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# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 WEST THIRTY-NINTH STREET, NEW YORK

## PROCESS CHARTS

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To be presented at the Annual Meeting of The American Society of Mechanical Engineers, 29 West 39th Street, New York, December 5 to 9, 1921.

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# PROCESS CHARTS

## FIRST STEPS IN FINDING THE ONE BEST WAY TO DO WORK

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Member of the Society

and

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Non-Member

*The process chart is a device for visualizing a process as a means of improving it. Every detail of a process is more or less affected by every other detail; therefore the entire process must be presented in such form that it can be visualized all at once before any changes are made in any of its subdivisions. In any subdivision of the process under examination, any changes made without due consideration of all the decisions and all the motions that precede and follow that subdivision will often be found unsuited to the ultimate plan of operation.*

*In the present paper the authors point out the place of the process chart in management and present established working data used successfully in numerous working installations for many years. They also point out its simplicity, field of application, its relation to standardization, etc., etc.*

*While the process-chart methods will be helpful in any kind of work and under all forms of management, the best results can come, the authors state, only where there is a mechanism of management that will enforce and make repetitive the conditions of the standards.*

THE Process Chart is a device for visualizing a process as a means of improving it. Every detail of a process is more or less affected by every other detail; therefore the entire process must be presented in such form that it can be visualized all at once before any changes are made in any of its subdivisions. In any subdivision of the process under examination, any changes made without due consideration of *all* the decisions and all the motions that precede and follow that subdivision will often be found unsuited to the ultimate plan of operation.

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For presentation at the Annual Meeting, New York, December 5 to 9, 1921, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

## PLACE OF PROCESS CHART IN MANAGEMENT

2 The process chart is a record of present conditions. It presents, in simple, easily understood, compact form, data which must be collected and examined before any improvement in existing conditions and methods is undertaken. Even if existing conditions are apparently satisfactory, the chart is useful as presenting much information in condensed form.

3 The process chart serves as an indicator of profitable changes. It assists in preventing "inventing downward," and stimulates invention that is cumulative and of permanent value. It is not only the first step in visualizing the *one best way to do work*, but is useful in every stage of deriving it.

4 This paper presents established working data used successfully in numerous installations for many years.

## FIELD OF APPLICATION

5 The process chart lends itself equally well to the routine of production, selling, accounting and finance. It presents both simple and complicated problems easily and successfully; it provides records that are comparable; it assists in solving problems of notification and interdepartmental discrepancies, and it makes possible the more efficient utilization of similarities in different kinds of work and in the transfer of skill.

6 During the stress of unexpected rush in production, it is often considered advisable to continue existing practice in present processes, even though inefficient. On the other hand, when production is normal or slow, it is more generally conceded that processes can profitably be bettered.

7 The use of this process-chart procedure permits recording the existing and proposed methods and changes without the slightest fear of disturbing or disrupting the actual work itself, and also regardless of whether business conditions are usual or unusual.

8 Those who are interested in improving their processes of production should utilize times of industrial depression for that purpose. Many concerns are now taking such action; many more could undoubtedly enter upon such procedure of scrutinizing all their processes with the idea of putting them in the best possible condition, if they knew a simple procedure of such analysis.

## SIMPLICITY OF THE PROCESS CHART

9 The aim of the process chart is to present information regarding existing and proposed processes in such simple form that such information can become available to and usable by the greatest possible number of people in an organization before any changes whatever are actually made, so that the special knowledge and suggestions of those in positions of minor importance can be fully utilized.

10 The time has passed — if it ever existed — when the engineer prided himself upon the abstruse material that he studied and

136. All the time of ALL our workmen must be entered on the regular time book sheets. When men are employed on EXTRA WORK see additional directions below.
137. Time book sheets must be mailed to the office the night that the payroll closes. Send at the same time all EXPENSE ACCOUNTS, CASH ACCOUNTS, (made up to date) and PAYMASTERS' REQUISITION.
138. Send original time sheet to the office regardless of its appearance.
139. Keep all time books with the greatest care.
140. DO NOT USE A NOTE BOOK. We find that most mistakes in workmen's time are caused by copying.
141. All remarks about the payroll must be written on the time sheet itself.
142. The full time of every one of our men must appear on the regular TIME BOOK ("TB") sheets. The time of any of workmen which is to be charged to EXTRA WORK must be entered on supplementary sheets under the proper ORDER LETTER number.
143. Keep separate sheet for each ORDER LETTER and fill out carefully the ORD. LET. (NUMBER) AND NATURE OF WORK.

FIG. 1 PORTION OF PAGE OF WRITTEN SYSTEM REPRODUCED DIRECTLY FROM TYPEWRITTEN SHEETS

presented. Today engineering ranks with the other sciences in conveying ideas in a form that is immediately usable. We avoid "translating," interpreting and adapting, thus eliminating waste.

11 The process chart has met the tests of a satisfactory teaching device from the psychological standpoint, as well as of a satisfactory working device from an engineering standpoint. It shows the planned process as well as the present process, and therefore gains the coöperation of those affected. In many instances recording industrial processes in process-chart form has resulted in astonishing improvements.

## COLLECTING THE INFORMATION

12 Process-chart notes and information should be collected and set down in sketch form by a highly intelligent man, preferably with

an engineering training and experience, but who need not necessarily have been previously familiar with the actual details of the processes. In fact, the unbiased eye of an intelligent and experienced process-chart maker usually brings better results than does the study of a less keen man with more special information regarding present practices of the processes. The mere act of investigating sufficiently to make the notes in good enough condition for the draftsman to copy invariably results in many ideas and suggestions for improvement, and all of these suggestions, good and bad, should be retained and filed together with the description of the process chart. These suggestions and proposed improvements must be later explained to others, such as boards of directors, managers and foremen, and for best results also to certain workmen and clerks who have special craft or process knowledge. To overcome the obstacles due to habit, worship of tradition and prejudice, the more intelligence shown by the process-chart recorder, the sooner hearty coöperation of all concerned will be secured. Any one can make this form of process chart with no previous experience in making such charts, but the more experience one has in making them, the more certain standard combinations of operations, inspection and transporting can be transferred bodily to advantage to the charts of proposed processes.

## UTILIZING SUGGESTIONS

13 A new viewpoint concerning old conditions invariably comes to those members of the organization who have become so accustomed to the traditional method that they cannot easily visualize a new method without prejudice until they actually see it in a new graphical form. After the rough notes of the process-chart maker have been redrawn and blueprinted, they are later exhibited in the executives' theater.

14 If discussions arise as to the correctness of the presentation of the existing facts, or as to further details of the operations being studied, as shown by the simple symbols of the process chart, the room can be darkened and inexpensive glass diapositives projected on the wall. In addition, those present may be supplied with a special small pocket folding stereoscope for use with the same glass diapositives.

15 As soon as the old or existing process is understood, a process chart of a better sequence and kind of operations which compose it is made. The procedure for this is the same for all cases as far as

they are carried for the time being, but of course those processes which warrant the most study should be carried farthest in the

BASKET NUMBERS

*CHANGE ORDER*

| SYMBOL | DRAWING NO. | PATTERN NO. | ORDER NO. | STANDING ORDER NO. | MONTH | DAY | YEAR |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

THE FOLLOWING CHANGES TO BE MADE

REASONS FOR MAKING CHANGE

SIGNED

| GENERAL MANAGER | TREASURER | COMPTROLLER | SALES DEPARTMENT | ADVERTISING DEPARTMENT | PURCHASING DEPARTMENT | TRAFFIC DEPARTMENT | ORDER DEPARTMENT | ACCOUNTING DEPARTMENT | COST DEPARTMENT | OFFICE MANAGER |
|---|---|---|---|---|---|---|---|---|---|---|
| SIGNED | SIGNED | SIGNED | SIGNED | SIGNED | SIGNED | SIGNED | SIGNED | SIGNED | SIGNED | SIGNED |
| DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOU | DAY HOUR | DAY HOUR | DAY HOUR |

| WORKS MANAGER | PLANT ENGINEER | QUALITY SUPERINTENDENT | PACKING SUPERINTENDENT | INDUSTRIAL ENGINEER | EMPLOYMENT DEPARTMENT | MASTER MECHANIC | STOREKEEPER | RECEIVING DEPARTMENT | SHIPPING DEPARTMENT | CHART DEPARTMENT |
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| DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR | DAY HOUR |

*CHANGE ORDER No.* 5

FIG. 2 STANDARD CHANGE ORDER BLANK

Note that all blank forms should be thus numbered in each blank space to be filled out for describing clearly the One Best Way to Learn Work.

process-chart procedure. The more people who see the process chart and the greater detail into which the regular process charts are divided, the more suggestions for improvement will come in.

## RELATION TO STANDARDIZATION

16 There is no process that warrants a process chart that does not warrant a "write-up" or "written system." Fig. 1 shows a portion of a page of the written system of our organization printed in 1899. It is interesting to note that it was reproduced directly from typewritten sheets and without being set up in type, and it is believed to be the first instance on record of a book being printed from zinc etchings made from typewritten manuscript.

17 The more care taken in making the written system, the more will develop the need for and appreciation of the value of clearly defined written standards. The better and the more detail in which the written system is developed, the better and easier will the standards and standing orders be developed.

18 Standards in writing should be made, even if there is not the managerial mechanism necessary to enforce and maintain them. Standards made even with enforcing mechanism absent will hasten the day when the enforcing and maintaining mech-

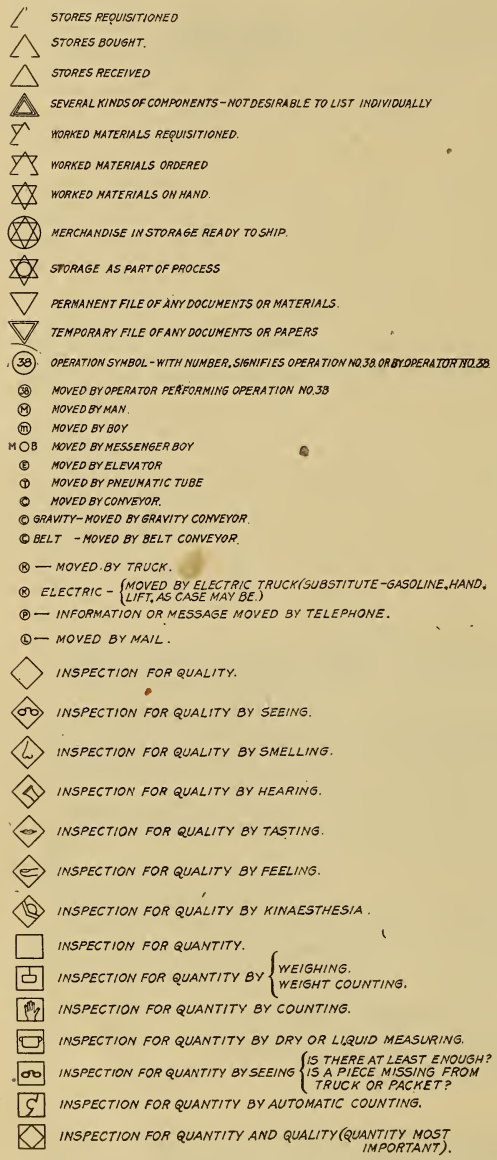



FIG. 3 STANDARD SYMBOLS FOR PROCESS CHARTS

(Continued on page 9)

anism will be installed and continuously operated. The procedure of making the standards will invariably lead to the simplifying and improving of the various steps as shown on the process chart.

19 If it is desirable to study, improve and still further identify the subject-matter of each part of the process chart, it should be submitted to the regular routine process of standardization. A standard is a matter of degree. In its best form it is identified and defined with all the care and precision of the best practice for making the standing orders. The range, however, is dependent upon the degree of perfection with which provision has been made for enforcing and maintaining standards.

20 While on the subject of range, it is well to call attention to the remarkable attempts of Germany and Holland to provide national standards. These standards already cover a very wide field, from the style of the hand lettering and the rulings to be used on the paper on which the standards themselves are printed, to a metal seat for a harvester, tractor or tank. The range, in fact, already covers a surprisingly wide list of things which have not been properly standardized in America, and is intended eventually to cover everything that is manufactured in quantity, or that will for any other reason reduce costs or improve quality. Although there is much to criticise in these foreign standards, they are highly meritorious, worthy of continuous and careful attention, and a great credit to those who have devised them.

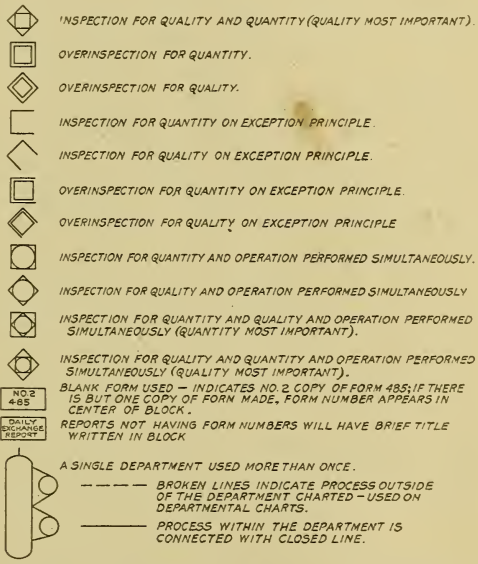



Fig. 3 Standard Symbols for Process Charts (*Continued*)

21 It must be remembered that the kind of standard adopted will affect the process almost invariably. Therefore standardization must be considered if the *one best way to do work* is to be derived.

22 Particular attention should be called to the fact that the creation of national standards of manufacture, even to the smallest components of the arts and trades, means also the stabilization of employment and business in general, because manufacturers without sufficient orders in their regular lines of business to keep going will find it more profitable, in many instances, to manufacture the national standards and thus to turn their stores inventories into money immediately, rather than let their specially trained and skilled men leave them, with all the disadvantages of a high labor turnover. Here is an endless spiral of benefit, for the more chances there are for a manufacturer to dispose of his inventory for cash and keep his organization together a little longer, even in times of general timidity, the more he will dare be a purchaser of raw material, for the process for such emergencies can be standardized and ready. The result is standardization combined with stabilization of employment, a quick capital turnover and a low labor turnover.

23 Many fear standardization of the component elements of a process chart as something from which, once done, it will be difficult to escape. For the purpose of allaying such groundless fears, the standard change order, Fig. 2, has been provided. This, when signed by the authorized party, instantly changes, or for a certain instance, or a certain time, waives the existing standard whether it relates to a thing, a method, a procedure or a process. It will be noted that this change order blank contains provisions for the notification of, and for the acknowledgment of receipt of notification of, all persons who are concerned with, or interested in, the change.

24 Note that in the lower right-hand corners of the various spaces in Fig. 2 there are small consecutive numbers. This is standardized to agree with write-ups and standing orders for using standard blank forms. It not only makes the writing of the standing order more simple, exact and clear, but it also shortens the time of the learning period for using these blank forms. This is a valuable feature at all times, but particularly useful during the transitory period of installing new methods of management.

25 Experience shows that if process charts are made use of, exceedingly few of the existing blank forms survive in their present form. The savings that can be made in any large organization resulting from submitting them to the test of this process will in variably prove it to be a good investment.

26 If all departments of the United States Government would adopt two features, namely:

*a* Put small numbers in each space to be filled out on all of its blank forms, and

*b* Make write-ups and standing orders of exactly how each blank form is to be filled out

and would then make a survey and criticism in accordance with the known laws of micromotion study, the resulting savings would be astounding.

27 We believe that, as a result, not one per cent of present

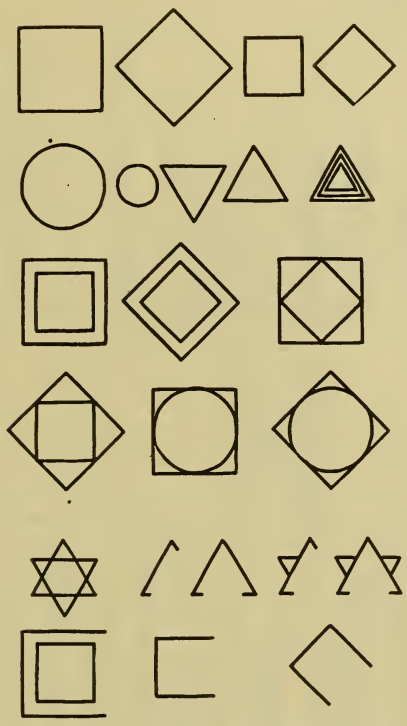
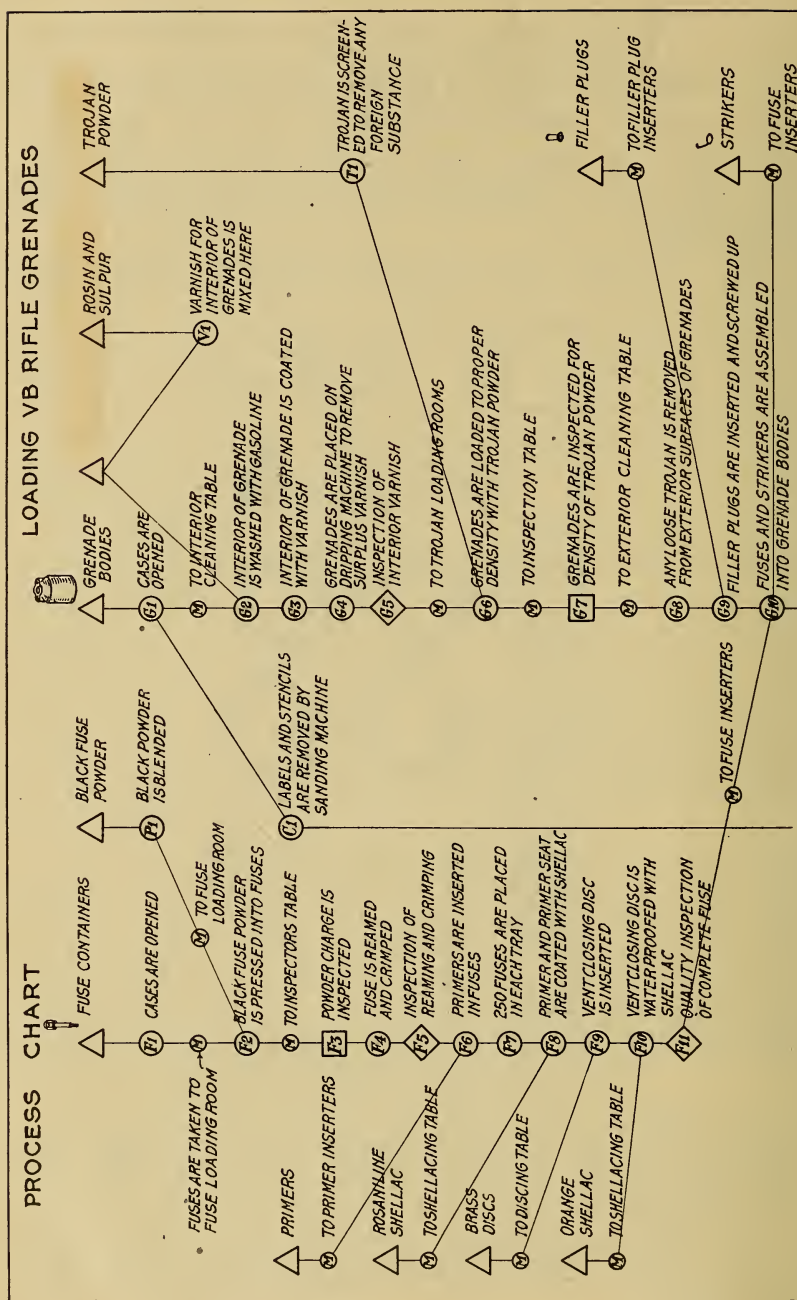


FIG. 4 STANDARD PROCESS-CHART SYMBOLS MADE WITH STANDARD CELLULOID GUIDES AND USING STANDARD PEN NO. 707

(One-fourth actual size)

blank forms would remain unchanged. All Government blank forms that we have seen violate all laws of motion study and learning methods of least waste.

28 The standing order is for enforcing standards and other standing orders. This has already been described in a paper before this Society.


PROCESS CHART
LOADING VB RIFLE GRENADES
FUSE CONTAINERS
F1 CASES ARE OPENED
FUSES ARE TAKEN TO FUSE LOADING ROOM
F2 BLACK FUSE POWDER IS PRESSED INTO FUSES
TO INSPECTORS TABLE
PRIMERS
TO PRIMER INSERTERS
F3 POWDER CHARGE IS INSPECTED
ROSANILINE SHELLAC
TO SHELLACING TABLE
F4 FUSE IS REAMED AND CRIMPED
F5 INSPECTION OF REAMING AND CRIMPING
BRASS DISCS
TO DISCING TABLE
F6 PRIMERS ARE INSERTED IN FUSES
F7 250 FUSES ARE PLACED IN EACH TRAY
F8 PRIMER AND PRIMER SEAT ARE COATED WITH SHELLAC
ORANGE SHELLAC
TO SHELLACING TABLE
F9 VENT CLOSING DISC IS INSERTED
F10 VENT CLOSING DISC IS WATER PROOFED WITH SHELLAC
F11 QUALITY INSPECTION OF COMPLETE FUSE
TO FUSE INSERTERS
BLACK FUSE POWDER
P1 BLACK POWDER IS BLENDED
TO FUSE LOADING ROOM
G1 LABELS AND STENCILS ARE REMOVED BY SANDING MACHINE
GRENADE BODIES
G1 CASES ARE OPENED
TO INTERIOR CLEANING TABLE
G2 INTERIOR OF GRENADE IS WASHED WITH GASOLINE
G3 INTERIOR OF GRENADE IS COATED WITH VARNISH
G4 GRENADES ARE PLACED ON DRIPPING MACHINE TO REMOVE SURPLUS VARNISH
G5 INSPECTION OF INTERIOR VARNISH
TO TROJAN LOADING ROOMS
G6 GRENADES ARE LOADED TO PROPER DENSITY WITH TROJAN POWDER
TO INSPECTION TABLE
G7 GRENADES ARE INSPECTED FOR DENSITY OF TROJAN POWDER
TO EXTERIOR CLEANING TABLE
G8 ANY LOOSE TROJAN IS REMOVED FROM EXTERIOR SURFACES OF GRENADES
G9 FILLER PLUGS ARE INSERTED AND SCREWED UP
G10 FUSES AND STRIKERS ARE ASSEMBLED INTO GRENADE BODIES
ROSIN AND SULPUR
V1 VARNISH FOR INTERIOR OF GRENADES IS MIXED HERE
TROJAN POWDER
T1 TROJAN IS SCREENED TO REMOVE ANY FOREIGN SUBSTANCE
FILLER PLUGS
TO FILLER PLUG INSERTERS
STRIKERS
TO FUSE INSERTERS

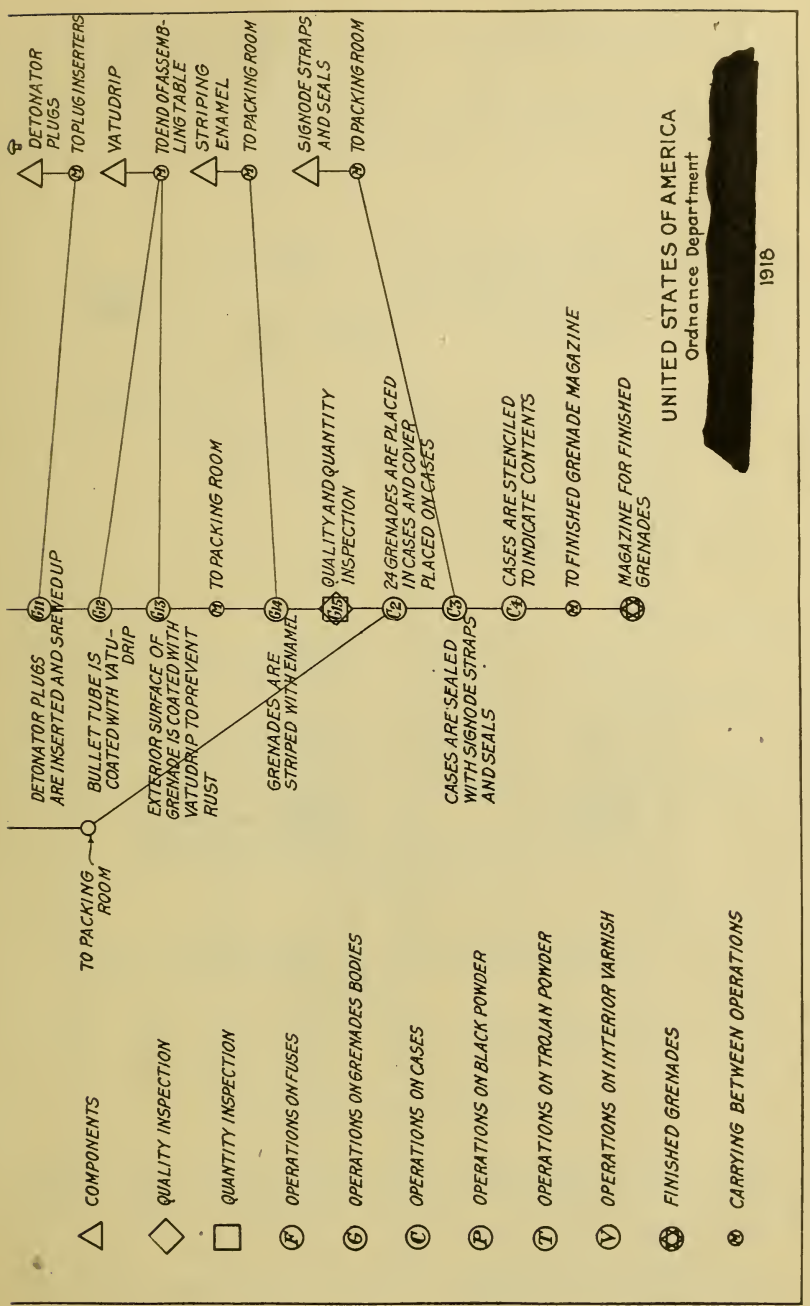



FIG. 5 PROCESS CHART FOR LOADING RIFLE GRENADES

29 The more detail in which the standing order is made, the better. The more the procedure is described by it, the greater will be the improvements and the greater the automaticity resulting.[1]

30 If any operation of the process shown in the process chart is one that will sufficiently affect similar work, then motion study

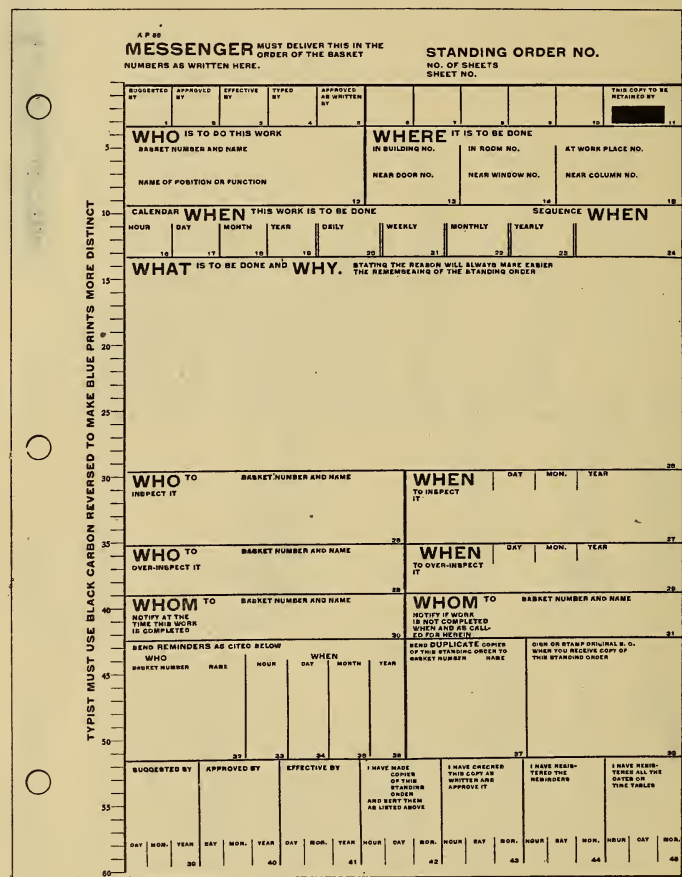



FIG. 6 STANDING ORDER BLANK

should be made of each part of the process, and the degree to which the motion study should be carried depends upon the opportunities existing therein for savings.

[1] See Psychology of Management; Applied Motion Study; and *Bulletin of the Taylor Society* for June, 1921.

31 If the operations are highly repetitive or consist of parts or subdivisions that can be transferred to the study of many other operations, then micromotion studies already made can be referred to; also new and further micromotion studies may be warranted in order that the details of method with the exact times of each of the individual subdivisions of the cycle of motions, or "therbligs," as they are called, that compose the one best way known, may be recorded for constant and cumulative improvement. Such motion study can be best visualized if seen in chart form and similar process charts can be made of any or all of the large or small circles, squares and diamonds shown on the process charts. These subdivided motion charts can be made of each and all of the cycles in any given operation. Much benefit can often be derived, even if such motion charts are made roughly. For best results, and especially when complete records are required, such, for example, as when the process charts are of work that is highly repetitive, micromotion charts can be made which will give the maximum amount of analysis and visualization of component parts of the existing

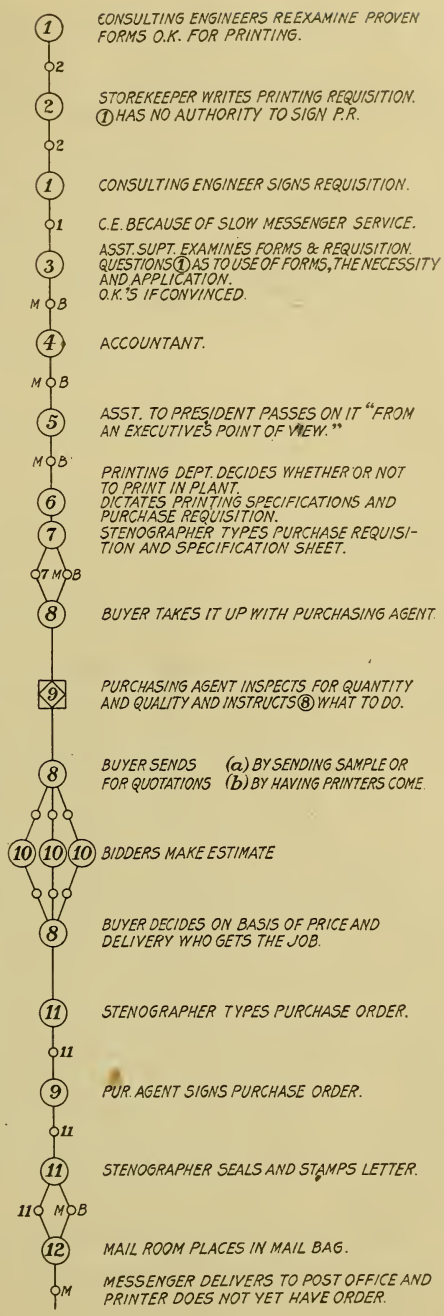



FIG. 7 PROCESS CHART FOR ORDERING BLANK FORMS — PRESENT METHOD

and proposed processes. These can be still further visualized by the chronocyclegraph processes. Both the chronocyclegraph and the micromotion process have been described before the Society and more recent developments in these methods and devices for visualizing existing and proposed processes will be the subject of a later paper.

32 The records of the micromotion study and the chronocyclegraph methods and devices present permanently all the facts in such form that they can be used at any time. These photographic records can be studied as slowly as desired, regardless of how fast the motions of the process were actually made and the marvels of the details of

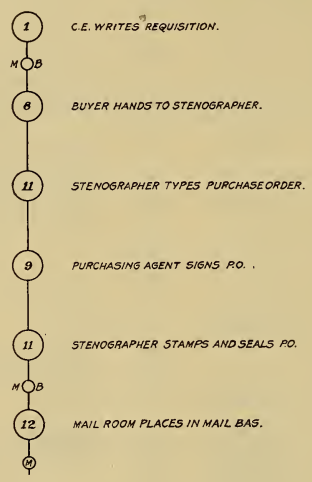



Fig. 8 Proposed Process Chart for First Orders

superskill, unknown and unrecognized even by those who possess it, can be studied at will, leisurely and intensively, by learners everywhere, far as well as near. If desired, these errorless records may be used only as far as to fill the need of present requirements, or they may be laid away until further needs demand further study, such records being in such perfect detail that they are practically as usable when old as when new. These permanent records of complete sequences of details of complete processes furnish the foundation of the best kind of trade and industrial education, namely, the dissemination of detailed instructions as to the synthesized processes of the best workers obtainable.

33 These synthesized records of details of processes in turn may be further combined and large units of standard practice become available for the synthesis of complete operations in process charts.

34 While the process-chart methods will be helpful in any kind of work and under all forms of management, the best results can come only where there is a mechanism of management that will enforce and make repetitive the conditions of the standards.

### MECHANISM OF MAKING PROCESS CHARTS

35 There are shown herewith:

*a* The symbols used with their meanings (Fig. 3)
*b* The mechanical devices for making the symbols on the process charts (Fig. 4)
*c* Completed process chart (Fig. 5)
*d* Accompanying forms (Fig. 6)
*e* Illustrations of collecting and using data.

### SUMMARY

36 The procedure for making, examining and improving a process is, therefore, preferably as follows:

*a* Examine process and record with rough notes and stereoscopic diapositives the existing process in detail

*b* Have draftsman copy rough notes in form for blueprinting, photographic projection and exhibition to executives and others

*c* Show the diapositives with stereoscope and lantern slides of process charts in executives' theater to executives and workers

*d* Improve present methods by the use of —

1 Suggestion system
2 Written description of new methods or "write-ups," "manuals," "codes," "written systems," as they are variously called
3 Standards
4 Standing orders
5 Motion study
6 Micromotion studies and chronocyclegraphs for obtaining and recording the One Best Way to do Work.

*e* Make process chart of the process as finally adopted as a base for still further and cumulative improvement.

37 Note that —

*a* Visualizing processes does not necessarily mean changing the processes

*b* Process charts pay.

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