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REBUILDING, MAINTENANCE AND REPAIR OF MACHINE TOOLS[1/]

by

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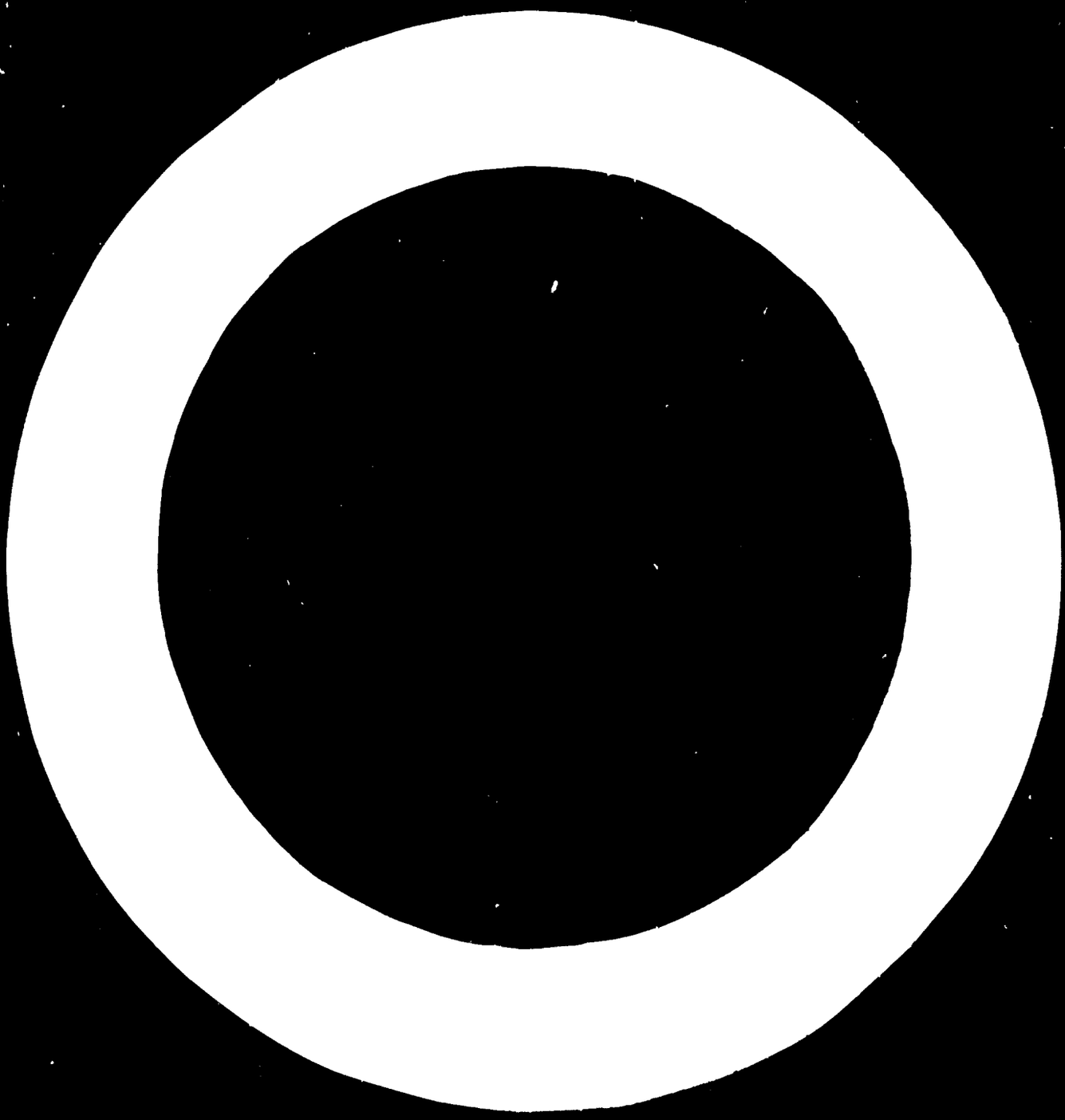

Foreword

The purpose of maintenance is essentially to increase the lifetime of machines by keeping them permanently in good operating condition in order to avoid breakdowns which hold up or stop production. The need for sound preventive maintenance is all the more essential the greater the degree of mechanization of the enterprise concerned .

Hit-or-miss troubleshooting and the anarchic situations which may result from it cannot be tolerated in rationally organized enterprises, whatever the sector concerned. Last-minute emergency repairs lead too often to hasty action and to the use of temporary solutions. They only make it necessary to intervene again to carry out the final repairs which cannot be avoided in the long run. Furthermore, emergency spares have to be stock-piled at each work post in order to prevent a breakdown of the assembly line, in the case of mass-production.

A preventive maintenance policy must now replace the emergency repair systems with which too many enterprises are still satisfied. Moreover, as examples of such a policy, one may quote the following in the case of France:

- in the field of civil aviation: the airlines (Air France)
- in the field of power generating stations: E.D.F. (Electricité de France)
- in the field of machine tools properly speaking: the S.N.C.F. (Société Nationale des Chemins de Fer Francais).

The D.T.A.T. (Direction Technique des Armements Terrestres), which possesses a larger stock of machine tools than the S.N.C.F., has had a plan for preventive maintenance of machine tools in operation in one of its workshops, the Atelier de Construction in TARBES, for more than ten years.

RENAULT has carried out a similar experiment with LANDIS crankshaft grinding machines (these machines working at three shifts are systematically checked every six months).

PLAN FOR PERIODIC LUBRICATION

Preventive maintenance calls in the first place for a rational machine lubrication programme. The problem is to use the correct lubricant for a given machine, and to apply it in suitable quantity and at the right time to all necessary lubrication points. Lubrication should not be left to the initiative of the operating personnel, since very specific instructions are necessary, and, as soon as the size of the enterprise makes it possible, lubrication teams should be organized.

In setting up a periodic lubrication plan, the following must be born in mind:

1. List of the equipment to be maintained and of all its lubricating points;
2. List of lubricants recommended by the equipment manufacturers;
3. Simplification of supplies and preparation of the lubrication table.

The lubrication table should show for each machine:
the lubricants for each part, and for each lubricant: the machines and parts for which it is to be used.

It is often very difficult to make comparisons between oils marketed by various companies as they use different references even if it is the same or nearly the same kind of oil.

In France for example 32o oils are on the market apart from motor oils and oils for heat treatment. Considering this, one comes to the conclusion that a lubricant classification should be prepared. A rational classification would lead to a substantial simplification of supply. In other words, instead of 320 kinds of oil you may retain, from a technical viewpoint, only eight for your own use.

The D.T.A.T. workshop in TARBES was able to reduce the number of products used to eight (classified on the basis of viscosity alone) by considering only products in general use and the main products for special uses.

It should be mentioned that WG 6 of the Technical Committee "Machine Tools" of the International Organization for Standardization - ISO/ TC 39 / WG 6 - is now studying this important question of the lubrication of machine tools.

4. Standardization of lubricating systems
   - Standard lubricators for oil and for grease;
   - Lubricators painted in different colours according to the viscosity of the oil used (white for the least viscous, black for the most viscous).

5. Preparation of machine records: To be attached to the log-book of each machine, showing:
   parts to be lubricated,
   capacity of the lubricators,
   operations to be performed (lubrication cycle,
   frequency of draining of the gearboxes,
   lubricants to be used).

6. Organization of lubricant storage and supply

7. Organization of distribution and correct use of lubricants (inspection reports, consumption reports)

It is essential to provide a special storeroom as well as suitable equipment for the distribution and application of these lubricants.

Recording operating hours of machines

The wear and tear of equipment is not measured by days, weeks or months but rather by the total amount of running time. Thus, in the case of the motor car, it is the mileage accumulated which is taken into account in the lubrication table which appears in the vehicle maintenance booklet. The operating time with and without lead can be taken roughly as a criterion of the wear of a machine tool, but the load really borne, i.e., the energy absorbed in Kw/hours appears to be much more reliable as a criterion. This measurement can be made using time-meters connected to the motor power supply.

The general conclusion which follows from the above considerations is that, along with the wattmeter measuring the power used by machining operations, every machine tool should be equipped with a meter measuring time. This would make it possible not only to provide for rational lubrication but also to study the law governing the wear of a given machine versus operating time, and to schedule in advance the necessary overhaul. This information is completely lacking at the present time in the case, for example, of spindle bearings and slideways.

During operations oils are inspected by means of analysis (colour, acidity number) which is repeated every 2,000 hours of operation.

Staff requirements

The staff required is less numerous than might be assumed. By having the long-term lubrications (monthly lubrication for example) carried out by the maintenance department, and the short-term lubrications (daily and weekly) by the workers operating the machines, the TARBES Atolier de Construction which we have already mentioned provides maintenance for more than 600 machine tools with a staff of four.

MAINTENANCE PROPERLY SPEAKING

Maintenance properly speaking includes two separate operations:

1. Normal maintenance confined to the repairs required in case of unsatisfactory operation of the machines.
2. Overhaul or rebuilding involving large repairs required in case of loss of accuracy of the machine.

A. NORMAL PREVENTIVE MAINTENANCE

The idea is to establish a plan for the periodic adjustment or replacement of certain parts of the machine - a plan which must be based on a permanent checking of the normal functioning of the machines:

- check the consumption of the machine running idle at various operating speeds,
- check any changes in the mechanical efficiency curve,
- note any abnormal noise or vibration.

A prior analysis of the equipment to be protected should obviously be made and, on the basis of the maintenance reports, a statistical analysis of operating incidents and accidents likely to occur, should be prepared.

Are breakdowns chronic in nature or accidental? Is the wear and tear observed normal or not? Such an analysis may, moreover, suggest certain technical improvements in the equipment to be maintained. Facilities for prevention should then be set up, with planning of maintenance operations designed to keep costs to a minimum.

Under these conditions it is appropriate to draw up preventive maintenance instructions as well as machine records (description of machine condition and operating history and to provide for regular inspection of maintenance operations.

A special planning department with a purely administrative role, coming directly under management, should be set up (the work of the maintenance staff should remain strictly technical). This department sends blank orders to the maintenance department which, while responsible for emergency jobs, carries out the planned maintenance as appropriate. It constantly supervises the cost of maintenance operations (time assigned to maintenance properly speaking). The times assigned must always be adjusted in the light of the experience acquired.

Maintenance, by its very nature, does not lend itself to a completely rational type of organization, but that part of maintenance which cannot be foreseen and which is beyond control must be kept to a minimum by a thorough and continuing review of past experience.

For the processing of maintenance records, depending on the size of the firm, either ordinary cards or punch cards may be used, or in the case of large companies, electromechanical accounting machines may make it possible, for example, to file in a few minutes the various job vouchers according to type of part replaced. (This system pays off as soon as the maintenance staff reaches ten.)

Frequency of inspection of critical points

Here we should follow the pattern commonly set in the motor car industry, where the frequency for oil changes, spark-plug and tyre replacements is specifically laid down. At the beginning, guidance may be sought from the manufacturers of the equipment, and later on, further guidance will be provided by the results indicated in maintenance reports.

Staff numbers

In determining the staff necessary, due provision should be made for emergency jobs and repairs which cannot be avoided, (for example, accidents).

Store room for spares

The main objective should be to keep the stock of spares to a minimum, for it represents a non-productive use of capital, but as in determining staff numbers, due provision should be made for possible unforeseeable breakdowns and accidents. Moreover, the simplification of maintenance leads to the standardization of equipment and hence of spare parts.

B. PREVENTIVE MAINTENANCE

The preventive maintenance plan must be based on a close review of changes in the accuracy of machines over a period of time.

- check the amount of scrap,
- check any changes in the machining accuracy (for example, information on the inspection cards),
- check any changes in geometrical precision: spindle play, wear of slideways, using teams of workers specialized in the inspection of machine tools and equipped with the necessary measuring devices (straight-edges, test mandrels, cylinders between centres, dial gauges, levels, microscopes, etc.)

Criteria determining the need for overhaul

As a first approach, the following criteria may be adopted:

A finishing machine may usefully be sent for overhaul when the machining accuracy is equal only to permissible deviations 2 or 2.5 times larger than those specified in ISO recommendations. In the case of roughing machines, tolerances may be exceeded by 3 or 3.5 times. (see annex)

Of course, finishing machines which require overhaul because of lack of precision may, if it is deemed possible, be assigned without reconditioning to the roughing workshop.

Lastly, it should be pointed out that in practice the need for overhaul is observed only after a certain number of years of operation, 5 to 10 years, and sometimes much more. We have seen single spindle bar automatics which have been working for 20 years without having required overhaul, and which continue to provide acceptable accuracy. Machine tools have a long useful lifetime. In tool rooms the average life may be up to 20 years; in the production shop it may vary from 10 to 20 years but very often the machine is obsolete before being worn out.

Machine tool repair shops

There are very few machine tool manufacturers who have a department for rebuilding the machine tools which they have sold to their customers. Even if repair companies for machine tools do exist, their numbers are very small and their resources would be rapidly exhausted if many firms required their services at the same time. Thus, the users of machine tools usually have to repair and recondition their machines themselves. This is true for example, of automobile manufacturers.

Before a major overhaul it is appropriate to take account of the cost of its replacement by a new machine. Complete reconditioning is carried out only if its cost does not exceed n % of the present price of the new machine, n being a function of the age and the extent of wear of the machine. Thus, in the case of a machine less than 6 years old, n is taken as = 65, and if it is more than 18 years old, n = 45. (These co-efficients express the fact that there is little point in reconditioning machines which are very old and perhaps obsolete, unless the cost of repair is very low).

More generally one may say that the cost of a major overhaul for a medium sized machine tool is 50 to 60 per cent of the cost of a new machine. This percentage is 25 to 30 per cent in the case of heavy machinery.

As regards machine tool repairing, instruction manuals for maintenance and repair are usually suitable. It is not always the case with second-hand machine tools and we may add that finding spare parts for second-hand equipment is often a problem; very often spare parts have to be manufactured by the customer himself.

SPECIAL CASE OF MACHINES LAID UP

It may occur that machines are laid up for several months. In this connexion it should then not be forgotten that machines laid up may suffer from the effects of corrosion. They must therefore be protected accordingly.

The first action to take is careful cleaning to eliminate any machining wastes (swarf, chips, cutting fluids), as well as used lubricants. To be effective, such cleaning usually requires the dismantling of certain machine parts.

The second action consists of applying protective products (special oils) to the machined parts likely to oxydize (slideways). On this specific point, which would require too much explanation, we refer the reader to the journals published by specialised firms such as Houghton, for example.

However, after thorough cleaning of the machine, a second possible solution is running without load at regular intervals (a few hours every three months, for example).

If the machine is stored in premises where there is much dust, some simple protection against dust may be provided.

C O N C L U S I O N

In order to keep equipment in permanent working order with a minimum expenditure of time and resources it is necessary to institute a maintenance system (overhaul, preventive operations; check to ensure the equipment is in good condition, that it is properly operated and lubricated, that minor troubles are corrected.

It is a fact that a repair and maintenance system is a must even in the early phases of industrialization.

Our intention has not been to provide the participants in the VARNA seminar with ready-made recipes for the creation of machine tools repair shops or for the training of technicians and repairmen, but rather to draw their attention both to the usefulness and the difficulties of the many tasks involved in maintenance of machine tools.

It goes without saying that we are thinking more particularly of the traditional type of machine tool (lathes, milling machines, boring and drilling machines), for gear-cutting machines, special machines etc., pose problems sometimes much more difficult to solve. One must not forget that up to date knowledge of electrical circuits, hydraulics, electronics is necessary for the maintenance of modern machine tools. 1/

1/ Because of the fact that this equipment includes highly complex electronic control circuits, the maintenance of N/C machine tools raises new problems.

The fact must also be borne in mind that the reconditioning of a machine requires a preliminary dismantling of the main parts in order to be able to judge whether reconditioning is advisable or whether some parts have to be replaced, as well as to determine the time necessary to carry out the operations envisaged, without overlooking the time required for the operations of re-assembly, setting and inspection. This is enough to indicate that the estimate alone for the work to be carried out is quite expensive to prepare, and furthermore, calls for competent specialized staff. It is with all these difficulties in mind that we think it advisable to suggest to the developing countries that they consider the reconditioning for the time being, only of those machines which are of the conventional type and the most widely used in mechanical workshops.

In any event we are ready to provide any organization interested, with bibliographic references, through UNIDO if necessary, concerning this subject, which we have intentionally dealt with in general terms without going into detail.

ANNEX I

Insofar as the maintenance of machine tools is concerned, it is important, in order to reduce inspection costs, to make a choice among the verifications specified in ISO recommendations with respect to the testing of machine tools. (see Annex II)

The most important points to be inspected as regards accuracy are obviously the run-out and the periodical axial slip of spindles, as well as the straightness of the travel of work-piece or tool-holder carriages. On a lathe, for example, special attention must be paid to the straightness of movement of the tool in the horizontal plane (an increasing lack of straightness indicates wear in the slideways of the bed and of the carriage which causes lack of cylindricity in the work-piece).

As for excessive run-out, it is due to wear of the spindle bearings, and increased periodical axial slip results from a defective condition of the thrust bearings; in this case, the faces turned on the lathe by transverse movement of the tool are lacking in flatness.

Of course, in carrying out these inspections it is appropriate to use the methods specified in the ISO Test Code for Machine Tools (ISO Recommendation R 230), as well as the measuring devices mentioned therein:

- mandrels
- cylinders between centers
- straight edges
- squares
- dial gauges
- levels

After these instruments have been purchased or made, (some are not available on the market, namely, mandels and cylinders, and the user is compelled to make them himself), they must be carefully checked. Thus, dial gauges should be in accordance with recommendation ISO R 463, and not only their accuracy should be calibrated, but also the variation in the local measuring force at different points, which should not exceed 60 grams.

Finally, as a general rule, a good dial gauge accurate to 0.1 mm should always be preferred to an unreliable gauge to 0.001 mm. Furthermore it is essential to train qualified teams for testing: measuring devices must be handled with caution and knowledge, so that thorough, practical and theoretical training is a prerequisite to their use.

I believe it useful to mention that French standard NF E 60 - 100 of June 1965, which corresponds to the ISO Recommendations R 230 "Test Code for machine tools", has been supplemented by a small handbook of 17 pages on metrology. We would advise all technicians interested to obtain and consult this handbook. It is available through their national standardization associations: The title, Standard N F E 60-150 of July 1965 "General Information on Metrology for Workshops". This is a collection of very useful advice for anyone wishing to do metrology under satisfactory conditions in the machine tools field. It is a fact that many users of machine tools are not familiar with some elementary ideas of metrology and thus it was deemed extremely useful, in France, to provide them with this knowledge.

In our opinion it is important for the developing countries to possess maintenance services well organized with a trained staff and proper equipment. While the main task of these services is to prolong the life of the national machine park, they should also report on equipment where performance is below standard, so that the producer of this equipment may be excluded from the list of suppliers.

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ANNEX II

PRESENT STATUS OF STANDARDIZATION OF TEST CONDITIONS OF MACHINE TOOLS

For some years now international efforts have been under way with a view to replacing by ISO recommendations, test conditions which differed from one industrial country to another.

a) As of new, the two following documents have been published.

ISO R 230

ISO R 1701 (April 1970) Test conditions for milling machines with table of variable height with horizontal or vertical spindle - testing of the accuracy.

ISO R 1708 (April 1970) Test conditions for general purpose parallel lathes - testing of the accuracy.

b) Other recommendations have been drawn up which should soon be published in Geneva: Test conditions for

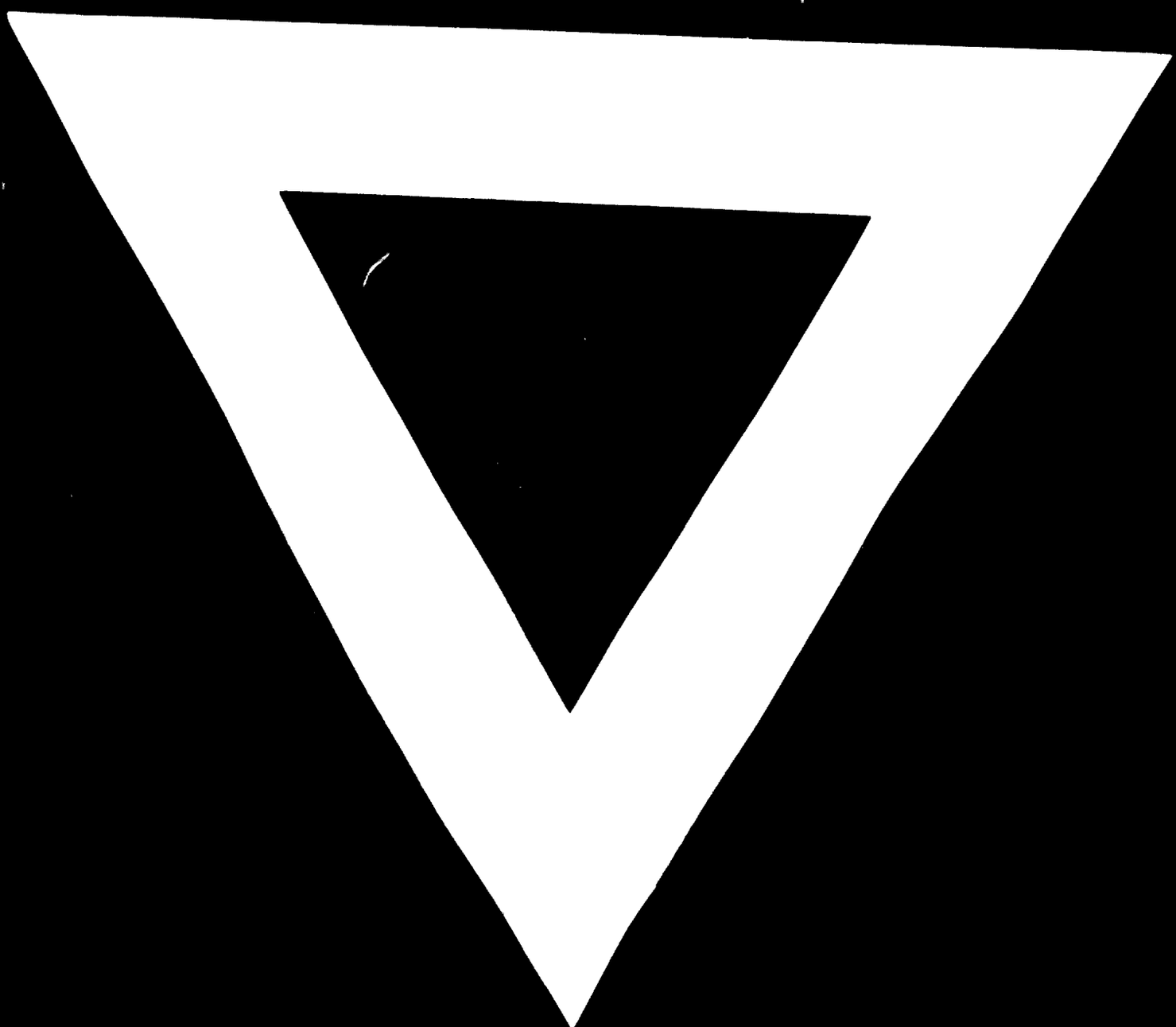
- milling machines with table of fixed height with horizontal or vertical spindle
- external cylindrical grinding machines
- internal cylindrical grinding machines
- surface grinding machines with vertical grinding wheel spindle and reciprocating table.

c) The following test conditions are now under study for:

- pillar type vertical drilling machines
- box type vertical drilling machines
- radial drilling machines with the arm adjustable in height.

d) Next, the test conditions for boring and milling machines with a fixed or movable column, will be studied.

The delegates who attended the Moscow symposium in September - October 1966 will note that their wishes have not remained a dead letter and that the international standardization of machine tool test conditions has made progress and is still moving ahead steadily.



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