ORNL/TM-6432

Laboratory Services Series—Machine Tool Rebuilding

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OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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PLANT AND EQUIPMENT DIVISION

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Maintenance and Rebuild Shop Supervisor

MAY 1976

OAK RIDGE NATIONAL LABORATORY
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ABSTRACT

The fabrication services function of a national research and development laboratory instituted a cost-effective program of upgrading obsolescent and used machine tools to original or better specifications. The program development, facilities, personnel, and techniques are described.

HISTORY

After the end of World War II, research program realignments began to change the Clinton Laboratories into the Oak Ridge National Laboratory. Included in this change period was the establishment of a Research Shops Department within the Engineering and Mechanical Division, which was to supply the experimental and prototype machining work necessary for the research and development programs of the Laboratory. (See Fabrication Department of Plant and Equipment Division now - Appendix A.) The machine tools in use at that time came from the War Assets Administration and defunct wartime industries. Condition of the equipment varied from obsolete and badly worn to practically new and in excellent condition. Some machines were first-rate industrial quality; others were home-shop grade. The following years of ORNL growth resulted in hard use of all equipment available in the machine shops. The older equipment was repaired enough to keep it running and several additional new machine tools were purchased by the early 1950's. Personnel levels continued to increase faster than the capital funding or the shop space for machines. By 1952, the older equipment began to show serious deficiencies in precision caused by the wear of constant use. Also by that time, several commercial rebuildings of machine tools had been purchased. The results

were found too costly, the schedules too long, and the work received was of unreliable quality. As stated, this experience was in 1952.

With the increasing amount of maintenance work necessary for the greater number of machine tools, the decision was made to apply some of the specialized craft skills and experience available in the craft work force by establishing a machine tool rebuilding program. Results proved very satisfactory from the start.

A machinist with the specific training and experience was assigned to rebuild a valuable horizontal milling machine right in its shop location. The machine was badly needed but was worn too much for accurate work. Funds for replacement were not available. The overhaul results were excellent. The second successful experience was in restoring the only jig borer in ORNL, the prime source for precision machining at that time. The machine was disassembled, the ways scraped, and the parts refitted and reassembled. Again, the jig borer could produce as precise work as when it left the factory new. Total costs were about twenty per cent of replacement costs.

This operation was continued with two men until about 1954 when machine shop expansion into another building brought available space, and a section for the major repair and rebuilding of machine tools was established in Building 2018. The supervisor was made responsible for lubrication, maintenance, and minor repair. Soon after, the volume of needed rebuilding work required six craftsmen in the activity, with some electrical and other speciality support from others. Refinishing and painting were included. The rebuilding requirements continued high through 1967 as personnel increased with ORNL growth, and the capital funding for replacement and additional machines remained very low. Many used machine tools were procured from government excess sources and were also overhauled before going into shop use.

The next year, research program changes initiated a five year period of gradually decreasing shop work requirements. The volume of machine rebuilding was reduced by disposing of the oldest and worst worn machines as shop personnel diminished. The activity was relocated adjacent to the largest machine shop building, and at times as few as three craftsmen and a lubrication man remained in the crew. Yet, by 1970, about 66 per

cent of the 417 machine tools of five types common in use had been rebuilt at least one time, and many more than once. See Appendix B for details.

OPERATION

The current level of machine tool rebuilding activity during 1975 saw the completion of nine major machine tools and fourteen minor pieces of equipment, in addition to several major repairs on other machines. See Appendix C. The craftsmen assigned to the rebuilding shop also perform the lubrication, adjustments, and inspections scheduled by the computerized preventive maintenance program. Minor repairs of machines in use are also covered by the group. This combination of activities allows very effective use of all available craft time.

There is a normal precision cycle that most shop equipment follows from manufacture through use to discard. Good maintenance practice extends the useful precision life of a machine, but rebuilding a machine recycles it to-as new precision capability and so through another entire useful life period. The economic gain in replacement, machine-cost avoidance can usually be cancelled only by a large obsolescence factor or product changes that decrease production needs for the type machine. The operational sequence of machine rebuilding is displayed in Appendix D.

PERSONNEL

In machine tool rebuilding, machinists are the majority craft assisted by millwrights, electricians, pipefitters, and painters. Each craftsman has broad experience and skill upon which to base added special skills that contribute to the restoration of machine precision and condition.

The number of craftsmen assigned to rebuilding machines is changed to match the planned work flow. At present, the crew includes five machinists, one millwright, one painter, and two electricians. The single supervisor for all machine tool maintenance allows excellent coordination of the rebuilding function with total maintenance requirements.

FACILITIES AND EQUIPMENT

Most rebuilding shop equipment is portable. Whole machine tools are set on heavy-duty steel pallets when received and are moved about as little as possible. Portable hoists and hydraulic lifts are much used for the machine parts and subassemblies. Hand tools, surface plates, master straight edges, and optical alignment tooling are included in the variety of small equipment. Most specialized shop support, other than painting and electrical work, is supplied from other shops. Electroplating, welding, metal spraying, way grinding, heat treating, and motor rewinding are examples.

The most serious deficiency is the lack of a monorail or bridge hoist for additional safety and economy. Installation of an adequate hoist system in the present wood frame building would be difficult and expensive.

The floor plan of the Rebuilding Shop is shown in Figure 1 with indication of general area uses.

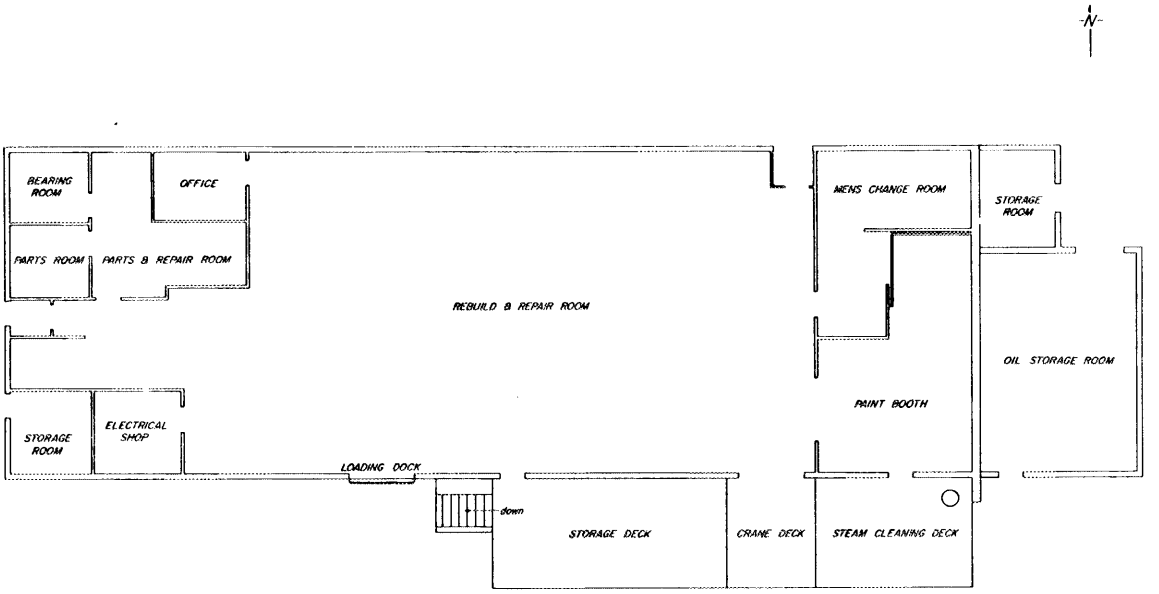

Fig. 1. Floor Plan of Machine Tool Repair Shop Building 2516

CASE HISTORIES

1. *Lathe, Monarch, Model EE, 10", Toolroom*

Serial Number 19960-R (rebuilt three times)

1947 Acquisition Cost - $9,185 (included every available accessory)

1975 Replacement Cost - $30,000

Records indicate that this lathe was used first in the Instrument Department Shop until 1951. It was then moved to the Central Mechanical Shops and used through 1963. Rebuilding at a cost of $1,458 restored it to original condition in January, 1964, after 16 years of use.

The lathe received more constant use following reinstallation and lost enough precision in just 5 1/2 years to require rebuilding for $1,051 in mid-1969.

Another 6 1/2 years of operation have again caused wear and precision loss, and the lathe was moved to the rebuilding shop in March, 1976. See Photograph 1, Appendix D.

The five to six year wear period is typical of ORNL experience with machine tool precision life cycles. It is interesting to note that the very worn condition after 16 years of use cost nearly 50 per cent more to correct than the second rebuilding after a more reasonable wear period. The difference in real cost is partly concealed by dollar inflation.

2. *Milling Machine, Bridgeport, Vertical Turret, Model 4067*

Serial Number M6746 (rebuilt three times)

1946 Acquisition Cost - $2,919

1976 Replacement Cost - $8,000

Records show that this mill was used in a small research machine shop for 15 years before being rebuilt in 1961 at a cost of $984.

Reinstallation was in a different shop. Use continued until six years later when wear required the second rebuilding. The 1967 cost was $860.

Another six years of precision use was realized before the third rebuilding in 1973. The cost was $1,075. Other than inflation, no cause

for the cost increase is noted in the file.

The three overhauls have cost as much as the machine did originally, yet only about 38 per cent of present replacement machine cost. The rebuilding costs also include improvements such as the sliding-ram mount for the work head, safety switch additions, and power feed on the table. It is no longer 1946 model Bridgeport and is not obsolete. Good maintenance and rebuilding have allowed 30 years of precision use with more to come.

3. *Milling Machine, Bridgeport, Vertical Turret, Model BRJ*

Serial Number J-38579 (rebuilt one time)

1960 Acquisition Cost - $2,498

1976 Replacement Cost - $8,000

This milling machine was used 15 years before its loss of precision and general condition required an overhaul starting in late 1975. It had been installed in three different shops during the period.

The rebuilding cost is recorded as $3,065, but includes the $1,500 price of a more powerful, new Model J2 workhead installed to increase productivity. The remaining $1,565 cost for restoring the machine to factory-new precision is probably realistic in 1975-76 dollars and at 19 per cent of replacement cost.

OPERATIONAL PROBLEMS

Machine Parts present some of the major problems. The dollar investment in inventory of spare parts, the selection of most frequently needed replacement parts, and the schedule delays caused by long delivery times for special purchases of parts not stocked— all are helped by experience. As machines continue to be used over a long period, some original parts are discontinued by the manufacturer's improvements and model changes. Machine updating by new-model subassemblies or parts is sometimes practical but can make rebuilding uneconomical. Some manufacturers go out of business. That circumstance soon renders further rebuilding impractical as parts become unavailable. One older brand of high quality milling machine was found too costly in rebuilding because of extremely high parts prices.

Repeated rebuilding of a machine tool can result in removal of the hardened surfaces of ways. The refinishing required depends on actual wear of the ways in each use period and varies widely. The most economic and satisfactory method of restoring a hard and wear-resistant accurate surface is being sought.

Scheduling can be well planned, but flexibility is often required. The delivery time for non-stocked parts purchased is uncertain. The effective use of manpower in doing other maintenance can affect schedules when several breakdowns pull the men away from rebuilding work more than anticipated. It is also possible to do a good basic rebuilding job, yet find a fault during final operational checks that is difficult to diagnose and delays completion during correction. One of the best helps to ease schedule problems is to have a spare machine where possible, or at least one machine of several similar units not fully scheduled to production. If only one or a few machines of a type are in use, scheduling any rebuilding in minimum workload periods, expediting parts procurement, and overtime to maintain production can all help provide the necessary rebuilding time.

Personnel selection and training are major starting problems and never cease to demand attention for a good rebuilding shop operation. The initial personal experience and skills must be hired or extensive training purchased for at least one craftsman. Each man needs proficiency and experience in his own craft, some knowledge of the work of other crafts involved, and a personal appreciation for precise machinery. Experience and study over several years will add most of the wealth of detailed knowledge required. Much updating information for these men is available from manufacturer's representatives and service engineers. These men with the ability to renew precision machine tools are seldom adequately appreciated outside maintenance organizations and must find satisfaction in expert accomplishment.

NEW TECHNIQUES

Leveling is one of the oldest requirements for machine precision in use. The master precision level is used in installation, preventive

maintenance, and machine rebuilding, but it is slow. The electronic level of equal precision pays for itself soon simply through the elimination of waiting for an accurate reading.

Optical tooling offers new degrees of precision in the assembly and adjustment of machine tool elements in parallel, perpendicular, or angular relation to each other. The optical square, microptic theodolite, and autocollimator allow alignment work superior to that used in manufacture of the older machine tools.

Refinishing of rebuilt equipment includes some difficulty with paint adherence on cast iron and cast steel that has absorbed oil over a period of years. Thorough surface cleaning is not an adequate solution. Special acidic enamels that resist loosening and softening by oil in the cast metal are on the market and are effective.

The Occupational Safety and Health Act now requires more attention to the safety provisions on older machine tools that may not meet present requirements. Emergency stop switches may not be in the positions specified. Control handle knobs may be the wrong color. The guards on cutter areas may be inadequate. The recognition of such deficiencies and corrective actions have become a necessary part of machine rebuilding.

APPENDIX A

ORGANIZATION CHART
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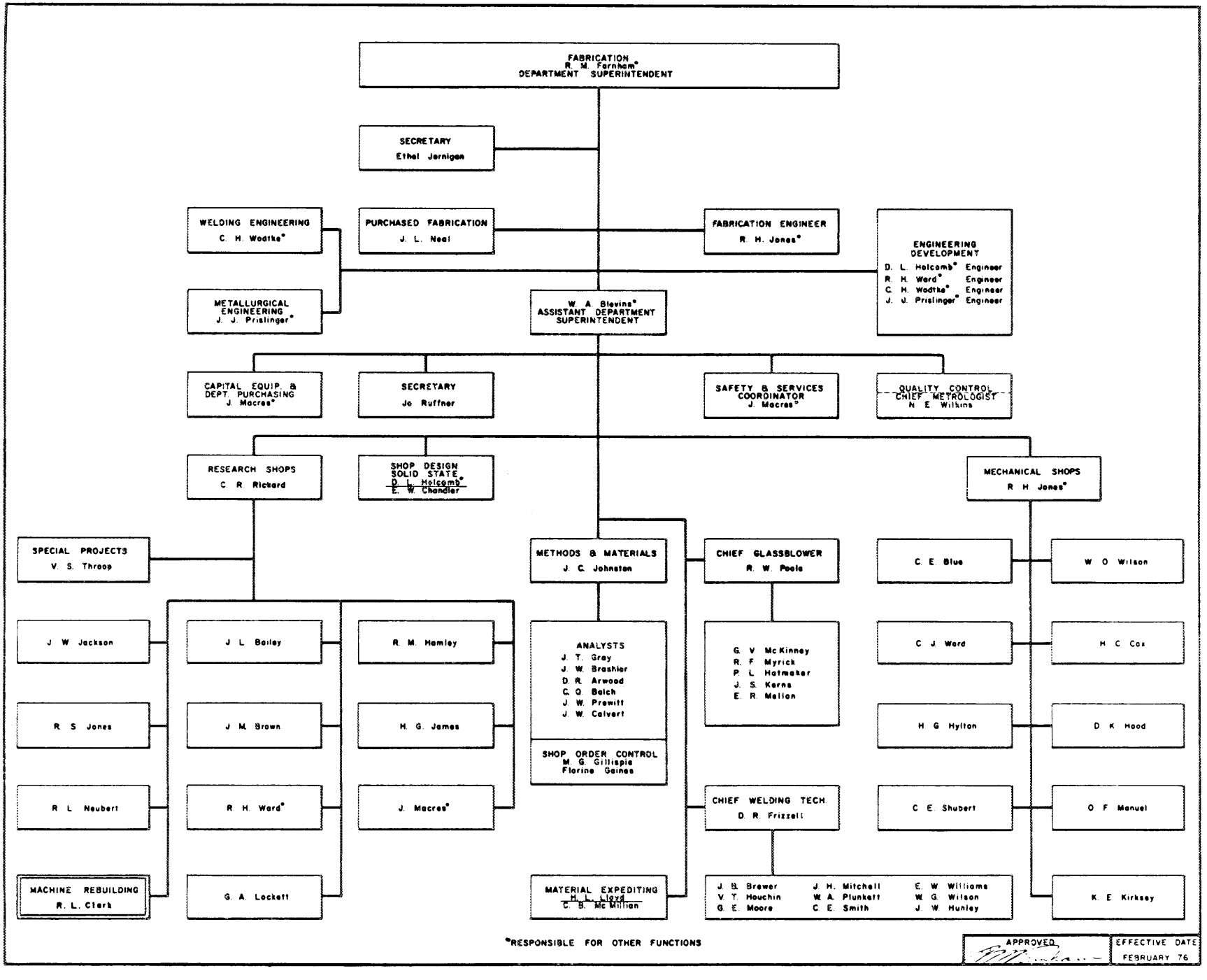
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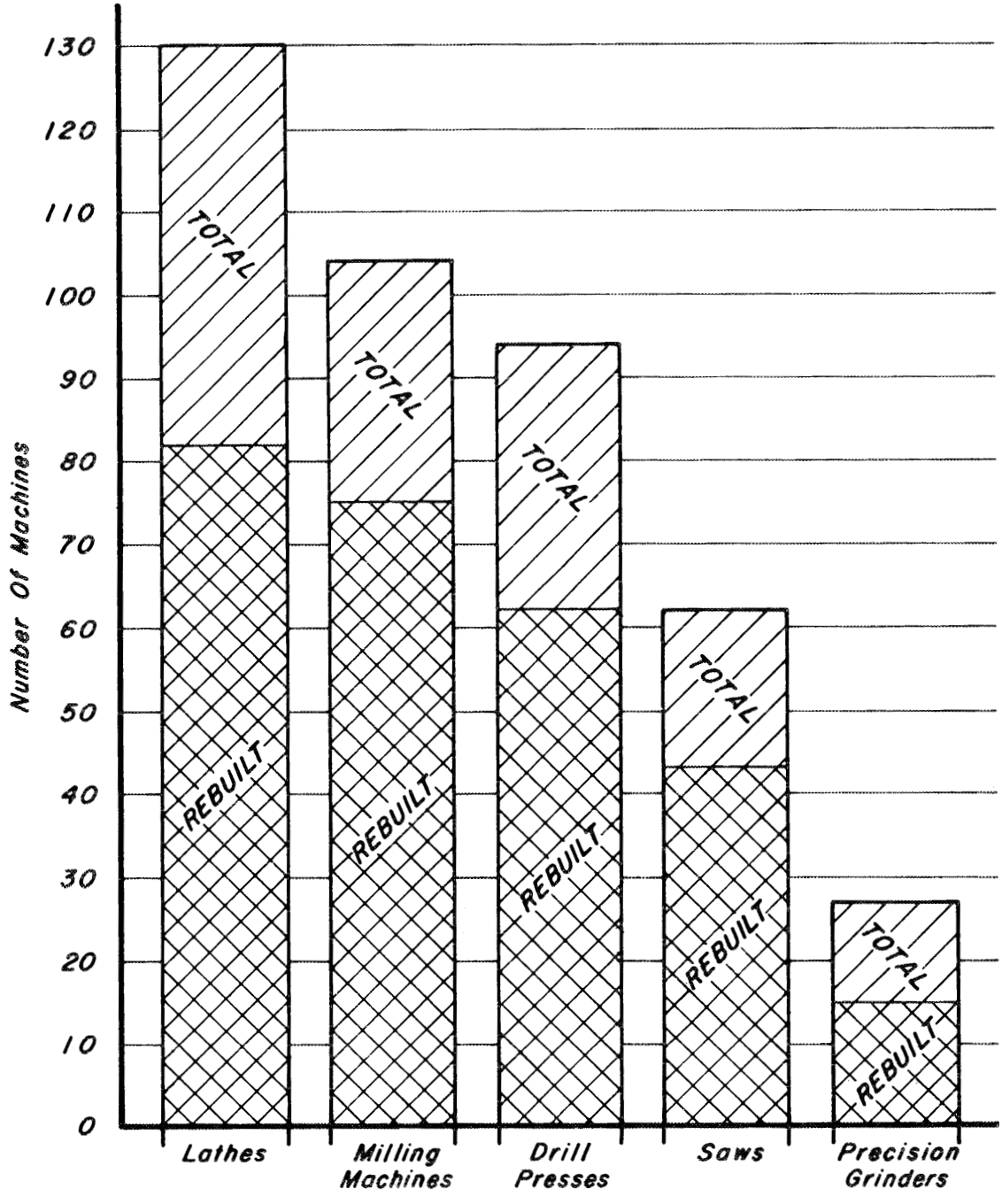
APPENDIX B

1970 ACCUMULATIVE REBUILDING EFFECT

SHOP EQUIPMENT IN USE
REBUILT & TOTAL
1970



APPENDIX C

MACHINE SHOP EQUIPMENT REBUILT IN 1975

MAJOR MACHINE TOOLS REBUILT IN 1975

Description	COST		
	Labor	Material	Total
Lathe, 10", Monarch	960	185	1,145
Grinder, D-8, DoAll, Surface	605	653	1,258
Mill, Bridgeport, #2	510	958	1,468
Lathe, 10", Monarch	1,784	280	2,064
Lathe, 10", Monarch	1,019	280	1,299
Bridgeport	764	75	839
Grinder, D-8, DoAll, Surface	764	60	824
Mill, Bridgeport, #2	764	320	1,084

MINOR EQUIPMENT REBUILT IN 1975

4 Grinders, 6"

1 Grinder, 10"

1 Polisher and Grinder, 12"

1 Belt Sander, 6"

6 Drill Presses

1 Saw, DoAll, ML-16

APPENDIX D

PREVENTIVE MAINTENANCE AND SEQUENCE OF OPERATIONS IN REBUILDING MACHINE TOOLS

A. Preventive Maintenance During Operational Use of Machine Tool

1. Lubrication
2. Adjustments
3. Minor Repairs
4. Inspection of Precision

B. When machine precision capability becomes inadequate, the continuing need for that particular machine is evaluated. Next, the availability of machine replacement funds and the estimated cost of rebuilding the machine are considered. Once the decision to rebuild a machine is made, the following sequence occurs:

1. Schedule for Rebuilding
2. Disconnect
3. Move to Rebuilding Shop (Photo 1)
4. Disassemble (Photos 2, 3, and 4)
5. Clean Parts with Steam or Solvent
6. Inspect Parts
7. Determine Parts to be Reused, Repaired, or Replaced
8. Request Purchase of Replacement Parts not on Hand
9. Collect and Store Replacement Parts on Hand
10. Plan and Coordinate the Repair Work Required on Machine Parts
11. Clean and Store Parts to be Reused
12. Inspect Repaired Parts and Store
13. Assemble Parts and Subassemblies
14. Connect Temporary Power
15. Test Operation
16. Inspect Machine
17. Make Any Adjustments Needed
18. Recheck Corrections
19. Disconnect Electrical
20. Refinish and Paint (Photo 5)
21. Coordinate Shop Installation
22. Check Operation

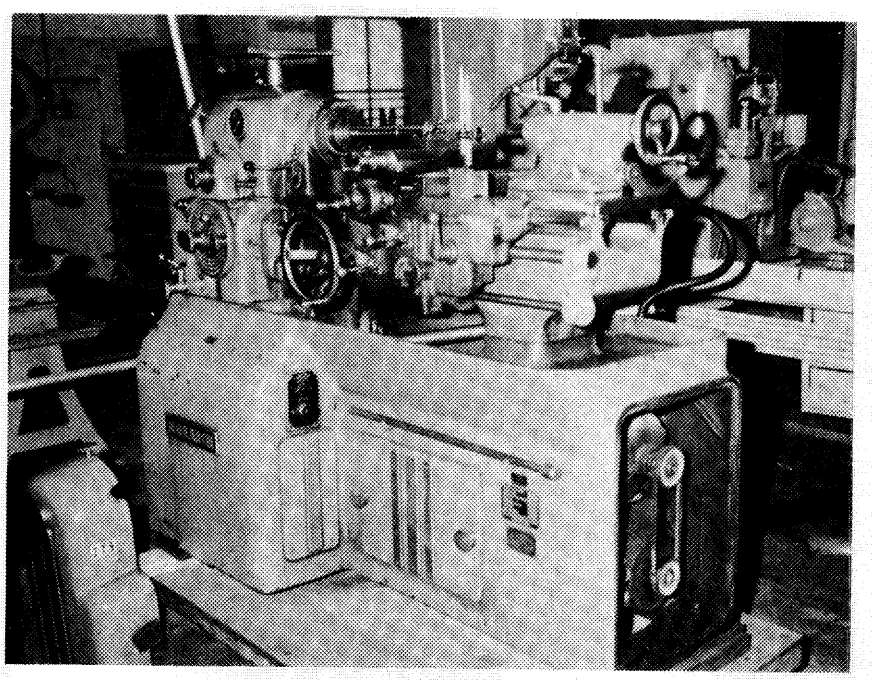


Photo 1 - Monarch 10" Toolroom Lathe Ready for Third Rebuilding Since 1947 Acquisition

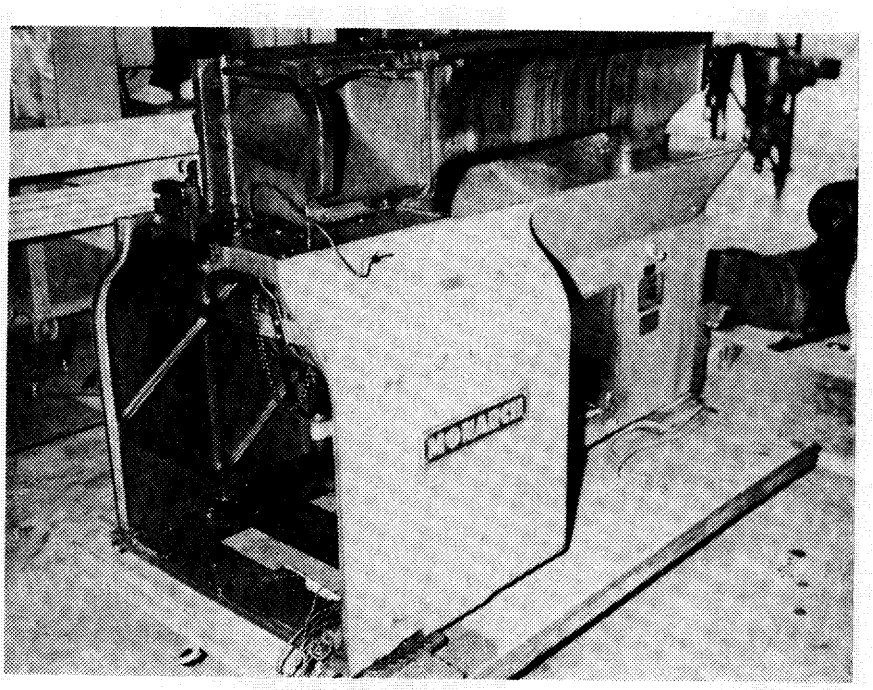


Photo 2 - Lathe Base and Way Castings Stripped Down

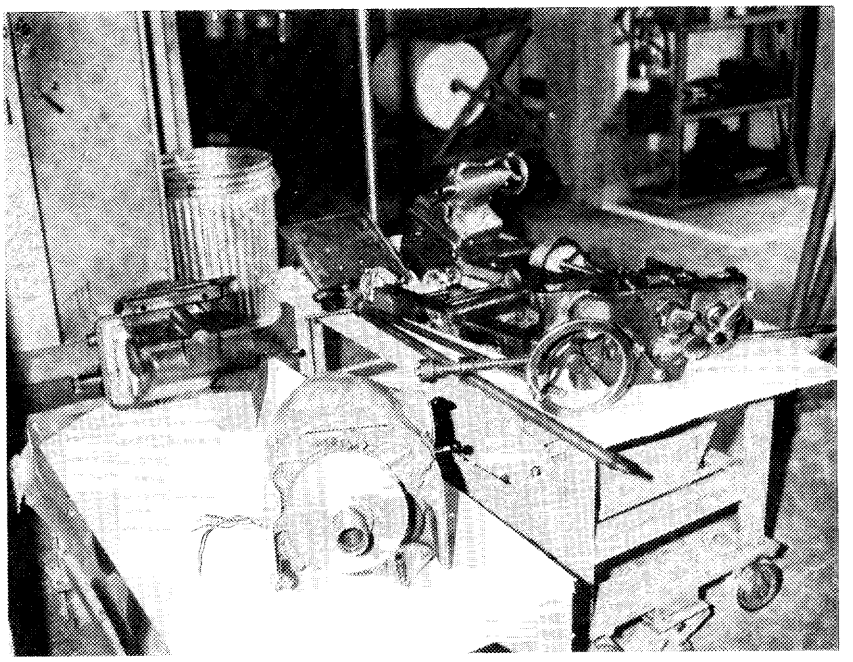


Photo 3 - Headstock, Tailstock, Carriage, Lead Screw, and Other Parts Removed

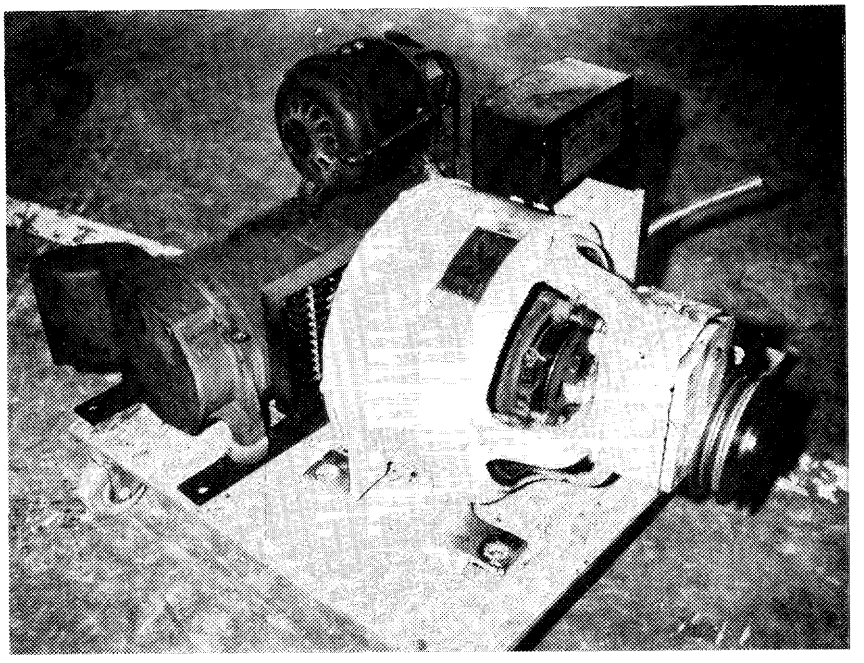


Photo 4 - Variable Speed Motor Generator from Lathe Base

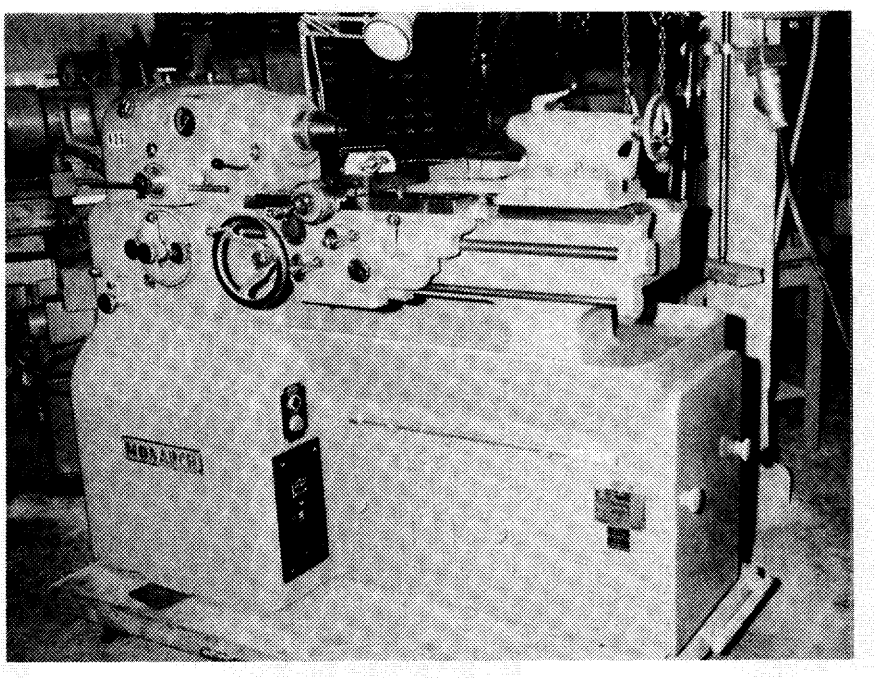


Photo 5 - Rebuilt Lathe Ready for Installation and New Life Cycle

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