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THE COLLEGE OF AERONAUTICS

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ADMINISTRATION

MACHINE TOOL LABORATORY

A report on the survey carried out at

W.H. Allens, Queens Works, Bedford

- by -

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Introduction

The original terms of reference under which the project was undertaken are included in this report and the requirements requested are satisfied.

On initial contact at Allens, I was introduced to Mr. Colson, who informed me that his company of Consulting Engineers had introduced a scheme of methods engineering work study and incentives payment and that the results on the grinding section were not fully satisfactory. The machine loading was based on synthetics which were working in other factories. There was methods and planning charts from which the Methods Engineering and Planning Sections worked when loading work onto the shops and it was required that the shortcomings of these charts should be corrected. I was then introduced to Mr. Sargent, Chief Methods Engineer. He assigned one of his staff to me. It was suggested that we went down to the shop floor and consider the Lumsden grinding machine, as this machine stalled when the feeds and speeds suggested from the methods sheets were applied, but the main problem which it was essential to tackle as soon as possible was the grinding of gudgeon pins. Details of the work carried out on each machine are included in separate sections.

The original terms of reference

(a) To make a complete survey of all machine grinding in the No. 1, 2 and No. 3 shops of Queens Works. Resulting from this, to draw up a report commenting on:-

i. Suitability of the machines for the operation concerned.
ii. Suitability of the techniques being used.
iii. Suitability of the grinding wheels used.

I would add to this the efficiency of the coolants being used.

(b) To make recommendations as to how the grinding processes may be improved. To increase quality and productivity.

Report on the Survey

I have been engaged on this project at Queens Works, for the greater part of 11 weeks and I have stated forcibly on more than one occasion to Mr. Sargent and Mr. Colson that I was not making the contribution I would wish and expressed my desire to make at least one step forward each day which could be consolidated. At this stage of the project I felt that more valid work could have been done, but looking back and considering what I would have written in this section after 2 weeks and comparing that which follows I feel that I can make the more knowledgeable contribution as follows:

I. The suitability of the machines for the operation concerned.

The machines are in general suitable and adequate for the operations There are very few occasions when any job causes difficulty due to the size or type of machine or the equipment available. Centreless grinding is an exception and is commented upon later. Many of the machines are 25 years old and some are older. They lack the developments which have been introduced during this time, but when one examines critically the contribution which these developments could make it is found that mainly they are:

1. easier manipulation.
2. Clearer indication of the relative positions of the various function of the machine and semi-automatic cycling.

The great variety of jobs presented to Allens grinders suffer little from the lack of the above machine features. The machines are worn and there is an urgent need for the tables and slides to receive attention. Quotations have been obtained for the regrinding of the work tables on the 2 Churchill cylinder grinders. This amount to £25 and £40, rebedding and other items could result in a cost of £100. These machines would then be adequate for their purpose.

The selection and purchase of any new machine in this section should be considered as part of the general provision for the grinding processes if duplication and unbalanced capacity is to be avoided. An expensive and highly productive centreless grinder would need special consideration in respect to the effect on existing facilities.

II. The suitability of the techniques being used

The techniques used are those which have been found successful over a long period of time. Some are not as I would recommend,for instance, using diamond dressing tools dry or disc wheels instead of formed cup wheels for facing operations on the internal grinders. These are points which could be corrected quite readily, but one must realise that these machine operators have worked on the same machines for almost the whole of their working lives. In fact, Messrs. Darnell, Smith, Garnett, Lovell and two other fellows out of the 8 in the section have between them over 150 years service, actually in this section. I feel sure that it is because the Consulting firms staff did not take the above into account that most of the antagonism exist in the section, though there is very great reluctance often amounting outright to resistance to any change. A feeling of distrust of the methods and planning is thoroughly established in this section.

Note: Had I written this section before I had experience these past 11 weeks on the shop floor I may have made a similar mistake.

After writing as I have above I will now state that it will result in increased efficiency, reduce floor to floor times and improved accuracy when

the methods which have been developed at Cranfield, introduced and applied in a wide range of industries during the past 10 years are used by Allens grinding machine operators.

It is common in many firms for the grinding wheel to be thrust into the work in excess of its maximum capacity. This causes the wheel to break down and the machine to deflect. These deviations from optimum result in a less efficient process than is achieved when using a wheel loading just less than maximum and at high feed rates.

The data for achieving this optimum performance is speedily obtained by using the method described in the College Report on 'The evaluation of the grinding process'. Most of the commonly used materials have been evaluated and the most efficient grinding wheel and coolant specifications determined.

The suitability of the grinding wheels and coolants used.

During the past 10 years many detailed investigations into the most efficient grinding wheels and coolants have been carried out at Cranfield, and except when very special materials are to be ground the vitrified alumina oxide type of wheel has proved most efficient. It is the selection of the grit size and hardness of bond which can vary the performance to the extent of 25% to 50%. Examples are when forming grinding or holding corners. The alternative to the Alumina oxide wheel would be silicon carbide for grinding very hard materials such as tungsten carbide and a mixture of alumina oxide and silicon carbide for use on titanium. When the efficiency of coolants was investigated it was found that an increase of some 10 times wheel face life in terms of volume of metal removed per wheel redress could be achieved from the cheaper type of water soluble coolant to the fairly expensive straight oil coolants, and between the least efficient to the best water solute coolant there is an improvement of some 5 times wheel face life. A series of tests which included 321 tests on grinding wheel coolant combinations has been carried out during the past 15 months and the combination found most efficient recommended for use in Allens works. Unfortunately there has been some very strong resistance to this from one man - but none from other operators using the same product.

A sample of the coolant has been sent for analysis to some specialist firm by Mr. Sargent. This is perhaps a reasonable step to take for if the result of the analysis is to approve the product there is no reason why this coolant should not be used in all machines using water soluble oil. The product METOL 77, is 20% more efficient than the next best and 5 times more efficient than that now in use.

III. Make recommendations as to how the grinding processes may be improved to increase quality and productivity.

The application of the methods developed at Cranfield will increase productivity and improve accuracy. But some improvement in the machine tools in the form of regrinding the work tables and possibly bedding these to the

machine beds, and general tightening of bearings, or renewal of friction-less types will make a worthwhile contribution. Finally I would like to draw attention to two major shortcomings:

1. There is no adequate provision on any machine for the efficient filtering of the coolant. This is a serious draw back to the productivity and quality of work and also to the life of the machine tables and slides.

2. There is a total absence of modern equipment for measuring work at the machine. This reduces productivity and quality considerably. An example of this is that Mr. Darnell processed 40 gudgeon pins on his cylinder grinding machine, using a micrometer and a snap GO NO GO gauge. After checking these later it was found that approximately 50% were over top limit and the remainder were just inside top.

A further 40 were processed by Mr. Patterson on another machine. He used a micrometer which had been checked by inspection before he started the batch. By the micrometer all his pins were in tolerance; by the comparator many were .0001 under bottom limit. When enquiries were made as to how Mr. Patterson had checked the gudgeon pins in the past it was found he had used his micrometer, but also, and after removing the work from the machine he checked using a surface plate and comparator, but the comparator had been knocked to the floor by the crane hook some months ago and was still not repaired. A pneumatic snap gauge and dial indicator was borrowed from Cranfield and a batch of 120 pins processed all inside tolerance.

Details of progress made on each machine:

The Lumsden Surface Grinder

There are two similar machines; one processing turbine blade blanks. This was not studied. The second was used for general work.

A study was carried out on this machine previous to my work. The segments in use at that time was found to be near optimum and were not changed. The coolant was one of the less efficient water soluble synthetic types and was replaced by Metol 77. The attached graph shows the reduction in processing time. The surface finish of the work was greatly improved and segment wear was reduced by 50%. SEE GRAPHS G1 TO G9

The existing filter system for the coolant was inadequate to handle. The 25 cubic inches of metal removed per hour against the previous 10 cubic inches and a new filter was purchased, but there has been some resistance to accepting this coolant and the splash guards have been made more efficient. Until this was done the less efficient coolant was returned to the machine and though the guards have now been completed the better coolant is not yet in use. (Maybe the reason for this is that it is waiting for the results of the analysis to become available).

The Centreless Grinder

A short report outlining briefly the alternatives which may be considered for providing centreless grinding capacity. No decision has been taken to date. See GRAPH G 10

This is one of the items which must receive very careful consideration before the purchase of a new machine is decided upon. A new centreless grinding machine together with the very wide range of attachments is a very productive machine, and it is doubtful on a brief consideration if there is sufficient work to utilise such a machine. A machine large enough to process the complete range of gudgeon pins, together with attachments to cover all other work which such a large machine could handle would cost approximately £7,000 and would relieve the cylinder grinders of a large percentage of the work they now carry out.
A double disc grinder presents a similar case, but there is no doubt that if full utilisation of such machines could be assured over a number of years the economies of the scheme would be very substantial. The above report is attached.

The centreless grinding machine

This machine is in need of a rebuild or replacement and processing of the large gudgeon pins to the ± .0003 inches with 6 to 8 micro inch CLA surface is not an economical proposition.

A report has been made to Allens Chief Production Engineer. This covers the alternative actions which are available for centreless grinding capacity, these are:

1. To strip the machine down, clean up the slides, tighten up and replace the minimum of parts.

This will result in the machine being capable of general purpose open limit work to ± .0005 up to 2 ins. diameter and 10 micro inch CLA surface finish.

2. Have the machine rebuilt by a specialist firm.

The original supplier of the machine will not undertake this due to the obsolescence of the machine. He will provide working drawings of the parts needing replacement. This scheme would result in a machine equal to new, but its obsolescence and non-availability of equipment would remain. And the cost would be approximately £1,500.

3. The supplier of the machine has 2 sets of parts for similar centreless grinding machines which we made obsolete when the latest machine was introduced at the 1964 machine tool exhibition. One of these machines could be made available in 5 to 6 weeks at a cost of approximately £3,000. This would appear to be a good investment.

4. The purchase of a new modern machine chosen to meet the present and foreseeable production requirements. Approximate cost £5,000 to £6,000 + attachments.

NOTE:- Before the No. 3 or 4 schemes are decided a detailed analysis of the work load which would be available must be made. This is suggested due to the effect that a new machine would have on the loading of other machines in the section and it could well be found that two of the cylinder grinding machines may become redundant. But adequate accessories would be needed for the centreless grinder, and these are fairly expensive, but production rates would be very much higher.

The cylinder grinder operated by Mr. Darnell.

This machine is in reasonable condition except for the work table which is badly worn on the top surface. (This has no doubt been caused by sliding the tail stock over dirty coolant).

Work was commenced on this machine and a more efficient grinding wheel and coolant selected. It was suggested that if it could get co-operation from Mr. Darnell, then the greatest hurdle would be taken. But after 5 weeks, any achievements were very limited. He played every card in the book, and repeatedly appealed to management and Trades Union to get his own way. I did eventually get the gudgeon pins processed as I wished, and reduced the time for grinding from 30 minutes each down to 17.7 minutes, and this included 2 minutes which was not necessary.* A planning sheet is completed and the new time established, but Mr. Darnell insisted he did not like the taste of the coolant and it was removed. Other operators are using this coolant and Darnell has again been instructed to use it. He now wears a mask over his face (when any one is in the section).

In the light of the above experience, it was decided to ignor any further efforts with Darnell until some firm management action had been decided upon. A graph of the error in the work table is attached together with a copy of the planning sheets.* SEE FIGS 2 AND 3 METHODS SHEETS BEFORE AND AFTER STUDY

The Crankshaft Grinding Machine

The grinding wheel used on this machine is satisfactory and the Metol 77 coolant was used in place of the cheaper less efficient which was in use. This change resulted in a very appreciable improvement in surface finish and Mr. Cornell informed me that he was saving between 15 and 40 hours lapping time on each shaft. The diamond dressing tool holder was presenting the diamond normal to the surface of the grinding wheel and thus producing a flat on the diamond which after a few days became very inefficient for producing a keen cutting wheel. The large diamond used for dressing these large wheels cost approximately £70 each and used in this way their life is very short. A new holder was made of an improved design. This incorporated

means of rotating the diamond and presenting it at 20 degrees to the wheel face, so that when a flat is worn on the stone it may be rotated and a new position used. The holder also incorporates a fine feed to eliminate the difficulty met when a large wheel head is needed to move very small amounts, i.e. .0002 ins. This new holder also improved the quality of work, and Mr. Cornell promised to make a report on the savings. A make shift filter system has been made, but it is necessary to provide an efficient unit, and also dynamic wheel balancing equipment. I suggested this to Mr. Colson, its cost would be less than £300, the wheels could then be dynamically balanced on the machine and maximum efficiency achieved and maintained. Note: There is NO complaints from the machine operator about the coolant.

Turbine Blade Grinding

The inside form of the turbine blades are ground on ORCUTT machines using white alumina oxide wheels and a high grade straight oil coolant. The grinding wheel is the correct specification, but the oil coolant is expensive and unpleasant to use. It was thought that the METOL 77 coolant may be capable of doing the job. But on trial it was a little less efficient and it was decided to try sulphur filled wheels together with the METOL 77, The cost of the Metol 77 is 1/- per gallon, compared with 10/8d a gallon for the straight oil.

It takes 2 days to treat the wheels with sulphur and during this time the straight oil was returned into the machine and when the wheel was ready it was used together with the oil. This combination resulted in the processing of 200 forms between re-crushing compared to an unsulpherised wheels 50 forms.

Mr Gilbert, the supervisor, decided that he would prefer to use the oil sulphor combination and a second wheel was treated. A closer controlled test was carried out which resulted in 67 chuck loads being formed compared to 8 loads previously. The scrap level was reduced and quality on form and finish is considerably improved.

The Cam Grinding Machine

This machine is an old cylinder grinding machine which has been fitted with a camming work table. It would be reasonably efficient if the operator would take care to try to maintain constant conditions. At present he slaps on 5 or 6 thou cut and stands aside until it sparks out, then complains of the wheel wear. The machine has now been made self feeding by fitting a fixed cam to the work head spindle. This operates a micro switch which energises a selonoid attached to the wheel head infeed pawl.

The operator will now load a part bring the wheel into light contact with the work. The automatic feed will be started and continue until a witness remains on the work; he then measures the work, determines the metal still to be removed, sets the infeed stop, continues the process until the stop is reached. Checks for finished size, and the cycle is complete.

A serious cause of wheel wear is the absence of an efficient filter.

The grinding wheels have been sulphorised. This is expected to increase the life by 3 to 5 times and also improve quality of work.

Conclusions

The four weeks during which Mr. John Newman assisted me enabled our combined effort to achieve some solid progress and I feel that Mr. Newman would benefit from attending the College Machine Tools Laboratory to receive full instructions on the new grinding techniques. This would take a period of two weeks, and it would be preferred to take one week immediately and after a few weeks back in the works to return for the second week. It is difficult to appreciate the reason for putting Mr. Higgs with me when he had previously been disciplined for not making a satisfactory effort, and when he was taken away he was warned that he would be asked to find alternative employment if the improvement is not apparent in one month. Mr. Higgs made no contribution and I doubt if he has gained any benefit from my effort.

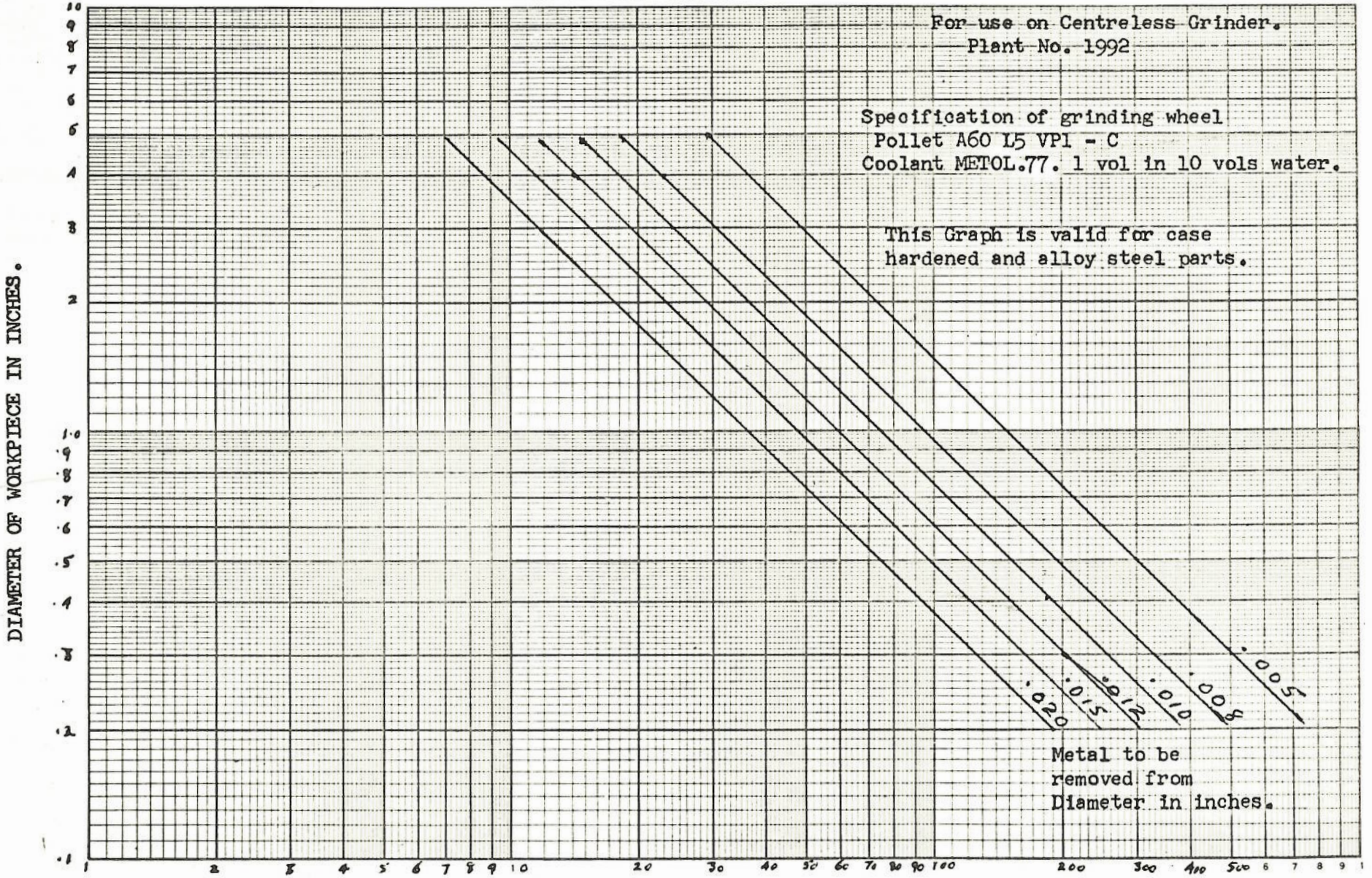
The spade work which has been carried out will prove that my visit has been satisfactory. If the work is continued and if I can make any further contribution I shall be pleased to help.

I would like to express my thanks to Professor J. Loxham and W.H. Allens for the opportunity to gain this experience.

G 10.

FOR USE WHEN PLUNGE GRINDING ONLY

Graph showing number of parts which can be ground per redress of the grinding wheel verses Diameter of Workpiece and thickness of metal to be removed from Diameter.



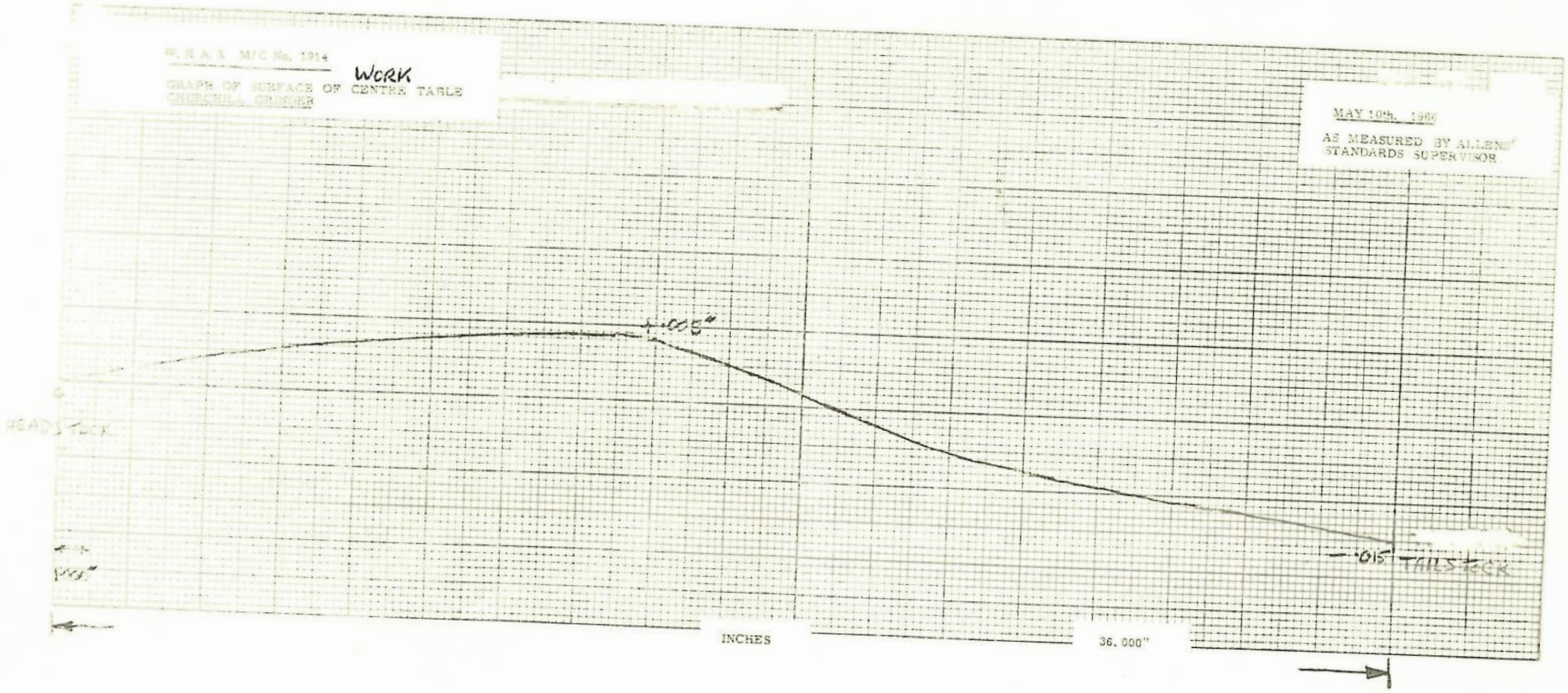


FIG 1
GRAPH OF WEAR ON CYLINDER
GRINDER WORK TABLE.