THE OBJECTIVES AND MACHINE TOOL EQUIPMENT FOR MACHINE SHOP COURSES IN THIRTY ILLINOIS HIGH SCHOOLS

by

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHOD	1
AREA STUDIED	5
PRESENTATION AND INTERPRETATION OF THE FINDINGS	
Personal Information of the Respondents	6
Nature of the Courses Offered	9
Length of Machine Shop Periods	9
Machine Shop Enrollment	11
Student Over-Load of Machine Shops	13
Percentage of Time Spent on Machine Work	14
Years of Instruction in Which the Objectives Were Met	16
General Objectives	16
Specific Tool Objectives	22
Specific Materials Objectives	26
Specific Measuring Instrument Objectives	29
Data of the Machine Tool Equipment	32
SUMMARY AND CONCLUSIONS	49
ACKNOWLEDGMENT	52

TABLE OF CONTENTS CONCLUDED

Page

BIBLIOGRAPHY 53

APPENDIX 55

The Letter to Instructors 56

The Check Sheet 57

INTRODUCTION

The increasing demand for the services of skilled machinists and metal workers, especially of tool and die makers, is causing many of the public schools to supplement their curricula with instruction in this field. They are not attempting to make highly skilled craftsmen out of senior high school students, but are striving to increase their knowledge of the manipulative processes involved in such vocations, and their appreciation of this field.

The purpose of this study was to determine the objectives of this field of industrial education and to ascertain what equipment is needed to accomplish these objectives.

METHOD

The plan was to survey the machine shops of 30 Illinois senior high schools in cities of 10,000 or more population that were located in industrial areas.

In these 30 schools 40 machine shop instructors were contacted. To do this letters were sent with an enclosed reply card to industrial education instructors of 53 shops in 41 senior high schools. Each instructor was asked if he would be willing to help in a study of machine shop objectives and equipment. The replies showed that of the 53 shops, five offered no metal work, three offered bench metal work, five offered general metal work and 40 offered machine shop work. From these replies

it was deemed most desirable to choose for the study the 40 shops that offered machine shop instruction.

To secure the information desired a printed check sheet was prepared. It consisted of three printed sheets (appendix, p. 57). Sheet I requested personal information concerning the instructor such as his educational experience, years in his present position, years he had taught machine shop, years he had been employed as a metal worker and in what capacity. The remainder of the first sheet asked for information concerning the courses and classes. This included the student enrollment of the school, the nature of the machine shop courses, the total machine shop enrollment, the size of class for which the shop was equipped and the percentage of time spent on machine work in the various years of instruction.

Sheet II dealt with the general objectives and specific objectives (machine tools, materials and measuring instrument) of the instruction. Four columns were provided to indicate in which year or years of instruction each of the objectives was met. Space was provided on the back of this sheet to allow for additional objectives the responding instructors might wish to add.

Sheet III gave a rather complete list of machine tools. Columns were provided in which to list the number and variety of machines in the shop, the type of power-drive to the machine, the year or years of instruction in which the machine was regularly used and if the machine was purchased in a new or used condition. Additional space was provided

Table 1. Cities included in the study with their population and high school enrollment.

Name of city	City population*	High school enrollment**
Chicago	3,376,438	
Austin High	"	6,635
Bowen High	"	3,894
Crane Tech. High	"	5,832
Harrison High	"	4,265
Lane Tech. High	"	8,430
Lindblom High	"	6,809
Pullman School of M.T.	"	6,017
Schurz High	"	6,323
Tilden Tech. High	"	4,647
Peoria	104,969	
East High	"	617
Manual Training High	"	1,459
Woodruff High	"	1,430
Rockford	85,864	3,325
East St. Louis	74,347	2,015
Springfield	71,864	1,977
Cicero	66,602	5,826
Oak Park	63,982	3,602
Joliet	42,993	3,607
Rock Island	37,953	1,186
Elgin	35,929	1,725
Waukegan	33,499	2,392
Moline	32,236	1,113
Belleville	28,425	1,518
Granite City	25,130	1,580
Chicago Heights	22,321	1,836
Freeport	22,045	1,210
Champaign	20,348	996
Harvey	16,374	2,833
Winnetka	12,166	2,600
Sterling	10,012	637

*Taken from the 15th census of the United States, 1930.

**Taken from the Illinois School Directory, 1939-1940, issued by the Dept. of Public Inst. Springfield, Ill.

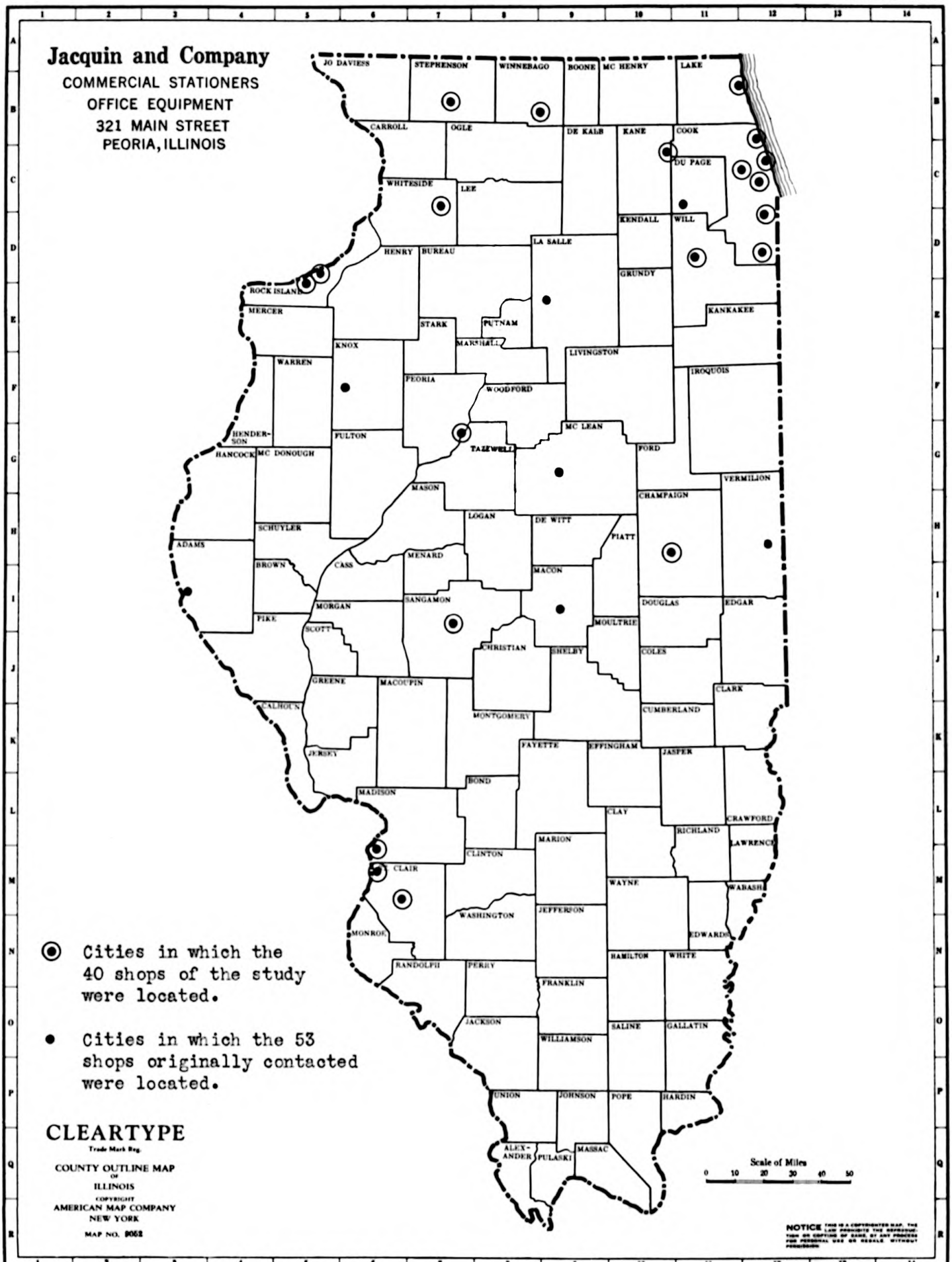

Fig. 1. The geographical location of the cities included in this study.

to allow for the listing of equipment not included in the printed list of machine tools.

AREA STUDIED

The 40 shops selected for study were in 30 senior high schools located in 20 cities with populations ranging from 10,012 to 3,376,438 (Table 1). Only schools having an enrollment of over 617 were included in the study since it was felt that this phase of industrial education would not be found in any schools under this size. From a previous study it was found that industrial education does not command any importance in the curricula of high schools with enrollments less than 350 (Ludington, 14).

The 30 schools included in the study were found in 20 cities located in the northern two-thirds of the state. These cities, with their population and high school enrollment, are shown in Table 1. The outline map (Fig. 1) gives the geographical location of the schools studied.

In the Chicago area 26 of the shops were located within a radius of 50 miles. There were three shops in each of the East St. Louis, Peoria and Rock Island areas. The other five shops were located in the north central half of the state.

PRESENTATION AND INTERPRETATION OF THE FINDINGS

Personal Information of the Respondents

In the study of the check sheets on tenure of instructors it was found that the length of tenure of the 40 instructors in their present position varied from one to 31 years as shown in Fig. 2. Of these instructors, 35 per cent had been in their present position from 11 to 15

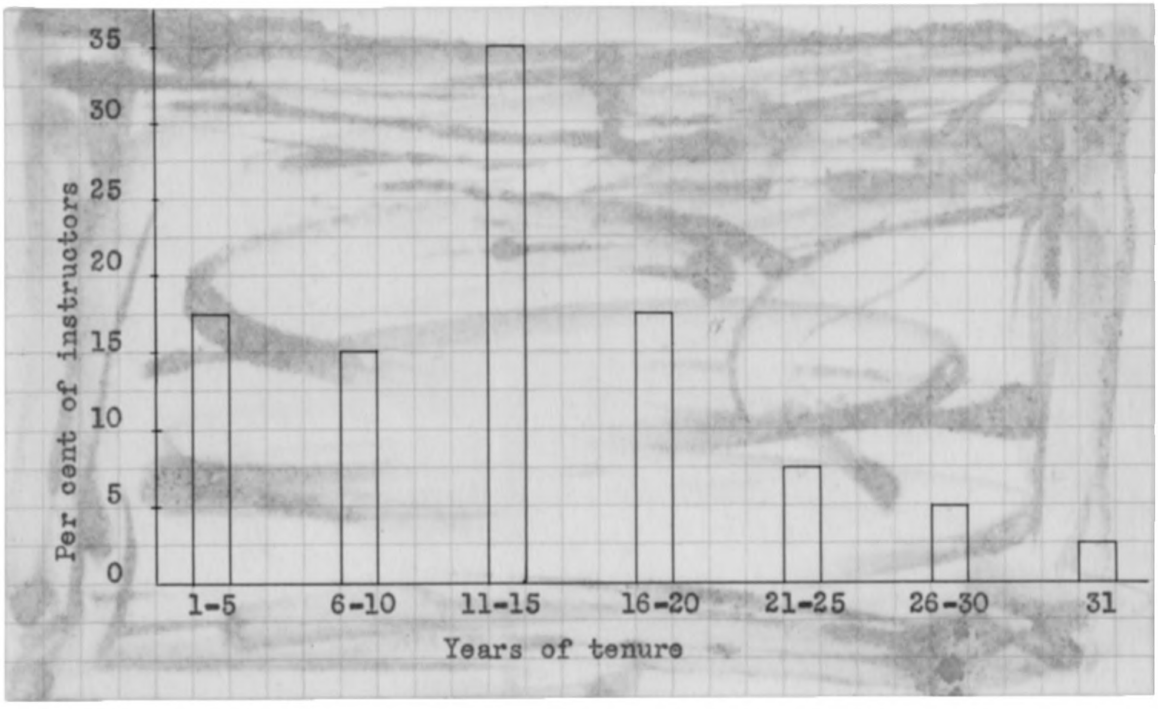

Fig. 2. Graph showing length of tenure in present position.

years. The groups representing one to five years and 16 to 20 years each made up 17.5 per cent of the total. Fifteen per cent had from six to ten years service in their present position, and 7.5 per cent had served 21 to 25 years. Five per cent had served 26 to 30 years,

and 2.5 per cent had a tenure of 31 years.

An examination of the replies from the respondents showed the number of years the 40 instructors had taught machine shop varied from one to 38 years (Fig. 3).

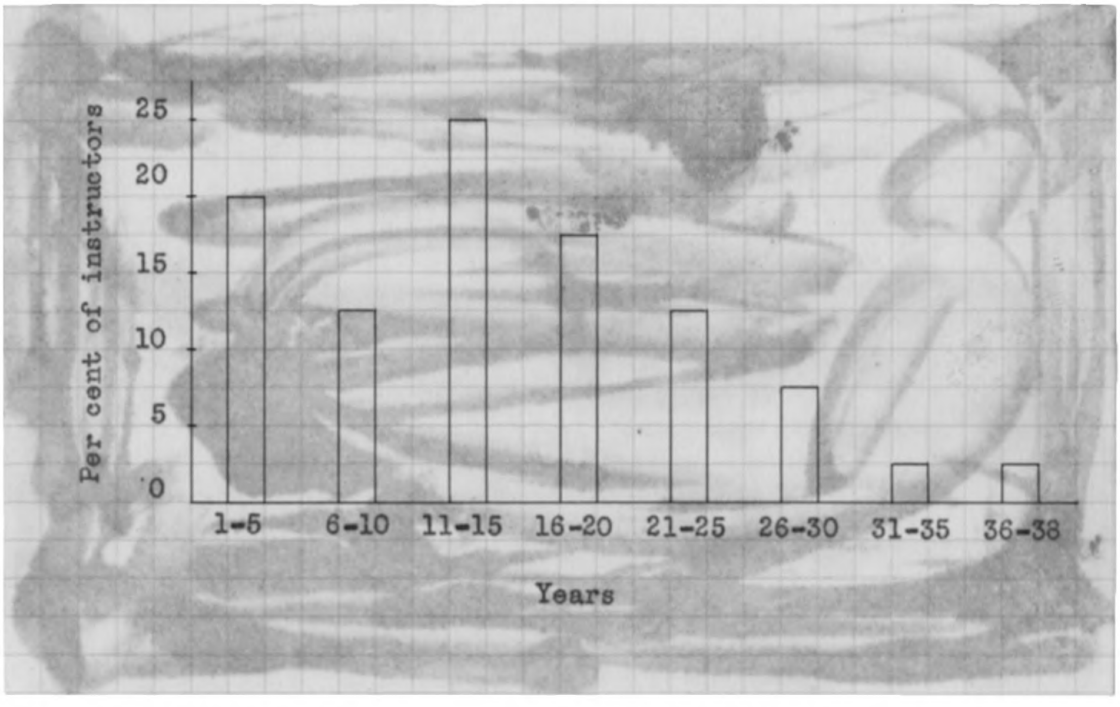

Fig. 3. Graph showing number of years the instructors had taught machine shop.

It may be seen that 25 per cent of the respondents had taught machine shop from 11 to 15 years. The one to five year group represents 20 per cent of the total. The group representing 16 to 20 years made up a total of 17.5 per cent. The six to ten year group and the 21 to 25 year group each made up a total of 12.5 per cent. Twenty-six to 30 years scored a total of 7.5 per cent. Two and one-half per cent represented the two groups of 31 to 35 and the 36 to 38 years.

Many of the responding instructors had several years of practical experience in their field. The number of years the various instructors had been employed in the metal trades varied from none to 25 years.

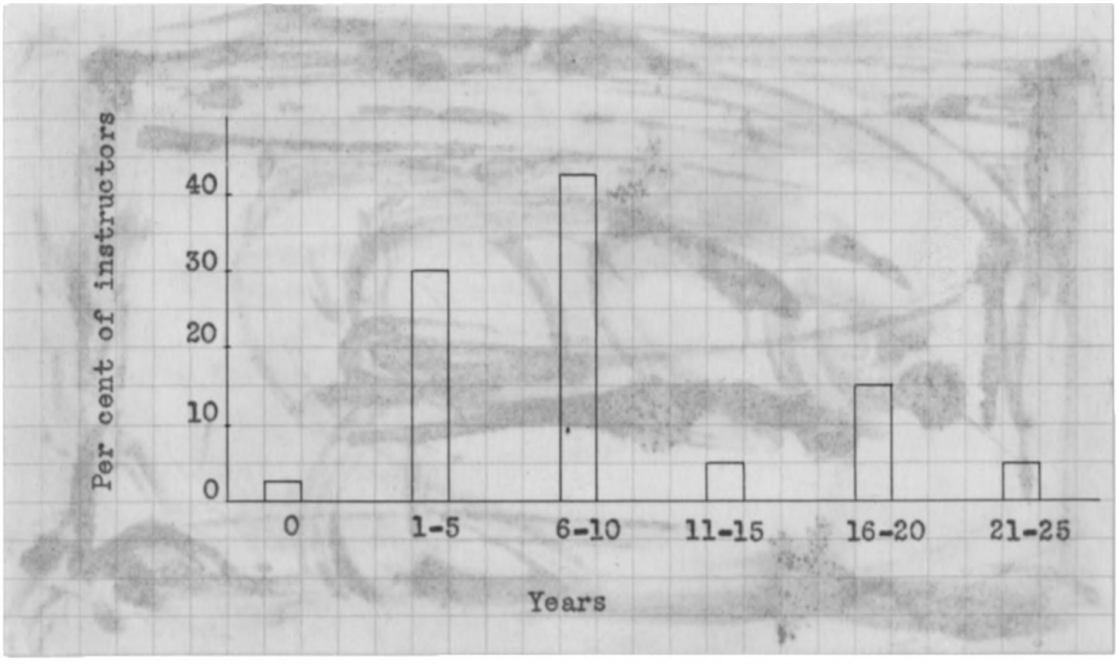

Fig. 4. Graph showing the number of years the instructors had been employed in metal trades.

As it is shown in Fig. 4, 42.5 per cent of the instructors had been employed in the metal trades from six to ten years. Instructors having worked from one to five years represented 30 per cent of the total. A total of 15 per cent had served from 16 to 20 years, 5 per cent accounted for each of the 11 to 15 and 21 to 25 year groups. One instructor, or 2.5 per cent of the total, had not enjoyed such employment.

Nature of the Courses Offered

There were three different types of instructional demand in the 40 shops studied. They were the industrial arts course, the trade course and the combination of trade and industrial arts.

Sixteen of the shops were used exclusively for industrial arts instruction. Trade instruction only was recorded in nine of the shops, and 15 of the shops offered a combination of trade and industrial arts.

Since all of the 40 shops studied were located in areas of considerable industrial activity and the fact that 31 of the shops offered some industrial arts instruction, one might rightfully assume that there is a definite place for machine shop instruction on a level other than vocational. To further substantiate this fact, one need only refer to the report of the Advisory Committee on Education:

> Training for a specific trade or industrial occupation is likely to be premature for most high school pupils 14, 15, or even 16 years of age. Pupils of these ages should be enrolled for vocational education only in introductory courses of an exploratory type. (1, p. 79)

Length of Machine Shop Periods

The length of the periods in the 40 machine shops studied varied from a single period of 55 minutes to triple 60 minute periods as is shown in Fig. 5.

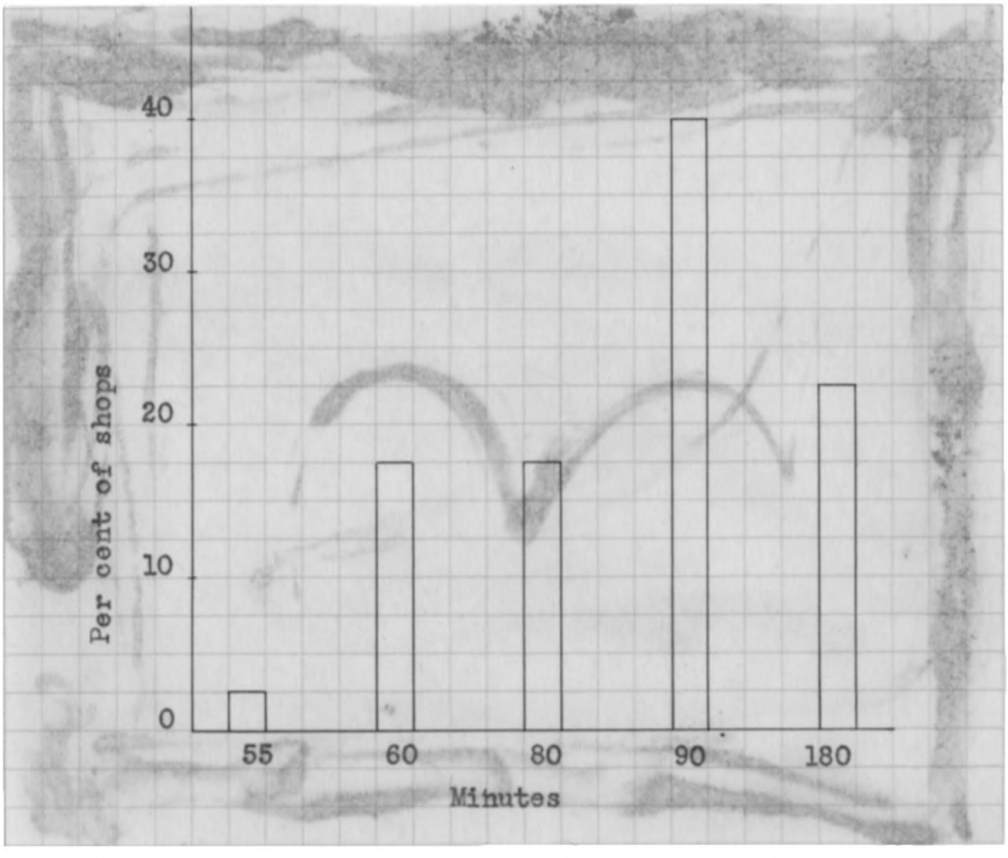

Fig. 5. Graph showing length of daily periods.

It can be seen that 40 per cent of the shops operated on a double 45 minute period schedule for a total of 90 minutes. The classes offering strictly trade instruction ran on a schedule of triple 60 minute periods for a total of 180 minutes. Twenty-two and one-half per cent of the shops were included in this group. The single period of 60 minutes and the double 40 minute period were each found to be in use in 17.5 per cent of the shops. Only one shop was using a single 55 minute schedule.

The time allowed for instruction and the amount and types of equipment available would largely control the variety of experiences, which

directly influence the objectives met.

Machine Shop Enrollment

Responses from the 40 machine shops showed daily enrollments that varied from 26 students to 200 students. It is shown in Fig. 6 that 32.5 per cent of the shops had a daily enrollment of from 101 to 125 students. Three of the shops in this group employed additional help to reduce the student load of the teacher. There were two shops with a daily enrollment of from 176 to 200, and both of these shops employed two instructors simultaneously.

The greatest daily teaching load, as figured from both time and students, was found to be in the one shop of the 151 to 175 bracket where one instructor daily handled five double-period classes with a total of 152 students. The other four groups not mentioned in the above description each had one case where more than one instructor was in charge of the class at the same time.

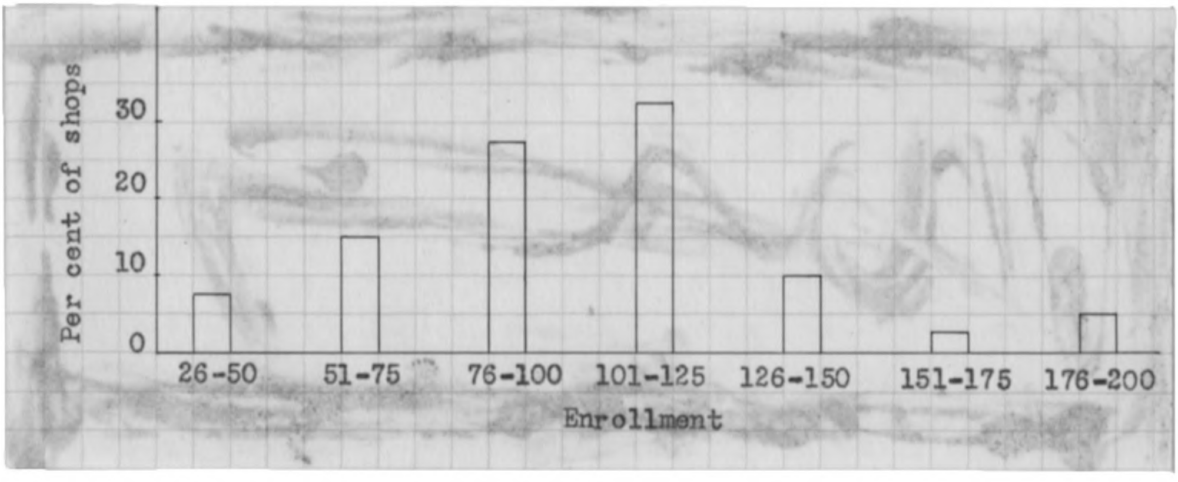

Fig. 6. Graph showing daily machine shop enrollment.

Mention probably should be made of the one shop having only 26 students enrolled. Prior to the 1939-40 school year the machine shop instruction had been offered as a related subject to automobile mechanics; however, the demand for machine shop, as a single unit of instruction, has been so pronounced that additional equipment is to be installed for the 1940-41 school year and a corresponding increase in enrollment is promised.

Table 2. Student capacity of equipment and enrollment of largest class in each shop.

Student capacity of equipment	Enrollment of largest class
65	66
65	62***
38	54
50	50***
40	39***
20	35
20	35
30	35
25	34
25	33
25	33
30	32
25	31
30	31
30	30***
25	30
27	30
25	30
20	29
25	29
25	28
24	28
22	28
25	27
25	27

Table 2. (Concluded)

Student capacity of equipment	Enrollment of largest class
22	26
25	26
20	26
21	26
25	26
25	25***
25	25***
20	25
24	25
24	24***
16	22
15	20
15	20
10	18
15	15***

***Shop enrollment below or equaling student capacity.

Student Over-Load of Machine Shops

The trend, seemingly, has been to enroll a large number of students for machine shop classes without respect to the capacity of the equipment to handle them. This practice should be discouraged because of the lack of efficiency and of the problems of discipline and safety involved.

It can be seen in Table 2 that 80 per cent of the shops had at least one class with an enrollment over the maximum capacity of the shop equipment. In rare cases this over-load might be attributed to the inability of the class schedule to meet the demands of a particular student without placing him in an already over-loaded machine shop class.

In larger schools, however, there usually are ample classes of all subjects, other than shop work, to permit a wide variety of class scheduling. It can be assured then, that the over-load found in the 32 shops is not a rare problem, but represents an unfortunate situation.

There were eight of the shops that had an enrollment equal to, or only slightly below, the capacity of the equipment. Six had an enrollment equal to the machine tool capacity, while only two had a class smaller than the equipment could handle. In these two cases one was under-enrolled by three students, the other by only one.

Percentage of Time Spent on Machine Work

A study of the data showed that of the 40 shops 38 of them offered the first year of machine shop instruction. As will be noticed later, the other two shops offered instruction only on an advanced level. The percentage of time spent on machine work in the various years is shown in Table 3.

It can be seen that no first year shop spent less than 25 per cent of the time on machine work, and 90 per cent was the highest per cent recorded. Thirty of the first year shops, or 79 per cent of the total, spent one-half or more of the time on the machine tools.

As the student progressed into the second year work the predominance of the machine tool instruction was quite marked. There were 31 shops offering the second year of instruction and all of them spent 50 per cent or more of the time on machine work. Of these 31 shops, 65 per

Table 3. The percentage of time spent on machine tool instruction in each of the four years.

No. of schools giving first year machine shop instruction	No. of schools giving second year machine shop instruction	No. of schools giving third year machine shop instruction	No. of schools giving fourth year machine shop instruction	Percentage of time spent on machine work
-	2	-	-	100.00
1	1	-	-	90.00
1	3	2	1	85.00
4	3	3	1	80.00
4	2	5	1	75.00
2	4	1	1	70.00
2	-	-	-	66.66
4	5	2	2	65.00
-	1	-	-	60.00
1	1	-	-	55.00
11	9	-	-	50.00
2	-	-	-	40.00
2	-	-	-	33.33
2	-	-	-	30.00
2	-	-	-	25.00
Total 38	31	13	6	

cent spent from 50 to 75 per cent of their time on machine tool instruction while the other 35 per cent spent from 75 to 100 per cent on the machines. Two of the shops spent all of their time on machine work. One had an enrollment of 30, the other, 15. By checking the machine tool equipment one would find that there were that number of machine tool stations in the respective shops.

The third year work which was given in 13 of the shops, and the fourth year work which was given in 6 shops consumed from 65 to 85 per

cent of their time in machine tool instruction.

Years of Instruction in Which the Objectives Were Met

In order to study the objectives of the various shops contacted the field of objectives was divided into four divisions: namely, general objectives, specific tool objectives, specific materials objectives and specific measuring instrument objectives.

General Objectives. The general objectives given in Table 4 show that all 38 of the first year shops strove to train the student in the correct use of hand tools, to teach him to understand and use a working drawing, to develop accuracy in his work and to train him to properly care for the shop equipment. The matter of safety was rated as a general objective in 97.3 per cent of the shops.

Only 50 per cent of the first year shops apparently gave instruction in design. This would probably indicate that this year of instruction was mostly on set problems and that little, if any, opportunity was given the student to develop or design an elective project.

Very few of the first year shops attempted to acquaint the student with the process of manufacturing standardized parts. This is to be commended, because the first year should be only a period of instruction in the basic fundamentals of general machine shop work. No first year shop attempted to acquaint the student with modern inspection methods.

Table 4. The number and percentage of general objectives met in the 38 laboratories offering the first year of machine shop instruction.

General objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
To develop correct habits of working with hand tools	38	100.0
To understand and use a working drawing	38	100.0
To instill into the student the necessity for accuracy in machine shop work	38	100.0
To develop good habits in the care of machine shop equipment	38	100.0
To acquaint the student with the dangers of the machine tools and develop habits of safety therefrom	37	97.3
To develop an appreciation of good workmanship	35	92.0
To develop acceptable methods in construction of metal projects	30	78.9
To acquaint the student with the possibility of future employment in the machine shop trades	20	52.6
To develop good taste in the design of attractive metal projects	19	50.0
To acquaint the student with the process of manufacturing standardized parts	12	31.6
To acquaint the student with modern inspection methods	--	--

From Table 5, which shows the objectives of the second year courses it can be seen that the objective of correct use of hand tools showed a considerable drop from the first year. In this period of instruction the process of manufacturing standardized parts showed a considerable rise over the first year of instruction.

Concern might be expressed, however, for the shops that did not meet the objectives of safety, use of the working drawing, accuracy, care of shop equipment and appreciation of good workmanship. Since there were 31 shops offering second year work, and only 13 shops offering third year work, it would seem that the above objectives should be met in all the second year shops because it is the last time many of the students would have the opportunity of receiving the proper instruction on these important points.

As the machine shop instruction advanced into the third and fourth years the percentage of shops meeting the general objectives increased considerably. This is shown in Tables 7 and 8.

The one shop that listed the general objective of training in modern inspection methods offered this work because a fair percentage of the graduates of this shop were absorbed in a local plant where the "NO-GO" and "Snap" gages were used by them in small parts inspection.

Table 5. The number and percentage of general objectives met in the 31 laboratories offering the second year of machine shop instruction.

General objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
To develop an appreciation of good workmanship	29	92.8
To develop good habits in the care of machine shop equipment	26	83.2
To develop acceptable methods in construction of metal projects	26	83.2
To instill into the student the necessity for accuracy in machine shop work	25	80.0
To acquaint the student with the dangers of machine tools and develop habits of safety therefrom	23	73.6
To understand and use a working drawing	22	70.4
To develop correct habits of working with the hand tools	21	67.2
To acquaint the student with the process of manufacturing standardized parts	21	67.2
To develop good taste in the design of useful and attractive metal projects	21	67.2
To acquaint the student with the possibility of future employment in the machine shop trades	20	64.0
To acquaint the student with modern inspection methods	1	3.2

Table 6. The number and percentage of general objectives met in the 13 laboratories offering the third year of machine shop instruction.

General objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
To develop an appreciation of good workmanship	13	100.0
To develop good habits in the care of machine shop equipment	13	100.0
To acquaint the student with the dangers of the machine tools and develop habits of safety therefrom	12	92.3
To acquaint the student with the possibility of future employment in the machine shop trades	12	92.3
To instill into the student the necessity for accuracy in machine shop work	12	92.3
To develop acceptable methods in construction of metal projects	12	92.3
To develop good taste in the design of useful and attractive metal projects	12	92.3
To develop correct habits of working with the hand tools	10	77.0
To understand and use a working drawing	10	77.0
To acquaint the student with the process of manufacturing standardized parts	10	77.0
To acquaint the student with modern inspection methods	1	7.7

Table 7. The number and percentage of general objectives met in the six laboratories offering the fourth year of machine shop instruction.

General objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
To develop correct habits of working with the hand tools	6	100.0
To acquaint the student with the dangers of machine tools and develop habits of safety therefrom	6	100.0
To acquaint the student with the possibility of future employment in the machine shop trades	6	100.0
To develop an appreciation of good workmanship	6	100.0
To instill into the student the necessity for accuracy in machine shop work	6	100.0
To develop good habits in the care of machine shop equipment	6	100.0
To develop acceptable methods in construction of metal projects	6	100.0
To understand and use a working drawing	5	83.3
To acquaint the student with the process of manufacturing standardized parts	5	83.3
To develop good taste in the design of useful and attractive metal projects	5	83.3
To acquaint the student with modern inspection methods	1	16.6

Specific Tool Objectives. In the study of the check sheets it was interesting to note that the greater percentage of first year specific tool objectives were met on six different machines as shown in Table 8.

The utility grinder, engine lathe, power hacksaw, speed drill, horizontal shaper and heavy duty drill press were the predominating machines listed for the first year of instruction.

Table 8. The number and percentage of specific tool objectives met in the 38 laboratories offering the first year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Grinder, utility	38	100.0
Lathes, engine	38	100.0
Hacksaw, power	37	97.3
Drill press, speed	36	94.7
Shaper, horizontal	30	78.9
Drill press, heavy duty	23	60.5
Milling machine, universal	16	42.0
Centering machine	15	39.4
Lathes, speed	15	39.4
Grinder, tool post	10	26.3
Index centers	10	26.3
Milling machine, hand	6	15.8
Grinder, cutter	5	13.2
Planer	5	13.2
Drill press, radial	4	10.5
Milling machine, plain	4	10.5
Grinder, surface	2	5.3
Lathes, turret	1	2.6
Grinder, universal	1	2.6
Filing machine	1	2.6
Grinder, centerless	--	--
Press, punch	--	--
Screw machine, automatic	--	--

Table 8. (Concluded)

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Screw machine, semi-automatic	--	--
Screw machine, hand	--	--
Grinder, cylindrical	--	--
Boring mill	--	--

The specific tool objectives of the second year shown in Table 9, lists all six predominating machine tools of the first year and adds the index centers, tool post grinder and universal milling machine to the group. This makes a total of nine different machines on which the greater percentage of second year machine tool objectives were met.

Table 9. The number and percentage of specific tool objectives met in the 31 laboratories offering the second year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Grinder, utility	31	100.0
Shaper, horizontal	31	100.0
Lathes, engine	31	100.0
Hacksaw, power	30	96.0
Drill press, speed	27	86.4
Index centers	25	80.0
Drill press, heavy duty	23	73.6
Grinder, tool post	22	70.4
Milling machine, universal	22	70.4
Lathes, speed	13	41.6
Grinder, cutter	12	38.4
Planer	12	38.4
Centering machine	9	28.8

Table 9. (Concluded)

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Milling machine, hand	7	22.4
Drill press, radial	6	19.2
Grinder, surface	6	19.2
Milling machine, plain	4	12.8
Press, punch	3	9.6
Lathes, turret	2	6.4
Screw machine, hand	1	3.2
Grinder, universal	1	3.2
Grinder, cylindrical	1	3.2
Boring mill	1	3.2
Grinder, centerless	-	--
Screw machine, automatic	-	--
Screw machine, semi-automatic	-	--
Filing machine	-	--

As the student advanced into the third year of instruction three new machine tools were added to the nine predominating machines of the second year. The new objectives of the third year work were learning the operation of the cutter grinder, the surface grinder and the planer. More than 50 per cent of the third year shops met these objectives, as may be seen in Table 10.

Table 10. The number and percentage of specific tool objectives met in the 13 laboratories offering the third year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Grinder, utility	13	100.0
Hacksaw, power	13	100.0
Index centers	13	100.0
Shaper, horizontal	13	100.0
Lathes, engine	13	100.0
Grinder, tool post	12	92.4
Drill press, heavy duty	12	92.4
Drill press, speed	11	84.7
Milling machine, universal	11	84.7
Grinder, cutter	9	69.3
Grinder, surface	7	53.9
Planer	7	53.9
Lathes, speed	6	46.2
Milling machine, hand	6	46.2
Milling machine, plain	6	46.2
Drill press, radial	4	30.8
Centering machine	3	23.1
Lathes, turret	3	23.1
Press, punch	1	7.7
Screw machine, semi-automatic	1	7.7
Grinder, universal	1	7.7
Boring mill	1	7.7
Grinder, centerless	--	--
Screw machine, automatic	--	--
Screw machine, hand	--	--
Filing machine	--	--
Grinder, cylindrical	--	--

It may be seen in Table 11 that 50 per cent of the fourth year shops met specific tool objectives on a variety of 16 different machine tools. The four machines that were added to the previous list of 12 were the speed lathe, turret lathe, hand milling machine and plain

milling machine.

Table 11. The number and percentage of specific tool objectives met in the six laboratories offering the fourth year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Grinder, utility	6	100.0
Hacksaw, power	6	100.0
Index centers	6	100.0
Shaper, horizontal	6	100.0
Lathes, engine	6	100.0
Drill press, speed	5	83.0
Grinder, cutter	5	83.0
Grinder, surface	5	83.0
Grinder, tool post	5	83.0
Drill press, heavy duty	5	83.0
Milling machine, universal	5	83.0
Lathes, speed	3	50.0
Lathes, turret	3	50.0
Milling machine, hand	3	50.0
Milling machine, plain	3	50.0
Planer	3	50.0
Drill press, radial	2	33.2
Centering machine	1	16.6
Press, punch	1	16.6
Screw machine, semi-automatic	1	16.6
Grinder, universal	1	16.6
Boring mill	1	16.6
Grinder, centerless	--	--
Screw machine, automatic	--	--
Screw machine, hand	--	--
Filing machine	--	--
Grinder, cylindrical	--	--

Specific Materials Objectives. In the study of the check sheet on the specific materials objectives it was found that eight different materials were in use in the instruction of the various shops as is

shown in Tables 12, 13, 14 and 15.

Instruction in the machining of cold rolled steel was an objective of all shops in all years of work. High carbon steel and cast iron were the next most prominent materials used in the first year of instruction.

Table 12. The number and percentage of specific materials objectives met in the 38 laboratories offering first year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Cold rolled steel	38	100.00
High carbon steel	30	78.90
Cast iron	27	71.01
Brass	15	39.45
Bronze	14	36.82
Cast steel	13	34.19
Aluminum	13	34.19
Copper	--	--

Specific materials objectives of the second year work were met by 75 per cent or more of the shops with cold rolled steel, high carbon steel, cast iron, bronze, brass and aluminum.

In the third and fourth years of instruction the above materials kept about the same prominence with the exception of cast iron, which was used in all of the fourth year shops. Cast steel was listed as a specific materials objective in 46 per cent of the third year shops and in 66 per cent of the fourth year shops. Copper was used in only one each of the third and fourth year shops.

Table 13. The number and percentage of specific materials objectives met in the 31 laboratories offering second year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Cold rolled steel	31	100.0
High carbon steel	29	92.8
Cast iron	26	83.2
Bronze	22	70.4
Brass	22	70.4
Aluminum	22	70.4
Cast steel	15	48.0
Copper	--	--

Table 14. The number and percentage of specific materials objectives met in the 13 laboratories offering third year machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Cold rolled steel	13	100.0
Bronze	12	92.4
Brass	12	92.4
Cast iron	11	84.7
High carbon steel	10	77.0
Aluminum	10	77.0
Cast steel	6	46.2
Copper	1	7.7

Table 15. The number and percentage of specific materials objectives met in the six laboratories offering fourth year machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Cast iron	6	100.0
Cold rolled steel	6	100.0
High carbon steel	5	83.0
Bronze	5	83.0
Brass	5	83.0
Aluminum	5	83.0
Cast steel	4	66.4
Copper	1	16.6

Specific Measuring Instrument Objectives. The fourth and last group of objectives dealt with the various measuring instruments and the years of instruction in which they were used. These objectives of the first year of instruction are given in Table 16.

It may be seen that the five most prominent instruments used in the first year were the outside calipers, the inside calipers, the micrometer calipers, the bevel protractor and the surface gage.

Table 16. The number and percentage of specific measuring instrument objectives met in the 38 laboratories offering the first year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Outside calipers	38	100.0
Inside calipers	34	88.4
Micrometer calipers	31	80.6
Bevel protractor	26	67.6
Surface gage	24	42.4
Dial indicator	3	7.8
Thread micrometer	1	2.6
Vernier calipers	1	2.6
Rockwell hardness tester	--	--
Sine bar	--	--
No-Go gages	--	--
Vernier height gages	--	--

The measuring instrument objectives of the second, third and fourth years, as shown in Tables 17, 18 and 19, kept the same prominence as they did in the first year of instruction. All of the third and fourth year shops met the measuring instrument objectives of the outside calipers, the inside calipers, the micrometer calipers, the bevel protractor and the surface gage.

Mention should be made of the absence of the steel scale. It was felt that the steel scale probably was in universal use throughout all years of machine shop instruction. Therefore, it was not included in the original list of measuring instrument objectives.

Table 17. The number and percentage of specific measuring instrument objectives met in the 31 laboratories offering the second year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Outside calipers	31	100.0
Inside calipers	30	96.0
Bevel protractor	30	96.0
Micrometer calipers	30	96.0
Surface gage	30	96.0
Dial indicator	8	25.6
Vernier calipers	1	3.2
Rockwell hardness tester	1	3.2
Thread micrometer	1	3.2
Sine bar	--	--
No-Go gages	--	--
Vernier height gage	--	--

Table 18. The number and percentage of specific measuring instrument objectives met in the 13 laboratories offering the third year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Inside calipers	13	100.0
Outside calipers	13	100.0
Bevel protractor	13	100.0
Micrometer calipers	13	100.0
Surface gage	13	100.0
Dial indicator	4	30.8
Vernier calipers	2	15.4
Rockwell hardness tester	1	7.7
Sine bar	1	7.7
Vernier height gage	1	7.7
Thread micrometer	1	7.7
No-Go gages	--	--

Table 19. The number and percentage of specific measuring instrument objectives met in the six laboratories offering the fourth year of machine shop instruction.

Specific objectives	No. of shops meeting each objective	Percentage of shops meeting each objective
Inside calipers	6	100.0
Outside calipers	6	100.0
Bevel protractor	6	100.0
Micrometer calipers	6	100.0
Surface gage	6	100.0
Dial indicator	2	33.2
Vernier calipers	2	33.2
Sine bar	1	16.6
No-Go gages	1	16.6
Vernier height gages	1	16.6
Thread micrometer	--	--
Rockwell hardness tester	--	--

Data of the Machine Tool Equipment

The information gathered concerning the machine tool equipment of the 40 shops should be of great interest to any machine shop instructor, industrial arts supervisor or administrator interested in this phase of industrial education equipment.

There were 26 different machine tools in use, to varying extents, in the shops studied as is shown in Table 20. No one school used the entire variety which was represented by this total.

It can be seen that 17 shops, or 42.5 per cent of the total shops, listed at least 13 of the total variety of machine tools as their

equipment.

Of the above 17 shops, in which 50 per cent or more of the total variety of machine tools were listed, four of the shops offered trade instruction only, four offered industrial arts instruction only and nine offered a combination of trade and industrial arts.

In the other 57.5 per cent of the shops where the variety of machine tools was below 50 per cent of the total, five offered trade instruction only, 12 offered industrial arts instruction only and six offered a combination of trade and industrial arts.

Table 20. Variety and number of machines in use in the various shops.

Name of city	Name of school	School Population	Boring mill	Centering machine	Drill Press, heavy duty	Drill, radial	Drill, speed	Filing machine	Grinder, cutter	Grinder, cylindrical	Grinder, surface	Grinder, tool post	Grinder, universal	Grinder, utility	Hacksaw, power	Index centers	Lathes, engine	Lathes, speed	Lathes, turret	Milling mach., hand	Milling mach., plain	Milling mach., universal	Planer	Press, arbor	Press, punch	Screw mach., hand	Screw mach., semi-automatic	Shaper, horizontal	Variety of machines represented	Percentage of the 26 machine tools in each shop
Chicago	Pullman Man'l Trg.	6,017	1	1	2	-	1	-	1	-	1	3	1	3	1	2	18	-	1	1	1	2	1	2	-	-	-	3	19	72.2
Cicero	J. S. Morton, Shop 2	5,826	-	-	2	1	4	-	1	-	1	1	-	1	1	3	19	2	-	1	1	1	1	1	-	-	1	4	18	68.4
Chicago	Harrison Tech., Shop 1	4,265	-	1	2	1	3	-	1	-	1	2	-	2	1	2	14	1	1	-	1	1	1	2	-	-	-	2	18	68.4
Chicago	Tilden Tech., Shop 1	4,647	-	1	1	1	1	-	1	1	-	1	-	2	1	1	21	-	1	-	1	1	1	1	-	-	-	2	17	64.6
Waukegan	Waukegan Twp., Shop 2	2,392	-	1	1	-	2	-	1	1	2	1	-	1	1	2	8	2	-	1	1	1	-	1	-	-	-	2	17	64.4
Joliet	Joliet Twp.	3,607	1	1	1	-	1	-	1	-	2	2	1	2	1	4	18	-	-	-	-	4	1	1	-	-	-	4	16	60.8
Chicago	Lindblom	6,809	-	1	1	1	1	-	1	-	-	1	-	2	1	-	18	3	-	1	-	1	1	1	-	-	-	1	15	57.0
Chicago	Crane Tech., Shop 1	5,832	-	1	1	1	1	-	-	-	1	1	-	2	1	2	21	2	-	-	-	2	1	2	-	-	-	1	15	57.0
Granite City	Granite City Twp.	1,580	-	-	1	1	3	-	1	-	1	2	-	1	2	2	18	-	-	-	-	2	1	1	1	-	-	1	15	57.0
Chicago	Schurz	6,323	-	1	-	1	4	-	1	-	-	1	-	2	1	2	21	1	-	-	-	2	1	1	-	-	-	2	14	53.2
Chicago	Harrison Tech., Shop 2	4,265	-	1	2	1	3	-	-	-	-	1	-	2	1	1	11	1	-	-	-	1	1	1	-	-	-	2	14	53.2
Rockford	Rockford Sr. High	3,325	-	1	2	-	2	-	2	-	2	2	-	3	1	2	20	-	-	-	-	3	1	2	-	-	-	3	14	53.2
Moline	Moline Man. Arts, Shop 1	1,113	-	1	1	-	1	-	-	-	-	1	1	3	2	1	18	-	1	-	-	2	1	2	-	-	-	1	14	53.2
Chicago	Austin High, Shop 1	6,635	-	1	1	-	1	-	1	-	-	1	-	1	1	1	17	-	-	-	-	1	1	1	-	-	-	1	13	49.4
Chicago	Crane Tech., Shop 2	5,832	-	1	1	1	1	1	1	-	-	-	-	1	1	-	12	1	-	-	1	1	-	-	-	-	-	1	13	49.4
Springfield	Springfield Sr. High	1,977	-	-	1	-	4	-	1	-	1	1	-	1	1	1	22	-	1	-	-	1	-	1	-	-	-	1	13	49.4
Peoria	Peoria Manual Trg.	1,459	-	-	1	-	2	-	1	-	-	-	-	3	1	2	18	1	-	1	-	1	1	1	-	-	-	2	13	49.4
Cicero	J. S. Morton, Shop 3	5,826	-	-	-	-	2	-	-	1	1	1	-	2	-	1	5	-	-	1	1	1	-	1	-	-	-	1	12	45.6
Harvey	Thornton Twp. High	2,833	-	-	1	1	1	-	1	-	-	1	-	1	1	1	14	-	-	-	-	1	-	1	-	-	-	1	12	45.6
Belleville	Belleville Twp.	1,518	-	-	1	-	2	-	1	-	1	-	-	2	2	1	10	-	-	-	-	1	1	-	1	-	-	1	12	45.6
Rock Island	Rock Island Sr.	1,186	-	-	1	-	1	-	-	-	-	1	-	1	1	1	14	-	1	-	-	1	1	1	-	-	-	1	12	45.6
Sterling	Sterling Twp.	637	-	-	3	-	-	-	1	-	-	1	-	2	1	2	15	-	-	-	1	1	-	1	-	1	-	1	12	45.6
Chicago	Lane Tech., Shop 1	8,430	-	1	1	-	1	-	1	-	-	-	-	2	1	1	25	-	-	-	-	1	-	1	-	-	-	1	11	41.8
Chicago	Crane Tech., Shop 3	5,832	-	1	-	-	4	-	-	-	-	1	-	1	1	1	13	1	-	-	-	1	-	1	-	-	-	1	11	41.8
Chicago	Bowen Sr. High	3,894	-	-	1	-	3	-	1	-	-	-	-	1	2	-	24	1	-	-	-	1	1	1	-	-	-	1	11	41.3
Freeport	Freeport Sr. High	1,210	-	-	1	-	1	-	-	-	-	-	1	1	1	1	12	1	-	-	-	1	1	-	-	-	-	2	11	41.3
Chicago	Lane Tech., Shop 2	8,430	-	1	1	-	1	-	-	-	-	-	-	2	-	1	23	-	-	-	-	1	-	1	-	-	-	1	10	38.0
Chicago	Tilden Tech., Shop 2	4,647	-	1	-	-	1	-	1	-	-	-	-	2	1	2	24	-	-	-	-	2	-	-	1	-	-	2	10	38.0
Oak Park	Oak Park-River Forest	3,602	-	-	1	-	1	-	-	-	-	1	-	1	1	1	9	-	-	-	-	1	-	1	-	-	-	1	10	38.0
Winnetka	New Trier Twp.	2,600	-	-	2	-	1	-	-	-	-	1	-	1	1	1	7	1	-	-	-	1	-	-	-	-	-	1	10	38.0
E. St. Louis	E. St. Louis High	2,013	-	-	1	-	1	-	-	-	-	1	-	3	1	1	13	-	-	-	1	-	-	1	-	-	-	1	10	38.0
Chicago Hgts.	Bloom Twp.	1,836	-	-	1	-	1	-	1	-	-	1	-	1	1	1	7	-	-	-	-	1	-	-	-	-	-	1	10	38.0
Chicago	Austin High, Shop 2	6,635	-	-	1	-	1	-	-	-	-	-	1	1	1	1	23	-	-	-	-	1	-	-	-	-	-	1	9	34.2
Peoria	Peoria Woodruff	1,430	-	-	1	-	2	-	-	-	-	1	-	1	1	1	9	-	-	-	-	1	-	-	-	-	-	1	9	34.2
Cicero	J. S. Morton, Shop 1	5,826	-	-	1	-	2	-	-	-	-	-	-	1	1	-	11	2	-	1	-	-	-	-	-	-	-	3	8	30.4
Elgin	Elgin Sr. High	1,725	-	-	-	-	2	-	-	-	-	1	-	1	1	-	9	-	-	-	1	-	-	1	-	-	-	2	8	30.4
Moline	Moline Man. Arts, Shop 2	1,113	-	-	-	-	1	-	-	-	-	1	-	2	1	1	11	-	-	-	-	1	-	-	-	-	-	2	8	30.4
Peoria	Peoria East High	617	-	-	1	-	1	-	-	-	-	1	-	2	1	-	3	-	-	1	-	-	-	-	-	-	-	1	8	30.4
Waukegan	Waukegan Twp., Shop 1	2,392	-	-	1	-	2	-	-	-	-	-	-	1	1	-	8	-	-	-	-	-	-	1	-	-	-	-	6	22.8
Champaign	Champaign Sr. High	996	-	-	1	-	-	-	-	-	-	-	-	1	1	-	5	-	-	-	-	1	-	-	-	-	-	1	6	22.8
	Total		2	17	42	10	67	1	22	3	14	35	5	65	42	47	588	20	6	8	10	46	18	33	3	1	1	61		

From the data of the check sheets it is believed that the amount of equipment depends more upon available funds and the activity and interest in the shops than it does on other factors. The distribution of the equipment according to the high school population, as shown in Table 20, bears out this fact in the larger schools where, obviously, one would expect greater financial backing.

In this study there were two exceptions to this rule: one school of 637 had a variety of machine tools equal to or above the larger schools; the other school of 2392 had the least variety of machines recorded. The latter case can probably be explained by the fact that it was a first year shop and that the advanced work was offered in an adjacent shop where one of the most complete and up-to-date shops of the whole study was found.

The total number of lathes, utility grinders, speed drills etc., is given in Table 20, yet in order to visualize fully their comparative importance, the reader must consult Table 21.

The rather overwhelming predominance of the engine lathe over all other machines is immediately evident. This, however, is not an unusual or unexplainable fact. In the first place, there was no shop that had less than three engine lathes and no shops that had over 25. Moreover, as it is easily understood by those engaged in this work, it is not only desirable, but also necessary, to have a sufficient number of engine lathes in the shop if a wide range of activities and experiences is to be given.

Table 21. Comparative importance of the various machine tools.

Machine	Total number of machines
Lathes, engine	********** (588)
Drill, speed	********** (67)
Grinder, utility	********** (65)
Shaper, horizontal	********** (61)
Index centers	(47)
Milling mach., Univ.	(46)
Drill press, H.D.	********** (42)
Hacksaw, power	********** (42)
Grinder, tool post	********** (35)
Arbor press	********** (33)
Grinder, cutter	********** (22)
Lathes, speed	********** (20)
Planer	********** (18)

Table 21. (Concluded)

Machine	Total number of machines
Centering machine	********** (17)
Grinder, surface	********** (14)
Drill, radial	********** (10)
Milling mach., plain	********** (10)
Milling mach., hand	******** (8)
Lathe, turret	****** (6)
Grinder, universal	***** (5)
Grinder, cylindrical	*** (3)
Punch press	*** (3)
Boring mill	** (2)
Filing machine	* (1)
Screw mach., hand	* (1)
Screw mach., aut'm	* (1)

Inclusion of other machines such as centering machine, cylindrical grinder, tool post grinder, index centers, milling machine and arbor press depends very largely on the basic machine tool, the engine lathe, because most work handled by the previously named machines passes through a "turning" stage at some time.

The seven machines that headed the list were almost universally found in the shops studied. They were the engine lathe, speed drill,

utility grinder, horizontal shaper, index centers, universal milling machine and power hacksaw. Reference to Tables 8, 9, 10 and 11 will show that the machine tool objectives of these seven machines ranked the highest in all four years of instruction.

There were a few machines in the equipment listed which are generally associated with quantity production machines, and doubt could be raised as to the advisability of investing the necessary money in such equipment, especially for industrial arts work. These machines may have a place, however, in trade classes if the work is offered on an advanced level. The milling machine has long been considered a machine tool too expensive, dangerous and difficult for the first year student, but Table 8 shows that 42 per cent of the first year shops met the machine tool objectives on the universal milling machine, 15 per cent on the hand milling machine and 10.5 per cent on the plain milling machine.

Considerable foresight has been shown, by those responsible for the selection of machine tools, in the purchase of the universal milling machine. Eighty-seven and one-half per cent of the shops listed at least one universal milling machine, and 20 per cent of the shops listed more than one.

The positions of the filing machine, the semi-automatic screw machine, the boring mill and the cylindrical grinder as shown in Table 20 are rather accurate indications of their value in industrial education laboratories. They might be termed "luxury" machines and the

expenditure for them not justifiable.

Another low ranking machine, the punch press, could now probably be considered the most dangerous machine of all listed. It is true that there are adequate safety devices to attach to this machine and make it one of extreme safety for the operator; however, its inclusion in a school shop, where the students have some freedom to move about the shop, is to be frowned upon.

The one trade instruction shop in which a punch press was included can be justified in having the machine, it is believed. The students, in their related drawing work, designed the machine and then built it in the shop. That has its value, especially for the students in the work at that time. Since the school is situated in a locality where considerable metal stamping is done in the local industries, a part of the course is devoted to the making of punch and die sets. The student then has an opportunity to test his own punch and die set and thus get the joy of producing a worthwhile tool, the craftsmen of which are in great demand today.

With the addition of heat treating to so many courses of study in machine shop work the surface grinder has taken a place in the list of machine tools, to quite a marked degree. The universal grinder is taking the place of the surface grinder in shops where both are a financial impossibility or floor space will not warrant the inclusion of both machines.

The power hacksaw was found in 38 of the shops. The two shops not having this tool included in their equipment were in schools where other adjacent machine shops had a saw and the machine was available to all shops when needed.

An attempt has been made to give a clearer conception of the comparative popularity of the machines by inserting Table 22, which shows the number and percentage of schools having at least one engine lathe, utility grinder, speed drill, etc.

It is quite probable that at this point two logical questions might arise. First, when is a shop over-equipped? Second, when is a shop under-equipped?

Ericson's (6, p. 362) opinion regarding the equipment situation in the school shop is, "A few may have all that they need, and still fewer have more than they need". Before attempting to define over-equipment and under-equipment, he states, "The question cannot be settled by making up a 'standard' list, altho such a list would be helpful". However, he gives a few general rules on which to base judgment.

A shop may be considered under-equipped when:

1. There are fewer tools than are needed to keep students busy according to a well-organized plan.
2. Special tools are so few that students must spend much time in waiting.
3. Tools are antiquated.

Table 22. The number and percentage of the 40 laboratories using each variety of machine.

Machine	No. of laboratories having at least one	Percentage of laboratories having at least one
Lathes, engine	40	100.0
Grinder, utility	40	100.0
Shaper, horizontal	39	97.5
Drill, speed	38	95.0
Hacksaw, power	38	95.0
Milling machine, universal	35	87.5
Drill press, H.D.	34	85.0
Index centers	32	80.0
Grinder, tool post	29	72.5
Press, arbor	28	70.0
Grinder, cutter	21	52.5
Planer	18	45.0
Centering machine	17	42.5
Lathes, speed	14	35.0
Grinder, surface	11	27.5
Drill, radial	10	25.0
Milling machine, plain	10	25.0
Milling machine, hand	8	20.0
Lathes, turret	6	15.0
Grinder, universal	5	12.5
Press, punch	3	7.5
Grinder, cylindrical	3	7.5
Boring mill	2	5.0
Filing machine	1	2.5
Screw machine, hand	1	2.5
Screw machine, semi-aut'm	1	2.5

4. Tools and equipment are worn out and have not been replaced.
5. The work which students may undertake must be kept more simple or less varied than should be the case because tools are not available.
6. Reasonable objectives for the course can not be attained because of limitations upon equipment and supplies.
7. Modern methods of working can not be maintained because of lack of facilities.

A shop may be considered over-equipped when:

1. Certain tools and items of equipment give evidence of being put there for show rather than for use.
2. Certain tools are installed which obviously the students can not profitably use. They are there for the instructor or for someone else.
3. Unnecessary duplication of special tools, so that a number are not used; such as an excess supply of marking-gages in woodwork, or micrometers in metalwork.
4. Certain tools or machines which are suited to production in industry, but are unnecessary or unsuited to the school shop.
5. Machines which are too costly in proportion to the training value or to the part they play in the particular course which is being taught.
6. A shop which is planned for any other than educational purposes.

According to McStay (15) school administrators are insisting that the student capacity of the industrial education class be increased on an average of 25 per cent without an increase in the floor area of the shops.

If the above requirements are going to be efficiently met by the industrial education departments, then, according to Klehm (13),

> Increase in classes will mean more careful selection and purchase of equipment and large, cumbersome machines of luxury type will be eliminated to reduce cost and preserve valuable floor space.

In considering the problem of securing equipment, Bauersfeld (3) discusses the problem from the standpoint of the large school system:

> Machine tools are generally divided by industry into three classes, "A, B and C", "A"-considered as precision machines for tool-room service, "B"-general production, and "C"-light weight, not so sturdy.....purchased where low initial cost is necessary. The "B"- tools are used in the Chicago schools. Extravagance is not excused, but the demand should be for efficient, sturdy machine tools that will give years of satisfactory use.

Since the engine lathe is far the most popular of the machine tools, it would be well to refer to the more common sizes of that machine as they were found in the survey. (In this case the size is referred to only as the "swing", or the diameter of work the machine will accommodate.)

Table 23. Number of the various sizes of engine lathes in the shops studied.

Size of lathe	No. of various sizes in shops studied	Percentage of the total of engine lathes
13"	142	24.14
14"	122	20.74
11"	91	15.47
16"	80	13.60
9"	65	11.05
15"	57	9.69
10"	23	3.91
18"	8	1.36
Total	588	

It is shown in Table 23 that 60 per cent of the 588 engine lathes found in this study were of the 11", 13" and 14" size. These machines will probably handle all work necessary for school shop instruction, and machines of these sizes would not be classes as cumbersome pieces of equipment.

Of the 16" lathes listed in Table 23, less than half were used in trade classes, and of the 18" size only half were used in trade classes. This would tend to indicate, therefore, that the larger lathes are not necessarily for use in trade training.

The last few years have seen a large influx of individual motor-driven equipment in the machine tool field.

Childs (4, p. 317) dealing with the modernizing of machine shop

equipment, condemned over-head supports, line-shafts, counter-shafts, and belting. He contended as the deficiencies of this antiquated practice, that over-head shafts and counter-shafts shut out light, cause students to lose time by belt breakage, and consume extra power. For example, "in many high school shops 10 to 50 per cent of all power consumed is used to run line-shafts, counter-shafts, and idle machines".

In the 40 shops, as is shown in Table 24, there were 1167 machine tools listed. Of this number, 1087 were machines that used some type of power drive to the equipment (this excludes the 33 arbor presses and 47 index centers). Eighty and one-half per cent, or 876 power-driven tools were equipped with individual motor-drive.

Table 24. Number and percentage of machine tools equipped with individual motor-drive.

Name of machine	No. of machines with individual motor-drive	Percentage of total machines with individual motor-drive
Drill, radial	10	100.0
Lathe, engine 9"	65	100.0
Punch press	3	100.0
Screw mach., semi-aut'm	1	100.0
Grinder, universal	5	100.0
Boring mill	2	100.0
Filing machine	1	100.0
Grinder, cylindrical	3	100.0
Grinder, tool post	34	98.6
Planer	16	88.0
Lathe, engine 16"	70	87.5
Drill, speed	58	87.0
Lathe, engine 14"	106	87.0
Grinder, surface	12	85.0
Lathe, turret	5	85.0
Lathe, engine 15"	47	84.6
Milling mach., universal	38	83.0

Table 24. (Concluded)

Name of machine		No. of machines with individual motor-drive	Percentage of total machines with individual motor-drive
Centering machine		14	82.6
Hacksaw, power		34	81.6
Shaper, horizontal		49	78.4
Grinder, utility		51	76.5
Lathe, engine	11"	69	75.0
Drill press, heavy duty		30	72.0
Milling mach., plain		7	70.0
Lathe, engine	13"	97	67.9
Grinder, cutter		15	67.5
Lathe, speed		13	65.0
Milling mach., hand		5	62.5
Lathe, engine	18"	5	62.5
Lathe, engine	10"	11	48.0
Screw mach., hand		--	--
	Total	876	

There was a time when used or rebuilt equipment was considered good enough for the school shop. Some school systems would buy used machines and rebuild them in the shop, others would buy rebuilt machines from the machinery concerns specializing in this type of equipment.

The latter practice has proved very satisfactory when dealings have been with reputable houses. This method of acquiring equipment has made it possible to equip shops for considerably less than would have been possible had new equipment been installed. The main objection to this method, however, is that this rebuilt equipment is usually of the production, cumbersome type and generally lacks the features of individual motor-drive.

The former method of acquiring additional equipment, by purchasing used machines and rebuilding them in the shops, is not to be commended at all. First, the craftsmanship necessary for such precision work is

Table 25. Number and percentage of machine tools purchased as new equipment.

Name of machine	No. of machines purchased as new equipment	Percentage of total machines purchased as new equipment
Punch press	3	100.0
Screw mach., semi-aut'm	1	100.0
Filing machine	1	100.0
Grinder, cylindrical	2	100.0
Lathe, engine 10"	22	94.0
Lathe, engine 9"	60	90.0
Lathe, engine 16"	71	88.8
Centering machine	15	88.5
Grinder, utility	59	88.5
Lathe, engine 18"	7	87.5
Grinder, surface	12	85.0
Drill, speed	56	84.0
Grinder, tool post	29	84.0
Index centers	39	83.0
Lathe, engine 15"	45	81.0
Hacksaw, power	33	79.2
Lathe, engine 14"	96	79.0
Lathe, engine 11"	71	77.4
Grinder, cutter	17	76.5
Arbor press	25	75.0
Lathe, engine 13"	104	72.8
Drill, radial	7	70.0
Lathe, speed	14	70.0
Drill press, heavy duty	29	69.6
Lathe, turret	4	68.0
Milling mach., universal	31	67.5
Milling mach., hand	5	62.5
Planer	11	60.5
Grinder, universal	3	60.0
Shaper, horizontal	36	57.6
Milling mach., plain	5	50.0
Boring mill	1	50.0
Screw mach., hand	--	--
Total	914	

not to be had in all instructors. Where you might find one capable of doing or overseeing such work you would find a great number that would not have the necessary experience. Second, many shops are not equipped to handle the rebuilding of used machines accurately and third, the student is being commercialized when his school time is spent on such activity.

In Table 25 is shown the number of machine tools that were purchased as new equipment and the percentage of the total machines thus purchased. The engine lathe data shows that at least three of every four were purchased new. Eighty-four per cent of the speed drills and tool post grinders and 79 per cent of the power hacksaws were purchased new. Nine hundred fourteen, or 77.5 per cent of the machines were purchased as new equipment. The milling machine, planer, universal grinder, horizontal shaper and boring mill all rated as those machines that were most frequently purchased as used machines.

Among the many purposes, which it is hoped this study will fulfill, is the selection of machine tool equipment and the use of that equipment to the best advantage of the younger members of our American society. America has become an industrial nation with an ever changing conception of the meaning of education. As our democracy slowly becomes applied to the social and economic phases of our national life the schools must change to bring them in unison with the new conditions. An increasing responsibility is being placed upon the public schools to train those who spend their lives in industry. Industrial education has

become a vital part of our modern school program, and if the material in this study should be of value to administrators, supervisors or industrial education instructors in planning the school life activities of our future citizens so that they become wiser consumers and producers, then it has served its purpose in a gratifying way.

SUMMARY AND CONCLUSIONS

The data gathered from 40 machine shops located in 30 Illinois high schools seem to warrant the following conclusions.

1. The experience of the instructors responding was of sufficient quality to guarantee reliable information. Eighty-five per cent of the instructors had been in their present position 10 years or more, 80 per cent had taught machine shop six years or more and 67.5 had spent six years or more in some field of industrial metal work.
2. In the 40 shops studied, 16 offered machine shop instruction as industrial arts, nine offered the work as trade training and 15 offered a combination of trade and industrial arts instruction.
3. Thirty-eight of the 40 shops offered first year machine shop instruction, 31 offered second year instruction, 13 offered third year instruction and six offered fourth year instruction.
4. Eighty per cent of the shops had at least one class per day with an enrollment over the maximum capacity of the shop equipment.

5. All first year shops spent at least 25 per cent of the time on machine work, the second year shops at least 50 per cent and the third and fourth year shops spent at least 65 per cent of the time on machine work.
6. Sixty per cent of the shops handled from 76 to 125 students per day.
7. The 90 minute (double 45 minute) period was in use in 42.5 per cent of the shops.
8. The greater percentage of the shops were either "under-equipped" or "over-enrolled".
9. The general objectives of the trade and industrial arts classes were practically the same in the respective years of instruction.
10. Most of first year machine tool objectives were met on a variety of six machines, the second and third year objectives on a variety of nine machines and the fourth year objectives were met on a variety of 11 machines.
11. The greater percentage of materials objectives of all four years of instruction were met on five different materials.
12. The greater percentage of measuring instrument objectives were met on five different instruments.
13. There was a variety of 26 different machine tools in use to varying extents, in the 40 shops studied. No one shop used the entire number, but 17 of the shops used at least 50 per cent of them.

14. A definite trend toward the purchase of new equipment for the school shop prevailed. Seventy-seven per cent of the machines had been purchased as new equipment.

15. There was a definite trend toward the use of individual motor-driven equipment. Eighty per cent of the machine tools had individual motor-drive.

16. Sixty per cent of the engine lathes were listed under 11", 13" and 14" swing.

17. There was no standard relation between the size of classes and the number of machines in the shop.

18. The high school enrollment seemed to control the amount of equipment found in the shops.

19. There was a trend toward two years of machine shop instruction in the 40 shops.

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APPENDIX

The Letter to Instructors

WOODRUFF SENIOR HIGH SCHOOL

1810 N. PERRY AVENUE

L. R. Mc DONALD
PRINCIPAL

PEORIA, ILLINOIS

January 15, 1940

Mr. Ray S. Lindenmeyer
Waukegan Township High School
Waukegan, Illinois

Dear Mr. Lindenmeyer:

I am making a study of the objectives and machine tool equipment of thirty (30) selected Illinois senior high schools.

Will you kindly indicate on the enclosed card whether or not you would be willing to help in this study by checking a three-page check sheet and returning same to me?

Your cooperation in this matter will be greatly appreciated.

Thanking you, I am

Yours truly,

(signed) O. W. Connett

PART I

THE OBJECTIVES AND MACHINE TOOL EQUIPMENT FOR MACHINE SHOP COURSES AND CLASSES IN THIRTY (30) SELECTED ILLINOIS SENIOR HIGH SCHOOLS

Note: Please answer the following questions by encircling or filling-in at the spaces provided.

PERSONAL INFORMATION

Name..... School..... Position.....

EDUCATIONAL EXPERIENCE

	Undergraduate work	Graduate work
College or University attended		
Degree received		
Major field of work		
Minor field of work		

How many years have you been in your present position?	
How many years have you taught machine shop?	

PRACTICAL EXPERIENCE

Have you ever been employed as a machinist? If so, for how many years?	
What was the nature of your work? ---A--- Repair, ---B--- Production, ---C--- Assembling, D	A, B, C, D

INFORMATION CONCERNING COURSES AND CLASSES

What is the student population of your high school?	
What is the male population of your high school?	
On what grade levels is machine shop offered in your high school?	
Is the nature of your course --A-- Industrial Arts, --B-- Trade, --C-- Combination of A and B?	A, B, C
How many periods of machine shop, per day, do you teach? Exclusive of night school.	
What is the length in minutes, of your machine shop class period?	
Do you offer machine shop as, --A-- a full year subject, --B-- a semester subject?	A, B
What is the total enrollment, under your personal supervision, in your machine shop classes? Exclusive of night school.	
Do you offer night school work in machine shop? If so how many are enrolled?	
For how many students, per class, is your shop equipped?	
What is the enrollment of your largest machine shop class?	
How many instructors are employed in your machine shop during the same period?	
What percentage of time does your first year course devote to machine work?	
What percentage of time does your second year course devote to machine work?	
What percentage of time does your third year course devote to machine work?	
What percentage of time does your fourth year course devote to machine work?	
What percentage of time does your first year course devote to bench work?	
What percentage of time does your second year course devote to bench work?	
What percentage of time does your third year course devote to bench work?	
What percentage of time does your fourth year course devote to bench work?	
What percentage of time is devoted to lectures?	
What percentage of time is devoted to class discussion?	
Do you desire a summary of the findings of this study when it is completed?	

PART II

OBJECTIVES OF MACHINE SHOP WORK

Note: The following comprise a list of some of the objectives of machine shop work in senior high schools. Place a check in the correct space to indicate in which year your course of study meets each of these objectives. Please add any other objectives to which your course is formulated and check as mentioned above.

Use back of sheet for additional objectives

GENERAL OBJECTIVES	I	II	III	IV
To develop correct habits of working with the hand tools.				
To understand and use a working drawing.				
To acquaint the student with the dangers of the machine tools and develop habits of safety therefrom.				
To acquaint the student with the possibility of future employment in the machine shop trades.				
To develop an appreciation of good workmanship.				
To instill into the student the necessity for accuracy in machine shop work.				
To acquaint the student with the processes of manufacturing standardized parts.				
To develop good habits in the care of machine shop equipment.				
To develop acceptable methods in construction of metal projects.				
To develop good taste in the design of useful and attractive metal projects.				
To afford actual experience in the proper use of the following machine tools.				
SPECIFIC OBJECTIVES				
Drill press —heavy duty—				
Drill press —speed—				
Drill press —radial—				
Centering machine				
Grinder, centerless				
Grinder, cutter				
Grinder, surface				
Grinder, tool post				
Grinder, utility				
Hacksaw, power				
Index centers				
Lathes, engine				
Lathes, speed				
Lathes, turret				
Milling machine —hand—				
Milling machine —plain—				
Milling machine —universal—				
Planer				
Press, punch				
Screw machine, automatic				
Screw machine, semi-automatic				
Shaper, horizontal				
Shaper, vertical				
To know the working qualities of the following materials				
Cast iron				
Cast steel				
Cold rolled steel				
High carbon steel				
Bronze				
Brass				
Aluminum				
To enable the student to use the following measuring instruments				
Inside calipers				
Outside calipers				
Bevel protractor				
Micrometer calipers				
Surface Gauge				

GENERAL OBJECTIVES	I	II	III	IV

SPECIFIC OBJECTIVES				

PART III

AN INVENTORY OF YOUR PRESENT MACHINE TOOL EQUIPMENT

Note: Please fill-in [check where possible] the desired information concerning your present machine tool equipment. In order to insure factual data please fill this in from your inventory sheet or while you are in the shop. If you have any machine tools that are not listed here please add them at the bottom of the list. Do not give the size of any machines other than the engine lathes.

Name of Machine Tool	Quantity	Type of drive		Check in which year of work the machine is regularly used.				Purchased as	
		Line Shaft	Ind'v'l Motor	1st	2nd	3rd	4th	New	Used
Centering machine									
Drill press [H.Duty]									
Drill, radial									
Drill, speed									
Grinder, centerless									
Grinder, cutter									
Grinder, surface									
Grinder, tool post									
Grinder, utility									
Hacksaw, power									
Index centers									
Lathes, engine									
" "									
" "									
" "									
Lathes, rivet									
Lathes, speed									
Lathes, turret									
Milling machine—hand									
Milling machine plain									
Milling machine universal									
Planer									
Press, arbor									
Press, punch									
Screw machine automatic									
Screw machine semi-automatic									
Shaper, horizontal									
Shaper, horizontal									
Shaper, vertical									

ADDITIONS

Please give the same information asked for on the above machine tools
