



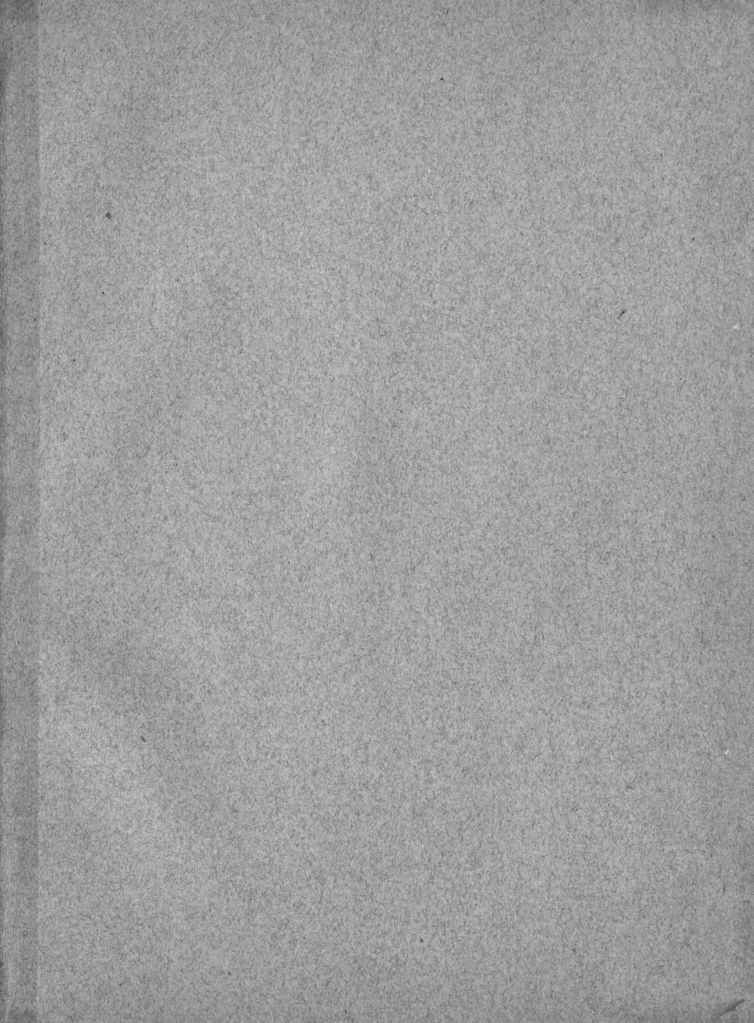
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REPORT
PROPOSED SYSTEM
OF ORGANIZATION FOR THE
POLYFUEL ENGINE CO.

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Fay Sydney Reynolds
Frederick William Spletstoser

1921

Engineering-Management





PROPOSED SYSTEM OF ORGANIZATION,
for
THE POLYFUEL ENGINE CO.

A REPORT SUBMITTED
to
THE FACULTY
MICHIGAN AGRICULTURAL COLLEGE
by

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Candidates for the Degree of
Bachelor of Science.

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THESIS



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INTRODUCTION

The total wealth that any people can create is governed primarily by two factors; the natural resources of the country that they inhabit, and the tools of production, both mental and physical, which they possess for developing these resources.

Thus, savages living in a rich and fertile territory do not rise above the level permitted by their tools of production, while nations with comparatively small resources may easily occupy a foremost position among civilized people because of their highly developed industrial processes and organizations.

In order to have an efficient organization it is necessary to have efficient factory routine. Factory routine is the custom and practices which guide and direct the men in their work. It produces desired results only when it accomplishes the work in the least amount of time and with the least expenditure of energy. The forces of competition are so strong at the present time that any organization having a routine which is lax in any respect and not based upon a thorough analysis of its business will not reap full profits and possibly suffer failure. Therefore, it behooves every organization to adopt its routine only after a thorough study and careful analysis of its particular problems.

Factory routine covers a very broad field and can be

divided primarily into two divisions; manufacturing and selling. Of these two, manufacturing is all important to the Industrial Engineer for he is concerned only with the manufacturing and not the selling of the product. Therefore, it becomes our problem in this Report to devise a system, whereby the product can be produced at the lowest possible cost. In devising a method for manufacturing we must consider two important problems; that of producing and that of cost accounting. Production depends upon two things; the equipment and the Human Being. The equipment once procured, becomes a stable fixture, whereas the Human Being once procured, may easily become dissatisfied and therefore his length of stay is indeterminable. This fact has become so disturbing to production routine that it has long since become policy to place the problem of employment in the hands of an employment man, thus leaving the production man free to concentrate all of his thoughts and efforts to production matters only.

It has become a recognized fact that the proper selection of employees results in better satisfied and more efficient workman. Proper choosing of employees constitutes in itself a big problem. A large organization can profitably carry out an elaborate system of selecting their employees. The size of our organization at the start will not warrant any such elaborate system. However, we have deemed it advisable at this time to make a study of Scientific Employment for future use.

In short the object of this Thesis is to propose a method of carrying on production, keeping of factory cost and employ-

ment records, and a discussion on scientific employment.

The Polyfuel Engine Company is a mythical organization formed for and by the members of the first Class in Industrial Engineering at Michigan Agricultural College. The purpose of the course is for the study of factory organization, planning, and supervision. The product "manufactured" is a one and one-half horse power Hvid type internal combustion engine.

At the time of this writing, all designs for the engine have been completed. One engine has been built and is in operating condition. However, the engine is undergoing certain stages of perfection. When this development work has been completed, it is the intention of the Mechanical Engineering Department to manufacture the engine by production methods, all of the work being performed by student members of the engineering college, supervised by the members of the Industrial Management class.

Up to the present time our articles of incorporation and by-laws for the Polyfuel Engine Company have been drawn up and accepted, Board of Directors chosen, officers elected and standard practices and instructions for all executives discussed and approved. Our location and site decided upon, plans for our factory with reference to our present needs and future growth made, choice of machines and necessary equipment completed, operations on all parts decided upon. In fact every thing lies in readiness for the realization of

our plans with the exception of the necessary technique and forms for the actual operation of the Polyfuel Engine Company.

In view of these facts, we have undertaken, that may really be deemed a completion of the work thus far carried on by our Industrial Management class.

A REPORT
of a
PROPOSED SYSTEM OF FORMS
for carrying on
PRODUCTION
in the
POLYFUEL ENGINE COMPANY

In this section of the Report the equipment for handling production on a more or less scientific basis will be described in considerable detail. By equipment we mean the necessary forms to handle routing, scheduling, dispatching, costkeeping and employment.

Routing is the inclusive term which refers to that division of the Planning Department that has to do with the analysis of orders, the requisition of material, the provision of operation cards and instruction sheets, and, in general, the arrangements of all details both informative and material that are required for the actual accomplishment of the work.

Scheduling defines that part of the Planning Department activities that has to do with the assignment of the work to the machine in the sequence or distribution required. It also should present the status of the production or process goods by means of some suitable form of control mechanism which will reflect the condition and at the same time indicate dates of completion.

Dispatching refers to that part of the work of the Planning Department which authorizes or initiates the start of actual operation and the start of the successive completing processes

Cost Keeping is taken care of in the Planning Department and has to do with recording all direct and indirect factory cost. A good Cost System should contain all forms

necessary to keep the actual cost of the product. It is not sufficient to know that the factory is paying as a whole, especially when competition is strong in a special line. With a good Cost System the Manager can keep himself informed regarding Shop Operations as they progress and can often avert losses and difficulties instead of waiting until the work is finished, when remedy will come too late.

Employment is taken care of in the Planning Department, and has to do with the employing of all men. The employment manager keeps a directory of all employees, while at work, and this record is kept on file after the employee leaves the employment of the factory.

The foregoing five functions interlace to a certain extent, and it is necessary for the smooth running of the machinery of the Planning Department to have a complete set of forms to take care of the factory routine.

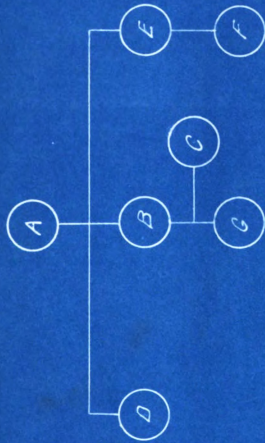
On the following pages are found all the necessary forms that we proposed to use in the mythical plant of the Polyfuel Engine Company. The forms are grouped according to the departments in which they originate. A drawing of the forms along with its complete description is given. The forms themselves are all of standard sizes, and we think that they would take care of the entire production of an engine, similiar to the one proposed to be manufactured by the Polyfuel Engine Company.

Preceding the forms, is given a chart of authority of all the officials who are concerned with these forms.

Another chart is given showing the routine of orders and material, this is self explanatory as it shows the path of orders, and the transfer of materials. These charts are given in order to clear up any disputes which might arise during the process of manufacture.

No more discussion is necessary here as a complete discussion is given along with each form.

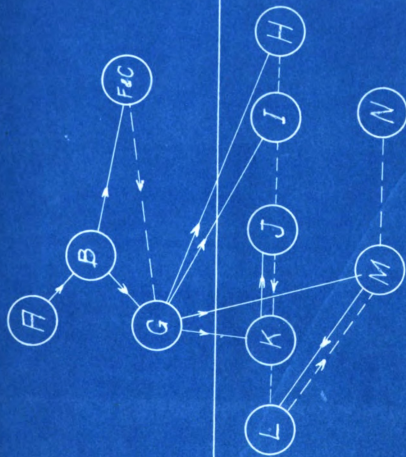
CHART SHOWING AUTHORITY FOR ORDERS



A- General Manager
B- Superintendent
G- Production Clerk
D- Secretary-Treasurer

E- Chief Engineer
F- Chief Draftsman
C- Production Maintenance

Chart Showing Routine of Orders and Materials.



Planning
Performing

H- Pattern Shop.

I- Foundry.

J- Rough Stores.

K- Machine Shop.

L- Finished Stores.

M- Assembly.

N- Shipping Room.

ENGINEERING DEPARTMENT FORMS

Form E-1. Drawing Index Card.

This form is made of light weight white card board.

Size, 3x 5 inches.

This form is made out and filed according to part number in the Engineering Department. It contains all necessary data to locate drawings, tracings, and blue prints. It also contains a brief description of the part as well as the signatures of all men concerned.

Form E-2 Machine Parts Record Card.

This form is made of light weight white card board.

Size 4x 6 inches.

This form is made out and filed according to part number in the Engineering Department. On this card is recorded the use and position of the certain piece on the machine. It contains a complete history of the part.

Form E-3 Castings Record Card.

This form is made of light weight, white card board.

Size 5x8inches.

This form is filled out and filed according to part number in the Engineering Department. On this card is found all data concerning and relating to the casting as can be seen by looking at the form.

5" x 8"

<i>Part Name</i>		<i>Port No.</i>
<i>Date</i>	<i>Material</i>	<i>Type</i>
<i>OPERATION</i>	<i>Unit No.</i>	<i>No. Required</i>
	<i>Machine No.</i>	<i>Rate per 100 Pcs</i>
	<i>GTQ.HRS PER 100</i>	<i>Mechanic Help</i>
	<i>AP No.</i>	<i>Dept.</i>
	<i>1</i>	<i>2</i>
	<i>3</i>	

 $8\frac{1}{2}'' \times 11\frac{1}{2}''$

NAME OF UNIT				UNIT NO.	
				MACH. SIZE	
				DELIVER TO DEP.	
MATERIAL	SIZE OF STOCK	NAME OF PIECE	NO. REQ'D.	PATTERN	

FORM-5-E.

Form 5-E. Unit Specification Sheet.

8½" x 11"

Pattern No.	Shell No.		Molding Price per C.	
Pcs. on Gate	Size Flask Req'd.		Date Price Set	
Hour Molded	Floor	Bench	Squeezer	Machine
Cores in Mold	Price per C. Cores		Date Price Set	
Core Box No.	Shell No.		No. Cores in Box	
Kind of Cores	Oil Sand		Green Sand.	
Pattern Made of	Brass	Grey Iron	Wood	Aluminum White Metal
Core Box Made of				
Kind of Flask	Iron		Wood	
FORM-6-E				

Form-6-E Pattern Record Card

3"x5"

Form E-4. Operation Sheet (Parts Only)

This form is made of plain white paper. Size 11x 8½ inches.

This form is made out as far as possible by the Engineering Department and sent to the Planning Department for completion. This sheet gives the operations required on each part, the Department in which the work is to be done, standard time per 100 and the number required on each engine.

This form is kept in a standard 8½ by 11 inch binder.

Form E-5. Unit Specification Sheet.

This form is made of plain white paper. Size 8½x 11 inches.

This form is filled out in the Engineering Department, copies going to the Planning Department and the necessary Production Departments. This form gives the necessary required parts to make up a certain unit. They are bound in a standard 8½x 11 inch binder according to unit number.

Form E-6 Pattern Record Card.

This form is made of light weight, white cardboard. Size 5x 5 inches.

This card is filled out by the Engineering Department and sent to the planning office along with the blue prints. From there both are sent to the Pattern Shop. When the pattern is completed this card accompanies it to the pattern storage which is in connection with the foundry. Here the card is filed for reference.

DECISION MEMO

Experimental Memo
No.

No. Date

Date Issued

The Following Changes Have Been Made (See)

Specification Changed In Depts.		Copies Sent To	
Date	Date	Gen. Mgr.	Dept. Foreman
-----	-----	Prod. Supt.	" "
-----	-----	Sales Dept.	" "
-----	-----	Planning Off.	" "
-----	-----	Cost Dept.	" "
Cost	Prod.		
-----	-----		
Specification Clerk		Engineer	

Form E-7. Decision Memo.

5" x 8" High.

PRODUCTION FORMS

AVOID VERBAL ORDERS

No.

----- Dept.

Date -----

Mr.

Part No. ----- Signature -----
Order No. ----- Signature -----

Form P-I. General Order

4" x 6"

Form E-7. Decision Memo.

This form is made of ordinary yellow paper. Size 5x 8 inches.

This form is used by the Engineering Department to inform other Departments of changes made in specifications. Copies are sent to the necessary officials and production departments. One copy is kept on file in the binder in the Engineering Department.

**PRODUCTION DEPARTMENT.
(planning)**

Form P-1. General Order.

This form is made of plain white paper. Size 4x 6 inches.

It is obviously ^{cn}convient to have a standard form to be used by heads of Executive Departments in issuing orders and for correspondance when special forms are not available. When used for correspondance one copy is sent to the Department concerned and one copy filed by the Issuing Department according to number. In case the General Manager uses it for ordering yearly production, he makes one original and two carbons. He sends all three to the Production Superintendent who also signs it, files the original and sends one copy to the Planning Office, and one copy to the Engineering Department.

4"x6"

[illegible]

4" x 6"

Form P-2. Pattern Order.

This form is made of ordinary yellow paper. Size 4x 6 inches.

This form is filled out in the Planning Department and sent to the Engineering Department where the necessary blue prints are attached. The order is then signed by the Superintendent who forwards it to the Pattern Shop and the pattern is made.

The pattern having been made and approved, form 2 then goes to the Cost Clerk, by whom the workmans time is charged in spaces designated, from the pattern makers job tickets filled out by the pattern shop time clerk. The cost clerk, also fills in the cost of material in material cost spaces from "Material used Cards", filled out in the pattern Shop.

The "Class", space at the bottom tells to which of three classes the pattern belongs;

Class-1. Standard Patterns, which may be either of wood or metal.

Class-2. Special Patterns.

Class-3. Special Patterns, which have no inventory value.

The class number is applied to the planning department when the order is made, and informs the pattern forman as to the quality of workmanship demanded.

Form P-3. Progress Record Card.

This form is of bluish gray color and made of light weight cardboard. Size, 4x 6 inches. The back of this form is a continuation of the record spaces on the front side.

This form is filled out in the Planning Office and serves as a working order and record card. A card is sent to Respective Departments for each operation. The daily progress both time and production is recorded on this card. When the order is completed the clerk closes the order and forwards it to the Planning Office which in turn sends it to the Cost Department. From this data a complete record is kept of the actual cost of production of each part.

Form P-4. Lot Card.

This form is made of heavy yellow cardboard. Size 5x 7 inches.

This form is made out by the planning department and will be furnished working departments, when material is in such departments.

Department foreman are held responsible for the proper handling of this card while card and material are in their departments.

When ready to start work on material covered by Lot Card, the foreman will give card to employee, who will present same to time clerk when starting time on job. The time clerk will enter on card the information called for and employee will return card to material. When the employee has completed his work on this material he will put down, or have put down

FORM-P-4

LOT CARD

Part Name _____ Part No. _____

No. Pieces _____ Ord. No. _____

DATE	OPERATION	MACH. NO.	OP. NO.	MAN NO.	COUNT		INSP.
					MAN	INSP.	

Dept. _____ Clerk's O.K. _____ Pieces Rec'd. _____

Form-P-4 Lot Card

7x5"

STOCK RECORD

Name _____						No. _____					
ROUGH STOCK						FINISHED STOCK					
Section			LOCATION			Section			LOCATION		
Received			on HAND	Delivered		Received			on HAND	Delivered	
date	Am't.	Scrap		date	Am't.	date	am't.	Scrap		date	Am't.

FORM-P-5

Form-P-5 Stock Record

8½"x11"

under man's count on the Lot Card, the number of pieces he has completed. When material is moved to next department the Lot Card must accompany it.

In the event that a lot of material is to be split the Planning Department is notified and they see that new Lot Cards are made up to cover the different lots.

When the final operation is completed material and Lot Card are sent to the stock room foreman, the stock room foreman will check the count and place card in receptacle to be picked up by stock record clerk for posting, after which will be turned over to the Planning Department to be checked with the progress record.

Envelopes are used in connection with Lot Cards for protection through the shop. Face of envelope to show part and order number.

Form P-5. Stock Record Sheets.

This record sheet is made of light yellow paper.
Size 8½x 11 inches.

When material is received in the stock room, either rough or finished, the stock room foreman inspects it and checks the count against the transfer. The transfer is sent to the record clerk in the Planning Office who records the amount received on these stock record sheets. He also keeps record of stock delivered from stock room on these sheets. These sheets must be kept up to date in order to have accurate check on material.

4" x 6"

Fbrl No.

6 7 8 9 10

Form-P- Control Chart

Form P-6. Customs Job Order.

This form is made of plain white paper. Size 4x 6 inches.

This form is used by the Planning Office in authorizing department foreman to allow special outside work to be done on machines under their supervision. On the back of this form spaces are provided to record factory expense to be charged.

Form P-7. Control Chart.

This form is made of plain white paper printed in light red. Size, large enough to take care of all part numbers.

The headings are filled in according to production orders issued from the Planning Office. One of these charts is kept for each of castings and finished parts.

The engine production is figured for each week and as the daily production reports come in, the production clerk who has charge of the Control Charts post the report. If production is up to date, he sticks a blue headed pin opposite the date and part number. If behind he sticks a red pin opposite the date to which production is O. K. If production is the head he sticks a white pin opposite the date up to which production is completed. If parts are purchased he uses a brown pin.

These Charts are kept on the wall beside the Production Clerks desk. The ideal condition would be to keep a straight line of blue pins on any certain date.

REQUISITION ON STORES

QUAN.

Part No.

Order No.

Only one item on each.

signed,

Form-P-8 Stores Requisition

3" x 5"

Cost Department
Forms.

No. _____

NAME. _____

Pay Ending _____

Form-T-1.
Pay Roll Time
Card 4" x 7"

	MORNING		AFTERNOON		OVERTIME		Total
	IN	OUT	IN	OUT	IN	OUT	
1/16							
2/17							
3/18							
4/19							
5/20							
6/21							
7/22							
8/23							
9/24							
10/25							
11/26							
12/27							
13/28							
14/29							
15/30							
31							

Total Time

Regular Pay

Over Time

Total pay

FORM-T-1

Form P-8. Stock Requisition.

This form is made in duplicate, the original of light weight pink paper, the duplicate of light weight straw colored cardboard. Size 3x 5 inches.

This form is made up by the Planning Office and sent to the stock room. The stock room foreman fills the order sending the duplicate to the specified department with the material. When the order is filled the original is sent back to the Planning Office, where the record clerk records the amount on the stock record sheets.

COST DEPARTMENT FORMS

Form T-1. Pay Roll Time Card.

This card is made of stiff yellow cardboard. Size 4x 7 inches.

This card is the standard type of Stromberg Clock Cards. This clock card should be used in keeping the daily time of all employees. They are required to ring "In" the morning and "Out" at noon; "In" at noon and "Out" at night; "In" for extra time and "Out" for extra time. The record for all of this is provided for on the card, each card showing also the pay period and the time it covers.

The factory clerk totals each days time and checks it with the time total on the job cards. At the end of a pay period the factory clerk gathers the clock cards and sends them to the time office, where the pay master has the Pay Roll made up.

MATERIAL COST RECORD

Material

Mat'l. Unit

Form T-2. Material Cost Card.

4" x 6"

[illegible]

Form T-3. Unit Cost Card.

3" x 5"

Form T-2. Material Cost Card.

This card is made of white, light weight cardboard.

Size 4x 6 inches.

This form is made on which to record the cost of all purchased material. The data on each card is obtained from bills received of purchase material.

Form T-3. Unit Cost Cards.

This form is made of white, light weight cardboard.

Size 3x 5 inches.

These cards are kept on file in the Cost Department and are filled in with data taken from form T-4(parts cost cards) which go to make up the certain unit. From these cards the actual cost of the product is figured.

Form T-4. Parts Cost Card.

This form is made of white, light weight card board.

Size 3x 5 inches.

On the front of this form is found individual costs, such as material, burden and labor costs, which make up the total cost per piece.

On the back of this card our spaces to figure and record the average cost per operation.

These cards are kept on file in the Cost Department according to Part number. The data is taken from reports sent in from the shop.

Form T-5. Depreciation Cards.

This form is made of red, light weight cardboard.

Size 3x 5 inches.

These cards are used to keep accurate depreciation data on each machine. On this card is also kept the value of improvements and the net value of the machine itself.

Form T-6. Pay Roll Sheet.

This form is made of ordinary yellow paper printed in black and ruled in red and green. Size 5x 8 inches.

These sheets are filled in by the Time Clerk each day before the job tickets are sent to the cost department. Spaces are furnished to distribute the cost according to job numbers. These cards are kept by the time clerk until after the pay period is closed and then sent to the Cost Department.

Form T-7. Time Clerk Note Book Sheets.

These sheets are made of white paper for a standard 4x 7 inch note book.

This note book is kept by the time clerk for his own reference. It contains the man's name and clock number, department in which he is employed, time he started to work and his present rate of wages.

Form T-8. Pay Roll Receipt.

This form is made of white light weight cardboard.

Size 3x 5 inches.

This form is a receipt for the wages received by all employees. This form is kept on file in the Pay Masters Office.

Name
 Department
 Rate
 Employed as
 Residence
 Date Started
 Where Born
 Date Born
 Age Now
 Married or Single
 Phone No.
 Where Last Employed
 Father Born Country
 Mother Born
 Citizens of U.S.
 Arrived in U.S.
 Date 1st. Papers
 Date 2nd Papers

FORM-C-1

[illegible]

Form-C-1 Employment Record Card

3" x 5"

FRAM-C-2

Polyfuel Engine Company.
Lansing Mich.

INTRODUCTION CARD

BIDG. NO.	FLOOR NO.	DEPT. NO.	TIME ST. NO.
To _____ in Dept. No. _____			
The bearer _____			
is sent to you in response to your order _____ 192 _____			
for _____			
Wages _____ per hour.			
_____ Employment Dept			
To be filled out and returned To Employment Dept.			
Started work at _____ o'clock. Month _____ Day _____			
Noted _____ Supt. By _____ Asst Foreman			

Form-C-2 Hire Slip

3" x 5"

EMPLOYMENT FORMS

Form C-1. Employment Record Card.

This card is made of white, light weight cardboard.

Size 3x 5 inches.

The employment man makes out one of these cards for each man hired. On one side it contains all personal information of interest to the Company. On the otherside is recorded the man's standing with the Company.

When the man quits or is discharged, this data is recorded on the card and kept by the Employment Department for future reference.

Form C-2. Hire Slip.

This form is made of plain white paper. Size 3x 5 inches.

This form is filled out by the Employment Man and given to the employee who presents it to the Time Man, who records all desired data and gives the man his time card. The man also presents this card to the foreman when reporting for work.

RELEASE SLIP			
		Date _____	
Pymaster:- _____			
Please Pay Mr. _____		Clock No. _____	
Hours worked period ending _____		Amount _____	
Hours worked period ending _____		Amount _____	
Reasons for leaving: _____			

O.K. Employment Dept. _____			
O.K. Tool Supply Dept. _____		Foreman O.K. _____	Foreman _____
Timekeeper _____		O.K. _____	Supt. _____

Form G-1. Release Slip.

3"x5"

OVERTIME SLIP	
To be allowed must be covered by this form, signed by Foreman	
Name _____	
No. _____	Date _____
In _____	_____
Filled by Foreman _____ Foreman _____	
Out _____	_____
Filled by Watchman _____ Watchman _____	
Charge to Job No. _____	

Form G-2. Overtime Slip.

3"x5"

JOB TICKET				Prod. Order No.	Operation No.	Lot No.
Pieces Made	Mach. No.	Dept. No.	Mens No.			
STOPPED	STARTED	ELAPSED TIME	REGULAR TIME			
			OVER- TIME			
These to be turned in Daily				O.K. _____	Foreman Clerk _____	

Form G-3. Job Ticket.

3"x5"

GENERAL DEPARTMENTAL FORMS

Form G-1. Release Slip.

This form is made of white, light weight cardboard.
Size 3x 5 inches.

One of these forms is made out by the foreman when a man quits or is discharged. When O. K'ed. by proper officials, it is presented to the Pay Master, who is authorized to pay the man his wages.

Form G-2. Overtime Slip.

This form is made of ordinary pink paper.
Size 3x 5 inches.

All overtime is covered by one of these slips which when properly signed authorizes the watchman to allow the workman to pass in and out.

Form G-3. Job Ticket.

This form is made of plain white paper. Size 3x 5 inches.

This form is made up by the Factory Clerk when the workman presents his Lot Card. The elapsed time is figured upon completion of each job or at the end of each day. This elapsed time is recorded each day on the Pay Roll Sheets and then the job tickets are sent to the Cost Department.

Form G-4. Daily Tally and Production Report.

This form is made of ordinary pink paper. Size 5x 8 inches.

This report is made out daily by the Factory Clerk and

DAILY TALLY AND PRODUCTION REPORT

DEPT. _____ TALLY CLERK _____ DATE _____

MAN NO.	NAME	PART NO.	ORDER NO.	OPERATION	TIME START	RATE	PREVIOUS JOB		NO. IN S.
							NO. PCS.	PART NO.	

FORM-G-4

Form-G-4 Daily Tally and Production Report 5"x8"

Daily Departmental Production Report

Dept. _____ Date _____

PRO. Order No.	Pattern or Unit No.	Pieces Made or Delivered	SIZE	DESCRIPTION	COST	Ent'd Inventory Record	Ent'd Job Cost Record

FORM-G-5

Form-G-5 Daily Departmental Production Report 7"x10"

FORM G-6

TRANSFER

NO. PCS.

Part No.

From Dept.

To Dept.

Date.

Signed

Form-G-6 Transfer Slip. 3"x5"

forwarded to the Planning Office. This report shows the production by operations, it is also a check on operations that have been assigned and performed.

Form G-5. Daily Departmental Production Report.

This form is made of ordinary light blue paper for a standard 7x 10 inch note book.

The report is made out in duplicate each day by the Department Foreman, one copy sent to the Planning Department and one held by the Department Foreman. From these reports the control charts are kept up to date.

Form G-6. Transfer.

This form is made in duplicate, the original of ordinary yellow paper and the duplicate of light yellow cardboard.

This form is used to transfer material from one department to another or from departments to stores. When used departments to stores, the original is filed in the Issuing Department with the transfer on which the material was received. The duplicate goes with the material to the stores, where the material is counted and inspected. Then the cardboard copy is sent to the Planning Department where the record clerk records the shipment.

Form G-7. Shortage Slip.

This form is made of ordinary paper and in triplicate.
Size 3x 5 inches.

This form is issued by the Stock Room when a requisition

is only partially filled owing to the shortage of material. Such items as are short will be crossed off requisition and shortage slips issued to cover same.

The original (yellow slip) is held by stock room. The duplicate (blue slip) is sent with the material to the Department foreman. The triplicate (pink slip) is sent at once to the Planning Department.

When material called for on shortage slip is received in Stock Room, it is delivered at once to department holding shortage slip and the duplicate held by such department picked up and with the original sent to the stock record clerk for posting.

Form G-8. Identification Tag.

This form is made of heavy red cardboard. Size 3x 5 inches.

This form is used by all departments sending material into machining or assembling departments. Each lot of material entering these departments must be accompanied by one of these tags, showing part and order number. If the lot is delivered in two or more boxes or trucks each box or truck must have a separate card. These tags remain with the material at all times in these departments and will accompany material back to stock room.

SHORTAGE		
Date	Quan.	Part
Due Dept.	From Dept.	Order No.
Unit No.	Date Filled	Signed
PRESENT THIS SLIP WHEN CALLING FOR MATERIAL		

FORM-6-7

Form-G-7 Shortage Slip

3"x5"

 IDENTIFICATION TAG	PART NO. ORDER NO.
--	-------------------------------

FORM-G-8

Form-G-8 Identification Tag 3"x5"

STORES FORMS.-5-

Bin No.	Sec. No.	Part No.
Part Name		

FORM-5-1

Form-5-1 Bin File Card.

STOCK ROOM FORMS

Form S-1. File Card.

This card is made of medium weight, yellow cardboard.
Size 3x 5 inches.

These cards are filled out by the Stock Room Foreman.
They are kept in a card index file according to part number,
simply for convenience of locating desired parts.

Form S-2. Bin Card.

This form is made of white, light weight cardboard.
Size 3x 5 inches.

This form is made for convenience of the Stock Room Man, and
is placed in a pocket on the bin or drawer.

INSPECTION FORMS

Form I-1. Defective Stock Tag.

This form is made of heavy, red cardboard.
Size 2½x 4½ inches.

These tags are filled out and attached to defective material by sub-inspectors so as to hold material until it can be inspected by the chief inspector. The chief inspector either attaches a Salvage Tag or Scrap Warrant.

Form I-2. Salvage Tag.

This form is made of heavy, blue cardboard.
Size 3x 5 inches.

These tags are filled out by the inspectors and attached

to defective material recommending repairs necessary to change parts so they will pass inspection.

Form I-3. Scrap Warrant.

This form is made in triplicate of ordinary paper, the original light blue, duplicate yellow, and triplicate pink in color. Size 3x 5 inches.

These are filled out by the Chief Inspector who retains the original copy. The duplicate is sent to the Planning Department where new stock is requisitioned if necessary, record made and then sent to Engineering Department where it is filed. The triplicate is sent to the Cost Department where it is charged against Department Scrap.

Form I-4. Short Tag.

This form is made of heavy weight, red cardboard.

Size

This form is made out in case some part is missing at final inspection. An engine bearing one of these tags is returned to the necessary department where missing part is to be attached and returned for final inspection.

Form I-5. Inspection Tag.

This form is made of white, light weight cardboard.

Size 3x 5 inches.

One of these tags is made out for each engine as it leaves the assembly floor and stays with the engine until it is sent to the shipping department at which time the shipping clerk collects

it and sends it to the Planning Office where it is filed for reference concerning the different stages of manufacture.

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"Factory Manager"	Arnold.
"Planning and Time Studies"	Armstrong.
"Accounting Methods for Industrials"	Woods.
"Principles of Industrial Organisation"	Kimball.
"Applied Methods of Scientific Management"	Parkhurst.
"Installing Efficiency Methods"	Knoeppel.
"Manufacturing Costs and Accounts"	Church.
"Factory Organisation and Administration"	Diemer.

A REPORT
on the
POSSIBILITIES AND ADVANTAGES
of employing labor by
APPLIED PSYCHOLOGY

PART ONE.

The Theory of Employment Psychology.

PART TWO.

A Demonstration of Applied Psychology.

PART ONE.

The word "Psychology" is one of the most misused words in the English Language today. It is assumed to be a science of uncanniness. An amusing fact of the matter is that the common layman can give an explanation of any phenomena wherein the personal element enters by simply saying, "It is the psychology of this or that", and we all understand perfectly. The trained psychologist, however, knows the point where psychology ends. He knows that it is not a cure-all for every perplexity that may arise. This fact places psychology in a very embarrassing position at times. Psychology can accomplish very good results only in the field of psychology.

Psychology is defined as a science of the human mind. The word "science" comes from the latin word "scire" which means "to know". However, to know is not necessarily to be a scientist. Science means a knowledge systematised and classified, a knowledge of certain laws, causes, and relations. The word "psychology" comes from the Greek meaning "knowledge about the mind". From this, we might rewrite our definition thus, "Psychology is a systematised, classified knowledge of the laws, causes, and relations of the human mind. Employment psychology, therefore, can be taken as the application of the scientific methods to the mental actions concerned in employment.

Psychology is no more indefinite than is chemistry or

physics. During the last fifty years, in small secluded laboratories, psychology has been rapidly developing into a real science. The days of speculation are over. It is true that in the sciences of chemistry or physics, the substances under investigation can be weighed or measured. We have the feeling, and rightly so, that our mental facts are our own personal affairs. I have my own memories, imagination, hopes, and resolves. Likewise, you have yours. Mine can never be made yours nor can yours ever be made mine.

Altho mental facts and physical facts are widely different in all essentials, there is a very close connection between them. To illustrate, notice a person when angry. There we have the mental fact, the feeling; and also the physical fact, the actions, and looks. If my mind is active, I am paying close attention, my jaws are tight, my head is set firmly, and perhaps I scowl slightly. These instances show that in some way or another, each mental fact is connected very closely with a physical fact.

Another way of distinguishing our mental experiences is by analysing the facts of our every day life. These experiences contain facts which are studied by two sciences, the physical sciences and the science of psychology. It is the results obtained from this angle of study that are of so much use to the psychologist in solving the problems of employing scientifically. These experiences come from the objects which we daily see, hear, taste, smell, and handle. We are more or less interested in these physical objects and their ways of behavior. We say that we see them, hear them, taste

them, etc., and that we are pleased or displeased with them, we remember them, we use them for our purposes, or they satisfy our desires. This again shows us that physical facts are widely different and yet very closely connected. That is to say, there can be no mental fact established in the mind without there being an accompanying or resulting physical fact.

But to be able to merely distinguish mental facts is not to be a psychologist. To properly study our subject, then, we must study the phenomena that we may properly classify them and attempt to ascertain the causes of them. To do this we are equipped with a faculty known popularly as Consciousness. To be conscious is to have feeling and memories. Thus, in order to investigate the phenomena, we must bring them up for thought in the same manner as in study of the phenomena of any other science. We must pay attention to the happenings in our mind. This is by far the most important method of obtaining the facts and is known as introspection, which means to look within. This method is accompanied with considerable confusion to the novice, for the facts we are searching for are so close at hand that they are more often overlooked than comprehended.

Other important methods of studying the phenomena are by observing what is going on in the minds of those about us. To do this, however, we translate their mental states from their actions, looks, manners, and words. We can do this by

what we already know of our own thoughts and feelings in connection with our own actions, looks, manner, and words. This method is known as observation. By introspection and observation, we obtain for examination all of the phenomena.

Now that we know that there are mental facts established in every mind, that these facts are very closely related to certain physical facts, that the mental facts can be obtained both by introspection and observation and can be grouped for a study of their laws and causes, let us attempt to apply these facts in a practical way. For example, let us take a piece of green cloth and display it to a group of persons. There will result as many different mental facts from this display as there were persons. To some, the cloth will be a light green, to others, a dark green, to still others, just green, and perhaps some may not be able to distinguish it as green at all. Again, let us bring up for display a button hook. This may bring to one's mind a pair of shoes, a smoky steel mill, a factory wherein the hook or shoes were made, or it may only produce the sight of a bent piece of heavy wire, and so we could go on indefinitely.

But if I am granted the truth of this, does it seem impractical to devise a test, a measurement of one's mind by which certain mental activities and inborn intelligence can be accurately gaged? This is not a new idea. Mental tests were first used by Alfred Binet, in France, in gaging the intelligence of school children. Binet's first works on

his investigations appeared in 1905. Unusually wide spread popular interest has been aroused over the subject.

Practical applications of psychology have made rapid strides since this time, particularly among American psychologists. The best known examples of the application of psychology, of course, are the mental tests used in the Army during the World War. The tests, naturally, were devised primarily for military needs, but would, nevertheless, have yielded invaluable data in the relation of intelligence to occupation if it were not for the artificial methods of selection used in the Army. Many tests have since been devised for civilian use, the literature and standards of which are obtainable in Whipples "Manual of Mental and Physical Tests".

But why go to all this extra trouble and expense in hiring, you say. You point out that when an employer wants a man for a job, he looks over a number of applicants, hires the one who "looks good", and that is all there is to it. Yet the same employer would not even dream of picking out a machine in such a haphazard manner. Choosing machines and labor is assumed to be two entirely different problems, but this assumption can only stand its ground so long as ignorance of facts prevail. The factory owner well knows the logic of standardizing his equipment and machines. Then why not standardize the labor, that is, ascertain the necessary qualifications for each job and place the man on that job who possesses those qualifications. Do away with the old style method of hiring according to the fraternity pin the applicant wears or the particular mood in which the employment

agent happens to be in. Choose your employees scientifically. This method places the right man on the right job which means a direct increase in production, It also gives the right job to the man which means a satisfied and contented workman. When authorities agree that it costs from \$25 to \$200 to train a new employee, and that by placing employees where they are most fitted and satisfied means a decrease in labor turn over which common sense and facts will prove; does it take much stretch of the imagination to see an increase in the profit account by adopting a scientific method of employing?

We have already dwelt, to some extent, on the method and advisability of choosing employees of the proper characteristics for certain jobs, but have only inferred that each job requires certain characteristics. It is very obvious that without an analysis of a job, it would be useless to attempt to analyze people for that job.

It is much more difficult to analyze jobs today than it was a few years ago. In times past, trades and occupations were limited in number and it was an easy matter for one man to be familiar with all of them.. However, with the advance of time came the great advance in mechanical discoveries and inventions which has brought about about the extensive division of labor, Then too, the growth of great industries have gathered together under one roof many trades and occupations that were formerly conducted in separate small shops. Centralization has

brought with it the central employment office, where, under the direction of one man, all of the employing is done. This has displaced the custom of each foreman hiring his own men. The advantage of the centralized method is apparent when you picture the dozens, yes, hundreds of foremen in the modern factory all doing their own hiring. Think of the confusion that would result, of the many different standards, rates, and methods that would prevail in the same shop under this old system. Yet, it had its advantages in that, every foreman is familiar with the jobs in his department and could interview his applicants with reference to the work which he expected them to do. In short, centralized function of employment has done away with the first knowledge of the different jobs, and as a result, hiring has been carried on in the most superficial manner. One of the direct results of this has shown itself in industry by the high labor turnover. All of this goes to show how important it is that the employment man should be given a careful and accurate analysis of each job for which it becomes his duty to supply the labor.

Already, many attempts have been made to analyze and draw up specifications for jobs. It seems to be the prevalent method in making such an analysis, however, to describe the job in terms of human qualities which are required in its performance. For instance, the job of book-keeping is described as a job requiring accuracy, patience, application, neatness, routine temperment, not much

initiative or creative ability, unwavering attention, and so forth. Other familiar terms used in the description of jobs are; dynamic, static, large dimension or small dimension worker, industrious, intellectual, volitional, manual, deliberate, impulsive, rapid or slow mental co-ordination, adaptable, self-centered, roving, settled, loyal, sincere, directive, dependent, responsible, irresponsible, phlegmatic, live-wire, slow but steady, and so on.

To attempt an analysis of jobs in this manner is impracticable because the terms are vague and really mean very little when tied down to a particular job. Also, it is impossible to measure patience, loyalty, or any other of the qualities named. Unless some reliable method for the measurement of these qualities can be devised, of what use is the knowledge of the qualities? In fact, this method is not a job analysis at all but only a sort of a character analysis. These qualities are far removed from the practical aspects of employment.

What then must a correct analysis do: what conditions must it meet? First, it must be comprehensive; that is, it must include all of the important factors which enter in to make each job what it is. Second, it must be brief; that is, it must give only the most necessary and fundamental facts concerning each job. Third, it must be made in standard terms. Fourth, it must be concrete; that is it must not describe the job in abstract and general terms, but only in terms of measureable abilities.

The following outline embodies the conditions set forth above. Altho, it does not contain many items which are important of certain kinds of work, especially the highly skilled trades, it does suffice for the description of a large majority of factory jobs.

JOB ANALYSIS

Name of job _____

Physical characteristics of job:

1. Machine _____ Number _____
2. Hand Work _____
3. Heavy _____ Light _____ Medium _____
4. Lifting _____ Hauling _____ Climbing _____
5. Standing _____ Sitting _____ Walking _____
6. Clean _____ Dirty _____ Hot _____ Cold _____
7. Kind of eyesight required _____

Mental characteristics:

1. Educational _____
2. Prerequisite experience _____
3. Ability in English: Read _____ Write _____ Spell _____ Talk _____
4. Ability in Mathematics: Copy figures _____ add _____
Subtract _____ Multiply _____ Divide _____ Decimals _____

Miscellaneous:

1. Earnings
 - a. Day work _____ Max. _____ Min. _____ Aver. _____
 - b. Piece work _____ Max. _____ Min. _____ Aver. _____
2. Hours _____
3. Possibilities of promotion _____

4. Time required to break in new man_____

5. Remarks of other essential features of the job_____

The outline is divided into three main parts; physical characteristics mental characteristics, and miscellaneous characteristics. Briefly, the physical characteristics are given much importance because from the psychological point of view, nothing does more to upset a workers state of mind than physical incompatibility. Many jobs also require a minimum of education along certain lines and hence the mental characteristics of a job must be given considerable weight. Under Miscellaneous are listed some very important items such as Earnings, Possibilities of Promotion etc., that bring the job out before the applicant in its true light.

The following form serves as an excellent guide in the analysis of office positions.

OFFICE JOB ANALYSIS

Name of job_____Classification_____

Dept._____Division_____Section_____

Characteristics of Work:

Manual:

Writing____Figures____Drawing____Posting____Sorting____

Machine:

Typing: Copying____Statistics____Dictation____Forms____

Stenography: General Dictation____Technical____

Secretarial_____

Comptometry: Add___Multiply___Divide___Decimal___

Miscellaneous_____

Mental.

Filing: Alphabetical___Topical___Symbolical___

Mathematics: Add___Multiply___Divide___Subtract___

Percentage___Decimals___

English: Conversation___Correspondence___Grammar___

Spelling___Handling Inquires___

Posture: Standing___Sitting___Walking___

Education (in years) : Grammar___High School___

Business School___College___

Prerequisite Experience_____

General Description of Duties_____

These forms are sent to the various foremen of the departments who, by means of this guide, are able to provide the Employment Office with a fairly accurate analysis of each job in their department. It has been argued that the foreman is frequently the last man who can adequately analyze his jobs, since he knows them so well that he cannot describe them in any but technical and colloquial terms. This outline of specifications, however, serves to confine the analysis to certain channels and predetermined essentials. The entire process, moreover, should be under the supervision of a group consisting of the employment manager, medical examiner, and psychological examiner.

When the Employment Office is supplied with an analysis of all jobs in a satisfactory way such as outlined, it is possible for the employment examiners, by determining the specifications of the applicant, to match the specifications of both applicant and job together. Only when there is the proper match will the best union between them result.

As has already been stated, standard tests have been devised for all types of jobs and positions. However, this does not mean that all that is necessary is to pick out a standard test and hire the applicants who make satisfactory grades in the tests so decided upon. Far from it. It takes a great amount of thought, time, and energy to decide upon the proper test to use. The preliminary step is, of course, to choose what the trained psychologist believes to be the proper test or tests. Even this preliminary choice is the result of much investigation and application of psychological principles to the particular job under investigation. The next step is to give these tests to as many workman of the same kind as possible. Obviously, more conclusive results can be drawn from several hundred tests than from only several. The tests of all the workers are graded. Accurate records are obtained as to each workers individual output and these records compared with each one's score made in the tests. The tests which are finally chosen as the ones with which to choose future employees are the ones which are said to correlate closest to the actual job conditions

and specifications.

To understand correlation, one must first understand the laws of chance. We must know what chance there is of accidental correlation. Let us, for example, write numbers from 1 to 10 across the sheet to represent, in order, the standings of 10 men. Then write the corresponding numbers on slips of paper, mix them, and draw haphazard, placing the number drawn under the drawn number. Below is shown the smallest and highest misplacement in 20 trials.

1	2	3	4	5	6	7	8	9	10
<u>6</u>	<u>2</u>	<u>8</u>	<u>4</u>	<u>6</u>	<u>7</u>	<u>3</u>	<u>9</u>	<u>1</u>	<u>10</u>
5	0	5	0	0	1	4	1	8	0

Twenty-four points out of place.

Average misplacement 2.4 places.

1	2	3	4	5	6	7	8	9	10
<u>7</u>	<u>9</u>	<u>4</u>	<u>10</u>	<u>2</u>	<u>8</u>	<u>1</u>	<u>3</u>	<u>5</u>	<u>6</u>
6	7	1	6	3	2	6	5	4	4

Fourty-four points out of place.

Average misplacement 4.4 places.

The ruling average misplacement is about 3.3, places. In other words, there is a possibility of obtaining a chance misplacement of 4.4, places, 2.4 places, and an average chance of 3.3 places.

Aside from chance, there is the possibility of obtaining a deliberate misplacement of 5 points. This is shown as follows:

1	2	3	4	5	6	7	8	9	10
<u>10</u>	<u>9</u>	<u>8</u>	<u>7</u>	<u>6</u>	<u>5</u>	<u>4</u>	<u>3</u>	<u>2</u>	<u>1</u>
9	7	5	3	1	1	3	5	7	9

50 points out of place
Average misplacement 5.0 places.

We have 100% correlation in a test when test records and actual operators piece records come out the same. The opposite of this would be 0% correlation when test records and operator's test records showed an average misplacement of 5 points, or, to make this a general rule, the correlation is 0% when the average misplacement is a number equal to half the number of operators rated.

To find the correlation of a test, then we must first find the average misplacement of the test records to the ability of the persons tested. Divided into this the extreme possible error in places (a number equal to half the men tested). This percentage subtracted from 100% gives the correlation of the test. By this method, a correlation of 33 1/3% indicates that the test is useless since this could be secured by chance. A higher correlation indicates that the test has some significance. Any correlation over 50% indicates that the test is a very good one.

Suppose, for illustration, that a test was given to a group of 10 men and that the amount of work turned out by the men and their respective standings in the tests were as shown below, and it was desired to correlate the test.

Ability of men in order	1	2	3	4	5	6	7	8	9	10
	<u>2</u>	<u>4</u>	<u>3</u>	<u>1</u>	<u>9</u>	<u>7</u>	<u>5</u>	<u>10</u>	<u>6</u>	<u>8</u>
	1	2	0	3	4	1	2	2	3	2 19

Average misplacement 1.9 places. Highest possible misplacement 5. $1.9-5 = .38$ $100\% - 38\% = 62\%$ correlation of the test.

By the laws of chance, it might have been possible to have made such a close estimate once, but there is practically no possibility of ever repeating it. By actual trial, you can come as close as 2.4 places once in 10 trials and 1.9 places once in 30 trials, whereas the average misplacement is about 3.3 places for all trials made. Out of the thirty actual trials made by drawing slips of paper haphazardly, sixteen of those trials resulted in misplacements below the average, or, in other words, in sixteen of those trials, the average misplacement was 3.4 or above. This is exactly what is true in employing men. Chance will allow you one exceptionally good man out of every thirty you employ, but at least one half of those men will be below average qualifications. And this is just what can be eliminated by adopting the method of employing by test, or scientific employing. There will then be no "below the average" men in your employ for the tests will point out the good and the poor men for any particular job even before they are hired.

I have attempted, in this report, to make clear five

points, namely; (1) what psychology really means, (2) mental tests are practical, (3) how to analyze a job in the most useable way, (4) how to choose the proper test or tests for the job, and (5) that employing by test is necessary if you are to obtain the most efficient grade of working men in your factory.

PART TWO.

In order to bring out the practicability and value of mental tests in determining the qualities and abilities of individuals in a more forceful way, actual tests were devised and tried on a number of Freshmen Engineering students of M. A. C. From the results of these tests, an attempt was made to estimate the grade which each student made in his Machine Shop course during the Winter Term.

The reason for selecting the grades made in their Machine Shop course and not grades made in their curriculum as the basis for demonstrating the value of the tests was primarily this: the qualities that go to make up a good student in academic work are not necessarily the qualities that go to make up a good student in Machine Shop work, and since this report is made on the application of mental tests to the proper and scientific employment of labor for the Polyfuel Engine Company, which labor will be, for the most part, of a mechanical nature; it is only natural and proper that the demonstration tests should be devised with that aim in mind of being as closely related to the real tests which will be drawn up in the future as possible. And, of course, the results of these tests would be absolutely worthless unless they were compiled and correlated against the corresponding grades which the student made in his Machine Shop Work. Merely for the purpose of establishing the truth of this last statement, the average college grade of each student will also be found in the tabulation of results.

After a thoughtful analysis of the qualities necessary, or in other words, after a job analysis had been made of the

Machine Shop Course, the following tests were chosen as the ones which would be given, namely; the Technical Test, the Expression Test, the Cube Test, the Peg Fitting Test, and the Match Board Test.

The Technical Test, a sample of which is herein given, is one of a series of six tests prepared by Dr. L. L. Thurstone of the Carnegie Institute of Technology. The tests were prepared for the Society of the Promotion of Engineering Education in an attempt by it to find some means of advising a High School Graduate whether he is properly qualified to study and enter the field of Engineering or whether he might better devote his energies to some other field of endeavour.

This test was chosen for this work in the desire to determine whether or not it was significant with regard to the recitation work in the Machine Shop Course. The test is self explanatory and the grading of it is a comparatively simple matter. There being an even one hundred questions, written out, all that is necessary is to count the number of wrong answers, subtract the amount from the total number of questions and the remainder will be the percentage which the student has made in the examination. As time is also an important factor in any psychological examination, it was also taken into consideration in this examination. The grading for the time consumed was done by assuming that the Theoretically perfect time in which to complete the test would be zero time and that each minute consumed in writing the test subtracted one percent from one hundred percent perfect mark. However, since the test was not primarily a

INTELLIGENCE TEST
for
TECHNICAL INFORMATION.

Name _____ Date _____

The object of this test is to determine how much technical information you have absorbed not only in school, but also in your activities outside of school.

Each question has four printed answers and you are to underline one of the four printed answers. Thus;

Electricity is conducted by
ropes wires twine yarn

Underline the word "wire" because that makes the truest statements in this test.

Do not write any other answers. Simply underline one, and only one, of the four printed answers.

Be sure to underline one of the four answers for each question even if you have to guess. Even if you do not know the answer you will make a guess. Try to guess the answer to you the most reasonable even if you know very little about the question.

You are expected to finish this test. Take as much time as you reasonably need to answer all the questions. When you have answered all the questions, return this test to the examiner and leave the room quietly.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO BEGIN

UNDERLINE ONE OF THE FOUR ANSWERS FOR EACH STATEMENT.

1. A magnet attracts
brass copper iron platinum.
2. The rear hub of a bicycle is often fitted with a
coaster brake cyclometer grease cup tail light
3. An air rifle uses for ammunition
.22 short BB shot .32 center fire CB caps
4. Oil is ordinarily used as a lubricant when drilling holes in
cast iron steel wood brass
5. A common diaphragm opening for snap shots is
8 64 128 400
6. In making a core for an induction coil one ordinarily uses
mahogany rubber copper iron
7. Harley-Davidson is the name of a
motor-cycle electric clock wireless detector
aeroplane
8. The distributor in an automobile is a part of the
cooling system ignition system oiling system
transmission
9. R. P. M. represents
volume speed content direction
10. In order to make solder adhere to metal surfaces it is
necessary to use
oil flux glue gasolene
11. To keep the barrel of a target rifle in good condition one
often uses
carborundum paste dutch cleanser vinegar
three-in-one oil
12. Low voltage fuse wire ordinarily contains
lead silver brass platinum
13. The regulation Ford is equipped on the rear wheels with
tires of a diameter of
2-1/2" 3" 3-1/2" 4"
14. The boiling point of water on the Fahrenheit scale is
212° 312° 512° 100°

15. A gas engine in which the explosion takes place in each cylinder once in every two revolutions of the shaft is called
one cycle two cycle three cycle four cycle
16. The material used for trolley wire is
galvanized iron aluminum copper brass
17. DeForest invented the
triple-valve vacuum-valve needle-valve safety-valve
18. What size wire is most commonly used for wiring a house for 110 volts?
6 8 14 20
19. The wrench to turn small sizes of gas pipe should be a
socket monkey Stilson box
20. Broaches are used in a
lathe boring mill drill press arbor press
21. What is the approximate daylight limit in miles radius of a quarter kilowatt spark gap wireless telegraph sending set?
one mile 10 miles 200 miles 1000 miles
22. The motion of the table of a planer in a machine shop is
rotary reciprocating continuous endless
23. Bricks are made of
clay granite sandstone gneiss
24. The gears used on a lathe for thread cutting are known as
helical bevel spur worm
25. The current obtained from dry cells is
rotary interrupted direct alternating
26. The purpose of back gears on a lathe is to
increase the speed cut threads turn tapers
decrease speed.
27. Balloons are filled with
compressed air hydrogen oxygen steam
28. Circles which pass thru the North and South poles are called
equator latitude longitude equinox.
29. Board measure pertains to
lumber cardboard paper metal
30. A file may be made to "bite" into cast iron by using
vaseline tallow beeswax chalk

31. The top of a shop bench is often made of
Douglas fir mahogany walnut maple
32. A split pulley on a shaft is held fast by
cement solder friction glue
33. A fillet in pattern making is ordinarily made of
leather wire twine sand
34. A bearing for a steel shaft, to wear well, is sometimes made of
cast iron bronze tool steel zinc
35. A file is held square across the blade and level in filing a
cross-cut saw rip saw back saw coping saw
36. A turret lathe is used in machining
bolts nails hammers scissors
37. Which of the following terms indicates gages of electric wires?
Winchester Roebling Brown and Sharpe Westinghouse
38. The chips made by a lathe in turning metals are long spirals
when turning
cast iron steel aluminum zinc
39. In ordinary pattern work patterns are made of
fiber rubber leather wood
40. Pica is term used in
navigation printing artillery railroading
41. The diameter of a Ford piston is
2-1/2" 3-1/2" 4" 4-1/2"
42. Locks are manufactured by
Corbin Maydole Starrett Brown & Sharpe
43. Which instrument is used to measure temperature?
dynamometer condenser pyrometer rheostat
44. A file is made of
Bessemer steel machinery steel cold rolled steel
high carbon steel
45. The number of leveling screws on an ordinary transit for
surveying work is
2 3 4 6
46. A soldering iron is made of
iron steel copper tin

47. How many legs are there in the tripod of an ordinary surveying transit?
one two three four
48. If you had to make a strong bolt but could not get steel to make it of, your next choice would be
cast iron lead wrought iron brass
49. The blade is ground on the upper side in a
smooth plane block plane rabbet plane jack plane
50. Which of these screws requires a counter sunk hole?
fillister head round head hexagon head flat head
51. Which of these taps has the largest diameter?
3/8" pipe tap 1/2" U.S. Std. tap 1/2" S.A.E. tap
1/2" pulley tap
52. The contours on a topographic map indicate
roads elevation streams longitude
53. Edge tools and cutlery are made of
cold rolled steel wrought iron carbon steel
cast iron
54. To whet a plane blade one should use
emery cloth a file sand paper an oil stone
55. The width of a standard gage railroad track is
4 feet 4 feet 8-1/2 in. 5 feet 5 feet 6 in.
56. Shellac varnish is thinned by
distilled water alcohol turpentine gasoline
57. Shafting is sometimes made on the
planer miller shaper lathe
58. What material is used in making the insulation of common bell or annunciator wire?
wool rubber cotton silk
59. Ordinary concrete contains
asphalt cement glass rubber
60. An automobile cylinder should be finished to a very smooth even surface. This is sometimes done by
lapping milling filing turning
61. Aeroplane motor frames are sometimes made of
brass copper steel cast iron

62. Incandescent lamps in houses are ordinarily wired in
tandem multiple series
63. A good fabric for aeroplane wings is
wool cotton linen canvas
64. A star wheel is used in a
motion picture machine sewing machine
steam engine bicycle
65. The split nut on a lathe is used for
reducing speed reversing speed driving carriage
increasing speed
66. A window sash holds the
jambs casings glass sills
67. The L.S. Starrett Co. manufactures
tools soap furniture automobiles
68. Small angles are measured on an ordinary surveying transit by a
vernier constant tripod leveling screw
69. A connecting rod bearing is sometimes made of
aluminum steel bronze cast iron
70. One part of the door is the
jamb head sill panel
71. A man six feet tall is best fitted with a diamond frame
bicycle when the frame measures
15" 18" 24" 36"
72. In sawing off a 10" board one uses a
cross-cut saw rip saw coping saw turning saw
73. A cotter pin is ordinarily used to hold in place a
nut side curtain spare tire spark plug
74. The joints in most picture frames are
dovetailed mortise and tenon butted mitered
75. The current used by a two-phase motor is
D.C. static A.C. storage battery
76. Ordinary house paint contains
oil water alcohol gasoline
77. The spark plug on a gasoline engine is located on the
crank case cylinder manifold carburetor

78. In boring a small hole one sometimes uses a
mitre brace and bit T-bevel spoke shave
79. A gauge point on a carpenter's gauge should extend about
1/16" 1/2" 7/8" 1-1/2"
80. What is the standard commercial wave length for ships?
200 600 900 1200
81. A mallet should be made of
white pine cypress bass wood beech
82. Which of these cars have air cooled engines?
Packard Dodge Franklin Ford
83. Hot glue is thinned with
water turpentine alcohol linseed oil
84. The best resistance wire for electrical circuits is
silver copper German silver platinum
85. The joists in a building support the
roof foundations chimney floor
86. Which of the following metals can be case-hardened?
wrought iron aluminum copper babbitt
87. A frame building is constructed mainly of
brick wood steel tile
88. To keep a motor commutator clean use
oil sand paper emery cloth file
89. Shingles are nailed to the
joists sheathing jambs sills
90. Machine screws come in numbered sizes No. 1 to No. 30.
Which is the smallest of these?
No. 6 No. 20 No. 12 No. 24
91. The uprights of a frame building are called
rafters lintels joists studding
92. Lead plate storage batteries are ordinarily filled with a
dilute solution of
hydrochloric acid acetic acid sulphuric acid
nitric acid
93. When gluing two pieces of wood together the surfaces should be
shellaced painted stained straightened

94. The cheapest heating system to install in a house is
steam hot water electric warm air
95. In cabinet work one most frequently uses
oak hickory catalpa cypress
96. The volt is a measure of
current pressure resistance power
97. A roof which has the shape of a four-sided pyramid is called
gable gambrel mansard hip
98. Small twist drills come in numbered sizes from No. 1 to
No. 60. Which is the largest of these?
No. 52 No. 12 No. 21 No. 36
99. Those parts of a staircase into which the treads and risers
are framed are called
stringers sandlels newels brackets
100. Auger bits increase in size in steps of
1/16" 1/8" 1/4" 1/64"

speed test it would be unjust to allow as much weight for time as for information in the final marking of the test.

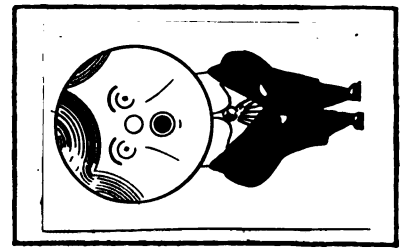
Therefore, the element of time was only allowed one-fourth as much weight in the final grade as the score made on the correct answering of the questions. For instance, one man gave seventeen wrong answers and consumed twenty minutes in writing his examination. His final grade was figured thus:

$$\frac{(100 - 17) \times 3}{4} + \frac{(100 - 20)}{4} = 82$$

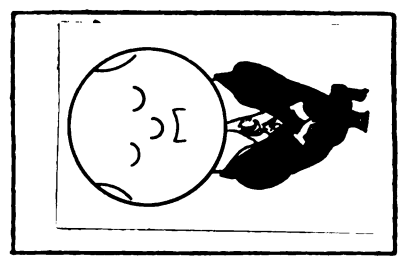
After the numerical grades of all the tests were obtained, A's, B's, C's, and D's were then awarded each student, these letter grades being decided upon by a comparative method only.

The Technical Test was given to a whole class at one time. On a following day it was attempted to give the remainder of the tests, which may be termed the manual tests, to the same group of men, but due to lack of time, only twelve men finished all of the tests whereas nineteen men were given the Technical Test. The manual tests were given in a definite order, it being desired that the shortest test should be given first and so on, saving the longest test for the last. Of the tests given, the Expression Test was chosen to be given first to serve as a "shock absorber", or to put the subject at ease. It is considered very good practice to give some easy, interesting task to a person taking examinations of this sort before subjecting him to the more difficult tests to follow. By doing this, a state of self-confidence and interest is created in the mind of the subject and this eliminates to a great extent the element of

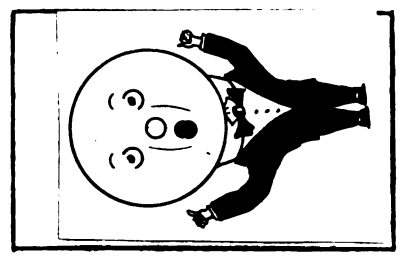
FRAZIER'S EXPRESSION TEST #2



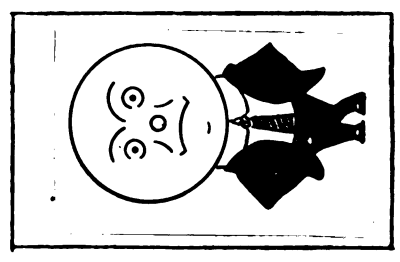
DISGUST



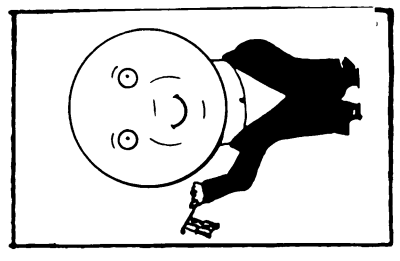
CONTENTMENT



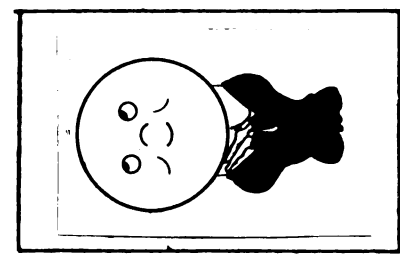
HORROR



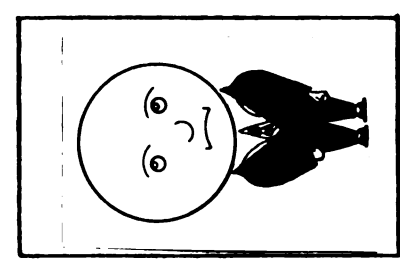
JEALOUSY



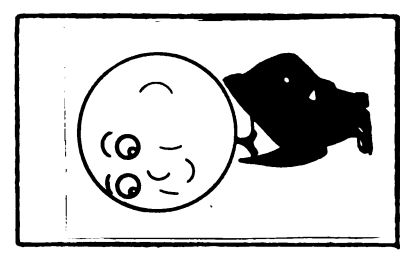
AMUSEMENT



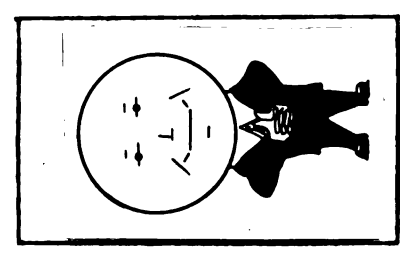
ADORATION



DISAPPOINTMENT



PRIDE



SATISFACTION

nervousness. Nervousness is very detrimental in work of this nature for it does not allow the individual to think and act in his natural way. This will spoil the value of the test. The expression test consists of nine pictures or cartoons which were drawn by Mr. K. S. Frazier each one representing an expression of either horror, disgust, satisfaction, contentment, jealousy, pride, disappointment, amusement, or adoration. It was decided that they would make up into an easy and interesting test as could be found anywhere. The test is shown on the next page correctly assembled. It was presented to the subject, however, all in disorder. The object of the test is to have the subject place each picture in what he thinks to be the proper square or frame. There are several pictures which could be interchanged with each other and still it would be unfair to mark off for it. For instance, the picture representing "Horror" might easily be taken to represent "Disgust". Therefore, in grading the test, a misplacement was only counted when two pictures were placed in the wrong places. Time was given equal weight with accuracy in this test. A grading of A, B, C, or D was obtained by comparing each man's performance against the average performance of all of the men tested. This system of marking was also used in the Cube and Peg tests.

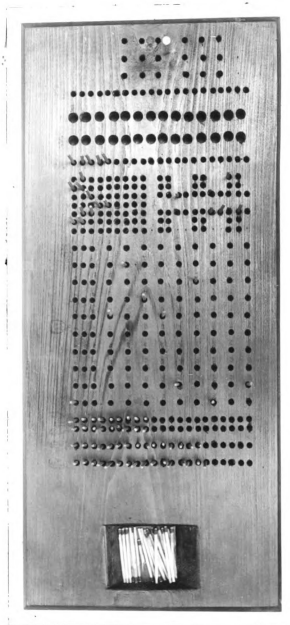
The next test given was the Cube test. This consisted of a three inch wooden cube painted black on all six spaces and then sawed into twenty-seven one inch cubes. It was presented to the subject in the assembled condition, the purpose of the test was explained, and it was then knocked to pieces by a

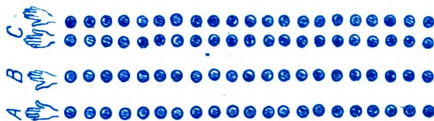
stroke of the hand. The time taken by the subject to re-assemble it was then recorded, it being required that he assemble it so that the painted surfaces of the blocks were all facing the outside. The marking or grading for this test was based entirely upon the time consumed in rebuilding the cube, the grades being awarded as before mentioned. By this test, it was hoped to bring out the alertness and the mechanical ability of the individual. This same test has actually been used, among others in choosing apprentice toolmakers and in this work, has shown a correlation of seventy-five percent which shows it to be a very good test for this kind of work.

The test given next in order has been termed the Peg Test. It was originated by the author and consisted merely of a block of wood one-inch thick, four inches wide and six inches long. In the middle of the face of this block was bored a hole one inch in diameter and one inch in depth. This hole was, in turn, covered over with a thin piece of iron in which was cut and obtuse angled triangle, the longest side of which was about seven eighths of an inch long, the hole in the iron being placed directly over the hole in the wooden block. A quantity of white wood sticks $1\frac{1}{2}$ inches by $1\frac{1}{2}$ inches by 6 inches were made ready and the subject upon completing the cube test was given a white wood stick together with the block containing the hole and was told that he must whittle a peg to fit the hole. This test was graded by giving workmanship, or fit, equal weight with time

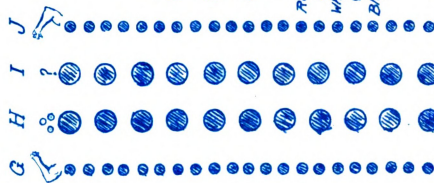
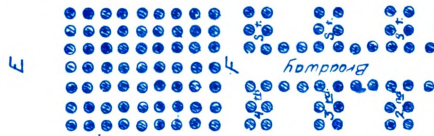
consumed in performing the work. The actual number of strokes taken to complete the peg were also recorded but as this was covered directly by the time taken to do the work, it was decided to give it no weight whatever in grading the test. In order to unify the conditions of the test the same knife was used by all of the men tested. The object of this test was to bring out the mechanical ability of the subject, for its performance necessitated the sizing up of the job, the adoption of some method of fitting, the ability to use judgment, and the sense of true proportion. That judgment and a sense of true proportion were necessary in the performance of this task was demonstrated by the fact that several wrong cuts were taken, that is, when the subject turned the peg towards him to cut, after a trial fitting, he frequently found difficulty in knowing what face to cut. In two instances, the peg was entirely spoiled by cutting the wrong face directly after making a trial fit to the hole.

The next and last test given was the Match Board Test. This consists of a board drilled with numerous holes and provided with a receptacle for a supply of matches as shown on the next page. This is a modification of the test used by Mr. Kemble in his tests on factory girls. The board as shown here, is equipped for eleven distinct tests, each test being given to determine some one characteristic. The tests have been designated as A, B, C, D, E, F, G, H, I, J, and K, and will be referred to as such in the balance of the discussion on the Match Board Test.





1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110



K

Red Yellow Grey
White Green Black
Blue Brown L.Red

Layout of Match Board. Test #5

81

Test A consists of a row of holes, twenty-one in number each hole being $\frac{3}{16}$ " in diameter. The match retainer is located only approximately three inches away. The subject is given only thirty seconds in which to transfer as many matches as he can from the receptacle to the row of holes, using his left hand and transferring only one match at a time. This test requires only a movement of the wrist. It is simply a test for dexterity. The test is graded on a ten hole basis, that is, if eighteen matches were correctly placed out of a possible twenty in the time limit allowed the grade would be $\frac{10 \times 18}{20}$ or 9.

It may be interesting to note that the average of the students tested was found to be a little higher than that of the factory girls tested by Mr. Kemble. The students averaged seventeen matches placed while the factory girls only averaged fifteen matches placed. No significance can be given to this fact, however, for only twelve students were tested whereas hundreds of factory girls have been given the same test.

Test B is really a repetition of test A except that it tests the dexterity of the right hand instead of the left hand. The grading of this test is the same as in test A.

Test C is a combination of the two previous tests. For this test, there are two rows of holes and the subject must fill as many holes in both rows as he can in the thirty seconds allowed, using both hands and not having more

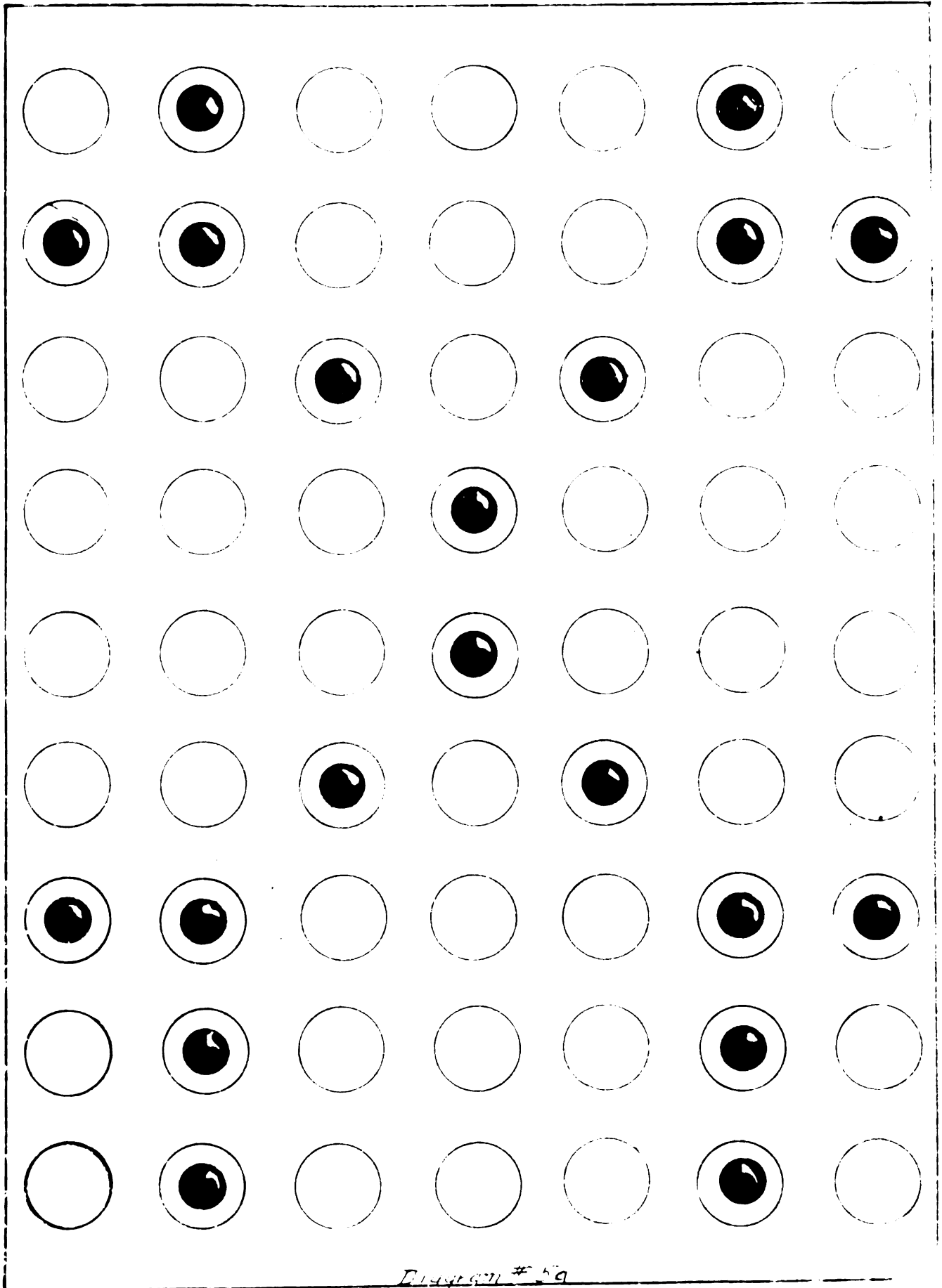
than one match in a hand at any one time. This test is also graded in the same manner as test A. It tests the ability of the subject to use both hands simultaneously or what is known as ambidexterity.

Test D consists of ten rows of holes, each row having eleven holes. Each hole is numbered consecutively from left to right beginning with the first row at the top and ending with the last row at the bottom. Fifteen numbers were then read at the rate of one every two seconds and the student being tested endeavours to place a match in the hole whose number corresponds to the one read, a supply of matches being held in one hand ready for instant use. He is then graded on this test on the same basis as in the previous tests, namely on a basis of ten. To find ones grade in this tests, the formula $\frac{N \times 10}{15}$ is used where N represents the number of correct placements. This test is for the purpose of determining the quickness of co-ordination between the ears and the hands.

Test E consists of a number of holes and an enlarged duplication of the pattern on a card as shown on the following page. There are twenty black dots on the pattern to form a simple diagram. The subject is instructed to place a match in a hole corresponding to each dot on the card. The time allowed which is counted from the instant the card is brought in sight, is thirty seconds. The grade is computed by the same formula as used in test A, namely, $\frac{N}{2}$

E

84



where N represents the number of correct placements. This test brings out the co-ordination between the eyes and the hands.

Test F consists of a number of holes forming an outline representing streets. Each hole represents a house. A slip of paper is presented to the subject. At the signal, this slip of paper is turned over and there appears the following instructions:

"Place one match in the second house on the north side of 3rd Street, east of Broadway. Place another match on the southwest corner of Broadway and 2nd Sts. Place two matches on the west side of Broadway in the block between 2nd. and 3rd. Sts., but not in a corner house. Place one match at the east end of 2nd St., on the north side of the Street".

The time taken to perform this task is recorded as also are the number of misplacements. From this, the grade is obtained by taking one minute as the allowable length of time necessary to perform the task and, giving equal weights to both accuracy and time, by substituting in the formula

$$\frac{\frac{N}{25} - \frac{1}{T}}{2}$$

in which N represents the number of correct place-

ments and T the length of time taken to perform the test. The purpose of this test is to determine the power of concentration and the ability to follow out directions.

Test G is really a duplication of test A except that the holes are removed about twenty inches from the match

box. The grading for this test is also done in the same manner as in test A. The test is conducted the same as test A and is intended to bring out the speed of arm movement.

Test H is similar to the preceding one excepting for the fact that the holes are larger and three matches must be placed in each hole. Both hands are used in this test, the left hand counting out the matches and the right hand placing them in the holes. This is a simple test but nevertheless it brings out the co-operation between the hands.

Test I was not used.

Test J was similar to G with the exception that the other arm was used.

Test K consists of two groups of nine holes each. In the first group of holes appear different colors. In the other group, the names of the corresponding colors appear beside the holes but not in the same order. Colored matches are placed in the second group of holes in correspondence with the names of the color appearing beside the hole. At a signal, the matches are transferred to the corresponding colored hole in the first group. The time taken for the performance of this is recorded. At the second signal, the matches are transferred back to their original holes. This test was devised for the purpose, I believe, of determining the memory qualities of each student for memory is the requirement necessary in replacing the matches in their holes in a short length of time. Hence, we may say that the length of time consumed measures, to some extent, the

subject's memory powers.

There being ten separate tests used on the Match Board, each test being given as much weight in determining the final grade as any other test, and the grade of each test being computed on the basis of ten, all that is necessary to obtain the final grade is to add up all of the separate grades.

Now that we are somewhat familiar with the tests, let us investigate the real values of them, or let us see how they correlate. For purposes of condensing our table of results, each student who was examined was given a number and only these numbers will appear in our tabulation. The men tested and their corresponding reference number are as follows:

TABLE ONE.

NAME	REFERENCE NO.
Armentreut, R. S	1
Bunker, V. W	2
Burris, T. F.	3
Dressel, O. G.	4
Eliot, M. F.	5
Camel, G. D.	6
Graham, F. E	7
Hughes, A. W.	8
Huntley, H. B.	9
Johnson, M. E.	10
Likens, F. G.	11
McBroom, R.	12

Table two show the grades made by each student on the various tests. From the grades made by a student in the Technical Test was estimated his grade in recitation and from the average of all the grades made by a student in the so-called "manual test", were estimated his grade in shop work. These two estimated grades were then averaged together and the estimated grades made in the course obtained. This method may be subjected to some criticism, but it is the logical method since the object of the Technical Test was to estimate recitation grades and the object of the balance of the tests to estimate shop grades of the men. In this way, the estimated course grade was obtained in the same manner as the actual grade, namely, by averaging the recitation and shop grades.

TABLE TWO.

REFERENCE NO.	1	2	3	4	5	6	7	8	9	10	11	12
Technical Test	A	C	C	C	A	D	D	C	B	C	C	D
Expression Test	C	B	A	B	C	D	C	B	B	B	A	B
Peg Fitting Test	B	B	B	C	C	D	C	B	B	A	C	D
Cube Test	A	C	C	A	X	D	C	B	C	A	B	X
Match Board Test	C	B	C	B	D	D	C	A	C	A	C	B
Average of all tests	B	B	B	B	C	D	C	B	B	A	B	C
Recitation Grade Est.	A	C	C	C	A	D	D	C	B	C	C	D
" " Rec'd.	B	A	B	A	B	B	D	D	C	C	B	C
Shop Grade Estimated	B	B	B	B	C	D	C	B	B	A	B	C
" " Rec'd.	B	B	B	B	B	B	B	B	B	B	B	B
Course grade Est.	B	C	C	C	B	D	C	B	B	B	C	C
" " Rec'd.	B	B	B	B	B	C	B	C	B	B	B	C
Average in College	C	C	C	B	D	C	D	D	C	C	C	C

The following table shows the correlation of each individual test and the average of the tests to the actual marks made in recitation and shop work, and also in the whole course.

TABLE THREE. Correlation of Tests.
Recitation Shop Work Course.

Technical Test	43%	20%	45%
Expression Test		14%	49%
Peg Fitting Test		36%	56%
Cube Test		23%	45%
Match Board Test		35%	45%
Average of Manual Tests			50%
Average of all Tests			45%

From the table of Correlations, it is seen that the technical test is significant of the work done by a student both in recitation and in the course. In other words, the grade made by a student in the Technical Test will show fairly well what can be expected of him in his recitation work and also approximately the grade he will probably make in the course. Each test tells its own story. Particularly striking is the correlation shown by the Peg Test. However, the reader should not lose sight of the fact that altho the individual test correlate as high or even higher than the average of the tests, still the average of the tests gives a much more accurate basis of estimating the ability of a student than any one test. The reason for this is obvious when it is considered that the tests were not all marked on

a numerical basis. There are a greater number of men who have the same grade in any single test than there are those who have the same average for all of the tests. Therefore, in correlating, the element of chance enters in to a greater extent in awarding first, second, third places and so on to the men based on their marks made in a single test than in awarding like places based on their average of all of the tests. For instance, five men made a grade of B in the peg test. And, as previously explained, in order to correlate it is necessary to arrange these men in the order of their ability, the best man first etc., How is it possible to pick the best man out of five who have all made the same grade? It is possible. But in correlating the average of the tests, altho the five men may be given a grade of B-, for example, the minus sign will have a different value for each man, for a man may have made a grade of B on two tests and a grade of C on two other tests or he may have three B grades and only one C grade. For this reason, the men can be accurately arranged according to their average grade of all of the tests and the correlation made correct.

Considering the small number of tests tried, the small number of men Tested, and the inexperience of the men who devised and conducted the tests, the results have been very gratifying. Altho a correlation of 50% for a group of tests is not as high as would be desired for practical use in employing men, nevertheless this correlation does not show that the tests were significant. It also should leave no

room for doubt that by trying a greater number of tests, devised and conducted by thoroughly experienced men, a group of tests could be found that would correlate very highly.

In closing, let it be said that the purpose for which this report was written have been fully covered, namely; a brief treatise of psychology and its application to employment, and an actual demonstration of the practicability of tests in rating the ability of men. It is hoped that the facts herein presented and demonstrated will prove to be of sufficient force to bring about the adoption of a system of scientific employment by the Polyfuel Engine Company.

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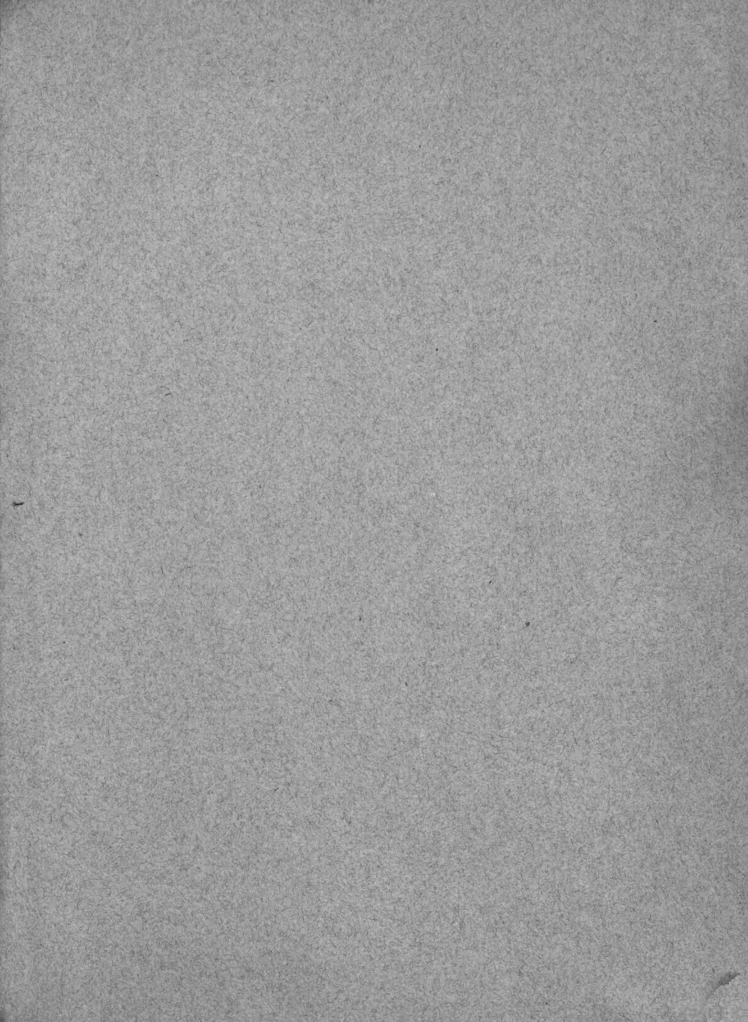
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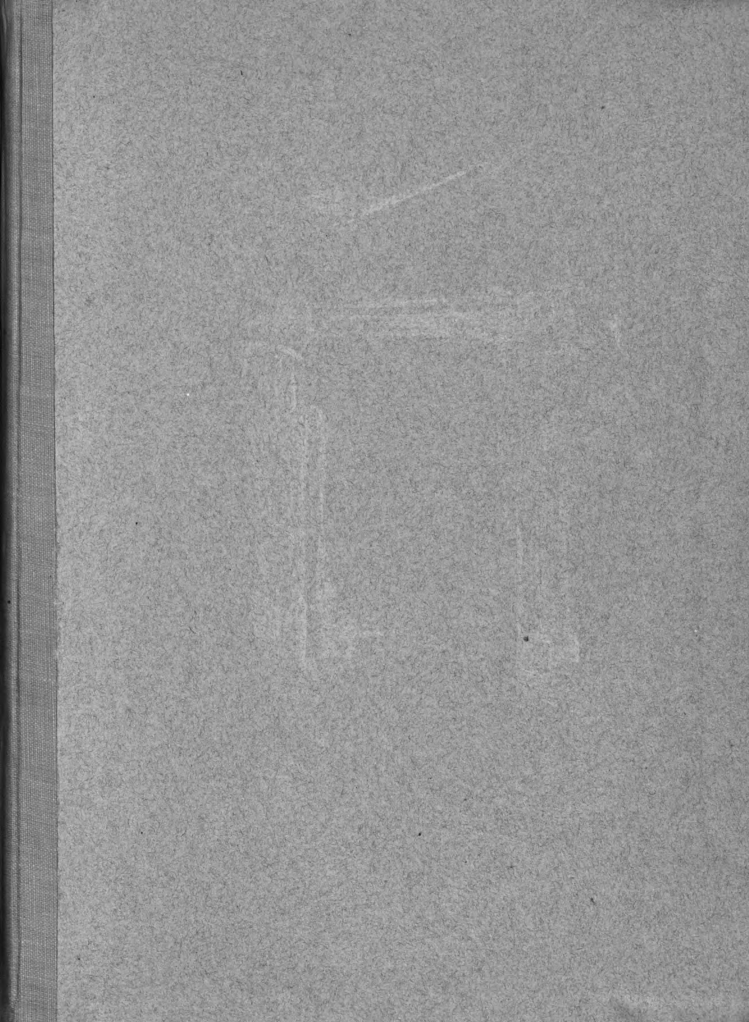
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