percentages falling in the following batch quantity ranges.

Up to 10	10-50	50-100	100-300	Greater than 300	
					%

Q.6. MATERIALS MACHINED

(This information is required for the determination of cutting speeds and feeds).

	Approximate Percentage
Aluminium	
Brass	
Mild Steel	
Alloy Steel	

Any other metallic materials, please specify:

Any other non-metallic materials, please specify:

Q.7. TOOLS

Indicate number of tools required per set up for :-

MILLING			
1-2	2-4	4-8	
			%

TURNING			
1-2	2-4	4-8	
			%

DRILLING			
1-2	2-4	4-8	
			%

Q.8. CONTROL

Would you consider a numerically controlled turning machine with a limited milling facility suitable for your needs.

YES	
NO	

Q.9. COMMENTS

Would you please make any comments that you think will help us in our analysis :-

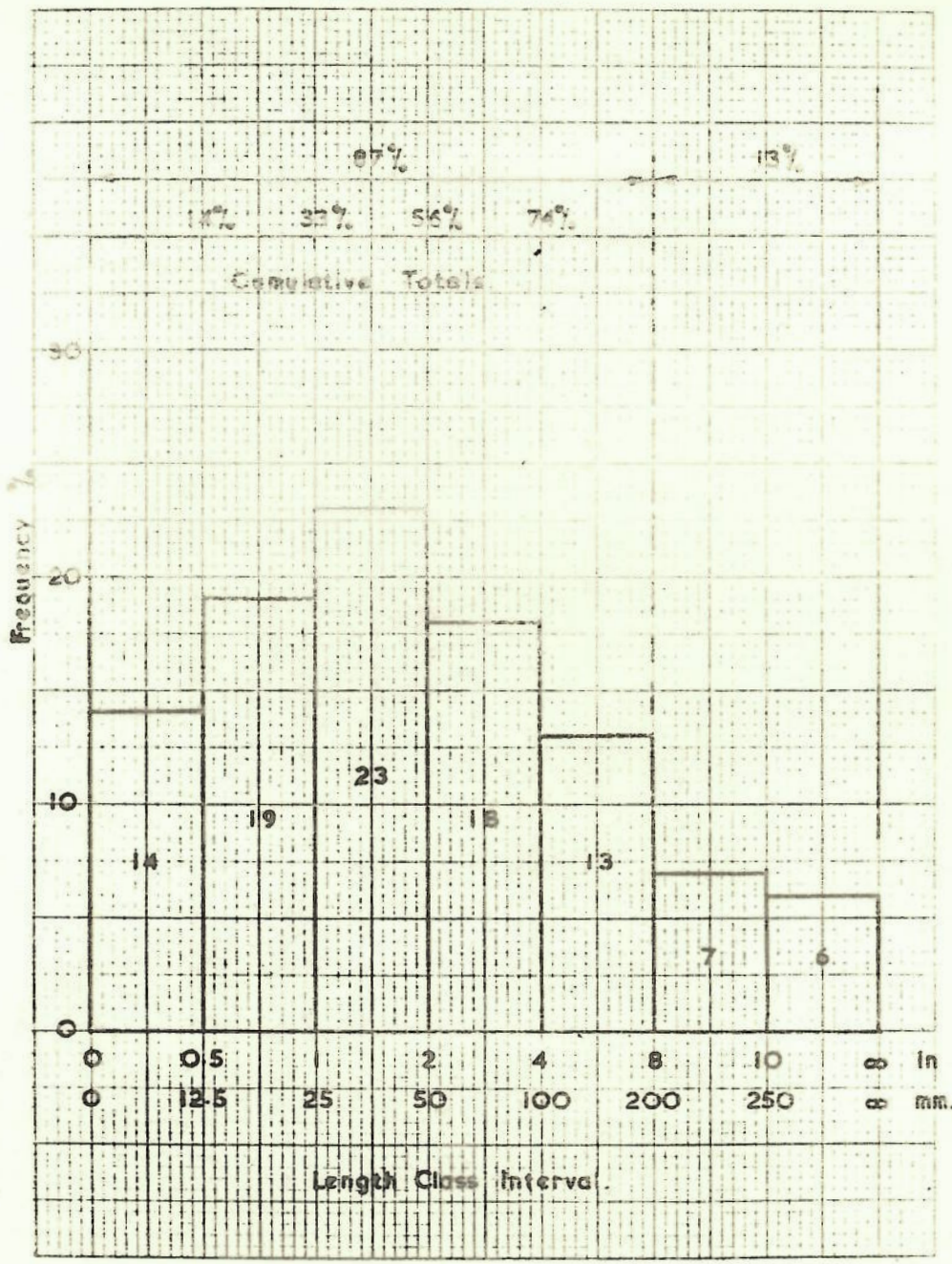

FIG. 6.1. DISTRIBUTION OF COMPONENT LENGTH

QUESTION 3

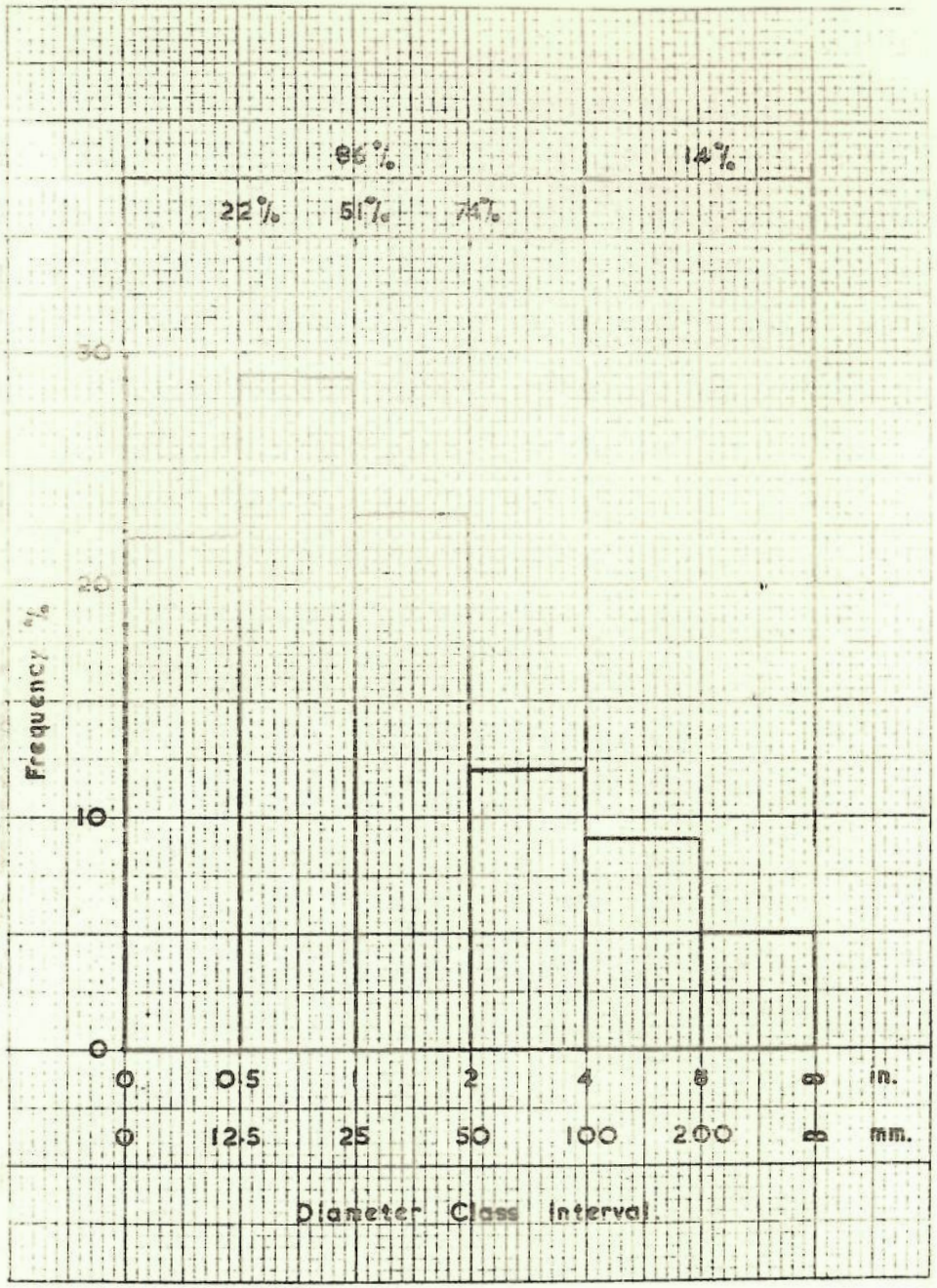

FIG. 6.2. DISTRIBUTION OF COMPONENT DIAMETER.

QUESTION 4.

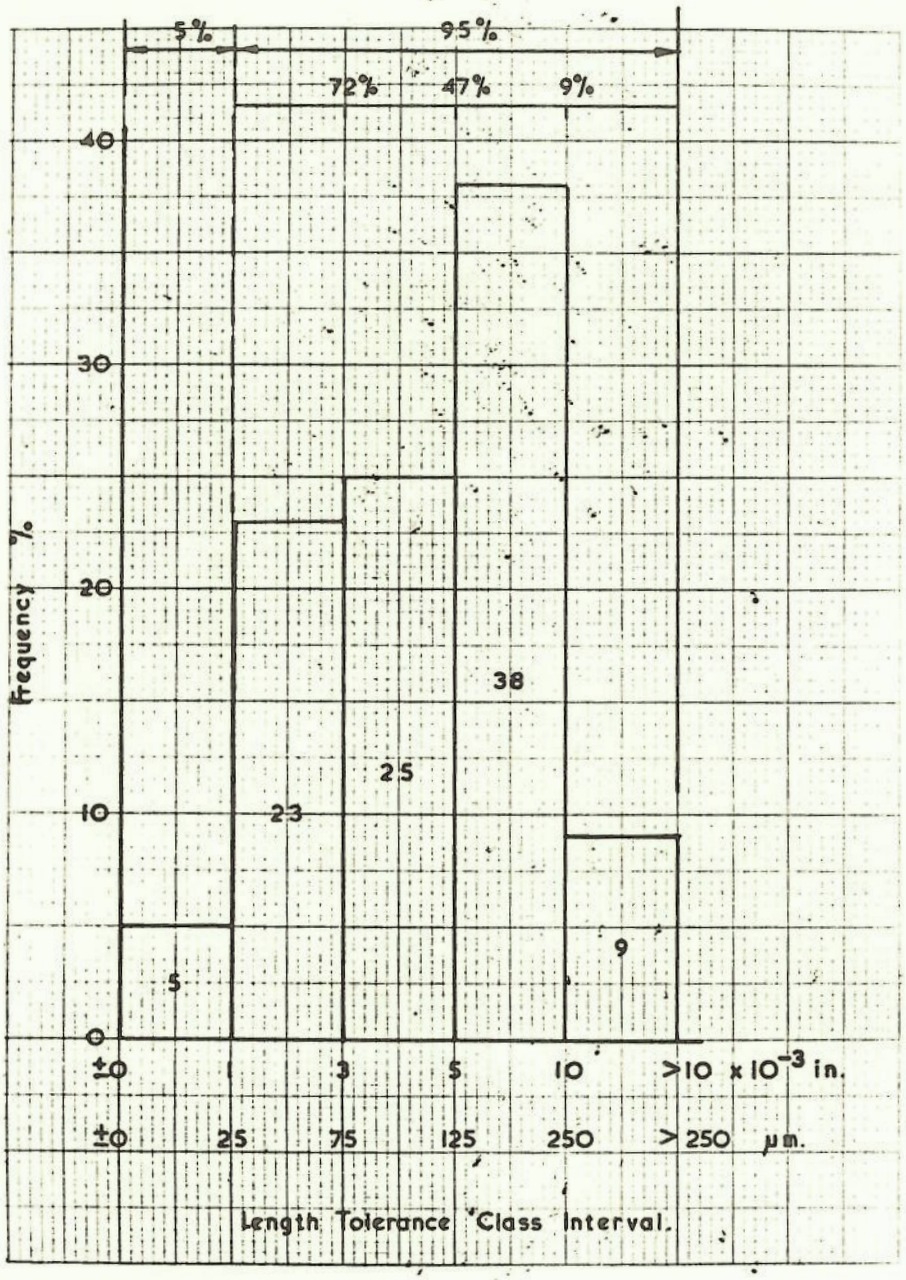

FIG. 6.3. DISTRIBUTION OF TOLERANCE ON COMPONENT LENGTH.

QUESTION 4

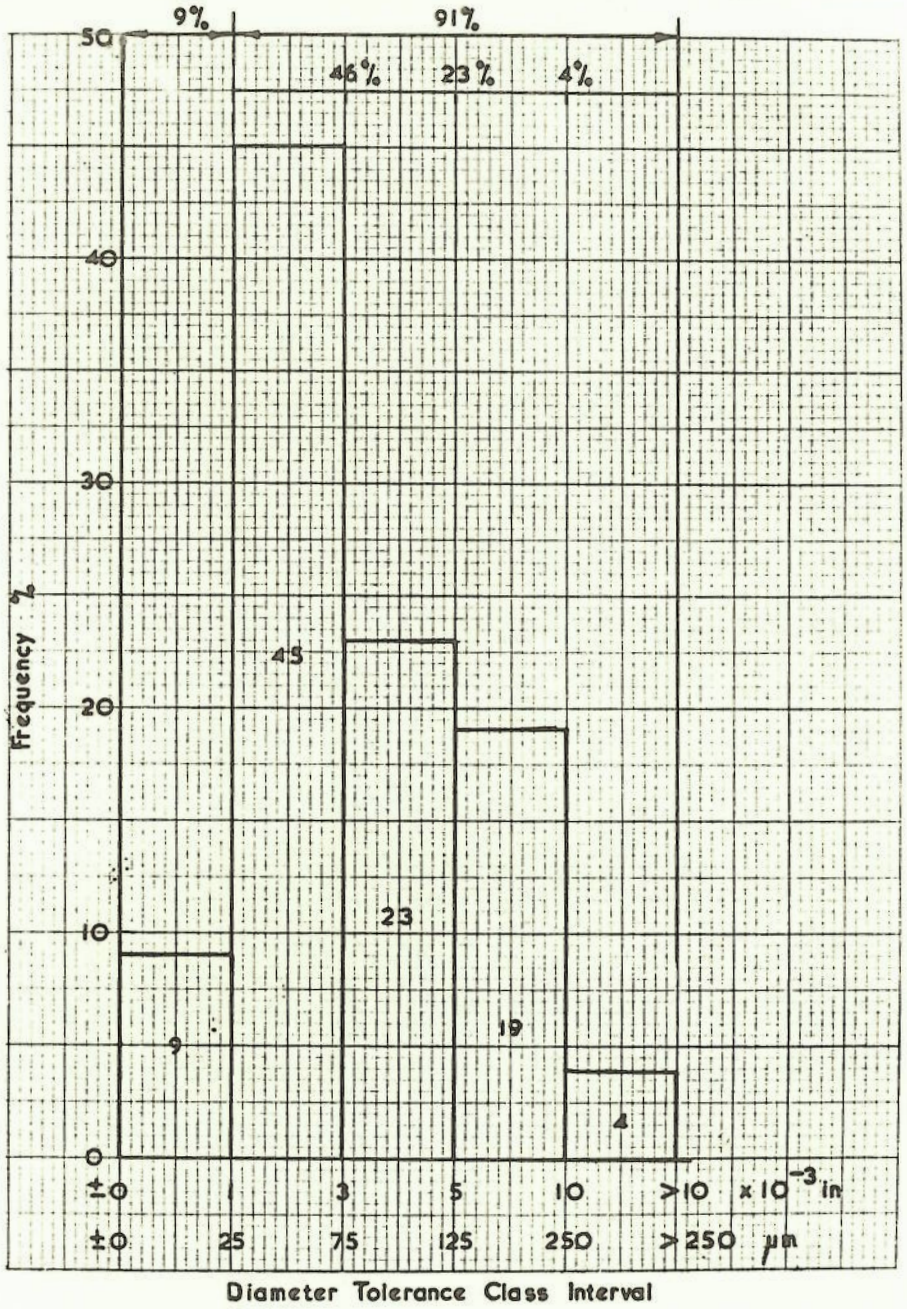

FIG. 64. DISTRIBUTION OF TOLERANCE ON COMPONENT DIAMETER

FIG. 64. DISTRIBUTION OF TOLERANCE ON COMPONENT DIAMETER

QUESTION 4

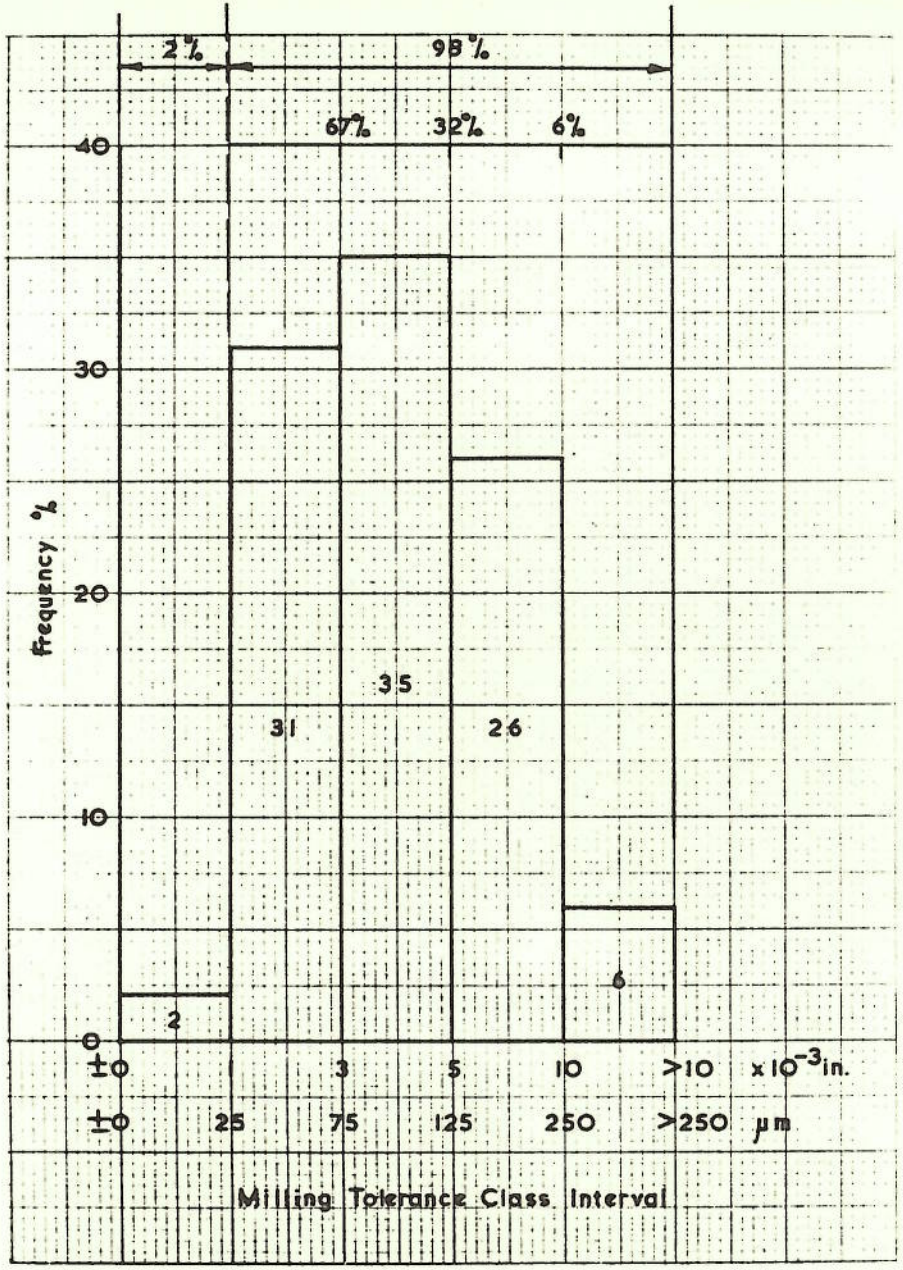

FIG. 6.5. DISTRIBUTION OF COMPONENT MILLING TOLERANCE.

QUESTION 5

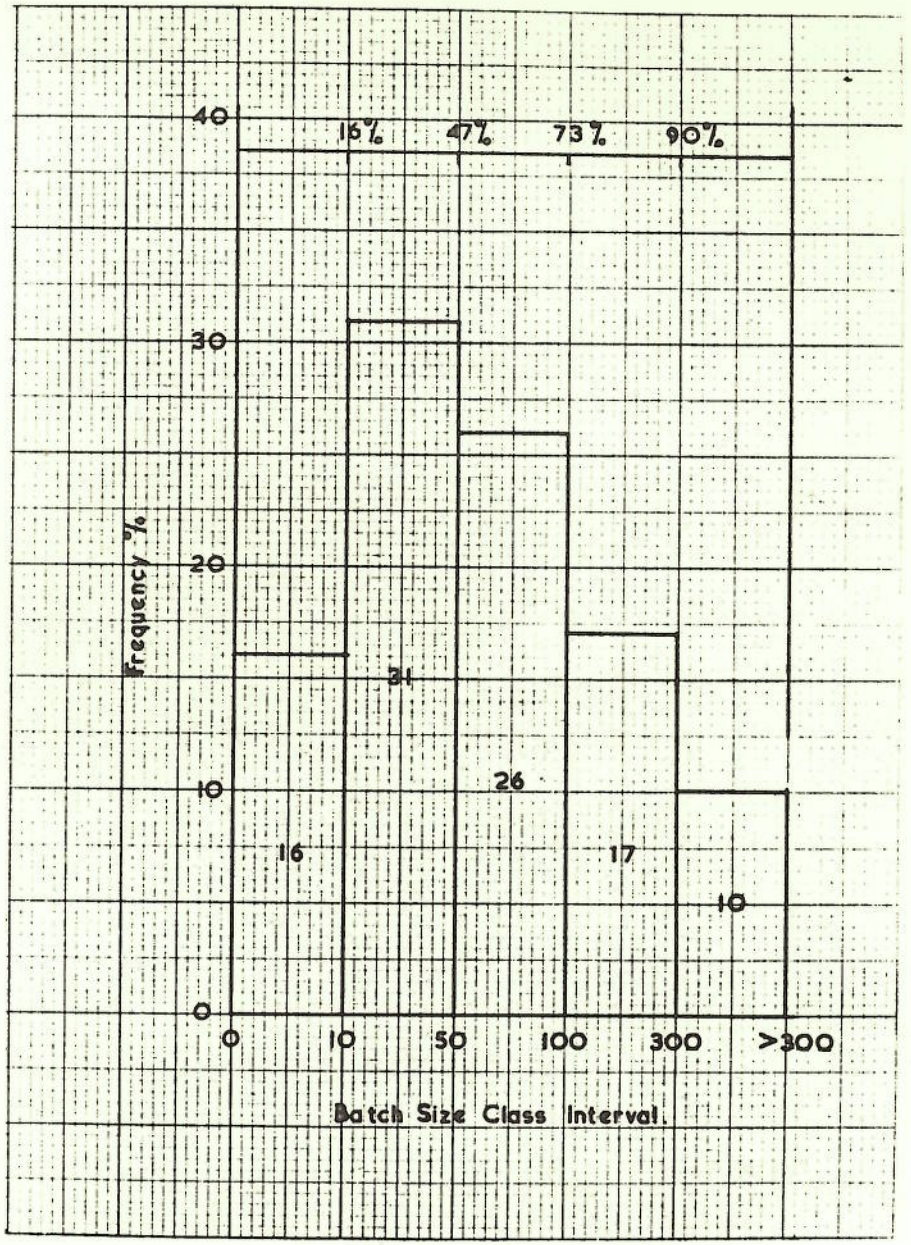

FIG. 6.6. DISTRIBUTION OF BATCH SIZE.

QUESTION 7

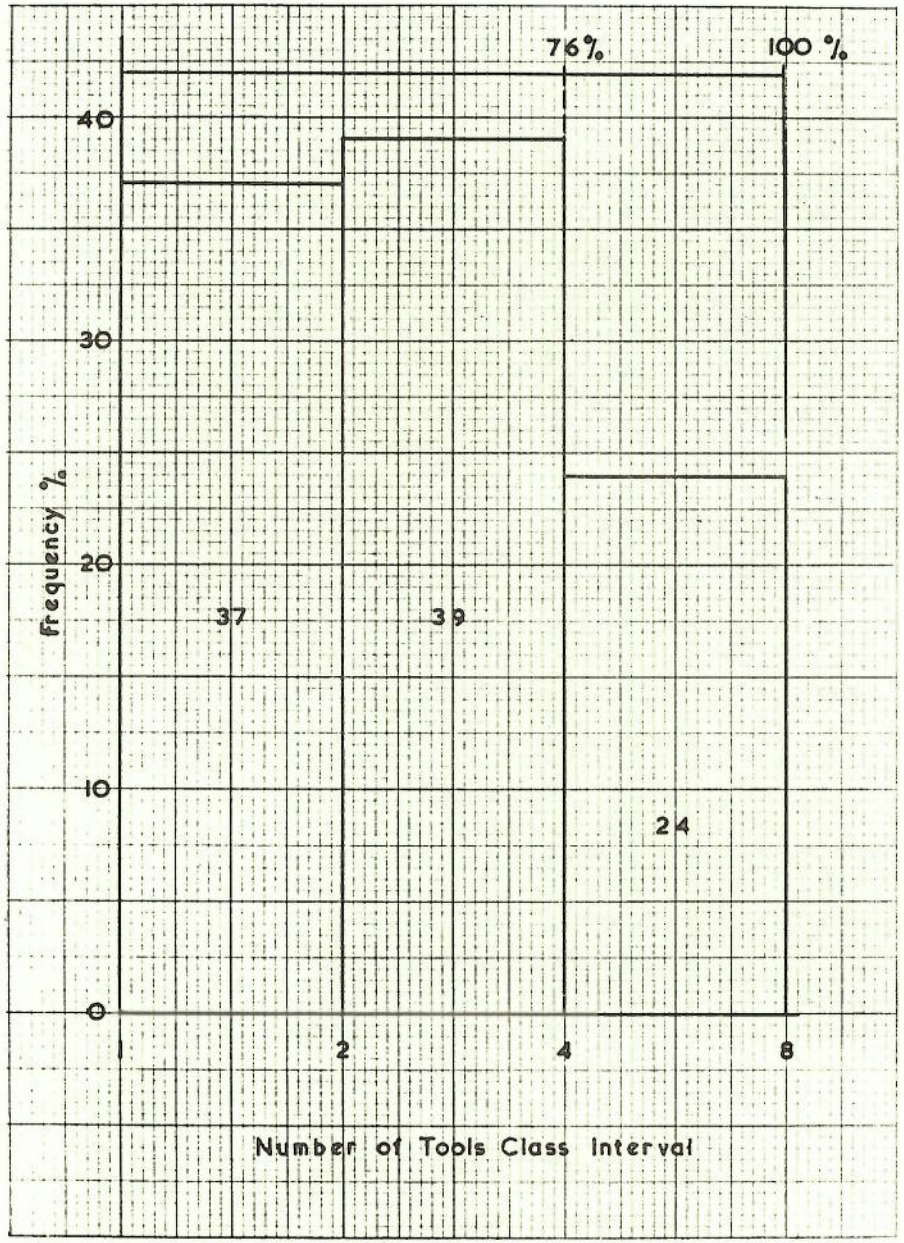

FIG. 6.8. NUMBER OF DRILLS REQUIRED PER SET-UP.

QUESTION 7

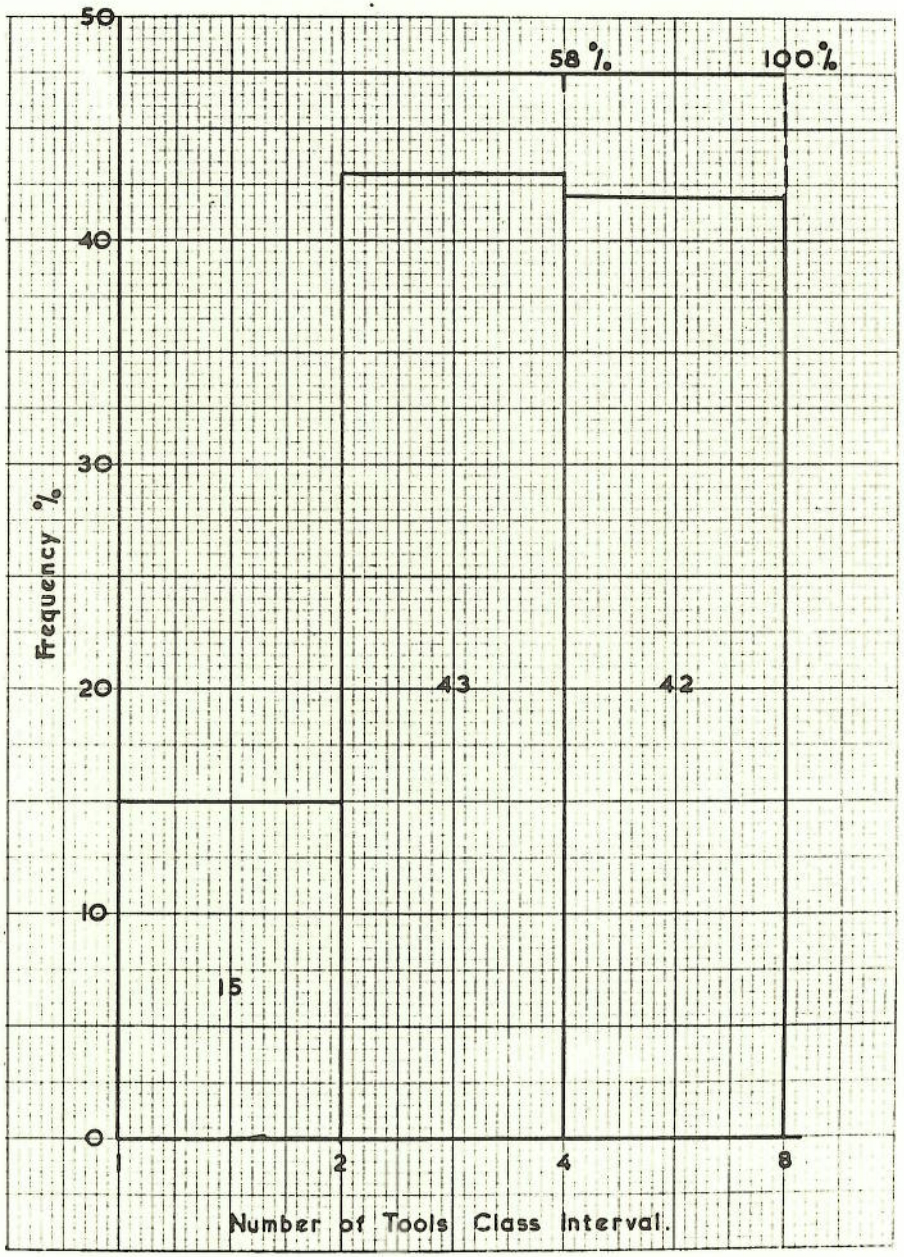

FIG. 6.7. NUMBER OF TURNING TOOLS REQUIRED PER SET-UP.

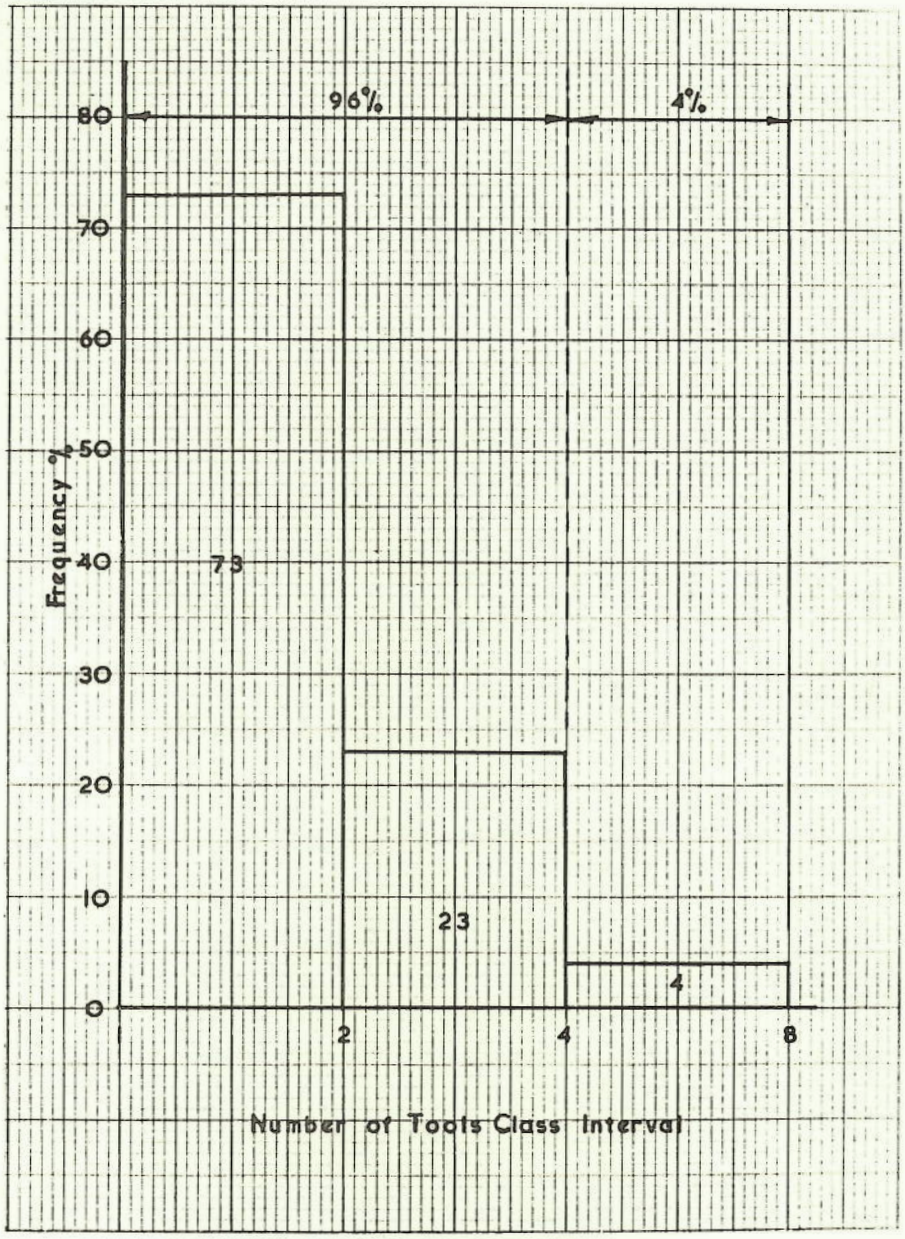

FIG.6.9. NUMBER OF MILLING TOOLS REQUIRED PER SET-UP.