DESIGN AND CONSTRUCTION OF A MECHANICAL DEVICE
FOR STORING, DISPENSING, AND ACCOUNTING FOR
SMALL TOOLS AND EQUIPMENT USED IN THE
INDUSTRIAL ARTS LABORATORY

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SMALL TOOLS AND EQUIPMENT USED IN THE
INDUSTRIAL ARTS LABORATORY

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CHAPTER I

INTRODUCTION

Craftsmen appreciate the tools that make it possible for them to express themselves. They select tools with discrimination and take proper care of them. The nature, habits, and managerial ability of the industrial arts teacher are reflected in the arrangement, storage, care, dispensing, and accounting for tools and materials in his laboratory.

Industrial arts is a phase of general education in which the primary purposes are to familiarize students with the tools, products, processes and occupations of industry as well as the social and economic phenomena of the technological world in which they live and work.¹

The industrial arts laboratories are designed for large classes in which individual and group projects are planned and constructed. This type of program involves the predominance of the hand tools which necessitates the dispensing, checking, and returning of the tools hour after hour. If a healthy social relationship is to exist in the industrial arts laboratory, the problem of tool care must operate smoothly.

Wherever tools are used, the problem of tool storage and checking is present. The industrial arts laboratory is no exception. Adequate tool storage facilities are vital to an effective and efficient industrial arts program. The commonly used methods for storing and checking tools and equipment in the industrial arts laboratory are matters that appear not quite settled to the satisfaction of many industrial arts teachers.

Statement of the Problem

This is a study to design and construct a suitable and effective mechanical device for storing, dispensing, and accounting for small tools and equipment used in industrial arts laboratories.

Purpose of the Study

The purpose of this study is fivefold: first, to survey the literature in the field in order to study the different methods of checking, storing, and dispensing tools and to determine the most apparent weaknesses or disadvantages of each method; second, from this study of the literature to identify the needs of an adequate system of caring for tools in the industrial arts laboratory; third, from the information secured from this survey to design and construct a mechanical device which will improve the present systems of tool checking; fourth, to design a cabinet in which tools can
be stored and a mechanical device whereby the individual student can quickly secure a needed tool and have a record automatically made of the tool received and of the student who receives it; and fifth, to incorporate in this mechanical device a means of checking to ascertain whether all tools have been returned to their proper places.

Need for the Study

There have been and still are several different plans or methods devised for storing, dispensing, and accounting for tools used in industrial arts laboratories. The methods which have been and are being used are the following: (1) the bench tool rack, (2) complete sets of tools in kits issued to each student, (3) the bench drawer, (4) the special tool cabinet, (5) the open tool panel, and (6) the tool room. Preliminary research reveals that each of these methods has certain advantages as well as disadvantages. The efficiency of the commonly used methods for storing and checking tools is a "matter that appears not quite settled to the satisfaction of many industrial arts teachers."²

The idea or plan of having all the tools on the workbench dates back to the old cabinet-maker's bench. With this arrangement the tools are convenient to the worker and

are easily inspected and checked by the instructor. Vaughn and Mays listed the following disadvantages of the bench rack method: there is the constant danger of the tools disappearing, frequent interference of the projecting tools with the student's work at the bench, breakages of tools, and the extreme difficulty of preventing pupils from using tools from other than their own benches. 3

To avoid the random use of hand tools, the individual tool kit was found to be effective. Each student was furnished with a kit which contained the most commonly used tools. These kits were usually stored in individual drawers in the work benches or in a tool room. This method was expensive, since each student must be furnished with a set of tools, and also an excessive amount of storage space was needed.

The bench drawer or some other conveniently located compartment for tools has the advantage of convenience, since the tools can be stored at the work station. Since the tools are stored in a drawer, inspection and checking of the tools is extremely difficult. Because of this fact there is a temptation for students to dump tools into the drawer, and often the tools become damaged. 4 The tool bench drawer


4 Ibid., p. 356.
method is expensive since each work station must be furnished with a set of tools.

The tool cabinet makes it possible for the student to secure only such tools as are needed at any one time and inspection and checking by the teacher are easy. This method is less expensive than that of having a set of tools furnished to each student. The tool cabinet is more inconvenient for the students than having the tools stored at the work benches. Another disadvantage is the difficulty of issuing and accounting for the return of the tools, since the cabinet is open to all pupils, and it is difficult to hold a student clerk in charge of the cabinet responsible for the proper distribution and collection of tools.\textsuperscript{5} This method is inconvenient and lends itself to a certain amount of confusion at the time of issuing and returning tools.

The tool panel attempts to meet the problem of tool storage and checking in the same manner as the tool cabinet. The tools are accessible to students and are easily checked, but this plan lacks the element of safety provided by the tool cabinet.

For years industrial arts departments have simulated real life industrial situations through the use of tool rooms. Various objections which have been raised to the tool room

\textsuperscript{5}Ibid., pp. 354-360.
method of storing and dispensing of tools have been listed by Ericson\(^6\) as follows: the instructor has difficulty in checking the tools, and the student tool clerk cannot always check on his predecessor; the tool room clerk's responsibility to appear at his next class is greater than his responsibility to stay and check tools; tool checking is difficult because younger students are not always capable of operating the system effectively. De Forest\(^7\) stressed the fact that students mill about, pushing and shouting, at the tool room window at the time of issuing and returning tools. Grosell\(^8\) listed the disadvantages of wasted time and space and the difficulty of checking tools.

**Definition of Terms**

Some of the terms used and peculiar to this study are defined as follows:

The term "small tools" refers to those tools or instruments that are relatively small with respect to size and which are commonly used in industrial arts laboratories by students and instructors.

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\(^7\)Ray De Forest, "Central Tool Crib Versus Individual Tool Panels," *Industrial Arts and Vocational Education*, XLIII (March, 1954), 112-114.

\(^8\)Grosell, *op. cit.*, pp. 91-95.
"Tool storage" is the term used to refer to a room or cabinet in which tools are kept and from which they are taken by or issued to students.

"Accounting" as used in this study is a system which involves keeping a record with the aid of an automatic mechanical device of any and all tools checked out and returned to a given place by a student.

"Tool cabinet" as used in this study refers to a case, cabinet, or closed panel designed for storing tools commonly used in industrial arts laboratories.

"Bank" as used in this study refers to a group or series of drawers arranged together on a horizontal plane.

"Tool room" is a room equipped with racks, hooks, shelves, and the like which is designed to provide a place to keep tools.

"Tool panel" is an open panel where tools are hung.

"Storage" refers to space or place for the safe keeping of tools.

"Tools" are instruments of manual operation such as pliers, micrometers, calipers, and the like.

Method of Procedure

The proposed method of procedure is as follows: first, to study the literature in the field to determine the advantages and disadvantages of the different methods used for storing, dispensing, and accounting for tools and from this
survey to identify the features of an adequate system of
caring for tools in the industrial arts laboratory; second,
to design and construct a mechanical device which will au-
matically check the issuing and returning of tools by indi-
vidual students; and third, to make the necessary drawings
and prepare explanations concerning the design, construc-
tion, and operations involved in the use of the device.

Related Studies

Burkhiser made a study of tools and supplies storage
and issuance methods and found that no type of tool storage
and issuance was definitely adopted by a majority of teach-
ers. More than 50 per cent of the shops he surveyed had a
tool room; 82.7 per cent of these were used in conjunction
with open tool panels, cabinets, or kits. Open tool panels
were used in 54.8 per cent of the shops he surveyed. He
found that the issuance of tools was delegated in different
ways. A student in charge of checking tools in and out was
used in 32.43 per cent of his cases. The student using the
tool was responsible in 44.4 per cent of the cases. The
teacher issued the tools in 6.3 per cent of the cases.

In 1949, Scott made a study of the methods employed
by Oregon high schools in checking and maintaining shop

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9Donald M. Burkhiser, "Methods Employed in Care of Tools,
Equipment, and Supplies by Industrial Arts Teachers in Iowa,"
unpublished master's thesis, Department of Industrial Arts,
tools. The instructors in this study indicated that they favored the tool panel method of storage. The tool crib or tool room was their second choice, but quite a number of teachers preferred a combination of tool storage devices. Woodshop instructors generally preferred the wall panel. General shop men also used the panel more often than any other system. Only shops working with metals—machine shops, auto-mechanics shops, or sheet metal shops—favored the tool room.

Quite a few instructors contemplated changing the methods of storage and checking tools. Some stated they planned to change from cribs to panels, others from panels to cribs; still others thought they would use student tool-checkers and make use of tool checks. Many of the teachers were of the opinion that the machine-tool and auto-mechanics shops which use many small and easily damaged tools needed a close check, and this would be possible only through the establishment of tool rooms with a full-time attendant and numbered tool checks. Others thought too many locks and too close checking might show negative results.

Most of the tool checking in smaller schools was done by the instructor. Students were more often given that responsibility in the larger schools. Students did more checking

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where the tool panel was used. The instructor checked more
where the tool room or tool crib was used.

Whatever plan was used by a certain teacher was usually
because he believed that particular plan was more efficient
for his teaching conditions or because he believed that fewer
tools were lost. Very few of the teachers made any mention
of the educational or training values for the pupils.

The groups of instructors from the smaller and medium-
sized high schools indicated that they did not use tool con-
trol as a medium of instruction. Instructors of the larger
schools gave more consideration to the educational value of
tool checking. One such group thought there was instruc-
tional value in their method of tool storage and checking.
The main educational value attributed was concerned with
responsibility and concern for community property.

The interviews and comments on questionnaires gave many
comments on the use of student management. Student manage-
ment of tool-checking and of other phases of the shop program
was recommended as a means of developing responsibility,
trustworthiness, and a democratic feeling among the students.

No group of teachers considered any system of tool con-
trol as foolproof. One instructor found the "tool room and
tool checks" satisfactory, whereas his neighbor tried the
same set-up with poor results. One teacher in a larger
school could perhaps use free and open tool panels with
student organization for checking, whereas another small
country high school with a different set of students and
with a janitor or patron problem found that system impos-
sible.\textsuperscript{11}

In 1952, David Harvey King made a study of tools and
supplies storage methods in the State of Illinois.\textsuperscript{12} He
found that many opinions had been given by various people
as to which type of tool storage was best. If it can be
assumed that the teachers were using the type of storage
they preferred, it can be concluded that the type used most
was also the best. It was shown that 43.1 per cent of the
teachers in this study preferred the area tool panel which
can be closed and locked. Individual tool rooms were pre-
ferred by 25.7 per cent. Individual tool kits were pre-
ferred by only 3 per cent. Many of this number were mechan-
ical drawing teachers.

There was much discussion as to the merits of having a
student clerk in the tool room. Some believed it a waste of
a student tool clerk's time and some felt it a waste of
class time to have the students stand in line to check out
tools at the beginning and to check them in at the end of
the class. It was shown that 53.8 per cent preferred free

\textsuperscript{11}\textit{Ibid.}, pp. 43-61.

\textsuperscript{12}David Harvey King, "Tool and Supplies Storage and
Issuance Methods," unpublished master's thesis, Department
of Industrial Arts, Illinois State Normal University,
access to the tool panel, and 36.8 per cent preferred the tool room clerk. Free access to the tool room was preferred by 6 per cent of the teachers.

The "honor system" was preferred by 57.6 per cent. Metal tags were preferred by 29.6 per cent. Honor system and slips of paper for special tools were preferred by three persons.

King summarized his findings as follows:

1. The area tool panel which can be closed and locked was preferred by 43 per cent of the respondents. The individual tool room was preferred by one-fourth of the respondents.

2. Free access to the tool panel was the preferred method of tool issuance.

3. The tools of each shop or area were preferred to be identified by different colors.

4. Fifty per cent of the respondents indicated that a silhouette painted on the wall in contrasting color was the preferred method of labeling tool positions.

5. Fifty-seven per cent of the respondents indicated that the honor system was the preferred method of tool out identification.

9. A panel for the accessories of each machine was the preferred method of machine accessory storage.

10. Sixty per cent of the respondents preferred to keep classes until tools had been checked for loss and damage although this would cause them to be late to their next class.\(^\text{13}\)

In planning tool storage facilities for industrial arts shops it would appear that one should use the area tool panel which can be closed and locked. This method was recommended by Hill who stated that "systems using tool panels are

\(^{13}\text{Ibid.}, p. 60.$
generally more economical of time than those using tool rooms." This study indicated that students should have free access to the tool panels and each student should be responsible for the tools he used. This gave the teacher an opportunity to attain such industrial arts objectives as orderly performance, cooperative attitudes, and appreciation.

Research revealed that several studies have been made concerning the storage, dispensing, and accounting for tools, equipment, and materials used in the industrial arts department. It was found, however, after examining the studies that they were concerned chiefly with methods, and no study was found in which reference was made to designing and utilizing mechanical aids for the storage, dispensing, and accounting for tools and equipment. As a result of this, additional reading in current professional and industrial literature was done to ascertain if possible to what extent, if any, industry was using mechanical devices. Although no specific reference or study was found that was directly related to this, several reports and articles were found concerning the progress being made in the use of

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15 King, op. cit., pp. 45-64.
mechanical devices, sometimes referred to as automatic.
This in turn involves the concept of automation and some of
the implications for education. A summary of some of these
articles and reports is given below.

The National Conference of Professors of Educational
Administration met recently, and one of the important items
in their discussion was meeting the needs of students in a
rapidly changing world. They recognized the fact that we
are living in a period in which the greatest rapidity of
change the world has ever known is occurring. Technologi-
cal advancement is probably the most outstanding of these
changes. The conference developed some conclusions of which
school people must be cognizant. The following is from
their report:

The conference recognizes:
1. That the processes of automation will develop
   rapidly and continuously.
2. That automation will accelerate presently
   evolving social trends and stimulate others.
3. That automation will automatically bring about
   vast change in man's habits and will require
   a great change in the way he spends his time.
4. That automation and its impact on man and his
   world requires that society reaffirm and empha-
   size its belief in human values.
5. That the school's responsibility for the edu-
   cation of people is greatly increased, and at
   the same time is given additional opportunity
   to discharge those responsibilities effec-
   tively.16

16 "What the National Conference of Professors of Edu-
   cational Administration Believe," School Executive, LXXVI
   (December, 1956), 64.
The industrial arts curriculum has contributions to make in this fast changing world. Tischler stated that in industrial arts

... Certain areas may have to be added and some removed from the curriculum. ... Many of us can see some changes are necessary in curriculum or course outlines. Some changes would mean new projects or experiments to some, while others may have to add new information. ...

In the hands of teachers are the powers behind the system of automation. How well the digital computer functions, or how many new techniques can be devised to cut production time are all by-products of the teacher's main production item. Pure academic teachers and industrial arts teachers share in the responsibility of maintaining an efficient production line.

Where is the model shop in our educational system? Why, of course, it's industrial arts. The academic teacher drills and grinds into the product all kinds of information which is most important for him to understand, but the final modeling is left up to the industrial arts teacher. In the laboratory, the arts teacher explains in great detail the concepts poured into the product, and permits the product to show some ability to operate in a controlled environmental condition. ...

If under laboratory tests the product does not perform as the designers planned it, it is usually left up to the model shop to suggest changes.

The model shop or industrial-arts shop, as we know it, offers man the opportunity to understand and work with materials he will use in future occupations.

... In industrial arts, one learns that a place exists for everyone on some level. Our products, whom we call our boys, learn that ours is a competitive enterprise and each one must perform to his utmost to secure a desirable position in society. To perform to his utmost means to strive to meet life's perplexities and to make suitable adjustments.

To meet the challenge of the era of automation, we, as teachers, must remain broad in
concept, and be willing to make adjustments when necessary.\footnote{17}

Fischer suggests that automation has definite implications for schools.

A possible effect of automation upon schools, centers about the problem of technological change. \ldots That the schools will be called upon for some part of this task seems inevitable. \ldots Whatever new forces or conditions the schools will have to face, children will still need to master the basic skills. \ldots But the ways people use their time and some of the specific competencies required of them are certain to change. Traditional approaches will be questioned and new elements will be added to school programs.

Another whole group of questions affecting the curriculum centers about the relationship of general education to specialized instruction and the wise balancing of the two. Vocational schools will need to adapt their programs to produce young men not only versed in the fundamental skills of their crafts, but prepared so thoroughly that they will be able to make creative and imaginative adjustments to the rapidly shifting industrial scene.

\ldots In a period of rapid change, it is essential that the teacher understand deeply the world he lives in, its effects on his pupils, and the role of education as the great mediating force between the environment and the growing individual.\footnote{18}

In a recent article by Norman Harris concerning automation and its implications for education, he stated as follows:

\ldots What kind of education will the new era demand? What sort of graduate will be most successful? It is certainly too early to discern

\footnote{17}{Morris Tischler, "Automation and Industrial Arts," \textit{Industrial Arts and Vocational Education}, XLV (January, 1956), 3-4.}

\footnote{18}{John H. Fischer, "Automation - Implications for Schools," \textit{School Executive}, LXXVI (December, 1956), 66.}
clearly the final pattern of employment which automation will bring, but certain broad outlines appear to be emerging.

... It is for the educator to recognize, however, that educational and training patterns as now organized in most secondary schools are not well suited to either the 'crystal balls' of the coming era.

... Certainly one signpost can be seen clearly. Appearing upon it in bold relief is the directive that our graduates must be educationally more nimble than ever before. They must be able to adjust to dislocation unemployment and rapidly learn the new skills which a new job demands. ...

Industrial arts departments, and trade and industrial departments, have a vital responsibility in the age of automation. It is from these curriculums that the vast majority of industrial workers and tradesmen come. The time honored trades and crafts will still be needed--machinists, welders, carpenters, electricians, mechanics and machine operators--but the workers will do things in new ways with new machines. No school program can possibly train all the trades on all the machines, or all the skills which will be needed. Here again we see the need for educational flexibility. ...

Automation holds the promise of a brighter future for us all. Industrialists and businessmen are studying its potentials for research, production, marketing, and finance. Labor union leaders are keenly aware of the problems it may pose for some segments of their membership. Political and government leaders are sensitive to its implications for the national welfare and for national defense. Certainly, educators can do no less than to keep themselves well informed on automation, for ours is the biggest concern of all.\(^{19}\)

According to Harris it is the responsibility of the schools, and particularly of industrial arts teachers, to explore the concept of automation in order to adjust the curriculum. Although it is commonly accepted, it is not

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\(^{19}\) Norman Harris, "Jack Be Nimble!" \textit{Phi Delta Kappan}, XXXVII (February, 1956), 211-216.
the responsibility of the schools to train tradesmen. It is
their responsibility to help each individual to acquire the
knowledge necessary for him to understand the society in
which he lives.

In discussing the problems of life related to the changes
brought about by automation, Gerbracht and Scholfield believe
industrial arts has a definite responsibility in educating
students and stated as follows:

It is clear that industrial arts teachers have
a dual responsibility: (1) imparting the avocational,
artistic, and creative skills in the handicrafts, and
(2) developing an understanding of the industrial basis
of our society through a combination of technical
knowledge and skill combined with abstract reason-
ing. . . .

It is equally clear that industrial arts educa-
tion, with its unique concern with both the indus-
trial process and the handicraft skills, is in a po-
sition to play an important role in preparing the
student to meet the challenges of life in a rapidly
changing society. On the one hand, we can help the
individual to understand what is happening as auto-
mation alters his way of life; and on the other, we
can aid him in his desire to retain worthwhile crea-
tive and artistic values in the face of these inevi-
table changes.20

As industry develops, educational leaders need to be
prepared to interpret, communicate, and use information in
a wide variety of fields. Data will not be enough; many de-
cisions involving school policy need to be determined. Al-
ready the industrialist, the labor leader, the economist,

20Carl Gebracht and Frank A. Scholfield, "And the Prob-
lems of Life Related to These Changes," Industrial Arts and
Vocational Education, XLVI (April, 1957), 113-114.
and the sociologist are faced with the problems related to automation. Leaders in education must keep abreast of what is going on in industry and use new approaches and add new phases to the school program.
CHAPTER II

METHODS OR PLANS USED FOR STORING, DISPENSING,
AND ACCOUNTING FOR TOOLS

"The care, adjustment and sharpening of tools is a fundamental part of shop instruction."¹ There is more or less agreement on this point, although some industrial arts teachers believe that the teacher's concern is each pupil, not each tool, each process, or each material.

Storing, dispensing, and accounting for tools are important items that deserve the most careful consideration in the industrial arts laboratory. The managerial ability of the industrial arts teacher is reflected in the arrangement and orderliness of his laboratory. There are different plans which have been developed and are in common use to varying degrees concerning storing, dispensing, and accounting for tools in the industrial arts laboratories.

The Student Tool Kit

A school of trades and industries was established in Moscow, Russia, in 1830. "By Imperial decree of June 1, 1868 this school was reorganized and raised to the rank of the

leading polytechnic schools of Europe."\(^2\) This school was the
Imperial Technical School. One of the underlying principles
in the development of these polytechnic schools was the
Russian system of manual training which provided that "each
shop is equipped with as many working places and sets of
tools as there are pupils to receive instruction at one time."\(^3\)

In the Russian system each bench or working place for a
single pupil was provided with a set of tools, kept in a
well-lighted closet, with a wire netting in front, so that
the tools could be easily examined. Each tool closet was
provided with a lock and key. At the close of a lesson, each
pupil was expected to lock his tool closet and deposit the
key in a closet provided for that purpose. This closet was
made with a netting door and contained a hook for each key.
The bench sets did not contain all the tools necessary for
some of the work; consequently, a few extra tools for common
use were placed on a board in the shop. Each tool on this
board was numbered; its place on the board was also numbered.
Any tool taken from this board was to be returned by the
pupil as soon as he had completed his work with it, or at
least as early as the close of the day's work in the shop.

\(^2\) John D. Runkle, The Manual Element in Education, Forty-
Fifth Annual Report of the Massachusetts Board of Education
(Boston, 1881), p. 135.

\(^3\) Charles Alpheus Bennett, History of Manual and Indus-
trial Education (Peoria, 1937), p. 17.
In every shop there was a board upon which was fastened one of the regular bench sets of tools with the name of each tool on the board in large letters. ⁴

Some of the early records of tool storage are given in an account of the educational sloyd developed by Salomon in the Scandinavian countries. Concerning the tool equipment, Salomon said:

The best plan of all is to furnish each child with a separate set of tools, so that each individual may keep them in order, keep them sharp, and return them to their proper places when done with. This plan is, of course, difficult to carry out where it is necessary to study great economy. If it cannot be done, it is important that the whole class be provided with sufficient tools, so that the children are not kept waiting for each other. ⁵

An outstanding feature concerning the educational sloyd of Salomon was that it provided experience with a large variety of tools. "The tools were the smallest sizes of standard tools used by adult workers."⁶ The knife was the principal tool used in the early part of the course in the educational sloyd.

Concerning the place for keeping the tools, the most satisfactory plan was said to be to keep them in cupboards where each tool had a definite place. The teacher, at a

⁴Ibid., pp. 18-19.


glance, could see if any tool was missing. This was also true when tools were arranged in racks along the wall instead of in cupboards, as was the case in many sloyd rooms. Otto Salomon said concerning the tool cupboard that

It is so arranged that every tool has a fixed, easily observed place, in order that the absence of any may be readily discovered when the tools are laid past. Tools must be further so arranged that when one is taken out another is not displaced, and all sharp edges must be protected.  

In early English and other European manual training schools, kits and cabinets were used to store the tools. Bennett said "it [the Kennington Road center] contained two rows of double benches with a row of double tool racks between them. The extra tools were in a wall cabinet."  

This method was carried into the early American schools. Kits for tools are still in evidence. Articles in professional magazines refer to this method of checking tools. In describing the Mooseheart Woodworking Shop, Brandt stated as follows:

Individual tool equipment is complete and of the best quality. Because it is desirable to limit the use of individual tools to one boy per each section, and to provide an efficient method for tool care and constant checking of these tools, and because conventional methods were found inadequate, a specially designed tool box was developed for this purpose. The box provides space or a compartment for every individual tool. The toolbox was left

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7Bennett, op. cit., p. 77.

8Ibid., p. 25.
open at the bottom to insure cleanliness. The use of this toolbox entailed the development of a storage cabinet in the toolroom and a compartment in the bench.

This cabinet makes possible the quick delivery of toolboxes at the beginning of class periods and for their thorough checking and return to the cabinet at the end of each shop period.9

Ericson's statement on the use of the individual tool kit shows that its use avoids some of the difficulties coming from the random use of tools. He stated as follows:

To furnish each student with a few most necessary individual tools for his own use and keeping is an excellent practice. Such sets of tools may be kept in individual drawers in work benches, or may be fitted into pigeon holes in a case on the wall or in the tool room. Such sets are most effective in woodwork, automotive work, and in other shops where success depends greatly upon the availability and condition of a few smaller tools.10

Although tools may not hold the all-important position in industrial arts that was assigned to them in theloyd schools, still a definite relationship exists between the boy and his tools. Struck said that "the superior instructor teaches pupils to value and love good tools; he impressed upon them the fact that they will be judged to a large extent by the way they keep their tools."11


10E. Emanuel Ericson, Teaching the Industrial Arts (Peoria, 1956), p. 110.

The Tool Bench Rack

The idea of having all the tools on the bench, especially in woodworking, was present in the earliest efforts in manual training and appears to have held its place quite steadily even in the shops of today. This arrangement of tools dates back to the old cabinet maker's bench before the advent of manual training, when the question of accommodating several people at different times with the same set of tools never, or very seldom, arose.

This arrangement of tools against an upright support on the bench was a familiar one. It has some advantages in that the tools are convenient to the worker, and they are easily inspected and checked by the instructor at the close of the class. In the minds of many the disadvantages of the bench rack outweigh the advantages.

Unless a laboratory is under lock or guard, there is the danger of the tools disappearing by theft or by the practice which many people in a school and community have of stepping into the shop and "borrowing" a tool for some purpose. Another disadvantage of the bench rack arrangement was the frequent interference of the projecting tools with pupils' handling of their materials about the benches, especially in connection with larger pieces of work. There were also certain breakages of tools due to this arrangement. One of the more common complaints made against this plan was the extreme
difficulty of preventing pupils from using tools from other than their own benches, in spite of the fact that the tools were properly marked. The ease with which tools may be taken from the benches and used by those to whom tools were not assigned made it quite difficult for a pupil working at a certain bench to be assured of the exclusive use of that particular set of tools. Thus it was possible that a student was held responsible for other pupils' misuse of his tools, especially when such misuse occurred when he was away from his bench.12

Another way in which students might be assigned a set of tools was to use an individual panel in conjunction with the tool room. The principle here was to have the board arranged so that it could be hooked on the end of the bench at the work station. It was checked out to the student and inspected for breakage or loss when the student returned it.

The Tool Bench Drawer

A procedure commonly used in the industrial arts laboratory is to assign the commonly used tools to each pupil at the beginning of the semester. These tools he keeps in a locker or bench drawer, and the tool room issues only special tools and appliances.13


The use of the cabinet bench with its drawer or other compartment for tools marked a great advance over the open bench rack. It has the advantage of convenience. There is greater security against theft and also the indiscriminate use of the tools by students at other benches. The bench top is left free from obstruction for the student in his work.

The drawer method is not favored as it is difficult to check, and it collects dust, shavings, and other debris. Another disadvantage of this method is the difficulty of securing the tools in such a manner that they will not damage each other. Also, there is the temptation for the student to throw the tools into the drawer, since he realizes inspection and checking up are difficult under this arrangement. Thus a careful student may leave his tools in the drawer all sharp and in order to find another student had left them in disorder.\(^{14}\)

The Tool Room

For years, industrial arts departments have attempted to simulate real life industrial situations through the use of the tool room. This tool storage arrangement requires a separate room with a checking window. In industry it is usually referred to as a "tool crib." This room may be built

\(^{14}\)Vaughn and Mays, *op. cit.*, p. 356.
up with a system of shelves and bins, or the tools may be displayed on boards or panels on the walls of the room. There has been a sentiment in favor of the tool room, especially since the prices of tools have been increasing so rapidly; the feeling has spread that useless duplication of tools should be eliminated. Such elimination of duplication of tools can be safely recommended only when the equipment has been made immediately accessible to one common storeroom and so organized and supervised that there will be no idle tools out in the benches for any considerable length of time. In this way one tool may serve the needs of several pupils.\(^{15}\)

The tool room plan places the responsibility for a tool upon the individual checking it out of the tool room. It furnishes protection against theft and against the indiscriminate use and misuse of tools by students, since it is not accessible to them. The individual in charge of the room for any given period of time may be held responsible for the tools and their conditions when he issues them from the tool room through the checking system.

Struck suggested that the following principles should receive consideration when tool rooms are being set up: tool room should be centrally located and should be open to inspection from the shop floor so that the instructor can see

\(^{15}\text{Ibid.}, \text{ p. 354.}\)
what is going on at all times. Ventilation and natural lighting should be as good as possible, and tools should be arranged so as to facilitate easy handling and checking.  

When shop organization is patterned after organization in industry, one department is the tool room. Hargrave described the duties of the tool room keeper as follows:

Most of the tools are kept in the tool room with a "tool room keeper" in charge. The boy is required to learn the names of all the tools, to keep the tools cleaned, oiled, and in good order. He must see that no tool is returned in a dirty or damaged condition. He must keep the tool room in order, sweeping the floor at the close of the period. As each workman wants a tool, he applies for it through the tool room keeper and hands in a check marked with his number. The checks are made with metal rimmed tags, stamped with a certain number for each pupil. The tool room keeper hands out the tool to the applicant and hangs the check in its place. Thus we can tell who is using the missing tool and in case of loss or breakage we charge the user with the tool and take the amount out of his deposit money. The tool room keeper is personally responsible for the proper return of all tools at the close of the period.

Various schemes have been worked out for the care of the tools and the tool room. The most common plan is to organize each class of students in such a way that each student takes his turn at being the keeper or clerk of the tool room for a definite time. One difficulty with this plan, however, is

16 Theodore Struck, Methods and Teaching Problems in Industrial Education (New York, 1929), p. 75.

17 George M. Hargrave, "Organization in the Wood Shop," Industrial Arts and Vocational Education, III (January, 1915), 92-93.
that unless each student devotes the necessary time to this particular duty, he will not know the system and the locations of the tools well enough to issue and account for the various tools in an efficient manner. If he spends sufficient time to gain the knowledge and skill necessary for the proper handling of the tool room, it may require too great a portion of his laboratory time and thus interfere with his progress in the course.

The tool room does have some arguments in its favor, one of which is its use in the commercial shops of industry. If a small room near the industrial arts laboratory is available, it makes a very good tool room. Shelving or other devices for storage of the tools must be provided, and a checking system must be carefully developed and used.

If there is no room available, some industrial arts teachers have worked out a solution to the problem by enclosing a small corner of the industrial arts laboratory and placing a counter and extending heavy wire from the counter to the ceiling. A window is provided for transaction of the business of checking tools in and out as the needs of the students demand. Such a tool room may be built with a very small outlay of money and time.

A common tool room may be maintained where two or more shops are strategically placed. In large schools where several shops are located so they can be served by one tool
room, the central tool room has been used. In this arrangement one tool room serves several industrial arts laboratories, such as machine work, woodworking, automotive, and others. The main objection to this type of central tool room is that the necessary organization for storing, dispensing, and accounting for tools becomes too complicated to handle efficiently. A paid tool room clerk must be hired in order to efficiently dispense tools, and this adds to the cost of laboratory operation. Student clerks may assist, but they encounter difficulty in handling this complicated system where many tools are combined in the central tool room.18

The separate tool room for each shop is the most common arrangement. The individual tool room is generally preferred by teachers because responsibility is fixed upon each teacher. It is easier to place responsibility for lost tools, because fewer students are using the tools; pride in proper condition of tools and tool room is more easily maintained and less opportunity is given for using tools for wrong purposes.

Often in the larger industrial arts setups, administrators and instructors favor the tool room because of the following reasons:

Responsibility for its condition is fixed upon each individual instructor; it is easier to place responsibility for lost tools because fewer

18Ericson, op. cit., pp. 105-106.
students are using the equipment; pride in proper condition of tools and tool room is more easily maintained—woodworking students caring little for metal working tools, and vice versa; less opportunity is offered for using tools for wrong purposes, such as checking out machinist's calipers for the woodturning lathe and the like. 19

Newkirk said that "the centralized tool room is a good method of caring for tools in the general shop." He describes the tool room as having the tools on panels on the walls of the room but not with the idea of free access by the students. "All hand tools are neatly arranged on a panel in the tool room and the students exchange a tool tag for the tool or tools needed. When the student has finished with the tool, it is returned and the tag taken down and given to the student." 20

De Forest listed some of the difficulties encountered in the tool room system of checking tools as follows:

With the larger enrollment in the classes, difficulties were encountered with this system. This was partly due to confusion at clean up time and partly to the number of tools checked out. The result was that inevitably some of the small tools were missing or overlooked. Thus over a period of time the stock of hand tools was rapidly becoming depleted, a demoralizing situation to both instructor and students. . . .

. . . demands of students for immediate service at the tool crib window, carelessness in cleaning or counting the tools checked out, borrowing other student's tools on the tool crib window shelf and leaving without waiting to see that proper credit was given, bluffing and arguing

19 Ibid., p. 106.

20 Newkirk, op. cit., p. 110.
with the instructor and other students, maintaining that the tools were turned in when they were not, blaming others for tool shortages, etc. Some students naturally took advantage of the situation when the instructor was in the opposite end of the room to borrow other student's tools when they were not looking, turn in the tools before the regular clean-up time, hide in secluded spots, etc.  

Ericson listed various objections which have been raised by teachers to the tool room method of storing and dispensing and also to the practice of using a tool clerk, whether paid or otherwise. Some of these objections are as follows:

1. The tool room is usually so arranged that many tools are not visible; hence the instructor cannot readily check up on the tool clerk, and the tool clerk cannot check on his predecessor.

2. If a paid tool room man is used, it is hard to find one who is honest or energetic enough to keep the room in good condition. The instructors lose the opportunity for close checking, and are relieved of individual responsibility.

3. If the student clerk is used, his responsibility to appear at his next class is greater than that to stay and locate tools. The "unwritten law" among high school boys keeps him from telling the instructor who has missing tools even if he knew.

4. It becomes a "game" among the boys to see who can beat the system. Some of them are quite successful in spite of tool clerks.

5. Students are not generally interested in the tool room job, and consequently do not use up extra energy in making it a success.

6. Young boys are not able, though they be interested, to keep a checking system in perfect running order.\textsuperscript{22}

Grossel listed some of the disadvantages of the tool room system of checking tools as follows: valuable floor space is wasted; valuable working time is wasted; complications restrict efficiency; student clerks lose valuable class time; and tool checking is difficult. He also stated that "regardless of arguments against tool rooms, they are feasible in certain school shop situations, one of which is shops where expensive, delicate, and precision equipment is used."\textsuperscript{23}

**Checking Tools**

Industry makes use of a tool checker and checks, and many schools have initiated such a plan. A tool checker will usually be found in the tool room setup. His duties are to check to see that all tools are in place on their respective panels at the beginning of the class, to get replacements if tools are misplaced or sent out for repair, to secure new hacksaw blades, coping saw blades, and the like from the supply foreman and see that they are replaced, to question and report any misuse of a tool, to check out and in the loan tools, to check the tool panels

\textsuperscript{22}Ericson, op. cit., pp. 108-109.

\textsuperscript{23}E. Milton Grossel, "Tool Storage in the School Shop," Industrial Arts and Vocational Education, XLIII (March, 1953), 91-95.
to see that all tools are accounted for and are in place
at the end of the period, and to file a report of breakage,
damage, or missing tools to the record foreman each day.

**Marking the Tools**

In any arrangement of tools, there must be a system of
marking by which any tool may be easily and accurately
designated and identified. Vaughn and Mays suggest some
simple methods for tool identification. They are:

Identification marks for tools should be so
made as to render them very difficult to change.
Perhaps the best method is the stamping of figures
onto the metal parts of the tools. This can easily
be done on the shanks of bits, the socket parts of
chisels, the backs of hack saws, etc., where the
metal has not been highly tempered. Another method
is the use of acid or corrosive ink with which to
number or letter the tools. Having the tools
marked, it is easy to work out a system of checks
or receipt cards for the students to use in secur-
ing tools from the tool room clerk. Even with the
bench tool rack arrangement, it is necessary to
have the tools marked. The marks usually agree
with or in some manner relate to the markings or
numbers of the benches.24

**Use of Metal Tags**

In any system of tool checking some system of fixing re-
sponsibility for the prompt return of tools in good condi-
tion should be devised. There are two widely practiced meth-
ods of insuring a check on tools. One is to issue to each
pupil a certain number of metal tokens or disks with a number

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stamped on them. This is the number assigned to the student. When he wants to secure a certain tool from the tool room of the general panel, he hangs one of the metal disks on a hook which is located over the place on the panel from which he takes the tool. Thus at all times there must be a tool on every holder on the panel or a disk just over the holder which indicates who has the tool if it is missing from the panel.

Newkirk and Stoddard have described a tool checking system which uses the metal tags as follows:

The checking system is really an arrangement problem and is equally important. A tag system is quite satisfactory. Each pupil is given six tin tags stamped with his shop number. For example, if a pupil’s shop number is 5, each of his six tags will bear the number 5. Six tags for each pupil are suggested because experience has shown that six are ample, while four usually suffice. The tags may be of any shape but should be of convenient size.

A 1/4" hole should be punched near the edge of each tag so that it can be hung on a nail without difficulty. Use 28 gauge sheet metal. In practice it is well to have a small cabinet in which the tags may be suspended in the correct order.

When a pupil is ready to go to work he goes to the tag cabinet and withdraws his six tags. To take a tool from a cabinet he simply takes down the tool and hangs one of his tags in its place. At the end of the period, the pupil takes down his tags, hangs up the tools in their proper places, and returns the tags to their proper place in the tag cabinet. This method has been used successfully from the sixth grade to the graduate student classes.25

Use of Requisition Slips

Another procedure for checking tools is to require the pupil to fill out a requisition slip or card on which there is a printed list of available tools in the tool room. The pupil signs his name or number and checks the tool he wishes to draw. This card or slip is filed by the tool room clerk and returned to the student when the tool is returned. 26

There are various other similar schemes also used; some are rather elaborate and time consuming, but whatever the scheme used, it is important to have some effective method of keeping a close check on tools taken from the panel or withdrawn from the tool room. Even in classes that are so small that the teacher can easily keep track of all tools without a special system of checking, some system should be used if only for its training value in developing the habit of systematic orderly procedures in the industrial arts laboratory.

The Tool Cabinet

Ericson states that,

The tool case with doors is simply another form of tool room, with the difference that when it is opened all the tools are exposed to view and easily checked. While it is possible to have a tool clerk for this case, and it is sometimes

26Mays and Casberg, op. cit., pp. 93-95.
done, it is customary to apply the honor system and to allow each student to remove and replace the tools as needed.27

In some industrial arts laboratories the tools are kept in locked cabinets. They are issued to the student by the instructor or a student clerk. This method has a number of disadvantages in that it is not accessible to students in the laboratory; it is not economical of teacher or student time; there is no possibility of educational value of tool selection or responsibility; limited storage space limits tools, and there is an increased tendency on the part of students to "beat the game."

Vaughn and Mays discuss advantages and disadvantages of the tool cabinet. They are as follows:

The tool cabinet meets in a very satisfactory way some of the objections raised to the other methods of caring for the tools. It leaves the bench top free for the pupil's work; it furnishes an element of safety; it makes possible for the pupils to secure only such tools as are needed at any one time; and it renders the teacher's inspection and checking up easy. The disadvantages are the elements of inconvenience; the impossibility of organizing the matter of issuing and returning of the tools, since the cabinet is presumably accessible to all pupils; and the consequent difficulty of holding a keper of the cabinet responsible for the proper distribution and collection of tools.28


28Vaughn and Mays, op. cit., p. 359.
The Tool Panel

One of the trends in school shop planning and organization is the increasing use of tool storage cabinets and tool panels. Some of their advantages are as follows: they make possible a more effective use of floor space; they tend to eliminate long, congested waiting lines; they eliminate the need for full-time tool room clerks during the entire class period; they simplify tool arrangement and facilitate ease in tool checking. Storing tools in the laboratory near the work stations increases effectiveness and efficiency in the industrial arts program. The tools should be stored as near to where they are to be used as possible.

Mays and Casberg described the use of tool panels as follows:

In most small schools all extra tools, that is, all tools except those kept at each work station in the shop, are kept on a tool panel conveniently located on one of the walls of the shop. The size of the panel and the number of tools kept on it depend on the number and variety of tools supplied as permanent equipment. For example, in a woodshop the tools such as planes, tri-squares, rules, chisels, mallets, and the like are usually provided for each bench and are either locked up in a drawer under the bench or kept in a rack at the back of the bench. Tools which are only occasionally used, such as turning saws, wood files, hammers, handsaws, gauges, and the like are kept on a general tool panel at the end or side of the room.

The allocation of tools either to individual work stations or to general panels is a matter determined by the nature of the courses of study,
the size of classes, and the amount of money available for equipment... By a careful study of the tool requirements of the course of study it is often possible to decrease the number of individual tools and increase the variety of general panel tools, thereby greatly reducing the total amount expended for tools.29

Miner, of Ohio University, believes the use of tool panels has been very successful and has listed criteria for use in evaluating tool storage.

The criteria for good tool storage are: first, a place provided for every tool; second, an opportunity for keeping the tools clean, sharp, and usable; third, tools accessible to the one who wishes to use them.

Better than either of the previously noted methods is the tool panel which is openly situated in the shop, where the student has access to the tools when he needs them. There is a time saving over the tool room plan. The open panel should display the tools in as functional a manner as possible. Systematic placing, outlining, designating and if possible an illustration of the most common uses of each tool should be aimed at. The outstanding advantage of this method is that it is valuable as a teaching aid in tool usage, good housekeeping, and tool care. A well arranged panel, painted attractively, is an asset to any shop.30

The Connecticut State Department of Education recommends that "tools be localized near areas to be served and stored in cabinets or on special panels. Tool cribs are generally not recommended."31

29Mays and Casberg, op. cit., pp. 93-96.


The National Council on School House Construction recommends that "where several shops are located together, tool and supply centers may be located and designed to serve adjoining shops. It is highly desirable to decentralize tool storage for those tools that normally are used in particular locations by installing tool panels in these locations." 32

Tool panels stationed in work areas are more practical than a central tool panel. Concerning this Miner stated:

A combination of tool panel and tool cabinet is often desirable. It combines the ready accessibility to tools with the protective feature of safe storage. A cabinet that cannot be secured is not a practical one and neither is a secure cabinet that is not within the reach of the tool users. . . . Hinged doors are so arranged that they will open to display a wide variety of tools.

The tool cabinet is not of a standard size or shape. Each shop represents a different situation and tool problems which may require different sized and shaped cabinets. The shop may require more than one panel. If more than one are used, they may be placed in such a manner that the opened doors display a continuous panel. 33

The matter of arranging the tools on the panel presents some problems. "The plan of painting silhouettes of tools on wall boards or on supporting panels, upon which they are kept when not in use, meets with much favor, as one can tell at a glance what kind of tool is missing in case it is not replaced at the end of the period." 34

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33 Miner, op. cit., pp. 7-8.
Regarding tool panels, Miner made the following statements:

Tool arrangement within the panel should be done with certain objectives in view. First, all tools of the same type should be kept together. Second, the tools most in use should be placed in a cabinet where they will be most easily accessible. Third, the tools should be placed in such a manner that they will not appear to take up much space. Of course, it is also important that tools be not placed too close together.

Individual tools present special problems. It is important, for the sake of safety, to place sharp edged tools below the eye level of the students. Thus, if any tools fall they are not likely to injure anyone about the head. Place tools with cutting edges in such a way that they will not be blunted or damaged by carelessness in handling tools in or near the cabinet.35

Vaughn and Mays described a tool wall board, which is a variation of the tool panel, as follows:

The tool wall board arrangement of handling tools has probably not become so common as some of the other practices. Some very successful teachers have used this method with satisfaction. It is simply a large board attached to the wall, or in some cases, the wall itself on which the tools are fastened by hooks, cleats, or other devices. Occasionally one finds simply a large table with inclined top on which compartments have been constructed for the planes, hammers, etc. This scheme attempts to meet the problem in the same manner as the cabinet except that it lacks the element of safety provided by the cabinet.36

De Forest, upon changing to the use of the individual tool panels after using the central tool crib, discussed the advantages of its use.

35Miner, op. cit., p. 10.

36Vaughn and Mays, op. cit., p. 358.
After several months of use of the individual tool panel system, results have been most gratifying. Many of the anticipated difficulties did not develop at all and the attitude and morale of both students and instructor have been raised immensely. Instead of the usual milling about, pushing, and shouting that formerly took place at the tool crib window at the beginning of the period, comparatively quiet conditions prevail.37

Another variation of the tool panel is the "dolly panel." This plan increases the accessibility of tools by placing the panels on wheels so that they can be moved about the laboratory to the different work stations in the laboratory. Ericson finds another advantage in the use of the "dolly panel," in that "it is possible to put such a rack on rollers so that, if desirable, it can be removed into a separate room for safekeeping at least during vacation time."38

The principal advantages of the tool panels are accessibility, easier housekeeping and tool care, tools do not get dumped into a drawer or bin, and an attractive tool panel can be an addition to a shop.

The tool panel does have some distinct disadvantages in that it is open to anyone in the laboratory; it is difficult to place responsibility for return of the tools; and there is need for constant checking. Miner has cited some disadvantages of the tool panel as follows:

37De Forest, op. cit., pp. 112-114.
38Ericson, op. cit., p. 110.
Certain disadvantages should be noted, however. There is less check on tools under this system. Should there be pilferers in the class, the panel will serve as a means by which they can get at the tools. Careless pupils will be more likely to leave their tools on the benches when class is finished if there is not any check on the returns. Moreover, there is no adequate means by which to deny anyone access to the panel on entering the shop.\(^3^9\)

Summary

There have been and still are several different plans in common use designed for storing, dispensing, and accounting for tools in the industrial arts laboratory. The plans most often found show the tools on the bench tool rack, in a special kit issued to each student or in a bench drawer, in a special tool cabinet, on an open tool panel, or in a tool room. Each method has its advantages as well as its disadvantages.

In the Imperial Technical School in Russia a kit of hand tools was furnished to each pupil. These kits were stored in an individual closet. Otto Salomon of Sweden approved of this plan, but because of the expense of the individual sets of tools recommended the use of a tool cabinet for storing sufficient tools to be issued to the class as they were needed.

The bench tool rack was used in many of the early school shops. It has the advantage of the tools being convenient to

\(^3^9\text{Miner, op. cit., p. 7.}\)
the work station and being easily checked by the instructor. Since the tools are stored on an open rack on the bench, there is the problem of having the tools disappear. They are too convenient for a person who steps into the shop to "borrow" a tool. The bench rack arrangement interferes with the easy handling of a project, and there is the difficulty of preventing students from using tools from other than their own benches. A student working at a particular bench cannot be assured of the exclusive use of the tools stored at his bench, and yet he is often held responsible for the tools from his bench which are used by other students.

The tool drawer has the advantage of convenience, since the tools are stored in the bench. It gives greater security against theft, and the bench top is free for materials and tools needed by the student. With this method it is difficult to secure the tools in the drawer so that they will not damage each other. The drawer is not favored as it is difficult to check, and it collects dust, shavings, and other debris. Then there is the temptation for the student to dump the tools into the drawer in a disorderly manner. Inspection and check-up are very difficult under this arrangement. A careful student may leave the tools in good order, only to find them confused by another less careful student assigned to the same bench at a different class period.
The tool cabinet is still in common use. This arrangement makes it possible to work with a minimum number of tools. The instructor must check constantly to see that no tools are missing. The amount of storage space in the cabinet limits the number of tools which can be stored in it. Also, it is practically impossible to organize the matter of issuing and returning the tools, since the storage cabinet is accessible to all students.

The tool room has probably been used more universally than any other method of tool storage. As the price of tools has increased, it has been felt that duplication of tools should be eliminated. This elimination of tools can be recommended only when the tools can be made accessible to a common store room and so organized and supervised that there will be no idle tools out in the benches for any length of time. In this way one tool may serve the needs of several students. In the tool room system the responsibility for a certain tool is placed upon the student who checks it out. There is a number of disadvantages in the use of the tool room. Since the tool arrangement is often such that many tools are not visible, the instructor cannot easily check on the tool room clerk, and there appears to be no satisfactory method whereby the tool clerk can check on his predecessor. If a student is used for checking tools, his obligation to appear at his next class is greater than his obligation to
stay and complete the checking. There is an "unwritten law" among students which prevents the student from telling the instructor who has the missing tools, even if he knows. It becomes a game among some boys to see who can beat the system. Students are not generally interested in the tool room job, and young boys are not able, even though they are interested, to keep the checking system in good order. Students lose class time in checking tools. Wilber stated that "the assigning of a student to check tools in and out can hardly be justified from an educational standpoint." 40

The tool panel has some distinct disadvantages in that it is open to anyone in the laboratory and it is difficult to place responsibility for the return of tools. There is less check on tools under this system, and if there should be pilferers in class, they have easy access to the tool panel. Careless students are more apt to leave their tools on the benches when the classes are finished. There is no adequate means to deny anyone access to the panel on entering the shop.

40Gordon O. Wilber, Industrial Arts in General Education (Scranton, 1948), pp. 294-295.
CHAPTER III

AN AUTOMATIC TOOL CHECKING DEVICE

In Chapter II information was presented concerning six methods or plans that have been devised and used, to varying degrees, for storing, dispensing, and accounting for small tools and materials used in industrial arts laboratories. These methods or plans were as follows: the individual kit of tools, the bench tool rack, the tool drawer, the tool cabinet, the tool room, and the tool panel.

Each of the aforementioned methods has certain advantages as well as disadvantages, and some of the latter plans are much improved over the earlier plans. After studying the literature and the opinions of persons concerned with storing, dispensing, and accounting for small tools and materials, it was found that there are four features that are desirable and essential in any workable plan designed to accomplish effectively the storing, dispensing, and accounting for small tools. These desirable features are as follows: first, the plan or method should provide a definite place for each small tool that is to be checked in and out for use by the student; second, the plan should be so designed that the individual student can secure the needed tool from a given place without the assistance of his instructor or a
fellow student; third, the plan should provide some method for accounting for each tool checked in and out by a student which would be accurate and "foolproof"; and fourth, the system should be so designed that the instructor can check, with a minimum of effort and time, at the close of each class period to determine whether or not all the tools have been returned to their proper places. These four features were used in designing and constructing a mechanical device for storing, dispensing, and accounting for small tools and equipment.

Based upon the premise that there should be a place for each tool used by students in the industrial arts laboratory, a cabinet was first constructed. This cabinet was constructed of wood and was 25 1/2 inches wide, 23 inches deep, and 45 inches high. (See Fig. 1 which shows an oblique view of the cabinet.)

Sixty drawers were constructed, each of which was 1 1/2 inches in width, 5 inches in depth, and 15 3/4 inches in length. These drawers were arranged in the cabinet in six rows or banks. The sides and bottom of each drawer were constructed of 28 gauge sheet metal in order to provide a maximum amount of inside space. Each drawer was constructed in such a way that a cradle or rack could be designed and inserted in each drawer to receive or hold each individual tool or part of a set of tools. (See Fig. 3.) Each drawer
was recessed into the cabinet one-eighth of an inch in order to make it more difficult to open the drawer when it was locked.

A mechanical device was designed and constructed which incorporated the following features: first, when each drawer is closed, it is automatically locked; second, a student wishing to check out a tool can select the needed tool and secure it without the aid of his instructor or fellow student; third, a record is made of each tool checked out by each student; and fourth, the instructor can check the tool cabinet in a minimum of time at any time to ascertain which tools, if any, are out of the cabinet and if any tools are out of the cabinet, which student removed the tool from its assigned place.

As previously stated, the tools were placed in designated drawers which were arranged in banks and identified as A, B, C, D, E, and F, as shown in Fig. 1. The tools, or tool, contained in each drawer are indicated by name and number on each drawer. For example, if a student wishes to use a micrometer located in drawer No. 5 of bank B, he would follow this procedure: the student would push forward a lever mounted on the right side of the cabinet (see Fig. 1, Part No. 1) which in turn makes a connection with the selection bar (Fig. 1, Part No. 9) located at the back of the cabinet and a selection knob (Fig. 1, Part No. 2)
mounted on the front of the cabinet. The student then turns the selection knob until the pointer rests on a letter indicating the bank B. Then the lever is pulled back; this in turn disengages the selection bar from the selection knob.

A second knob (Fig. 1, Part No. 3) is turned counterclockwise until the pointer rests on the figure 5 stamped on a metal dial which is the number of the drawer which contains the micrometer. At this point the student inserts into the key slot a key which has been issued to him and which contains a designated number. (See Fig. 1, Part No. 10 for further details concerning the key slot.) The student presses down on a lever (Fig. 1, Part No. 7) and turns the lever one-half turn clockwise; this procedure unlocks the master shaft. A handle (Fig. 1, Part No. 8) is then turned counterclockwise as far as possible and this causes drawer number 5 to open. When the handle is returned to its original position, the key which was inserted is released and returned to a container mounted on the outside of the cabinet (Fig. 1, Part No. 11). The student may then remove the tool from the drawer, and the drawer is left open until the tool is returned to the drawer by the student.

When the student places the key issued to him in the slot and turns the handle which opens the drawer, a record is made on a paper tape showing the number of the key that was used to open the cabinet and the number of the tool that was removed from a given bank and drawer.
At the close of each class period, the instructor can make a final check by turning a switch to ascertain whether or not each tool removed during the class period has been returned (Fig. 1, Part No. 4). If each tool has not been returned to its proper place and the drawer closed, a light is automatically turned on when the switch is turned, indicating the exact drawer from which a tool is missing.

A more detailed account and explanation of how each part of the mechanical device is constructed and how it operates will be presented.

Selecting a Bank

The first operation involved in selecting a designated bank in which certain tools are located is to push a lever (Fig. 1, Part No. 1) forward which forces a floating sleeve (Fig. 4, Part No. 66) forward and connects it with a slotted collar (Fig. 4, Part No. 67). This makes a direct connection between the knob designed for selecting the banks (Fig. 1, Part No. 2) and a gear which rotates the selection bar (Fig. 4, Part No. 9). The selection bar may be rotated to the position desired and is retained in this position by a friction catch which engages a slotted collar (Fig. 4, Part No. 67). The lever (Fig. 1, Part No. 1), which is also a part of Part No. 1A, as shown in Fig. 4, is pulled back and disconnects the floating sleeve from the slotted collar.
The manipulation of this part of the mechanical device just described concerning the selection of a given bank is necessary before the mechanism designed to open a designated drawer can be operated.

Selecting and Opening a Designated Drawer

In order to operate the mechanism with respect to selecting and opening a designated drawer, the following explanation is given: the knob (Fig. 1, Part No. 3), designed and used to select the individual drawers or tools, is turned until the pointer rests on the number of the tool desired. This knob (Fig. 1, Part No. 3) is connected to a wheel (Fig. 6, Part No. 54) by a shaft (Fig. 6, Part No. 53), and as the wheel rotates, it pulls the selection bar assembly (Fig. 6, Part No. 27) across the back of the cabinet utilizing a cable (Fig. 6, Part No. 55). A catch (Fig. 6, Part No. 56) was designed to engage a pin on the wheel which retains the selection bar in alignment with the drawer catch (Fig. 3, Part No. 60). When the cross rod is raised, as described in the section on unlocking a tool drawer, page 56, it raises the selection bar on which is mounted a projection (Fig. 3, Part No. 61) which releases the drawer catch, and the drawer is moved forward by a push rod.

When the cross rod is raised, the end of a bar (Fig. 6, Part No. 58) slides under a part designated as No. 59 in
Figure 6 and with a downward thrust forces the catch (Fig. 6, Part No. 56) to release the pin and allow the wheel (Fig. 6, Part No. 54) previously described to turn by the force of a spring pulling the selection bar back across the cabinet to its original position.

Unlocking the Device

A key was designed and made for use in unlocking the device (Fig. 11, Part No. 6). The key is inserted into a cylinder through a slot which is revolved mechanically one-half turn. The lower end of the key protrudes through the cylinder and engages the end of a right angle lever (Fig. 11, Part No. 16) and moves it away from the cylinder and through a linkage which connects to a lock (Fig. 2, Parts No. 16 and No. 17), moves the catch back, which in turn releases a lever (Fig. 2, Part No. 18), making it free to revolve. The lever (Fig. 8, Part No. 18) is rotated by a handle (Fig. 2, Part No. 8) until it engages a catch (Fig. 8, Part No. 24). When the catch (Fig. 8, Part No. 24) is moved forward by being engaged by the lever (Fig. 8, Part No. 18), the tool drawer is unlocked.

The Secondary Lock

In order for a student to unlock a selected tool drawer and for the device to operate as it was designed, a secondary locking device was constructed and installed. The handle
(Fig. 2, Part No. 8) is revolved to the left as far as possible and then returned to its original position. For this purpose a ratchet wheel (Fig. 9, Part No. 19) was fastened to the master shaft (Fig. 2, Part No. 14). To operate the secondary lock the ratchet wheel (Fig. 9, Part No. 19) revolves with the master shaft (Fig. 2, Part No. 14) until a pin (Fig. 9, Part No. 72) strikes a rocker arm (Fig. 9, Part No. 21) and releases the catch on the pawl (Fig. 9, Part No. 20). The pawl engages the teeth on the ratchet wheel which permits the shaft (Fig. 2, Part No. 14) to be revolved in the reverse direction until the master shaft is revolved manually by turning the handle (Fig. 2, Part No. 8) to the original position. As the pin (Fig. 9, Part No. 72) is revolved back to its extreme position, it strikes the other end of the rocker arm (Fig. 9, Part No. 21) and forces the pawl (Fig. 9, Part No. 20) away from the ratchet wheel (Fig. 9, Part No. 19) and retains it in position, thus freeing the shaft (Fig. 2, Part No. 14) so it can be revolved in the opposite direction again. This secondary lock guards against the possibility of the handle (Fig. 2, Part No. 8) being oscillated back and forth which would upset the operation of the device.

Unlocking the Tool Drawer

The unlocking of the tool drawer is as follows: the lever (Fig. 1, Part No. 1) is pushed forward, and then a
knob (Fig. 1, Part No. 2) is turned until the pointer rests on the bank desired and the lever is pulled back. The knob (Fig. 1, Part No. 3) is now turned until the pointer rests on the number of the tool desired. The key is inserted and the device unlocked. The handle (Fig. 1, Part No. 8) is turned counterclockwise until the lever (Fig. 8, Part No. 18) engages a catch (Fig. 8, Part No. 24). The catch is forced forward, which actuates an angle lever (Fig. 5, Part No. 25). The angle lever is pivoted at "x" so that when the lever is moved forward, the cross bar (Fig. 5, Part No. 26) is raised. When the cross bar (Fig. 7, Part No. 26) is raised, the selection bar assembly (Fig. 7, Part No. 27) is also raised. The projection (Fig. 3, Part No. 61) on the selection bar (Fig. 3, Part No. 9) rests under the drawer catch (Fig. 3, Part No. 60), and as the selection bar (Fig. 3, Part No. 9) is raised, it springs the catch which unlocks the drawer. As the drawer catch is raised, it compresses the spring on the push rod (Fig. 3, Part No. 62), and when the drawer is unlatched, it is forced open by the spring.

Recording Mechanism and Its Operation

When a drawer bank is being selected, the knob (Fig. 1, Part No. 2) is turned until the pointer is on the letter of the desired bank; this action also turns a shaft (Fig. 4, Part No. 47) which revolves a sprocket wheel (Fig. 4, Part
No. 46). A second sprocket wheel (Fig. 4, Part No. 45) is the same size and is connected to the first sprocket wheel (Fig. 4, Part No. 46) by a sprocket chain which causes it to revolve in conjunction with the second sprocket wheel.

Raised letters are placed on a wheel (Fig. 4, Part No. 44) which is fastened to the second sprocket wheel (Fig. 4, Part No. 45), and when the pointer on the knob (Fig. 1, Part No. 2) comes to rest on the letter selected on the metal plate, the letter mounted on the wheel (Fig. 4, Part No. 44) is synchronized so that it strikes the printing pad (Fig. 10, Part No. 41).

When a certain tool drawer is selected, the knob (Fig. 1, Part No. 3) is rotated until the pointer rests on the number desired. A wheel mounted on a shaft (Fig. 6, Part No. 53) which is connected to the knob (Fig. 1, Part No. 3) is revolved when the knob is turned. A steel cable is attached to a second pulley (Fig. 6, Part No. 51) which is mounted on a shaft (Fig. 6, Part No. 53), and the turning action of the shaft causes it to travel a definite distance. The steel cable is run through a system of pulley wheels and attached to the hub of another wheel (Fig. 4, Part No. 49) which is revolved by turning the knob (Fig. 1, Part No. 3). On the wheel (Fig. 4, Part No. 49) there are mounted ten raised figures which correspond to the numbers of the tool drawers, and as the pointer on the knob (Fig. 1, Part No. 3)
comes to rest on a selected number, the corresponding number on the wheel (Fig. 4, Part No. 49) is synchronized so that when it comes to rest it will come into contact with a printing pad (Fig. 10, Part No. 41).

The number on the key previously mentioned and described (Fig. 11, Part No. 6) is printed by the following operations: the key is placed in the key slot which delivers it to the key cylinder (Fig. 11, Part No. 15), and the cylinder is turned one-half turn clockwise by the action of a lever (Fig. 1, Part No. 7). The cylinder is held in this position by a friction catch (Fig. 11, Part No. 31). The cylinder and key are moved into position so that the number on the key will contact the printing pad (Fig. 10, Part No. 42) by the action of a cam (Fig. 2, Part No. 29) which moves an assembly (Fig. 2, Part No. 28) a definite distance and places the number on the key in position to print the number.

The printing operation takes place when the handle (Fig. 1, Part No. 8) is turned counterclockwise. A gear mounted on a shaft (Fig. 2, Part No. 14) is engaged with a gear (Fig. 10, Part No. 33) and causes the cam (Fig. 10, Part No. 34) to rotate against two flat rectangular plates (Fig. 10, Parts No. 41 and No. 42) which force the printing pads against the letter of the drawer bank, the number of the tool, and the number on the key. The figures are pressed
against carbon paper which rides over the paper to be printed, as shown in Figure 10. The handle is reversed and returned to its original position, which causes a reverse action on the cam and releases the pressure on the paper.

The paper is drawn through by an assembly actuated by a cam (Fig. 10, Part No. 36) which is connected to a second cam (Fig. 10, Part No. 34). When the action on the cam (Fig. 10, Part No. 34) is reversed, the cam (Fig. 10, Part No. 36) causes the lever (Fig. 10, Part No. 35) to move. This action on the lever (Fig. 10, Part No. 35) forces a pawl (Fig. 10, Part No. 37) which is attached to the end of the lever against a notched wheel (Fig. 10, Part No. 38) which is attached to the rubber cylinder (Fig. 10, Part No. 39) to revolve a predetermined distance and causes the paper to move with it. When this operation is repeated, the pawl (Fig. 10, Part No. 37) engages another tooth on the notched wheel each time.

The cylinder (Fig. 10, Part No. 40) places pressure on the paper holding it against the rubber surface of the cylinder (Fig. 10, Part No. 39) which furnishes sufficient grip on the paper to pull it through. The printed paper enters a closed and locked case and is accessible to the instructor when he wishes to check the record of all transactions or tools checked out.
The Key Return

The key (Fig. 11, Part No. 6) is inserted into a slot which delivers it to the cylinder (Fig. 11, Part No. 15). After the key is placed in the cylinder, the key and the cylinder are revolved one half turn which places the figure on the key in position to be moved forward by the action of a cam (Fig. 2, Part No. 29) on the master shaft (Fig. 2, Part No. 28). The assembly (Fig. 2, Part No. 28) moves the key (Fig. 11, Part No. 6) into position to print the key's identifying number upon a strip of paper. When the cam action is reversed, the key assembly is returned to its original position through the action of a spring. The end of the key which protrudes through the end of the cylinder strikes the end of the angle lever (Fig. 11, Part No. 16) as it returns and forces a catch (Fig. 11, Part No. 30) to disengage and allow the cylinder (Fig. 11, Part No. 15) to rotate to its original position through spring action.

The next step is to release the key. The key is released by a lever (Fig. 11, Part No. 22) which pivots at point "0" on the releasing bar. This lever is moved through the action of a second lever (Fig. 7, Part No. 23) which is actuated by the return of the selection bar underneath. As the second lever (Fig. 7, Part No. 23) is contacted by the selection bar assembly (Fig. 7, Part No. 27), the key is released and drops through a chute into a container mounted on the outside of the cabinet.
Checking for Unreturned Tools

An auxiliary device was designed and constructed in such a way that if a tool is not returned, it may be detected quickly. This auxiliary device was constructed and operates as follows: when a tool is placed in the drawer in a cradle designed to receive each particular tool and the drawer is closed, the tool operates a lever switch (Fig. 3, Part No. 64) which breaks an electrical contact at a designated point, "Y". If the tool is missing and the drawer is closed the lever switch makes a contact at point "Y" and when the switch (Fig. 3, Part No. 4) is closed, a light automatically comes on (Fig. 3, Part No. 12). This switch is shown in Figure 1, Part No. 4. The switch is actually a multiple switch, and as it is turned, it checks each bank of drawers. If a light comes on as the switch is turned, this indicates that a certain tool is missing from a particular bank and drawer. As previously described, a record has been made of the removal of each tool, and this record may be checked to see who was the last pupil to check the tool out and who, therefore, is responsible for its return.

This chapter has presented a description of the cabinet which was designed and constructed for storing, dispensing, and accounting for tools in the industrial arts laboratory. The desirable characteristics of tool storage, dispensing, and accounting, as revealed from a review of the literature,
were incorporated into the construction and design of this cabinet. A description, including drawings, of the cabinet and its mechanical operation was given.
CHAPTER IV

SUMMARY, FINDINGS, AND RECOMMENDATIONS

Summary

The purpose of this study is fivefold: first, to survey the literature in the field to study the different methods of checking, storing, dispensing, and accounting for tools used in industrial arts laboratories to determine the most apparent weaknesses or disadvantages, if any, of each method; second, from this survey of the literature to identify desirable characteristics of an adequate system for storing, dispensing, and accounting for tools in the industrial arts laboratory; third, from the findings of the review of the literature to design and construct a mechanical device which will improve the present systems of tool storage, dispensing, and accounting; fourth, to design a cabinet where tools are stored and some mechanical device whereby the student, individually, can secure the needed tools, automatically make a record of the tool received and of the student who receives it; and fifth, to incorporate in this mechanical device a means of checking when all tools have been returned to their proper places.

A survey of the literature in the field was made to study the different methods of checking, storing, dispensing,
and accounting for tools and to determine weaknesses or disadvantages of the different methods. It was found that there have been several different methods in use in industrial arts laboratories for checking tools to students, such as the individual tool kit, the bench tool rack, the individual tool drawer, the tool room, the open tool panel, and the tool cabinet.

The practice of supplying each student with a full kit of tools began with the Russian system. This system was convenient in that each student had the needed tools and was individually responsible for their care. This method was expensive, since each student had a complete set of tools, some of which he seldom used. The amount of storage space needed in this system was great, and since the tools were in a kit, they could not be systematically checked.

An early method of tool storage was the tool bench rack. This was patterned after the cabinet maker's bench which had the tools at each work station. This method was convenient, but because of certain weaknesses did not adapt itself to the industrial arts laboratory. The disadvantages of the tool bench rack method were that the tools were accessible to anyone who entered the shop; the rack was an obstruction when larger projects were handled at the bench; tools were easily damaged and lost; and placing responsibility for tools was difficult.
The tool bench drawer was convenient for use in the industrial arts laboratory in that the tools were at the work station. This method was expensive since each work station had a complete set of tools. The students using the bench drawer had a tendency to dump tools into the drawer at the close of the class period, since they could not be readily checked. A student was often held responsible for carelessness and misuse of tools by another pupil.

The tool room method was patterned after industry and is widely used in industrial arts laboratories today. In this method a student can have experience with a variety of tools, as one tool can serve the needs of several students. Adapting the tool room method to the industrial arts situation presents problems that have not been solved to the satisfaction of many industrial arts teachers. An instructor or a tool room clerk is necessary for issuing, checking, and accounting for tools in order to place responsibility for the return of the tools. The tools are located at a distance from the work station, and student time is lost in securing a needed tool. Also, there is confusion at the time of issuing and returning tools. Checking is difficult and students, generally, are not interested in the tool checking job.

The present trend in tool storage is the use of the tool panel. The tool panel is located at or near centers of
activity, and tools are readily accessible. An attractive tool panel adds to the appearance of the industrial arts laboratory. This method has a number of disadvantages since the tools are accessible to anyone who enters the shop; the tools are easily checked, but an instructor must constantly check to see that the tools are in order; it is difficult to place responsibility for tool care.

A modification of the tool panel is the tool cabinet which can be closed and locked. Tools are usually issued from this cabinet in a manner similar to the tool room; a student tool clerk or the instructor usually checks. The tool cabinet furnishes an element of safety. Students secure only those tools needed at any one time. This method is inconvenient as it is difficult to organize the matter of issuing and returning tools, since the students have free access to the cabinet once it is unlocked. It is difficult to hold a student clerk responsible for the distribution and collection of tools.

Related studies conducted by Burkhisier,1 Scott,2 and King3 indicating current practices in methods of issuing, checking, and accounting for tools were reviewed. The study by Burkhisier revealed that tool cabinets and kits were

1Burkhisier, op. cit., pp. 1-19.
2Scott, op. cit., pp. 48-49.
3King, op. cit., pp. 12, 63.
preferred and that tool rooms were second in order of preference. The studies by Scott and King indicated that instructors of industrial arts favored the tool panel which could be closed and locked and that tool rooms were in second place. A few instructors favored free access to tools by students.

These studies indicated that instructors were not satisfied with the present methods of accounting for tools and many of them contemplated changing their present system. The studies suggest that shops where there were small and easily damaged tools needed a tool room and a tool clerk to issue tools to students. These studies further reveal that students did more checking when the tool panel was used and that the instructor checked more often in the tool room method. Instructors checked tools more often in smaller schools and students checked more often in larger schools. No group of teachers considered any system of tool control as "foolproof." No particular method was recommended as the best by any group of instructors.

Findings

Industrial arts teachers and other educators recognize the fact that industrial arts has a contribution to make in the education of students to adjust to changing conditions and that automation has definite implications for schools.

From a survey of the literature it was found that none of the methods for storing, dispensing, and accounting for
or checking tools in the industrial arts laboratory appeared to be quite satisfactory to most industrial arts teachers. Some important considerations recommended in regard to tool storage, dispensing, and checking are as follows: providing the minimum amount of tools, safety, economy of space, efficient arrangement, a simple method for checking and placing responsibility, ease of issuing and checking, and provisions for additional space for the addition of tools in the future.

Using the aforementioned considerations or desirable features as guides, a mechanical device was designed, constructed, and tested which possesses the following features.

1. A cabinet was designed and constructed which would involve a minimum amount of floor space in that it is only 25\(\frac{1}{2}\) inches wide, 23 inches deep, and 45 inches high. The cabinet contains six banks with ten drawers per bank, or a total of sixty drawers, which can be used for storing small tools.

2. The drawers are locked and automatically opened through the synchronization of a series of mechanisms, one of which is a specially designed key which will contain different numbers when made in quantities so that each student would be issued a key.

3. A printed record is made of each tool removed and the number of the key used in opening the cabinet.
4. An auxiliary device was designed and constructed so an instructor can check the cabinet at any time by turning a switch to determine whether all tools are in their proper places, and if a light automatically comes on, this indicates the exact bank and drawer from which a tool is missing.

Recommendations

Based upon this study the following recommendations are made: first, that further study and experimentation be continued in an effort to improve the mechanical device; and second, that industrial arts teachers should include as many mechanical and automatic devices as possible in industrial arts laboratories in order to provide learning experiences for the students that will give them a better understanding of industry.
Fig. 1--Pictorial drawing of cabinet
Fig. 2--Top view of cabinet showing locking and recording mechanism.
Fig. 3--Tool drawer showing tool cradle, drawer lock, and checking mechanism.
Fig. 4--Bank selector and printing device
Fig. 5--Side view of cabinet with portion cut away.
Fig. 6--Selection bar and operating mechanism
Fig. 7--Selection bar assembly and lever actuating key return.
Fig. 8--Primary locking device

Fig. 9--Secondary locking device
Fig. 10--Printing mechanism
Fig. 11--Key cylinder assembly
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