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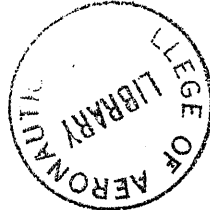
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THE COLLEGE OF AERONAUTICS

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ADMINISTRATION



Polishing and lapping of silicon discs

at Texas Instruments

Report by

Students of The College of Aeronautics, Cranfield.

S U M M A R Y

The polishing and lapping of silicon discs at Texas Instruments Ltd. was investigated by a team of students from Cranfield as a project for the Spring Term, January/March 1965.

Unfortunately, the process was not operating during the period available to the team and therefore detailed measurements could not be obtained. This report is based on discussions with Texas Instruments, on analysis of a short film of the main parts of the process and subsequent analyses and investigations.

Although a detailed and quantitative list of precise recommendations cannot be made, a number of worthwhile points arise together with some suggestions for longer term investigation.

The Cranfield team has learnt a great deal from the project, but there is naturally a sense of frustration at not being able to present a complete and comprehensive analysis of the process.

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1. Introduction

The investigation was made possible by the kind co-operation of Texas Instruments Ltd. with The College of Aeronautics, Cranfield.

It was, of course, understood that all information obtained from Texas Instruments would be treated in the strictest confidence.

The system to be investigated is briefly described as follows:

The processes of lapping, polishing and inspecting the silicon discs take place in one room, partitioned off from the main factory working area by glass walls. The whole operation is carried out by four girls together with one male supervisor. It may be described under the following headings.

1. Heat stainless steel blocks.
2. Apply wax to these blocks.
3. Place discs on waxed blocks.
4. Bed in discs on waxed blocks.
5. Cool blocks.
6. Clean surplus wax from blocks.
7. Discs lapped.
8. Blocks cleaned.
9. Discs polished.
10. Blocks cleaned.
11. Blocks heated.
12. Discs removed from blocks.
13. Discs cleaned.
14. Discs inspected (twice)
15. Discs stored until required for next process.



Members of Team

The team responsible for carrying out this investigation was as follows:

Mr. W.T. Singleton and Mr. T. Gardiner Staff Members.
Mr. Bevans, Mr. Chandan, Mr. Cotton, Mr. Crosbie, Mr. Nicholson,
Mr. Robertshaw and Mr. Rose.

A different member of the team acted as secretary each week.

Terms of reference

The aim of the investigation was to apply the fundamental techniques of Work Study and Method Study in an attempt to make the total operations of lapping, polishing and inspecting the discs more efficient, in the sense of reducing to a minimum:-

- (a) The total time taken to process the discs.
- (b) The number of people necessarily involved in the operation.
- (c) The total cost of the product.

II Analysis of the process

The process was analysed in four stages by preparing:-

1. A Flow Process Chart.
2. A two handed Chart.
3. A Man/machine Chart or Multi Activity Chart.
4. A 'String' diagram of Operator and Material Movements.

1. Flow Process Chart: see Chart 1.

As a first step towards tackling the project a flow process chart was prepared using the available commentary and the short film of the process.

This chart gave a more detailed picture, describing the activities associated with materials, men and machines and it recorded the sequence of operations, transportation, inspections delays and storages. Standard ASME symbols were used.

2. Two Handed Chart: See Charts 2

This chart was prepared to compare the activity of the two hands of an operator. The film was viewed frame by frame and activities of two hands were plotted on standard charts using the standard ASME symbols. The following points were noted:

- a) Some operators had too much transportation.
- b) Some of the operations took a long time.
- c) Operators had difficulty in performing some operations and there was room for method improvement.
- d) Some of the jobs were only 'one-handed', the other hand being idle.
- e) The times for the different operations were noted.
- f) The lapping and polishing operations took a much longer time than the rest of the operations in the process.

3. Man/Machine or Multi Activity Charts: See Charts 3A and 3B

This chart showed the relative periods of activity and idle times of men and machines. Two such charts were prepared: 1) for 2 lapping machines, 1 heater, 1 washer, 1 cooler and one operator. 2) for 4 polishing machines, 4 washing machines, one hot plate with one operator.

The first chart gave a 100% operator and machine utilization for a production of 36 discs per hour.

The second chart gave a 87% operator utilization for 67% lapping machine utilization giving a production of 48 discs per hour.

4. String Diagram

This diagram could only be rough due to lack of information which would have been given by a time-lapse film. However, the following points were noted:-

- a) Operator and Material movement could be reduced by the provision of storage areas before and after the placing and removal of the discs.
- b) The long narrow room demands long travelling distances. It is presumed that relayout would be too expensive to justify.

III Investigations

A. Technical Aspects

1. Specification of the Finished Discs

Thickness - 0.0052 ± 0003

Flatness - Within 0.0002 F.I.M. across the disc from $\frac{1}{8}$ " of the edge to $\frac{1}{8}$ " of the edge.

Surface finish - Purely subjective: very high polish on one side only no value quoted but estimated at 1 micron.
There must not be a scratch longer than half an inch and not more than three pit marks over the complete surface.

2. Thickness of the Disc prior to Lapping

The thickness of the disc prior to lapping is from 0.010 to 0.012. This size was questioned with the intention of decreasing it.

The process prior to lapping is a diffusion process. The discs are heated in a controlled atmosphere. Impurities diffuse from this atmosphere into the silicon to a depth of approximately 0.0025". The function of the transistor depends on the impurities being on one side of the silicon only, therefore the impurities are ground off in the lapping process. To allow a margin of safety the minimum thickness of the disc has been set at 0.010.

Attempts have been made to mask one side of the disc but these have proved unsuccessful. It is therefore unavoidable that .005" to .007" thickness of disc must be removed. And, furthermore, it was not possible to reduce the thickness of the slices arriving for lapping and polishing.

3. The Lapping and Polishing Processes

These are specialised processes and it was therefore decided to consult a firm engaged in this work. The firm of Engis Ltd., of Maidstone, Kent, were contacted and they sent their representative Mr. R. Scott to discuss this problem with us.

It was Mr. Scott's opinion that the lapping and polishing times would be reduced by approximately 50 per cent but it would be necessary for him to experiment with his products on the discs to determine the optimum conditions. The optimum conditions being those which created the minimum crystal damage and reduced lapping and polishing times.

It is essential that a minimum of crystal damage takes place during the lapping and polishing processes. The depth of crystal damage is approximately twice the grit size.

Texas Instruments were informed of the discussion with Engis Ltd., and have decided to deal with this matter direct. It was suggested that trials could be carried out by Engis Ltd., the checking of crystal damage after lapping and polishing being done by Texas Instruments Ltd.

At present Texas Instruments use 'Lustrox' Zirconium Oxide slurries of 12 micron for lapping and 0.5 micron for polishing. The Engis product is diamond paste ranging from 0.1 micron upwards. They require no mixing since they impregnate the lapping surface, a small quantity being added periodically. The Zirconium oxide powers must be mixed into a slurry and is drip fed to the lapping surface.

No comparison of cost can be made until the experimental work is carried out and the usage determined.

4. The Waxing Operation

Problems have been encountered in the process due to the inconsistency of the wax film. Alternative methods of holding the discs on the block were discussed with a view to replacing or improving the waxing operation. Suggestions included:-

- a) Vacuum chucks with a reservoir to maintain the vacuum during the lapping and polishing operations.
- b) Counterboring the face of the block to accept the disc to maintain it in position during the lapping and polishing operations and then connecting it to a vacuum line for lifting the block and discs off the plate.
- c) An alternative adhesive.

For both a) and b) a certain amount of experiment and development work would be necessary. Therefore they have been recorded as suggestions for further improvements.

The question of an alternative adhesive was discussed with Mr. Scott and it appeared that wax is the standard method of mounting for lapping. However he did suggest the use of 'Cut Rock', a wax with reasonably constant melting point which would give a consistent spread across the block.

This wax was suggested to Texas Instruments who state that they were aware of this product and were reviewing the relative merits of using an expensive wax with a constant melting point or using a cheaper wax and adjusting the process and controlling the heating of the blocks to suit the wax.

5. The Inspection Operation

The inspection operation was discussed and it was felt that the use of

a comparator may damage the discs. An air gauge was suggested to replace it.

Two discs were inspected on the College. The surface finish was estimated at approximately 1 micron and there was three indentations on each disc. Texas Instruments confirmed that this was caused by the comparator.

B. Labour Utilization

When the process was filmed three or four girls produced two thousand slices a week. If it was desired to change the production rate, then the number of girls working the process was altered accordingly.

A quick calculation, based on times supplied by Texas Instruments, shows that, for a polishing rate of 50.5 slices/hour for all the four machines, it is impossible to increase the production rate beyond $50.5 \times 40 = 2020$ slices/week (assuming a forty hour working week) without increasing the polishing rate and/or increasing the number of machines used to more than four. Thus to improve labour utilization when the production rate is at about two thousand/week it is necessary to either improve the figure of 50.5 for the polishing rate per hour for all machines or to reduce the number of girls working the process. If further studies show that it is possible to improve on the figure of 50.5 then the ways of improving labour utilization are the ways of reducing delays; these are of two sorts, demanding different approaches.

1. Delays During, and Unnecessarily long times needed for Individual Operations

The two handed charts made of all the operations show where delays occur and how the operations might be modified in order to reduce the time required for their completion. Recommendations are made in section V below.

2. Delays Between Different Operations

The flow process chart shows the sequence of the operations that go to make up the process. However this chart does not show how the different operations must be scheduled; scheduling is necessary in view of the restricted number of girls and machines available, and should be done in such a way as to maximise the utilization of the labour available, or of the existing machinery, whichever is considered to be of greater importance. Two different scheduling methods were investigated, but owing to lack of accurate data on the times of individual operations and the inter-relations it is not possible to make any specific recommendations. When the exact times for all operations, above, or from the time-lapse film are available this scheduling could be done.

The first scheduling method investigated was quite conventional, and was worked out on a bar chart for the polishing and dismounting operations, using one operator, four machines and the approximate times available. This chart is attached (See Chart 3B). W1 refers to the first ultra-sonic washer, P3 to the third polishing machine.

The second scheduling method involves the application of an Operational Research technique called mathematical programming. This method allocates operators' time in the most efficient way to the competing needs of the different operations, each of which has a weekly requirement of time, (dependent on the rate of production per week), that must be satisfied in every case. Appendix A shows how the mathematical model may be manipulated to produce figures showing to what production rates the fullest utilization of labour leads for different numbers of operators. The figures in the Appendix are exemplary only; they have no basis in fact since the actual figures depend on the times for all the operations, which, as mentioned before, are not available. The fairly complex computations involved mean that it would not be worthwhile applying it to the case where only two operators could meet the required production rate, when the first method should be used.

C. Materials Handling

The analysis divided materials handling problems into four areas from which certain points emerge.

1. Mounting of Discs on Blocks:

This operation has a great deal of transportation in it once the materials have been assembled. The operations of moving and fixing the discs were relatively slow and cumbersome and require improvement. The operation of waxing the block is time consuming.

2. Lapping and Polishing of Discs

All materials are stored on the left hand side of machines. The lapping and polishing took a great deal of the process time. The machines required a great deal of discontinuous operator attention during the early stages of lapping and polishing to ensure that the blocks continued to rotate.

3. Cleaning Discs and Inspecting Discs

These operations are both one handed jobs. The operator has difficulty in handling discs and in avoiding surface damage to the discs. The paper placed between the discs was difficult to handle.

A more detailed time lapse film is required to make a complete analysis of materials handling but in its absence some points of operational improvement are recommended for further investigation:

- a) A larger hotplate to hold 12 or 15 blocks. This would save delay in waiting for the blocks to heat up and give continuity to operations like the waxing and mounting of discs.
- b) Improved disc handling to simplify the grasping of the discs and to reduce or prevent surface damage by steel tweezers. This would require use of preferably, a vacuum gun, or secondly plastic tweezers or felt tipped tweezers.
- c) A large tray at the cleaning and inspection stage holding 6 or 18 discs would reduce the handling time of paper padding between layers.
- d) Storage spaces are required:-
 - i) Before the hot plate and before the polishing machine.
 - ii) After the hot plate.
 - iii) After the cooler and before the lapping machine.
 - iv) After the ultra-sonic cleaner and before the polishing machine.

D. Costs

Cost data provided by Texas Instruments was:

Value of disc entering department	106d
Value of disc leaving department	169d
Value added in lapping and polishing	63d

Of this value added:

Value of labour required for disc in department was	5.5d
Other costs were	57.5d

The production rate in the department was given as 2,000 discs a week and was not expected to rise. At this rate, labour and other costs in the department would be approximately £46 and £480 a week respectively.

The major portions of the cost element which could be reduced are:

- i Time
- ii Scrap

Both these elements are directly related to the lapping and polishing operation which takes the greater proportion of the time and produces the greatest proportion of scrap. It is evident that the investigations with Engis Ltd. into the lapping/polishing process are of prime importance from the point of view of reducing costs.



V Recommendations

The following points arose from the analysis of the process:-

A. Lapping and Polishing Operations

1. It is suggested that, in the first place, a joint investigation is made with Engis Ltd. into the use of diamond abrasives with a view to:

- a) reducing machining time,
- b) reducing scrap,
- c) reducing costs.

When any improvements have been achieved, the whole process should be analysed by Work Study Methods to ensure that the best possible use is made of the facilities.

B. Inspection

- 1. The air gauge suggested in IV.A.5 above is now installed.
- 2. A large tray to be used, holding groups of six (or multiples of six) discs at the cleaning and inspection operation.
- 3. The use of a vacuum gun to grasp and transport the discs.
(As an immediate step plastic or felt tipped tweezers could be used).

C. General

- 1. Provision of storage spaces between the various operations to improve flow and reduce operator travel.
- 2. A larger hot plate for 12/15 blocks. This should have a good temperature control.
- 3. Switches on the machines should be relocated at the front.
- 4. Handles should be fitted to the large weights used in the lapping operation.
- 5. All three blocks should be placed on a machine before the weights are placed on top, instead of the present block by block sequence.

Appendix A

A Mathematical Model of the process

Accepting the process technology, we aim to maximise the weekly production for, in turn, 1,2,3 and 4 operators. This is done using the 'Max-flow' transportation model, which is best described by reference to the table below:

Labour time requirements per week for each operation at a weekly production rate of 6x discs per week					
	<u>1st</u>	<u>2nd</u>	<u>3rd</u>	<u>etc</u>	<u>dummy</u>
Labour availabilities per week	.6x	4.5x	2x		hrs
1st Operator, 45 hrs	X	0	X		0
2nd Operator, 30 hrs	0	X	0		0
3rd Operator, 40 hrs	0	0	X		0
4th Operator, 35 hrs	X	X	0		0

0 indicates that the particular operator has the necessary skill to do the particular operation, but need not in the solution be compelled to do it.

X shows that she does not have the necessary skill.

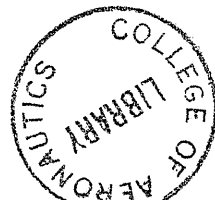
In the process of the model's solution we maximise the 'flow' of labour availabilities to the labour requirements, making sure that the requirements are always satisfied. This does not mean that all the labour availabilities will be used up. The dummy requirement represents that labour available that is not used up; this will be: $(45+30+40+35-.6x-4.5x-2x-etc.)$ hrs.

The next stage in the solution is to increase the previous (estimated) value of X until the requirements are no longer all met; the maximum production rate has now been found, for the number of operators considered. The same computation is done for other similar tables drawn up for 3 and then 2 operators.

The results of these computations can then be summarised as follows:

Numbers of Operators:	4	3	2	1	
Weekly Production:	1259	895	689	253	discs
(maximum possible)					

These figures are only hypotnetical, but give one an idea of how the results of these computations may be used by management. Costs may be



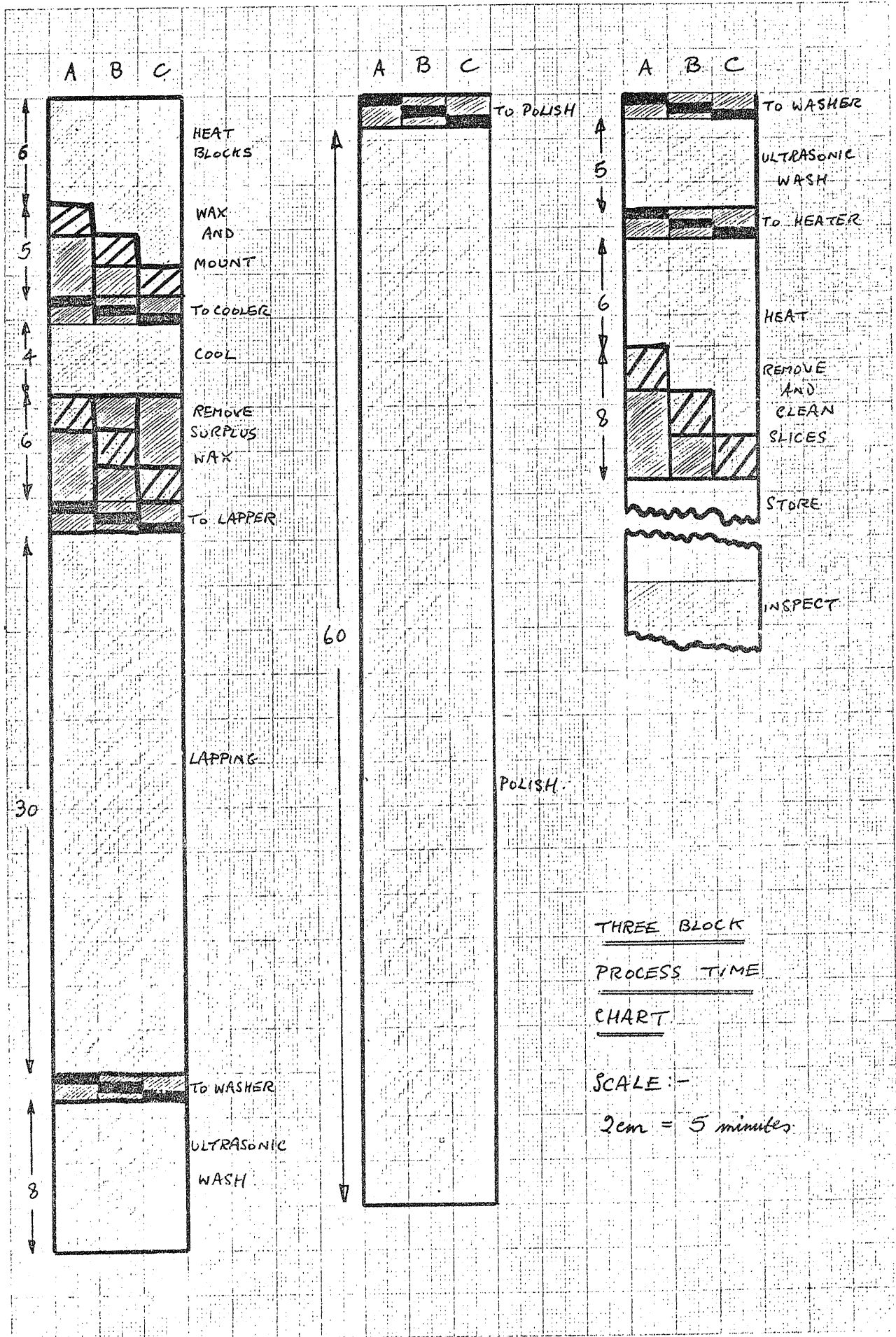
attached to the different number of operators needed for a particular production rate, and so the most suitable production rate may be chosen for the required number of discs.

The other useful results are the 'allocations' of labour available to labour required. Mathematically these show through what cells flow occurs and how much flows, i.e. these show many operations an operator does (and hence how many she does not do) and how many hours she spends on the operations she does do.

When we come to apply this model to the practical problem, we should realise that the model is only as good as the data that it is supplied with. This data is the labour availabilities for each operator, the range of each operators skill (for the cell entries), and the figures such as: .6, 4.5, 2, etc. which are the times that a disc must spend in each operation. Also as there is often an upper limit to the time that a machines can be used for each week (due to the restricted number of machines), we must be careful not to increase the labour requirement for each operation beyond this limit. Any improvements that can be made in the technology will result in a modification to parts of the data, and so the effects of the modification can be tested.

This model maximises the production rate by optimising which operator does which operations and for how long, and also by ignoring the time that a disc may spend in between different operations. It essentially produces a steady state solution, that is to say, it gives the best way of running the process when the process has already started; it does not say how the process should be initiated at the beginning of a shift. Also implied by 'steady state' is that if a machine is used up to its (upper) limit of capacity it must be fed with a continuous supply of work and not be kept waiting for work. There will therefore have to be a small store of partly-processed work waiting to go onto such fully utilised machines. The existence of these small stores between operations would allow the batch size (expressed either in terms of discs or blocks) for the included operations to be varied at convenience.

In order to use this model, the data must be carefully prepared especially when associating labour time with such operations as lapping, polishing, and washing where the labour is not needed for the whole operation but is required to start, and ensure no hold-ups occur in, the operation. Much time could be saved in the computation if the Pegasus could be used for this.



PROCESS CHART

JOB PROJECT P 41

	L. H.	R. H.		
○	4	6		
□	0	0		
◇	2	7		
D	0	0		
▽	2	0		
Dist.	Feet	Feet		

CHART BEGINS INSPECTION OF DISCS

CHART ENDS

CHARTED BY M.J.N. C.J.R.

DATE 19.1.65

SHEET NO 2

PRESENT METHOD LEFT HAND MAN TYPE	Dist	T	PROPOSED METHOD RIGHT HAND MATERIAL TYPE
Hold paper containing disc	666	○□◇D▽	660 Move to disc
		○□◇D▽	668 Grasp disc
Move to tester	669	○□◇D▽	669 Move disc to tester
Raise measuring head	694	○□◇D▽	
		○□◇D▽	696 Inset disc under head
Lower measuring head	698	○□◇D▽	
		○□◇D▽	700 Release disc
		○□◇D▽	707 Move to new position
Raise measuring head	711	○□◇D▽	
		○□◇D▽	742 Regrasp disc
		○□◇D▽	743 Move to storage dish
		○□◇D▽	750 Release disc into dish
Lower measuring head	751	○□◇D▽	751 Move to counter
Move to rest position	752	○□◇D▽	
		○□◇D▽	759 Records on counter
		○□◇D▽	760 Move to 2nd disc
Holds paper containing disc	772	○□◇D▽	
		○□◇D▽	777 Grasp 2nd disc
		○□◇D▽	
		○□◇D▽	
OPERATION REPEATED 3		○□◇D▽	
TIMES. IN ONE CASE		○□◇D▽	
DISC PLACED ON A SEPARATE		○□◇D▽	
SHEET OF PAPER & DOES NOT		○□◇D▽	
RECORD ON COUNTER.		○□◇D▽	
		○□◇D▽	
		○□◇D▽	
		○□◇D▽	

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PROCESS CHART

JOB PROJECT P 41

	L. H.	R. H.		
○	2	10		
□	0	1		
◇	5	13		
D	3	0		
▽	14	0		
Dist.	Feet	Feet		

CHART BEGINS INSPECTION FOR SCRATCH

CHART ENDS

CHARTED BY M.J.N. C.J.R.

DATE 19.1.65

SHEET NO 3

PRESENT METHOD LEFT HAND MAN TYPE	Dist	T	PROPOSED METHOD RIGHT HAND MATERIAL TYPE
Delay	966	○□◇D▽	966 Move to stick beaker
		○□◇D▽	981 Grasp 2 sticks
		○□◇D▽	982 Move to left hand
Move to right hand	985	○□◇D▽	
Receive stick from r.hand	997	○□◇D▽	997 Release 1 stick to l.hand
Move to 1st disc	998	○□◇D▽	998 Move to 1st disc
Hold 1st disc with stick	1016	○□◇D▽	1016 Rub 1st disc with stick
Move to right hand	1046	○□◇D▽	1046 Move to left hand
Grasp 2nd stick fr r.hand	1057	○□◇D▽	1057 Release 2nd stick to l.hand
Move to paper	1058	○□◇D▽	1058 Move to tweezers
Hold paper	1065	○□◇D▽	1065 Grasp tweezers
		○□◇D▽	1066 Move to 1st disc
		○□◇D▽	1080 Grasp 1st disc with tweezers
		○□◇D▽	1081 Move disc to inspect visually
		○□◇D▽	1106 Finish inspection
		○□◇D▽	1107 Move disc to storage dish
		○□◇D▽	1115 Release disc into tray
		○□◇D▽	1116 Move paper covers
		○□◇D▽	1137 Pick up paper with tweezers
		○□◇D▽	1138 Move to tray
		○□◇D▽	1174 Release paper onto disc
		○□◇D▽	1175 Move to counter
		○□◇D▽	1181 Record on counter
Move to right hand	1189	○□◇D▽	1189 Move to grasp 1st stick fr.l
		○□◇D▽	
		○□◇D▽	
		○□◇D▽	

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PROCESS CHART

JOB PROJECT P 41

○					
□					
→					
D					
▽					
Dist.	Feet		Feet		Feet

CHART BEGINS CLEANING OF DISCS
 CHART ENDS BEFORE INSPECTION
 CHARTED BY M.I.N. C.J.R.
 DATE 19.1.65
 SHEET No 1

PRESENT METHOD LEFT HAND MAN TYPE	Dist	T	PROPOSED METHOD RIGHT HAND MATERIAL TYPE	Dist	T
Delay	0		0 Move disc to edge of block		
Move to right hand	47		47 Move left hand		
Receive stick from R. hand	59		59 Release stick to left hand		
			60 Move to 1st disc		
			76 Grasp 1st disc		
			78 Move 1st disc to 1st beaker		
			100 Dip disc into liquid		
			122 Take disc from liquid		
			123 Move to 2nd beaker		
			138 Dips disc into 2nd beaker		
			157 Move to 3rd beaker		
			172 Dips disc into 3rd beaker		
			185 Move disc to paper		
			208 Release disc onto paper		
			209 Move to 2nd disc on block		
			250 Grasp 2nd disc		
OPERATION REPEATED FOR					
EACH OF THE 6 DISCS					
ON BLOCK					

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PROCESS CHART

JOB PROJECT P 41

	L.H.		R.H.		
○	8		10		
□	0		0		
→	13		14		
D	19		9		
▽	0		7		
Dist.	Feet		Feet		Feet

CHART BEGINS WAXING OF BLOCKS
 CHART ENDS COOLING OF BLOCKS
 CHARTED BY J.D.B. R.S.R.
 DATE 21.1.65
 SHEET No 1

PRESENT METHOD LEFT HAND XXXXXXX	Dist	T	PRESENT METHOD RIGHT HAND XXXXXXXXXXXX	Dist	T
Hand idle			Rag to block		
			Apply wax to block		
			Rag to bench		
			To tweezers		
			Pick up tweezers		
			To box of silicon discs		
			Pick up disc		
			Disc to block		
			Bed disc in wax		
			To box of discs		
			Pick up disc		
			Disc to Block		
			Bed disc in wax		
			To box of discs		
			Pick up discs		
			To block		
			Bed disc in wax		
			To bench		
			Hold tweezers		
To handle					
Pick up handle					
Handle to block					
Remove handle					
Handle to block					
Block to cooler					
Disengage handle					
Handle to bench					
To rubber pad					
			Tweezers to bench		

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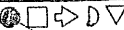
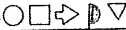
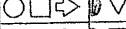
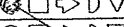
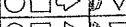
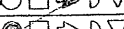
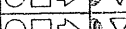
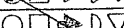
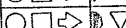
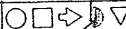
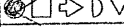
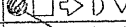
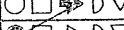
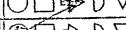
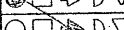
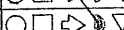
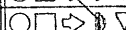
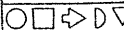
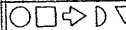
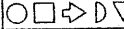
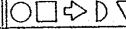
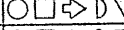
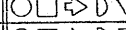
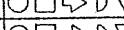
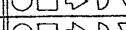
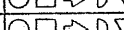
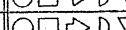
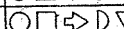
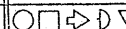
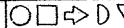
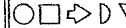
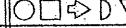
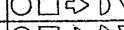
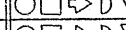
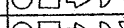
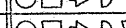
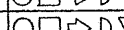
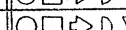
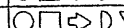
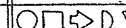


JOB PROJECT P 41

○				
□				
→				
D				
▽				
Dist.	Feet	Feet	Feet	

SHEET No 2

PRESÈNT

PRESENT METHOD LEFT HAND MAN TYPE					PROPOSED METHOD RIGHT HAND MATERIAL TYPE	
	Dist	T			Dist	T
Pick up pad						
Pad to block						
Pad on to block						
To weight						
Pick up weight						
Weight to block						
Weight on to pad						
To large weight						To large weight
Pick up weight						Pick up weight
To block						To block
Weight on to block						Weight on to block
To bench						To bench
Hand on bench						Hand on bench
						
						
						
						
						
						
						
						
						
						
						

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JOB Silicon Discs P41

	L.H	R.H		
○	21	16		
□	0	0		
⇒	21	16		
▷	0	7		
▽	0	0		
Dist.		Feet	Feet	Feet

SHEET NO. 1

PRESENT METHOD			PROPOSED METHOD		
LEFT HAND			RIGHT HAND		
MAN TYPE	Dist	T	MATERIAL TYPE	Dist	T
		0			
To Tap		10			
DRUM AND ADJUST		64			
To MORGAN SWITCH					
SWITCH ON		76			
To TAP		72			
ADJUST		102		102	
To BLOCK.					To BLOCK
PICK UP					PICK UP
To M/C.		175		175	To M/C.
LOCATE BLOCK		177		177	LOCATE
To WT. 1.		182			
PICK UP		187		195	
To M/C		206		200	To M/C
LOCATE WT				220	STOP M/C
		223			
To BLOCK 2					
PICK UP					
To M/C		280			
LOCATE BLOCK.		295			
To WT 2		303			
PICK UP		305		311	
To M/C.				318	To M/C.
				319	STOP M/C
		329			
LOCATE WT		333			
To DRIVE WHEEL		338		338	

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JOB Silicon Discs P.41

○			
□			
➡			
▷			
▽			
Dist.	Feet	Feet	Feet

CHART BEGINS POLISHING OF DISCS

CHART ENDS POLISHING OF DISCS

CHARTED BY

DATE 21-1-65

SHEET N^o 2

PRESENT METHOD LEFT HAND MAN TYPE						PROPOSED METHOD RIGHT HAND MATERIAL TYPE		
	Dist	T				Dist	T	
ADJUST WHEEL			⊗ □ ⇨ D V	○ □ ⇨ D V	363			To WT 2
	348		⊗ □ ⇨ D V	⊗ □ ⇨ D V				GRIP WT
Ho WT 1			○ □ ⇨ D V	⊗ □ ⇨ D V	355			WT
			○ □ ⇨ D V	○ □ ⇨ D V	360			To WHEEL 1
			○ □ ⇨ D V	⊗ □ ⇨ D V	371			ADJUST WHEEL 1
	373		○ □ ⇨ D V	⊗ □ ⇨ D V				
GRIPS VT-TURNS PINTI CHECK	378		⊗ □ ⇨ D V	⊗ □ ⇨ D V				
To TAP	384		○ □ ⇨ D V	⊗ □ ⇨ D V	393			
ADJUST FLOW			⊗ □ ⇨ D V	○ □ ⇨ D V	404			To WT 2
			⊗ □ ⇨ D V	⊗ □ ⇨ D V	414			GRIPS-SPINS VT
			⊗ □ ⇨ D V	○ □ ⇨ D V	418			To WT 2
			⊗ □ ⇨ D V	⊗ □ ⇨ D V	421			GRIPS-SPINS SECOND WHEEL
			⊗ □ ⇨ D V	○ □ ⇨ D V	430			To WT 1
	437		⊗ □ ⇨ D V	⊗ □ ⇨ D V	436			GRIPS - TO SPIN
	442		⊗ □ ⇨ D V	○ □ ⇨ D V	462			REST
To BACK 3			○ □ ⇨ D V	○ □ ⇨ D V				To BACK 3
PICK UP			⊗ □ ⇨ D V	⊗ □ ⇨ D V				PICK UP
To M/C	518		○ □ ⇨ D V	○ □ ⇨ D V	578			To M/C
LOCATE	527		⊗ □ ⇨ D V	⊗ □ ⇨ D V	527			LOCATE
To WT 3	531		○ □ ⇨ D V	○ □ ⇨ D V	534			To WT 2.
GRIP BACK	536		⊗ □ ⇨ D V	⊗ □ ⇨ D V				SPIN.
To M/C.			○ □ ⇨ D V	⊗ □ ⇨ D V	539			
	557		○ □ ⇨ D V	○ □ ⇨ D V	557			To WT. 1
LOCATE	559		⊗ □ ⇨ D V	⊗ □ ⇨ D V	559			SPIN.
To WHEEL 3	563		○ □ ⇨ D V	⊗ □ ⇨ D V	562			
ADJUST	571		⊗ □ ⇨ D V	○ □ ⇨ D V				To WHEEL 1
To WHEEL 2			○ □ ⇨ D V	○ □ ⇨ D V	573			

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JOB PROJECT 241

○				
□				
➡				
D				
▽				
Dist.		Feet	Feet	Feet

CHART BEGINS POLISHING OF DISC

CHART ENDS POLISHING OF DISCS

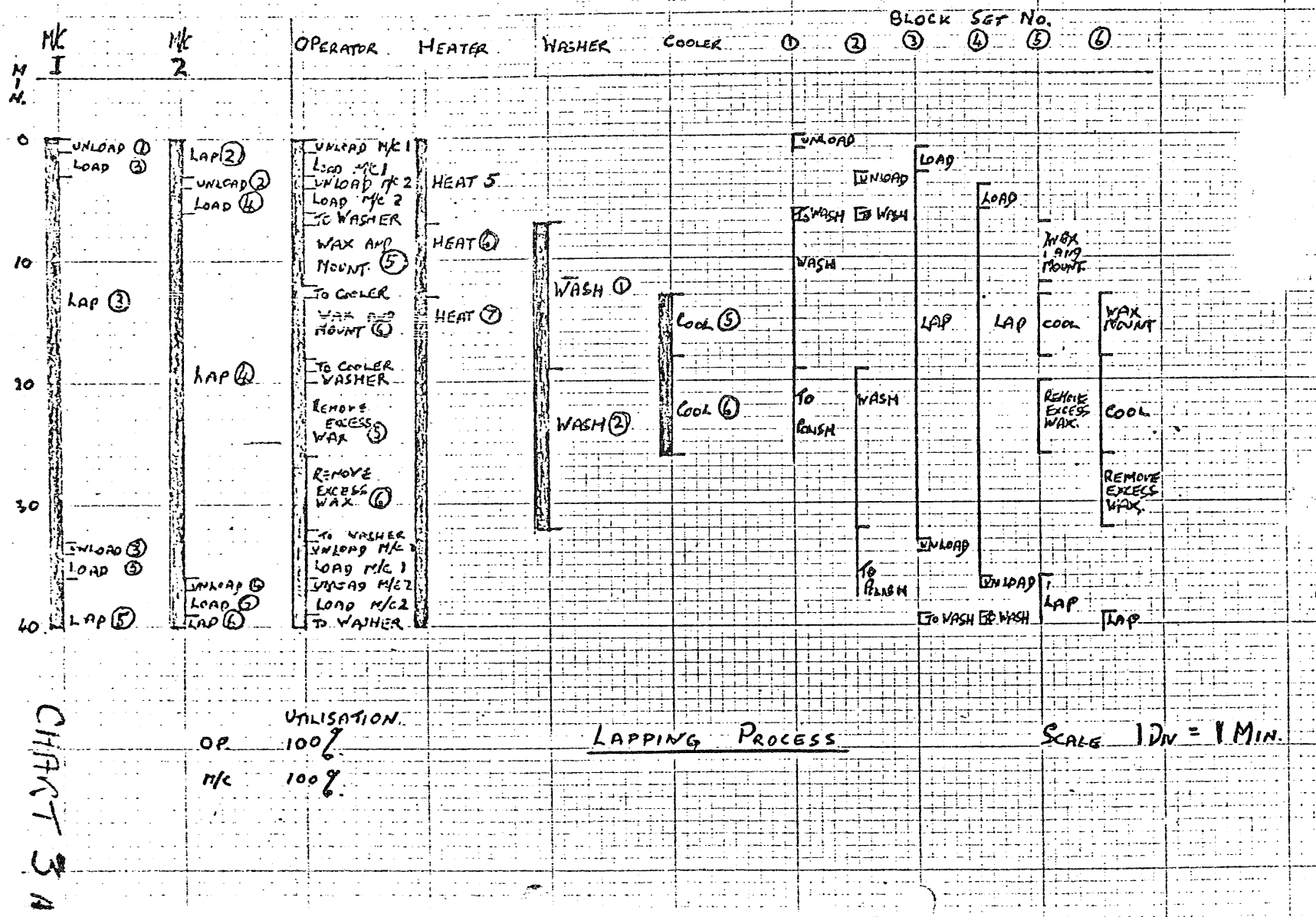
CHARTED BY

DATE 21 - 1 - 65

SHEET NO 3

[illegible]

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output : 12 blocks = 72 pieces every 90 minutes (= 1900 per week).

CHART 3B

utilisation:

16%

67%

29%

87%

