COST KEEPING AND MANAGEMENT ENGINEERING

A TREATISE FOR ENGINEERS, CONTRACTORS AND SUPERINTENDENTS ENGAGED IN THE MANAGEMENT OF ENGINEERING CONSTRUCTION

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To Frederick W. Taylor, Past President of the American Society of Mechanical Engineers, as a tribute to his monumental work in applying the methods of exact science to the problems of management engineering, this book is dedicated.

PREFACE.

This book is intended to assist engineers, contractors and superintendents in reducing construction costs to a minimum. To accomplish this it is necessary to understand the laws or rules of management, and to have daily reports that show the efficiency of the men and machines employed. That there are any scientific laws of management will be denied by many men of the old school, but such a denial cannot be logically maintained. If there is a science of psychology, there must be a science of management, for management is a mental process that follows certain definite laws, obscure and complex at times, but none the less definite when once they are understood.

The Farady of the science of engineering management is Mr. Frederick W. Taylor, Past President of the American Society of Mechanical Engineers, for he not only perceived and applied certain of the fundamental laws of management, but, in his various papers, and particularly in his presidential address to the American Society of Mechanical Engineers, gave definite verbal form to the laws he had discovered.

In a subject so complex it is impossible for any one man to discover all the laws of management. Each student of the subject will be able to add his quota, until, in the course of the next few years, the science of engineering management will become as complete as any of the other younger sciences.

We have spoken of the science of management as being a branch of the science of psychology. It is, and it is more. Engineering management involves not only the directing of the human agents engaged in production but the economic application of the forces of nature through the medium of machines. Hence engineering management postulates a knowledge of the physical sciences, and particularly the science of applied mechanics. Many an ordinary foreman possesses a fair working knowledge of applied mechanics, having acquired it by observation and experiment; but such a foreman would be far more efficient as a manager if he also had a grasp of the theory of the principles that he applies.

For example, it is of great assistance, in planning the organization of a working gang of men, to know well the simple law that Work = Resistance × Distance, so as to apply this law consciously rather than to apply it intuitively as does the ordinary foreman. On the other hand, every engineer knows this law, but, due to lack of proper instruction or training in engineering management, many engineers do not apply it when they are engaged in construction management.

The science of engineering management involves, therefore, a knowledge of certain elemental principles that control the action of the human mind, combined with a knowledge of methods to be used in applying the principles of the science of mechanics.

In the application of the laws of this new science of management, the first requisite is a record of daily performance of each working unit, whether the unit be an individual workman or a gang of workmen. This recording of the performance of workmen is termed cost keeping. Cost keeping, as we show in Chapter V, is, in our sense of the term, a thing entirely different from bookkeeping. Bookkeeping has been evolved by merchants, and is essentially a system for showing debits and credits. Cost keeping has been evolved by managing engineers, and is essentially a system for showing the efficiency of workmen and of machines. One of the most common blunders arises from attempts to graft a cost keeping system upon a bookkeeping system. The two should be kept entirely distinct, for reasons given in Chapter V.

This is not the first book written on the general subject of cost keeping, but it is, so far as we know, the first book on cost keeping for managers of engineering construction in the field. Cost keeping systems for manufacturers differ quite materially from cost keeping systems for contractors or constructing engineers. The contractor is a manufacturer, it is true, but he manufactures bridges, pavements, sewers, and the like, with a *movable* plant, out in the open air, and, usually, with a gang of workmen picked up for each particular job. The fact that the plant must be installed and dismantled at comparatively short intervals, coupled with the fact that the plant must be frequently shifted as the work progresses, is alone sufficient to modify both methods of management and methods of cost keeping ordinarily used by manufacturers. Weather conditions cause still further modifications.

In no book hitherto published has an attempt been made to present not only methods of cost keeping but the principles of the science of engineering management. The two are so interrelated that it seems best to discuss them as parts of one general subject.

It is, perhaps, not hoping too much that a book of this sort will be soon adapted for use in the engineering colleges, because, for every engineer who can find employment as a *designer* of machines and structures, there are ten who can find employment as the *managers* of structural operations and plants. As high an order of engineering is required in mastering and applying the laws of engineering management as is required in calculating a stress or in selecting the means to resist it. Moreover, the greatest financial rewards for engineering work go not so often to successful designers as to successful managers. This may not be as it should be, but it is the present condition and seems likely to remain so.

In this connection the authors would suggest that, on certain kinds of work performed by engineering students, each student should be required to report daily his own output. Thus, in field surveying practice, each student should report the organization of the surveying party, the time spent on the different operations, and the amount of work performed. In stadia work, for example, the number of "shots" taken from each station, the time required to take them, and the time to shift the instrument from one station to the next should be reported on a suitable report card. In drafting work, a similar report should be made, giving the area of the drawing, and, if possible, the total length of the individual lines drawn.

Indeed, would it not be wise to run an engineering college very much as a modern factory is run? Every student could be regarded as a workman whose duty it is to report daily, and in detail, his time spent and the number of units of work performed. In some subjects the number of pages of lecture notes taken, or the number of pages of text read and studied, would be the number of units of work performed. In other subjects the number of problems solved would be recorded.

Thus, without burdening the students with additional hours of work, the *habit* of recording work units and of analyzing output would be formed—a habit of incalculable value to the future manager of men.

Within the last few years a number of engineers have been specializing as traveling instructors, if we may so call them, in cost keeping and management, particularly in the field of manufacturing. Several of these engineers have been astonishingly successful in reducing manufacturing costs; but, what is equally astonishing, they have found it exceedingly difficult to persuade many manufacturers to give them an opportunity to improve existing conditions. The same difficulty confronts the engineer who proposes to reduce construction costs for a contractor. The contractor says to himself: "If this engineer can do all that he claims to be able to do in reducing unit cost, he would not be asking me to employ him, but would become a contractor himself." Reasoning of this sort is fallacious in that it fails to recognize the fact that there is more to any business than a knowledge of *how* to do things. There must also be *means* with which to do. These means are, in many cases, cash capital. In other cases it is an organization of experienced foremen and workmen. Even capital cannot always buy such an organization. Years spent in weeding out inefficients, and in training men, are required to build up any organization. The intelligent engineer recognizes this fact, and is not too eager to plunge into contracting on a large scale, even if he can secure the necessary capital.

Finally, the world must always have its teachers—men with the natural aptitude and liking for the work of instructing other men how to do things. When this aptitude is strong, a man will frequently care less for a great income, with its attendant worries, than for an opportunity to exercise his talents. This fact is well illustrated in every engineering college, where professors of splendid mental strength devote their lives to training the minds of young men, and do so for a recompense in money that is pitifully out of proportion to the class of work done and to the ability displayed in doing it.

A knowledge of local conditions is often one of the greatest assets of a contractor, and this, too, comes only from years of experience. If an engineer skilled in the science of engineering management can associate himself with a contractor having capital, having an organization, and having a knowledge of local conditions, the result is almost invariably a great reduction in unit costs of construction.

Another obstacle that confronts the management engineer is the belief on the part of the contractor or manufacturer that he himself can develop and install a satisfactory cost keeping system. Often he can; oftener he cannot, for he is apt to be like the man who is his own lawyer and has a fool for a client. In this age of specialization, it is about as much as any man can do to keep up with the developments of his own specialty. This will be particularly the case with management engineering, because it is one of the youngest sciences.

Cost keeping is but a means to an end. The means is the daily report showing what each unit of the organization has accomplished. The end is the economizing of labor and materials, *as a result of the scientific study of the cost reports and of special timing records of performance.* We have italicised the last clause, because this is the thing that is usually overlooked by a contractor who is considering employing a managing engineer.

Cost records of themselves possess some value, but the great value arises from the scientific study of those records. Who will undertake to say that any ordinary manufacturer could have taken the timing records made by Mr. Frederick W. Taylor and from those records have deduced the methods of producing high speed tool steel that revolutionized a great part of the steel working industry? Here it was that the brains and scientific knowledge of the engineer came into play in interpreting the results of timing records and in developing a great labor saving method.

The word engineer has the same derivative as the word ingenious, as is particularly well seen in the French word for engineer, which is *ingenieur.* It is one of the functions of the engineer to invent—to exercise his talent of ingenuity. This is true of the designing engineer and it is not less true of the managing engineer. It is this very feature of engineering that gives the profession a charm that is irresistible. It leads engineers to spend their lives working more for the benefit of humanity than for their own financial betterment. As a class, engineers are like all inventors, careless of personal remuneration, craving the gratification that comes from having conserved materials or from having increased the output of men. The management engineer, however, is more likely to receive a greater measure of reward for his services than the designing engineer, for the results of his work are more strikingly evident to those who employ him, to say nothing of the fact that he is oftener able to patent devices that he has designed during the process of studying how to reduce operating and constructing costs.

For his efficient and painstaking labor in assisting in preparing cost keeping cards our acknowledgements are due to Mr. Charles Houston.

We owe thanks to Mr. A. D. Mellar for his assistance in the preparation of Chapter VII on bookkeeping.

Finally we, in common with the rest of the whole engineering profession, must acknowledge our indebtedness to Mr. Frederick W. Taylor, the dean of cost analysts.

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CHAPTER I.

THE TEN LAWS OF MANAGEMENT.

The managing of industrial enterprises, such as construction work in the field, is still an art, and there are few who realize that it can be reduced to a truly scientific basis. Nevertheless, there are certain underlying principles of effective management of men which may be expressed in the form of laws. Application of these laws leads invariably to a greater output on the part of workmen, and this invariability of result proves the scientific basis of the laws. The most important of them can be grouped under ten general headings, which are as follows:

1. The law of subdivision of duties.
2. The law of educational supervision.
3. The law of coordination.
4. The law of standard performance based on motion timing.
5. The law of divorce of planning from performance.
6. The law of regular unit cost reports.
7. The law of reward increasing with increased performance.
8. The law of prompt reward.
9. The law of competition.
10. The law of managerial dignity.

Below are given the main characteristics of each:

The Law of Sub-Division of Duties.—Men are gifted with faculties and muscles that differ extremely. One man will excel at running a rock drill, another is better at lifting loads, a third is clever in the application of arithmetic, a fourth is a born teacher—and so through the gamut of human occupation. Moreover, practice serves to accentuate these inborn differences. It is clear, therefore, that the fewer duties any one man has to perform, the easier it is to find men who can do the task well. But give a man many duties to perform, and he is almost certain to do at least one of them poorly, if, indeed, all are not miserably attended to. Hence the following law of management: *So* *organize the work as to give each man a minimum number of duties to perform.*

This law needs little emphasizing as to its general truth, but it is nevertheless ignored frequently by those who have not applied a scientific treatment to management. Thus, a foreman is often charged with a multitude of duties. He is expected, for example, to watch the workmen and spur them to action when slothful, to teach his men how to do their work in a more economic fashion, to discover and remedy defects in the machines and tools employed, to plan the arrival of materials at the proper time and in the proper amount, to keep records of daily performance, etc., etc.

Mr. Fred W. Taylor was the first, we believe, to urge the subdivision of the duties of foremen and to have what he calls "functional foremen." One foreman, for example, is the machinery and tool foreman. It is his sole duty to study the work done by machines and tools, to effect improvements, to reduce delays, and to supervise repairs.

Another foreman is the gang foreman. His function is to organize the gangs, to direct their operation, and to instruct them in the performance of their work.

A material foreman is employed on large jobs. His function is to confer with other foremen and ascertain what materials, machines and supplies will be needed. He orders the materials, arranges for their shipment, and follows up the manufacturing and railway companies to secure prompt delivery. If necessary, he sends men to the factory, to the stone quarry, or to the freight yard, to see to it that deliveries are made with dispatch. Such a man is often invaluable, for upon him may depend the entire progress of the work.

According to the magnitude of the contract there may be different kinds of foremen, all coming in contact with the same men, perhaps, but all performing different functions. Such an organization as this differs radically from a military organization wherein each man reports to only one superior officer on all matters.

Most industrial organizations to-day resemble military organizations, with their generals and intermediate officers, down to corporals, each man reporting to but one man higher in rank. There is little doubt that the present tendency in industrial organizations is to abandon the military system to a very large extent, and for the following reasons:

A soldier has certain duties to perform, few in number, and simple in kind. Hence the man directly in command can control the actions of his subordinates easily and effectively. Control, moreover, should come invariably from the same officer, to avoid any possibility of disastrous confusion, and to insure the instant action of a body of men as one single mass. On the other hand, industrial operations do not possess the same simplicity, particularly where men are using machines; nor is there the necessity of action in mass. The military organization, therefore, should be modified to suit the conditions; and one of these modifications is the introduction of two or more foremen in charge of certain functions or duties of the same men or groups of men.

On contract work it is often impossible to subdivide the duties of men to as great an extent as can be done in large manufacturing establishments. The smaller the contract, the less the subdivision of duties possible. In such cases, an approach to the ideal system of subdivision is secured not by employing different men for different purposes, but by a systematic assignment of duties to the same men to be performed at specified hours of the day or days of the week. Thus, a small gang of carpenters is engaged in builing forms for concrete, in repairing wooden dump cars, and in framing and erecting trestle work. By timing the men, and by planning their work upon the timing records and the requirements of the work, this carpenter gang can be assigned certain hours or days for each class of work. Thus is avoided the intermittent and uncertain shifting of the gang from one class of work to another, involving not only a loss of time in frequent shifting but a loss of interest in work that is done piecemeal. Moreover, a methodical change of occupation permits a methodical record of the number of units of each class of work performed, and thus leads to the use of the bonus system of payment.

The Law of Educational Supervision.—It is not alone sufficient to give instructions to workmen and foremen from time to time by word of mouth, but the gist of all important instructions should be reduced to written or printed form. Among contractors the pioneer observer of this law is Mr. Frank B. Gilbreth, whose "Field System" is a 200-page book of rules for his superintendents, foremen and others to follow. His "Bricklaying System" is another set of rules for the guidance of his brick masons and foremen.

Among manufacturers there are many examples of those who have prepared more or less elaborate sets of rules to be followed, but the most interesting of these compilations that have come to our attention is the one furnished to its salesmen by the National Cash Register Co. In this book are gathered a vast number of useful hints and practical suggestions and arguments to be used in selling National cash registers. Each possible objection that a prospective purchaser may raise is met with one or more specific answers. This company not only provides its salesmen with a text-book but has a school for training salesmen. At regular intervals all the salesmen meet together and discuss their respective methods of selling cash registers. Any new suggestions that are good become subsequently a part of the book of instructions. Thus the combined wisdom of hundreds of salesmen is preserved and delivered to every salesman that the company employs. This plan is followed also by many of the life insurance companies. Railway companies have long made it their practice to furnish their civil engineers with printed sets of rules for railway location, as exemplified in McHenry's "Railway Location." All these are forms of educational supervision, and some are very elaborate. The small contractor need not necessarily have a printed book of rules of his own making, but he can supplement some such book of rules and hints by a typewritten or mimeographed set of sheets containing the most important of his own instructions. In this manner the repetition of a costly blunder by a foreman or workman can be avoided by a special rule or hint, while a labor saving "trick" can be passed on to other men in the contractor's employ.

In developing a system of educational supervision, the greatest assistance can be obtained from articles in engineering and contracting periodicals, for there will be frequently recorded labor saving methods well worthy of trial by other contractors. In a long article it may be only a small hint that is worthy of being abstracted and placed among the hints for foremen.

In preparing a set of rules and hints, take pains to distinguish sharply between what is a rule always to be followed and what is a hint to be followed optionally. It is well to have a set of *rules,* each with its specific number, and a separate set of *hints,* also numbered.

The second law of management is briefly this:

Secure uniformity of procedure on the part of employees by providing written or printed rules, supplemented by educational suggestions or hints to guide them in their work.

The Law of Co-ordination.—*So schedule the performance of each gang of men that they will work in perfect coordination with other gangs, either adjacent or remote.*

Perfect coordination involves the working of each man to his capacity all the time. This necessitates not only the organization of gangs of just the right size, but the prompt arrival of standard supplies and materials, and freedom from breakdowns of plant.

An examination of almost any piece of construction work in progress will disclose the fact that most of the men spend a considerable portion of their time waiting either for somebody else to do something or for materials to arrive, before they can proceed. The cause is improper coordination of the work. One gang may have too many men, and therefore may be able to work considerably faster than another, and be continually catching up with it. They will then adopt a slower pace, keep seemingly busy, and manage to kill a large percentage of their working time. These delays are chargeable to lack of coordination, although a careless inspection of the work may seem to indicate that everything is going smoothly. A job can look smooth and at the same time be so badly coordinated as to be uneconomical.

The necessary adjuncts to proper coordination of work are briefly as follows:

1. A carefully drawn schedule of performance.
2. Regular arrival of material and supplies.
3. Prompt and proper repairs to equipment.
4. The proper quality of supplies.

The best method that has so far been devised for making things happen on time is first to prepare a time table, and then to live up to it as far as the interruptions of the weather and the limitations of human nature will permit. To prepare a time table properly, it is necessary to know how fast work can be done under the conditions which are to govern it. At the best, there will be a considerable variation to be accounted for by ignorance on the part of the planning department on the one hand, and by the interference of the elements on the other. A form of chart, made on tracing cloth, with various symbols to indicate the kinds of work to be done, has been found very useful. As the work progresses the performance can be checked off on the chart, and thus indicate whether the work is proceeding on time. Where the work is such as that of building construction, and there is but little storage capacity for materials, it is best to have the chart prepared a considerable time in advance, so that materials will arrive when they are needed and yet not so much in advance of the proper time as to require large storage capacity at the site of the work.

The principal railroads now use, for preparing time tables, a large blackboard on which the locations of stations are represented by ordinates and time by abscissas. Pins, over which are stretched threads of different colors, indicate trains, and the running speed of each train and its direction can be noted at a glance from the angle made by the thread with the horizontal. The principle of this arrangement can well be applied to the preparation of time schedules which can be afterward made up in more permanent form for record. Like the operation of a railroad, but more so, a piece of construction will always be ahead of time or behind time, and some parts may be ahead while others are behind the schedule. For this reason a form of chart which will admit of many alterations and additions is to be preferred to one on which changes cannot easily be made.

On a large piece of contract work it is often not easy to have on hand a very large supply of material, and the progress of the work is thus dependent upon its regular arrival. The man whose business it is to distribute and handle material will have to be placed upon some other sort of work or laid off altogether if the material fail. This can rarely be done without considerable loss of time and impairment of the efficiency of the men. When a man has been handling reinforcing bars until he has become quite proficient in it, when he knows what sizes of bars go in the different elements of the work, and what lengths are called for in different parts of a structure, a portion of the time spent in educating him to this point is likely to be lost if he has to be unnecessarily thrown upon another kind of work, and it is very difficult to tell by ordinary inspection how much loss of efficiency is involved. By shifting men on emergency in this manner it is impossible to keep the work coordinated unless each department has more than its economical number of men assigned to it and a continual process of shifting takes place.

When times are dull and the railroads are not overloaded with business, it is fairly easy to get railroad deliveries on time, by seeing to it that shipments are promptly made; while in times of financial prosperity, when the railroads are congested with freight, some consignees are sure to suffer from tardy delivery. Therefore, under such circumstances, it is essential to have larger stock piles and more storage capacity than when the railroads are not busy.

It needs no argument to demonstrate that a derailed car, or a broken steam shovel, or a wrecked derrick, is a sure obstacle to any proper coordination of the work. The best way to avoid break-downs is to keep the equipment in repair. Every engineman on the job should make a daily report in writing of the condition of his engine when he leaves it at night, and these reports should be filed just as regularly as any other records on the work. It should be the business of some one daily to go over these records and call the attention of the equipment foreman, or some one acting in that capacity, to any trouble which may cause interruptions to the service. Thus the equipment foreman becomes responsible for a large proportion of the break-downs, and he will see to it that these break-downs are as rare as possible.

Poor supplies are likely to cause disarrangement of work. There are few more expensive blunders than that of having the wrong grade of dynamite for rock work, unless it may be to have the right grade in the wrong condition, as when dynamite is frozen.

Bad coal will upset the temper of the blacksmith and of his steel, thus disorganizing the drilling operation sufficiently to cause delays to that and to blasting. Where boilers are worked under an "overload" and require careful nursing on the part of the fireman with good fuel, bad coal will cause a startling falling off in performance and greatly impede the processes involved. A 30 H. P. boiler with the best of fuel may be worked to a

35 H. P. rating, but then come down to a 20 H. P. rating upon feeding it from a shipment of slaty coal.

Systematic inspection of supplies that have been purchased under specification as to quality will eliminate most of this sort of trouble.

The Law of Standard Performance Based on Motion Timing.—Nearly every operation performed by a workman involves several motions, although at first sight it may often seem that there is but one.

Mr. Frank B. Gilbreth has coined the term "motion study" to denote his method of observing the number and kind of motions made by a man—a bricklayer, for example—in performing a given operation. His plan is to analyze the motions, assigning a name to each motion. His next step is to endeavor so to arrange the supply of materials, the position of tools, etc., as to reduce the number of motions and the distance of each motion to a minimum.

Mr. Fred W. Taylor was the first, we believe, to adopt the practice of invariably studying each motion by the aid of a stop-watch. A large number of stop-watch observations not only give the average time of a motion, but, what is of far greater importance, they indicate what the minimum time for each motion may reasonably be expected to be. It then follows that the sum of these minimum times for the different motions represents a standard time of accomplishment of the entire process. Hence our law of motion timing:

In the performance of every process, the sum of the minimum times observed for each motion gives a standard of performance possible of attainment under sufficient incentive.

Mr. Harrington Emerson calls this standard of excellence 100%, and has developed the plan of rating all actual performances in percentages. Thus, if the standard time for drilling a 10-ft. hole in a certain rock were 60 minutes and, if the actual time were 90 minutes, this performance would be rated at $60 \div 90 = 66.67\%$.

In establishing a standard time of performance, the first step is to ascertain the unit times upon the work as ordinarily performed. The next step is, by study of the time elements and the local conditions, to eliminate as many motions as possible and to reduce the time of others, either by shortening the path of motion, or by accelerating the velocity of the motion.

To illustrate by an example, we give the following time study, which was made by one of the authors some time ago on some cableway work. Since this was done the Lidgerwood Mfg. Co. have completely redesigned their cableway engine and fall rope carriers and have introduced new features in control (notably in the Gatuñ cableways in Panama). Therefore, while the data are correct as history, they must not be taken as indicating the limit of present possibility. A considerable number of studies was made, but one only is given for purposes of illustration:

TABLE I.

1908. Cableway No. 2, Handling Concrete.

Process.	Observations.	Min. time.	Ave. time.	Max. time.	Standard time.	Efficiency. Per cent.
Rl 40 ft.	30	6.0	10.5	17.3	6.0	57.1
Tl 470 ft.	33	31.0	47.3	63.0	31.0	65.5
Fl 123 ft.	37	22.0	30.8	44.7	22.0	71.5
———D	37	16.8	61.7	140.4	16.8	27.2
Re 123 ft.	36	19.4	23.7	29.3	19.0	80.4
Te 470 ft.	36	26.5	37.2	64.5	26.5	71.2
Fe 40 ft.	35	11.0	42.9	96.0	11.0	25.6
———L	28	12.0	73.2	234.0	9.4	12.8
Totals, 1,266 ft.		144.7	327.3	689.2	141.7	

TABLE II.

1908. Cableway No. 3, Handling Concrete.

Process.	Observations.	Min. time.	Ave. time.	Max. time.	Standard time.	Efficiency. Per cent.
Rl 40 ft.	18	8.0	13.6	18.2	6.0	44.1
Tl 470 ft.	17	35.5	39.3	68.0	31.0	78.0
Fl 123 ft.	21	25.0	39.4	77.0	22.0	55.9
———D	22	20.0	62.5	119.0	16.8	26.9
Re 123 ft.	22	19.0	28.5	36.0	19.0	66.8
Te 470 ft.	22	30.0	46.6	102.0	26.5	56.9
Fe 40 ft.	20	18.0	29.1	48.0	11.0	37.8
———L	16	38.0	75.6	220.0	9.4	12.4
		193.5	334.6	688.2	141.7	

The first column gives the abbreviations of the processes, distances, etc.; the second gives the number of recorded observations on each process; the third gives the minimum observed time in seconds for each process in that table; the fourth gives the average; the fifth gives the maximum time; the sixth gives the minimum of all the observed times for each process. While this is by no means the shortest possible time in which the process could be accomplished, it is the shortest one observed, and has here been taken to represent standard (100%) efficiency. By dividing the standard time by the average for each process the average efficiency as observed is obtained. This is shown in the seventh column.

As a result of this time study, it was possible to make an estimate of the probable increase in efficiency that could be obtained by rebalancing the engines. A further improvement was discovered in the method used in signaling to the operator, and an estimate of the saving to be obtained in this manner was made. A further improvement in regard to the position of the operator was discovered. A collateral improvement was perceived in the line of altering the design of the towers, so that the cost per unit of handling materials could be reduced, and further suggestions of a confidential nature, which we are not at liberty to discuss here, were made.

The Law of Divorce of Planning From Performance.—As a corollary to the law of the subdivision of duties, we have the law of divorce of planning from performance, first formulated by Mr. Taylor.

According to the old style method of management, each foreman is left largely to his own resources in planning methods, in addition to his other functions. This multiplicity of duties can be properly performed only by a foreman possessed of a multiplicity of talents. Since few men can comply with such a specification for brains, it follows that good foremen of the old style are rare indeed. The modern system of management consists, as far as possible, in taking away from the foremen the function of planning the work, and in providing a department to do the planning. Under planning we include inventing, that is, the improvement of existing methods and machines.

A common error in management is the assumption that the man on the job in direct charge of the work is the man best fitted to plan and improve. Nothing is further from the truth. Rare, indeed, is the man possessed of a trained inventive faculty, and it requires such a faculty not only to develop new methods and machines but to plan the use of any machine with greatest economy. Nearly every piece of contract work presents new conditions, and this solving of new economic problems is beyond the power of any but the trained and skilled economist. But even where the problems remain identical, the necessity of a divorce of planning from performance exists, as we shall indicate.

The brain is an organ that requires frequent exercise in doing the same thing before it becomes proficient enough not to suffer great fatigue. Thus, the man who is learning to ride a bicycle finds that half an hour's lesson has tired him more than ten hours' work at his accustomed occupation. Attempting to do something new is wearisome beyond measure, except to the mind whose training has been in solving new problems. Hence the ordinary man finds much fatigue and little pleasure in attempting to do his work in a fashion that differs at all from that to which he has long been accustomed. The mental inertia that resists a change in methods of performing work is almost beyond comprehension, and it is found not only in the lowest type of workman but in the highest.

Repetition develops skill, and skill gives pleasure. To a strong man used to his work there is actual pleasure in mowing hay, as Tolstoi has admirably pictured in one of his novels. Conversely, fatigue merges into pain and is repulsive.

In addition to these fundamental reasons why men adhere to precedent in their performance, there is the fear of ridicule in case of failure to succeed in any new attempt. The child learns to speak a foreign language more rapidly than an adult not only because of a more "flexible tongue" but because it does not fear laughter at its blunders. Partial failure is expected of the child, and it is not ridiculed. But an adult seems witless if he does not immediately learn the new word and its pronunciation; hence the laughter. So it is with every new performance. Furthermore, a serious mistake may lead to the loss of a position, thus adding another reason for sticking to the "good old way."

Finally, there is no method so fruitful in effecting improvements in methods and machines as a study of the time required to perform each movement or operation. A workman or foreman rarely studies his own work in this manner. Hence his experience, upon which he is wont to brag, is like the experience of the swallow building its nest—an unchanging adherence to precedent, regardless of possibilities of improvement.

It is a significant fact that nearly all the great inventions have been the product of brains divorced from the actual performance of the machines that they have invented. Eli Whitney, inventor of the cotton gin, was a lawyer, and not even a southern planter. Smiles' "Self Help" is a volume full of instances of important inventions made by men remotely, if at all, connected with the class of industry in which their machines are used. Nothing, therefore, is more ridiculously illogical than the common belief that the "men behind the gun" are either capable of being the inventors of the gun or the ones most likely to improve it. Yet it is this illogical belief that prevents railway companies, manufacturers and contractors from making hundreds of radical economic improvements.

There is another difficulty, one which is most insidious and not generally recognized among contractors. It depends upon a mental peculiarity, to which we know of not a single exception, which becomes increasingly evident as a man's familiarity with the work develops. The fact referred to is this: A field chief can see inefficiencies in operation and prescribe remedies far more unerringly when his personal active touch with any one piece of work is intermittent than when one job is his constant care. The ultimate reason for this fact belongs to the science of psychology rather than engineering, and its theoretical investigation is not our present concern, but the fact is there and it has got to be respected. Coming back to a job after two or three days spent on another kind of work, with another kind of responsibility and among another set of men, things are seen that were not before suspected, and the prejudices of practice, as they may be called, are offset by the distraction of other fields, without the analytical perception having had the opportunity to grow rusty from disuse.

Still another fact, equally important, equally elusive, equally difficult to demonstrate to the theorist who has not had field experience and to the old-timer who is hide-bound by precedent, is this: A man, no matter who he is, can do his work better, vastly more efficiently, when he is being coached than when he is his own guide, philosopher and friend. Why this is true we will not here take the time and the space to discuss. It is true at a rifle range, on the baseball diamond, on the football field, in rowing, in track athletics, in the machine shop, and in field construction work. A man can steal third base better under coaching, even with the handicap of the impressions having to go through the mind of the coach before he can make use of them, a matter involving a considerable interval of time. The coach must know his business, of course, and have the confidence of the worker; and in its field application the cost of the coaching must not be excessive, nor need it be. A coach can act in that capacity to a good many men at once, and, if he be allowed to confine himself to just one function for a considerable time, he can obtain a control of other men on this function that is astonishing. This is the basis of the employment of functional foremen first developed by Taylor.

We might multiply instances indefinitely, but it is clear from the above that the economic systemizing of any specific piece of work of any considerable size must be done by a thoroughly disciplined and well trained staff under the leadership and direction of the best man available; and it is further evident that if the services of the field chief on any one job can be made intermittent, visits being at reasonably short intervals, his efficiency will be a maximum. The superintendent in charge of the work has a continuous responsibility and a continual care. His coach, his friend and his chief must have a broader and a less confining field.

Not being on the job continuously, the chief will obtain unfair impressions unless fortified by an efficient and well ordered cost keeping system.

In agreement with the three preceding paragraphs, it has been found that the reorganizing of work is done much more efficiently by men who have not been a part of the permanent organization, than when attempted by an old employee on the work. This statement applies to large organizations as well as small, and has been proven true on the railroad, in the shop and in the construction field time and time again; and the fact frequently offers a particularly unfortunate obstacle to the employment of the best men for the work, because many men in the construction business dislike to entrust their trade secrets to an outsider. As a matter of fact, the trade secrets on construction work that are worth concealing, if shaken up in an ordinary peanut shell, would make a distinct rattle; but a contractor seldom likes to have his precise costs known outside of his own organization, lest someone else might have an advantage in bidding against him. He has confidence that the men in his own employ will not give away his figures to his business rivals and he has not the same confidence with regard to a rank outsider.

In practice, however, it works out differently. The employee who has gained such knowledge of the business as to make his information valuable can, and often does, better his job by going over to another contractor. The outside expert is under the strictest obligation of professional honor not to betray to one client the secrets of another, and we have yet to learn of such a thing being done by men with a reputation to sustain. A contractor's "costs" are safer in the hands of his consulting engineer than in his own office.

Summing up, we have this law:

For maximum economy of performance, the planning of methods of doing work should be the sole function of a manager who is not a workman himself nor in direct charge of the workmen.

The Law of Regular Unit Cost Reports.—Having planned a method of performance, it becomes necessary to secure daily, weekly and monthly reports of such completeness that a manager can tell, almost at a glance, what the actual and relative performances are. This systematic reporting is more fully treated under the head of cost keeping. The success of nearly all large corporations, such as the Standard Oil Company, is due, in large measure, to a system of regular reports that put the various managers in constant touch with the performance of the men under them. Reports to be of much value must come at short, regular intervals, must be in the same form, and must show quantitative results that admit of instant comparison with previous reports. To permit comparison there must be either similarity of conditions, or there must be a reduction to units that are themselves practically identical. For example, a weekly record of the number of yards of earth excavated and hauled at a given unit cost is usually of little or no value to the manager unless there is a further subdivision of units of cost. The cost of loading per cubic yard should be segregated from the cost of hauling, so that the cost of hauling can itself be expressed in the unit of the yard-mile or ton-mile hauled.

The law of regular unit cost reports may be formulated as follows: *Report all costs in terms of units of such character that comparison becomes possible even under changing conditions, and let these reports be made daily if possible, weekly in any event, and with a monthly summary.*

It is in the adherence to the terms of this law that managers of contract work in the field will find their greatest difficulty. First, there is the difficulty of selecting suitable units upon which to report costs. In pavement work, the square yard is a convenient unit and the number of units is easily measured daily. But in reinforced concrete building construction, there is needed not merely the cubic foot or cubic yard unit, but many others, some of which are not easily ascertained every day.

For example, the pound of steel reinforcement is one unit upon which reports should be made, for the number of pounds of steel per cubic yard of concrete differs widely. The thousand feet board measure in the forms is another necessary unit, and the square foot of concrete area covered by the forms is still another. Yet these and other units must be used to admit of any rational comparison of performance from day to day and week to week.

Furthermore, such units must be properly selected for the still more important purpose of paying the workmen according to any bonus system. In another chapter we discuss this problem of selecting units of measurement at considerable length, for upon such selection depends the success of contract work under the modern method of management.

The Law of Reward Increasing With Increased Performance.—*All payments for work should be proportionate to the work done.* This is the fundamental law of economic production. When this law is ignored—and it is partly ignored to-day on practically every class of work—the producer ceases to take keen interest in his work. Under the common wage system of payment, one brick mason receives as much as another, regardless of skill and energy. Individual incentive is lacking, save as it is supplied by fear of discharge. When laborers, working under the wage system, are put at the task of shoveling earth into a wagon, each man seeks to do as little as his neighbor, and the slowest becomes the pacemaker for the rest. Such ambition as any individual may possess is stifled by the knowledge that his increased output will never be known by his employer, and consequently never rewarded. Moreover, an ambitious man in such a gang is chided by his fellows who warn him not to set a "bad example" by working himself out of a job.

The wage system is responsible in the first place for lack of sufficient incentive to good performance, but its vicious effects have been greatly augmented by the stupid actions of many labor unions, such as the restriction of daily output, the limiting of the number of apprentices, the demanding of wages that have no relation whatever to the output of individuals, the refusal to work under foremen who are not also members of the union, the refusal to do any sort of work except that prescribed by the union, and the like. In the long run, all such restriction of output, whether due to the lack of sufficient incentive, or to the rules of labor unions, or to the customs of a country crystallized into castes such as exist in India, lead to a reward commensurate with the output. Summing up: The wage received becomes ultimately proportionate to the output. The high wages prevalent in America are due neither to labor unions, as some profess to suppose, nor to abundance of natural resources, but to the fact that in America labor unions have not thus far greatly restricted the output of individuals except in a few trades, and more particularly to the fact that they have not opposed the introduction of labor saving machinery. In addition, American managers are far in advance of all others in their recognition of the fundamental law of management—namely, that the reward should be proportionate to the performance. Hampered though they have been by the wage system, American managers have been liberal in their policy of payments for work performed. In recognition of his share in the greater output of earth excavation, the steam shovel engineman in the United States receives $125.00 to $175.00 a month.

Within the past decade still further strides have been made by American managers toward a more effective recognition of this fundamental law of proportionate reward. Various systems of payment, known as the bonus system, the differential piece rate system, and the like, have come into more general use, and even the old piece rate system has received a new lease of life, all tending wonderfully to stimulate the energy and wits of workmen, because they are in accord with the law of proportionate reward.

The Law of Prompt Reward.— Any reward or punishment that is remote in the time of its application has a relatively faint influence in determining the average man's conduct. To be most effective, the reward or punishment must follow swiftly upon the act. Hence a managerial policy that may be otherwise good is likely to fail if there is not a prompt reward for excellence. Most profit-sharing systems have failed, principally because of failure to recognize the necessity of prompt reward, as well as because of failure to recognize the necessity of individual incentive.

The lower the scale of intelligence, the more prompt should be the reward. A common laborer should reecive at least a statement of what he has earned every day. If, in the morning, he receives a card stating that he earned $2.10 the previous day, he will go at his task with a vim, hoping to do better. But if he does not know what he has earned until the end of a week, his imagination is not apt to be vivid enough to spur him to do his best.

A daily or weekly statement of earnings, followed by prompt payment, is a stimulus essential in securing the maximum output of workmen.

The Law of Competition.— The pleasure of a competitive game lies in conquering an opponent, and this follows logically from the fact that competitive games are an evolution from the primitive chase or battle. Work conducted as a competition becomes a game, and thus stimulates those engaged not only to strive with great energy but to derive keen pleasure from the contest. The business man who continues to pile up millions, long after his wealth is sufficient to satisfy every possible want, does so from pure joy in the contest to excel others engaged in the same business. He is following the law of competitive work.

By pitting one gang of workmen against another gang, the spirit of contest is easily aroused. But it is impossible to maintain this spirit indefinitely without following the seventh law of management of men—namely, by making the reward proportionate to the performance. When, however, this seventh law of management is observed, an added spirit is given to men by pitting one gang against another. Thus, in laying concrete by hand for a pavement, the best method is to have two distinct gangs working side by side, each gang concreting from the center of the street to the curb. When this is done under a bonus system of payment, the output is astonishing.

Where competing workmen cannot see one another's output, a bulletin board should be used, whereon the number of units of work performed by each man or each gang of men should be posted.

Convert work into a competitive game by organizing competing gangs of men and by posting their performance.

The Law of Managerial Dignity.—That there should be anything like caste among managers seems, at first, repulsive to democratic principles of government, whether the government be political or industrial. Nevertheless, a study of the personality of the most successful managers usually discloses a characteristic of firmness coupled with a sort of austere dignity. The best manager is never "one of the boys."

Managerial control reaches its acme of excellence in the army, and there we find class distinctions most scrupulously observed. The officers do not "mess" with the men, nor do they form close friendships with the soldiers in the ranks.

Familiarity breeds contempt, or it breeds at least a feeling that the great man is not so great after all. All managers are under the constant fire of criticism of their subordinates, whether they realize it or not. The best shield that a manager can wear is distance. His little foibles—and all men have them—may thus be kept concealed. It is essential that they be concealed, for men of less mental endowment will always seize upon the little defects of greater men's character or attainment as evidence of lack of any real superiority. The eye of criticism is a miscroscope for human frailties. Being a microscope, it is wise to keep beyond its range, so that the whole character may be viewed by the naked eye in its true perspective.

Discipline in an industrial army is as essential as in a military organization, and it is best secured by military methods. This involves: (1) The social separation of the officers from the men; and (2) a sequence of responsibility from the man in the ranks to the highest officer.

For every act on the work every man should be responsible to some particular man higher in authority. There should never be any doubt as to whom a man is responsible; but it does not follow that a man should be responsible to only one person, except for certain acts. As we have previously shown, an industrial organization may have several *classes* of foremen, to each of whom each workman is responsible for certain acts. What we now emphasize is the importance of not dividing the responsibility for any particular act. A contractor, for example, should rarely give any orders to a workman. All orders should come through the proper foreman. To do otherwise results not only in reducing the workman's respect for the foreman, but it frequently angers the foreman, who feels that he has lost dignity in the eyes of the workmen.

It is often wise to change foremen from one gang to another, in order to preserve the class distinction between foremen and men. As foremen become acquainted with the men, they generally want to be regarded as good fellows, and will then permit infractions of rules and a general decrease in activity. Who has not noticed that short jobs usually move with a "snap" that is not always characteristic of longer jobs?

We may sum up thus:

Discipline is best secured by managerial dignity, and dignity is best preserved by social separation of managers from subordinates and by an invariable sequence of responsibility.

CHAPTER II.

RULES FOR SECURING MINIMUM COST.

In our own work we have found it of great advantage to formulate certain rules for reducing costs; for a study of specific general principles leads to many improvements in management that would not occur if reliance were placed upon haphazard attempts to reduce costs. The following are some useful rules:

1. The sum of the items of unit cost must be a minimum.

2. Work every element of a plant to its capacity.

3. Since the principal factor of the unit cost of production where power machines are used is the labor of attending the machines, reduce the cost of this attendance even at the expense of a large increase in plant charges.

4. Transport and handle pieces in groups, each group being the unit handled.

5. Make the sum of the items of work, measured in foot-pounds, a minimum.

6. Consider the animal body, whether of a man or a horse, as a machine burning a limited amount of fuel daily, in the form of food, and therefore having a limited daily capacity for work.

7. Use low-priced men to do all work involving merely foot-pounds of energy.

8. Resolve each class of construction into the elements of work involved and study means of reducing the foot-pounds of each element.

9. Ascertain the percentage of dead work done in conveying and elevating material, with a view to determining its relative importance and thus deciding upon what it is worth to reduce it.

10. Express all items of cost as percentages of the total, to ascertain the relative economic importance of each item and thus determine where it is best to make the first efforts at cost reduction.

11. Express the value of all lost time in percentages of the

total cost of each part of the work, classifying the various items.

12. In selecting plant consider particularly the unit cost of moving and shifting it and the cost of lost time.

13. Make all designs for work, whether permanent or temporary, in the office as far as possible, instead of leaving this to the ingenuity of foremen or carpenters, to be done in the field.

14. Keep down the ratio of overhead charges to direct charges by night shift work.

15. Use every possible means to avoid accidents to plant by proper inspection and study of precautionary measures.

16. Do the most profitable part of the work first wherever possible, so as to avoid carrying interest charges.

17. Do as much work as possible in a yard or shop instead of in the field.

Rule 1.—*The sum of the items of unit cost must be a minimum.* These items are:

a. Plant and tool charges.
b. Operating labor charges.
c. Material.
d. Preparatory and incidental charges.
e. Cash capital.
f. Overhead charges.

The plant and tool charges comprise:

1. Interest.
2. Depreciation.
3. Repairs.
4. Installing and removing, including freight.
5. Shifting during construction.
6. Supplies, such as fuel, oil, waste, etc.
7. Watchman.
8. Storage during idle periods.
9. Insurance.

The total plant charges for an average year must be calculated and divided by the total number of units of product for an average year, or for the fiscal period on the basis of which the work in question is to be considered. This result will give the unit plant charge.

The operating labor charges comprise the labor which is directly productive, such as that of a man handling a pick and shovel; it comprises the incidental labor, such as that of the water boy, etc.; the monthly labor, such as that of the timekeeper and storekeeper; and the labor of superintendence. The sum of the amounts paid for this labor for the fiscal period under examination divided by the total number of units of product will be the total unit labor charge.

The total cost of material for a given result, or for a given period, divided by the total number of units of product, will be the total unit material charge.

The sum of all the charges for getting ready to do work which are not plant charges and which are incidental to the particular job handled, and yet not necessarily proportionate to the amount of work to be done, divided by the total units of product or profitable work upon the job for which these incidental charges are incurred, will be the total unit preparatory charge.

The interest upon the cash capital involved for a given period divided by the number of units of product or profitable work of each kind for a period under investigation will be the total unit capital charge.

The total charges which are not directly apportionable to any one job, and yet are essential to running the business, divided by the total number of units of product or profitable work handled by the entire organization for an average fiscal period, will be the total unit overhead charge.

The sum of these six unit charges should be a minimum in order to obtain the minimum cost. It naturally follows that it is not necessary for each of these items to be itself a minimum, since, if by an increase in the unit plant charge, the unit labor charge can be more than proportionately decreased, there is a resultant economy; and, similarly, if by increasing, even temporarily, the unit overhead charge, the efficiency of the general work can be sufficiently improved, the total economy will be increased.

It is very important to consider items 4 and 5 of plant charges, for it often happens that a plant that is too large and too expensive is employed on work which is not heavy enough to justify such a plant. The use of a 90-ton steam shovel, costing perhaps $80.00 per day to keep in operation and turning out 400 yards of material per day, costing a great deal to install and afterwards to remove, instead of a 30-ton steam shovel which might under similar conditions do 300 yards of material at a cost of $35.00 per day, seems rather ridiculous; yet this sort of thing very frequently is seen.

Rule 2.—*Work every element of a plant to its capacity.* A contractor's plant is usually composed of a number of elements, or units—e. g., steam roller, traction engine, rock crusher, rock drills, boilers, etc. The plant should be so designed and handled as to work each of these elements to its full capacity. This may be accomplished thus:

(a) By coordinating the elements so that each element working to capacity keeps every other element that depends upon it working up to its capacity.

(b) By providing extra machines to avoid delays due to break-downs or to necessary stoppages. Thus, for every eight rock drills in service, provide one extra drill. Also, provide an extra wagon or two when loading by hand on short hauls.

(c) By providing extra parts of machines and means for rapidly replacing worn or broken parts. It is not the cost of repairs that is usually an expensive item per unit of product, but the lost time of the entire plant and the working force.

(d) By giving each machine as uniform a "load" as possible, no "peak loads." If a machine is designed to provide for intermittent periods of heavy work, there is a great waste of interest and depreciation on the investment in the excess power capacity during the periods of normal exertion. Moreover, the machine subject to "peak loads" is heavier than one not thus subject to periods of extreme work, and is consequently more costly to transport, install and shift, which is not important in manufacturing but is very important in contracting.

(e) By giving the operating tool of the machine a rotary motion, if possible, instead of a reciprocating motion. This is a corrolary of (d), for a rotary tool is generally constantly at work. Thus, a rotary auger should be used in all fireclays and soft shales instead of the ordinary reciprocating or percussion drill, for the constant application of the power to the rotary cutting tool puts no pulsating or "peak loads" on the machine.

(f) By providing stock piles large enough to tide over irregularities in delivery of materials. This is of exceeding importance on contract work, but is usually given scant consideration.

(g) By having one or more men at the manufacturing plant, stone quarry, or sand pit, from which the important materials are being purchased. In no other way is it possible to get uniform delivery of materials by rail from points distant from the site of the contract work. Often it pays to have a man whose sole duty it is to get empty cars from the railways and to go to freight yards and see that loaded cars are not held at the yard.

(h) By having, if necessary, an extra man or two on hand, and idle a good part of the time, who can jump in and clear away any material or obstacle that is blocking the full operation of the plant. A particular instance of this occurred some time ago on some steam shovel rock work in which considerable drilling had to be done in front of the shovel. As soon as the shovel stopped working it was necessary to get drills going immediately in order that the shovels should be idle as short a time as possible; and it was found highly economical to have a drill crew handy so that they could at once be turned over to the work in front of the shovel. Their time was economized, of course, to some extent by having them ordinarily work as near the shovel as possible and calling them by whistle signal as soon as a shovel was blocked.

(i) By not having in service plant which is ordinarily capable of much more work than it is likely to be called upon to do. The most efficient way to work a dynamo or a boiler or a steam shovel is to work it to its regular capacity, and when it is working at less than this it is not as economical of fuel, of capital charges, or of the wages of the men who handle it as when its work is properly balanced.

Rule 3.—*Reduce the cost of attending machines even at the expense of a large increase in plant charges.* This may be done:

(a) By using as much power as one man can direct, without unduly increasing the weight of plant to be shifted. Thus, a 6-horse team driven by one man, so commonly seen in the West, greatly reduced the cost of operating the common transporting machine, the wagon. If each horse can pull one ton, in addition to the weight of the wagon, we have:

	Per day.	Per cent.
2 horses at $1.00	$2.00	57.1
1 man at $1.50	1.50	42.9
Total, 20 ton miles at 17½c	$3.50	100.0
6 horses at $1.00	$6.00	80.0
1 man at $1.50	1.50	20.0
Total, 60 ton miles at 12½c	$7.50	100.0

(b) By having one man attend two or more machines, as when one driver attends several one-horse carts in a quarry or on excavation.

(c) By using gasoline instead of steam, so as to dispense with a fireman.

(d) By using a central power generating plant, conveying the steam, air or electricity to the operating units.

(e) By using belt conveyors for short hauls.

(f) By using moving water to transport earth, sand or gravel in pipes or flumes.

(g) By concentrating the work where power can be applied at a few points. This is well exemplified in the use of a contractor's double track railway operated both ways by gravity, with an incline at one end having a power driven endless chain for raising the single cars. In this way the cars travel both ways by gravity without attendants. Gravity is especially adapted to short hauls on contract work, where, either by building a light trestle or by digging a trench on an incline, the necessary grade can be secured cheaply.

(h) By use of power in the driving parts of a plant ordinarily driven by hand—e. g., bull-wheel on a derrick—thus enabling the engineman to do not only the hoisting but the swinging of the boom.

(i) Often by the purchase of electric power and use of motors, thus avoiding the cost of handling fuel, and paying firemen, to say nothing of the cost of shifting boilers.

(j) By specializing the work of attendance, such as the delivery of material and supplies, which ought to be done as a special department by itself. When a drill runner has to run to the blacksmith shop for sharp bits or oil, the cost of attendance upon the plant becomes unnecessarily high. By having someone whose business it is to see that the high priced men spend little time waiting upon themselves, the economy can be much improved.

Rule 4.—*Transport and handle pieces in groups, each group being the unit handled.* This is, perhaps, one of the most important rules for economic construction, and is susceptible of wide application. The following are some examples:

(a) Brick handled in packets as described in Gilbreth's "Brick Laying System." This method of handling bricks is to load 16 or 17 bricks upon a little wooden frame made of four pieces of wood nailed together and of such shape that they can be carried by the workmen as a convenient load. These 17 bricks will weigh about 76 pounds and make a packet which is of convenient weight for one man to handle economically where the carry is comparatively short. Mr. Gilbreth's method is to load the bricks upon the packets in the car on which they are delivered to the work, or even in the loading yard, and to handle them in units in this manner until they are deposited about 21 inches from the wall alongside of the brick layer in such a position that he reaches for every brick with his left hand in the same manner and in the same relative position, thus avoiding the necessity of mental work on the part of the brick layer in choosing one brick after another, enabling a comparatively large number of packets to be handled upon a wheelbarrow, and eliminating the element involved in the picking and choosing done by the man who is loading a hod. Incidentally, when handling a hod, a hod-carrier must do considerably more foot-pounds of work than are necessary, and this accounts for something in the long run of a day's work.

(b) Quarried stone handled in skips, from the time it leaves the quarry until it reaches the rock crusher or the mason.

(c) Dump wagon box loaded with sand in a pit, lifted by a derrick and placed upon the wagon gear, lifted by a derrick at the concrete mixer and dumped into sand bin.

(d) Forms for concrete built in movable units—e. g., sewer and tunnel lining centers.

(e) Girders for bridges and roofs, transported and handled as one piece.

(f) Bents for trestles, framed and joined while lying flat on the ground, and then placed in position as one unit.

(g) A further illustration is in the riveting together of as many bridge members as can be carried upon a car or combination of cars for transportation and which can be erected as a unit. Appreciation of this fact has led to the general use of plate girders wherever possible, since the erecting costs are low and by far the greater part of the riveting work can be done in the shop under the most favorable conditions for economic work.

Rule 5.— *Make the sum of the items of work, measured in foot-pounds, a minimum.* This rule is axiomatic, but, in spite of its self-evidence, it is rarely applied to all parts of a job. Work equals resistance in pounds multiplied by distance moved in feet ($W = R \times D$). Obviously, then, one of the first applications of this rule is:

(a) Reduce the distance from a machine to the center of gravity of the materials in the adjacent stock piles to a minimum. Thus, the broken stone stock piles should be placed nearest the concrete mixer, the sand next, and the cement farthest. The reverse is usually done, although there are six times as many pounds of stone as of cement in a yard of concrete. Engineers have often made this sort of blunder when designing cableways for transporting materials from scows, so that the broken stone was to be moved about twice as far as the sand, and the cement was moved the shortest distance of all.

(b) By motion study and second-hand timing, eliminate unnecessary motions and shorten the distance of necessary motions—e. g., low wagon boxes loaded by hand (2 ft. of height saved may add 10% to man's output).

(c) Reduce the resistance:

1. By using rollers and wheels for transporting—e. g., "dolley" for transporting lumber instead of carrying it; (2) by using runways, roads and tracks; (3) by balancing the dead load of buckets and skips, so that journal friction is substituted for a dead lift against gravity.

Rule 6.— *Consider the animal body, whether of a man or a horse, as a machine burning a limited amount of fuel daily, in the form of food, and therefore having a limited daily capacity for work.* A horse walking at a speed of 220 ft. per minute, or 2½ miles per hour, can exert a steady pull of 10% of its own weight for 10 hours. For a horse weighing 1,200 lbs. this means 15,840,000 ft. lbs. of work daily, in addition to the work of raising its own body every time it takes a step. A man weighing 150 lbs. can exert a steady pull of 5% of his own weight, or 7½ lbs. at 220 ft. per minute, which amounts to 990,000 ft. lbs. per day, in addition to the work of raising his own body every step, which amounts to another 1,000,000 ft. lbs.

When this rule (six) is observed, the contractor will:

(a) Feed the workmen, as well as the horses, with abundance of nourishing food. On the Panama Canal the Jamaica negroes were at first regarded as being almost worthless as workers. Later it was found that the trouble lay largely in the poor food to which they were accustomed, and proper feeding greatly increased their output.

(b) Either house the workmen near the work, or transport them to the work, thus saving every foot pound of energy for useful work.

(c) Teach workmen to use the heavy leg muscles instead of the arm and back muscles in lifting, shoveling, etc.

(d) Do not let the workman carry loads, if avoidable, for half his available energy is then consumed in the lifting of his own body (1/7 ft. each step) when walking. On timber work, men are often seen carrying heavy timber with "lug hooks" or on their shoulders, where they should be pushing the timber on a "dolley" (a roller with a small platform on it) over run-planks. Hod carrying up a ladder should give place to lifting the loaded hod by a handpower elevator, if the size of the work does not justify a power elevator.

(e) Remember that at $1.50 a day for labor, and 1,000,000 ft. lbs. of useful work performed, the cost is $1.50 per million foot pounds. That at $1.00 a day for a horse plus $0.75 for the services of a driver and 16,000,000 ft. lbs. performed, the cost is 11 cts. per million foot pounds or 1/14 the cost of man work. Hence horse power should be substituted for man power wherever possible.

(f) Select heavy men where heavy work is required, as in feeding a stone crusher whose output depends largely upon the strength of the men feeding it, for muscular strength is usually a function of weight.

(g) Use only heavy draft horses or heavy mules. A 1,600-lb. horse will do 33% more work than a 1,200-lb. horse, hence a team of 1,600-lb. horses will do 66% more work, yet with no increased expense for driving.

Rule 7.—*Use low-priced men to do all work involving merely foot-pounds of energy.*

(a) Don't let carpenters at 35 cts. an hour carry lumber that a 15-ct. man can carry as well.

(b) Have laborers clear away earth, loose rock, etc., over each proposed drill hole, instead of permitting drillers to do so.

(c) Plan the layout of work in such a way that the high-priced men have not only to move the shortest possible distance in order to handle their tools and materials, but arrange the direction of this motion so that as far as possible it may be down grade. Thus, have the bricklayers' helpers so place bricks for the bricklayers that, when the bricklayer grasps the brick, instead of raising it to its position upon the wall, he moves it either horizontally or down grade. The amount of fatigue incidental to the moving of one brick weighing 4½ lbs. is almost inappreciable, but, when a man is laying as many as 3,000 bricks a day, the difference between raising it 2 ft. and bringing it down 1 ft. is over 25,000 ft. lbs., which makes a big difference in the total fatigue of the bricklayer.

Rule 8.—*Resolve each class of construction into the elements of work involved and study means of reducing the foot pounds of each element.*

(a) Shoveling involves: (1) Penetrating the mass, (2) elevating the material, and (3) moving it horizontally (overcoming the inertia of the shovel and the mass). By shoveling off an iron plate, the work of item (1) is greatly reduced, especially where the material is broken stone. By loading into skips, or very low wagons or cars, item (2) is reduced, or it may be largely eliminated by caving the earth from a breast directly into a bucket or skip.

Rule 9.—*Ascertain the percentage of dead work done in conveying and elevating material, with a view to determining its relative importance and thus deciding upon what it is worth to reduce it.* In all conveying, the work of moving the conveyor itself is "dead work." Thus, a wagon weighing 1 ton is used to transport 3 tons of load; therefore 25% of the work of transportation is "dead work." A shoveler uses a shovel weighing

5 or 6 pounds to shovel 15 or 20 pounds of earth, and thus performs 25% of "dead work" so far as elevating and transporting the earth is concerned. It might well pay, therefore, to substitute a higher-priced shovel made of aluminum, so as to secure a much lighter shovel that would reduce the "dead work."

Rule 10.—*Express all items of cost as percentages of the total, to ascertain the relative economic importance of each item and thus determine where it is best to make the first efforts of cost reduction.* Following this rule will frequently disclose astonishingly high percentage costs of items that seemed normal. Thus, foremanship expenses are often 10 to 15% of the total cost, where they could be cut in two by using larger working forces, by not working in winter weather when there is much lost time, etc.

Rule 11.—*Express the value of all lost time in percentages of the total cost of each part of the work, classifying the various items.* Such a classification should show:

(a) Time lost waiting for supplies or materials.

(b) Time lost waiting for other parts of the plant.

(c) Time lost shifting the plant.

(d) Time lost by breakdowns (which may also be classified).

Rule 12.—*In selecting plant consider particularly the unit cost of moving and shifting it and the cost of lost time.* Contracting is really manufacturing with a plant that is moved either continuously or intermittently. Too much emphasis cannot be laid upon the necessity of studying the costs of moving the plant by ordinary methods, and the devising of less expensive methods.

The unit cost of transporting by means of a cableway is usually greater than by a railway, but the unit cost of installing and shifting the cableway is often much less. Bear in mind that a plant of large capacity often is least economic, because of the large unit cost of installing and shifting it. The unit cost of plant erecting and shifting may be reduced in many ways:

(a) By mounting it on a traveler, as when several rock drills are mounted on a traveler on wheels. This is often done in tunnel work, and could be frequently adopted to advantage on open cut work.

(b) By the use of light derricks or gin poles for erecting heavier derricks.

(c) By using guy-derricks instead of stiff-leg derricks.

(d) By using "locomotive cranes."

(e) By a light one-rail track fastened to the side of a steam shovel, and provided with a trolley for carrying the sections of steam shovel track from rear to front.

Rule 13.— *Make all designs for work, whether permanent or temporary, in the office as far as possible, instead of leaving this to the ingenuity of foreman or carpenters, to be done in the field.* Carpenters and foremen almost invariably use factors of safety that are unnecessarily large for posts, and often are altogether too small for beams. Moreover, their fastenings and joints are usually disproportionately weak. Hence they produce temporary structures that are much too heavy in most of the parts, and often dangerously weak in others. The "old hand at the business," as such men always claim to be, is often pretty much of an old fool when it comes to designing structures to resist stresses. On the other hand, the young engineer is apt to use too large a factor of safety throughout for temporary structures, particularly those of wood. The large factors of safety for timber recommended in bridge books are intended in part to cover subsequent weakening by incipient rot. Bins, forms, platforms, etc., that are to be moved frequently, should be bolted together, instead of spiked. Timbers can often be so fastened together, and left in full lengths without framing, as to be marketable after being used as falsework.

Where many moves are to be made, steel is frequently cheaper than timber in the long run, for it is less injured and shows a higher salvage value, e. g., steel sheet piling, steel centering, etc.

Scaffolding may be largely reduced in cost by supporting such scaffolding as is necessary from the partly finished structure. This is well illustrated in the American method of erecting apartment houses and office buildings.

Falsework may often be done away with entirely by the use of a traveler, e. g., the method of erecting steel viaducts with a traveler.

Rule 14.— *Keep down the ratio of overhead charges to direct charges by night shift work.* A large and expensive organization which is occupied in running a small job is a great burden upon the unit efficiency of work. To remedy this the usual method employed by contractors is to try to carry as many contracts as they can. In lieu of this when it is not feasible to get many contracts the ones on hand should be pushed at their utmost speed consistent with economy of operation. Sometimes this will involve working night shifts. On most steam shovel work night shifting is from 10 to 20% more expensive than day work as far as the direct labor charges are concerned, but this expedient enables the whole work to proceed faster, and aside from keeping down the percentage of overhead items it reduces the interest and depreciation charges on plant. Where the overhead charges are large, or when much expensive plant is being utilized, it is generally advisable to work double shifts excepting in very severe weather.

Rule 15.— *Use every possible means to avoid accidents to plant by proper inspection and study of precautionary measures.* It is possible to make out an insurance policy against suits brought by men who are accidentally injured upon the work, but it is not possible to obtain an insurance policy protecting the contractor from the economic disadvantages resulting from accidental interruptions to the smooth progress of the work. The fall of a derrick may injure a man and the contractor be relieved from legal responsibility by the insurance company, but nothing relieves him of the loss in the efficiency of his work incidental to getting a derrick repaired and set up again, to say nothing of the discouraging effect of an accident upon all the workmen.

One of the commonest causes of delay to such operations as those involved in steam shovel work is the derailment of cars. This can best be guarded against by keeping the tracks in good line and surface, and by seeing that the cars are regularly inspected so that defects in the coupling or running equipment are speedily detected and repaired.

Where steam drills are running, breaks in the pressure supply pipe are to be looked for, and in freezing weather general bursting of pipes must be carefully guarded against as one of the most expensive things on the job. The pipes should be protected by lagging, burying in trenches, manure troughs, etc., and in addition to this many of them must be regularly drained at night. Carelessness in this particular is so common on the part of the average men on the work that the best method known to us is to organize a regular pipe gang whose business it is to see that pipes are kept open, and who are responsible for delays of this kind.

The break down of a flue in a steam boiler can come overnight through careless firing on the part of the watchman. The discharge of the watchman is small compensation for the damage that occurs as a result of it.

Rule 16.—*Do the most profitable part of the work first wherever possible, so as to avoid carrying interest charges.* For illustration we will take an example based on an actual experience, names and figures being assumed:

Contractor Jones had a capital of $15,000.00 and obtained a contract for $145,000 worth of earth and rock work. His estimate of cost was as follows:

Earth, 140,000 yards at 35c (including 4c profit)......	$ 49,000.00
Rock, 120,000 yards at 80c (including 9c profit)........	96,000.00
Total contract	$145,000.00
Estimated profit—	
140,000 yards at 4c..................................	$ 5,600.00
120,000 yards rock at 9c..................................	10,800.00
Total	$16,400.00

or 11 3-10% on the whole amount.

The contract was for "unclassified" work; there was no discrimination made between rock and earth, but because he had been very friendly with the engineers who made the original survey Jones felt that he was safe in trusting to the figures. The contract simply provided that for doing 260,000 yards of excavation Jones was to receive the total sum of $145,000, payable in monthly installments as the work progressed, 10% to be retained until the completion of the work. The plan of campaign, which is the subject of this discussion, was as follows:

The earth was to be done first, and would yield the following results:

140,000 yards earth at 55.769c, contract price	$78,077.00
Ten per cent retained until completion	7,807.70
Balance to be paid as work progressed	$70,269.30
Actual cost (estimated) 140,000 at 31c	43,400.00
Balance available for running expenses	$26,869.30

Then the rock was to be done, amounting to

120,000 yards rock at 55.77c	$66,923.00
Ten per cent until completion	6,692.30
Balance to be paid as work progressed	$60,230.70
Actual cost, estimated, 120,000 at 71c	85,200.00
Deficit on the rock	$24,969.30
Balance available on the earth work	26,869.30
Difference for leeway	1,900.00
Total of amounts retained	14,500.00
Total profit	$16,400.00

The work thus would "carry itself" except for the first month, supplies could be paid for on 30 days, a plant costing $20,000.00 could be paid for on 90 days, and the money borrowed to pay three-quarters of this amount. On completion of the work the plant could be sold for a fourth of what it cost, and thus it was figured that a cash capital of $15,000.00 would be ample. What happened was this: When the time came to start on the earth-work there was no drainage, and no one thought of using a centrifugal pump in the shovel pit. It was then decided to get into the rock work first, borrowing some more money if necessary and do at least ⅓ of the rock work before starting the earth, then to do them both together. It works out as follows:

50,000 yards rock at 55.769c	$27,884.50
Ten per cent retained	2,788.45
Balance available	$25,096.05
Actual cost (estimated) 50,000 at 71c	35,500.00
Deficit on which interest must be paid	$10,403.95

When he had about 19% of his contract finished he was saddled with a fixed charge of 6% on $10,403.95, or $624.24 per year. With extensions the working time was five years, or four years on which he was paying the above interest, and moreover, once having started the rock work, it would have been expensive to drop it, so it was continued, the deficit and interest charges growing. The engineer in charge happened to be strictly honest and honestly strict, and would not budge an inch from the specifications. The surface of some of the rock work had to be "sand-papered," no latitude was allowed in regard to making waste heaps. If blasting did not go beyond the clearance plane the corners had to be knocked off, while if the blasting did go beyond the clearance plane the extra amount was not paid for. Before Jones took hold of the contract he had interested some strong financial people with him, more money was raised, and the work went on, at a loss and a big one, pushed to save the financial reputation of all the parties and because it was cheaper to go on at a loss than to default on a bond.

Rule 17.—*Do as much work as possible in a yard or shop instead of in the field.* We have already touched upon this matter in Rule 4 (g). Where economic means of transportation exist, and particularly where the work is of any considerable magnitude, but spread over a large area, it is usually desirable to do as much of the manufacturing of a structure in a shop or yard as possible. In this manner the plant loses no time from being shifted, and, since the expense of shifting is eliminated, a heavier plant with a larger daily output can be operated.

In building small reinforced concrete culverts, we have found it most economic to make the floor, side walls and cover in a yard instead of on the site where the culvert is to be erected.

Timber structures can usually be framed at a very low cost in a small yard equipped with power saws, augers, and plant for handling timbers. Hence where there is much falsework to erect, either install such a plant, or have the framing done at a mill.

A cheap roof of boards covered with tar paper can be placed over a small yard and thus enable the work of framing, riveting, stone cutting, concrete slab making, etc., to go on without interruptions from the weather. Considering the slight cost of such roofs, it is surprising how seldom contractors build them.

CHAPTER III.

PIECE RATE, BONUS, AND OTHER SYSTEMS OF PAYMENT.

The fundamental law of management involves that payment for work done shall be proportionate to performance—that is, an increased number of units of work done by a man shall result in his receiving increased pay. The ordinary wage system is based upon this law, but only in a very crude manner, since it throws men into large groups or classes, individuals of which receive the same pay, or practically so.

We shall now consider some of the various methods that aim to recompense a workman in proportion to his performance.

Profit Sharing.—According to the method of profit sharing, each individual receives not only his wage but a pro rata of any profits that arise from the business. Either quarterly, semi-annually, or annually, the profits of the business are estimated, and a certain percentage of these profits is distributed to the workmen and their managers. Often this distribution of profits is confined to the managers only.

While this is an improvement over the wage system, it violates the eighth law of management—namely, the law of prompt reward. The imagination of the ordinary workman is not enough to maintain his interest in his work at the high pitch necessary to enable him to do his very best. Moreover, any community interest in a commercial enterprise lacks sufficient stimulus. It requires a more direct, personal interest in the outcome to arouse a man to action.

Profit sharing, whether by the payment of profits direct, or in the form of dividends on stock held by the workman, is, at best, only a moderate step in advance of the ordinary wage system so far as the average workman is concerned.

Piece Rate System.—According to the piece rate system, each workman is paid a certain stipulated amount per unit of work done by him. If all managers were fair in their dealings with workmen, and if all workmen were reasonable, the piece rate system would be almost ideal as a method of paying men wherever the work is of a character that admits of measuring individual performance. Due to hoggishness on the part of managers and unreasonableness on the part of workmen, the piece rate system usually fails to accomplish the desired end.

Having established a piece rate of, say, 10 cents per cubic yard for shoveling earth into wagons, on the assumption that 15 cubic yards per day per man is a fair output, it requires more than ordinary foresight and liberality not to cut the rate when laborers begin to load 25 cubic yards a day. The typical contractor will then begin to reason about as follows: "These men have been soldiering on me in the past. I always thought so; now I know it. Well, now that I do know it, and they know I know it, they will have to work at this rate hereafter or get out. What's more, I am not going to be gouged out of an extra dollar a day, either. If they make 25 cents extra a day, it's more than they ever got before, and it's all they are entitled to, so we will just drop that 10-cent rate down to 7 cents. That will satisfy them." But the trouble is that it doesn't. The men immediately become angry, and rightly so. If they do not quit entirely, they lose all further ambition and desire to increase their output, knowing full well that the piece rate will be so cut as to enable them to earn only a slight advance over their original day's wages.

This experience has been so general that nearly all labor unions have put a ban on the piece rate system. Bear in mind, however, that the piece rate system is not inherently at fault, and that it is used with great success in many places where the management has been liberal and far-sighted.

On piece rate work that involves the use of machinery, it is manifest that any improvement in the machinery which enables the men to turn out more units daily, should be accompanied by some reduction in the piece rate. Workmen, however, are usually unreasonable and oppose any reduction in the rate. This unreasonableness disgusts the manager as much as a manager's hoggishness disgusts the workmen. If the manager goes to the expense of buying and operating improved machinery, he is entitled to his share of the increased profit, but the workman is not quick to see things in that light.

Obviously, any piece rate system is productive of more or less friction between managers and men, yet no system is free from some friction. Probably the chief function of the labor unions of the future will be to protect workmen in agreements with managers, and to be parties in arriving at what those agreements shall be.

The Bonus System.—This system involves paying each workman a daily wage plus a piece rate on each unit in excess of a stipulated minimum. This piece rate on excess product is called a bonus. For example, a laborer receives $1.50 a day for shoveling earth, and on each cubic yard in excess of 15 cubic yards shoveled per day he receives a bonus of 7 cents. If he shovels 25 cubic yards, he receives $\$1.50+(0.07\times 10)=\$2.20$.

The bonus system is really a piece rate system with a guarantee of a certain minimum wage. Slight though this difference from the piece rate system is, it is generally viewed with more favor by workmen.

The Differential Piece Rate System.—The principle of this system is to pay a certain piece rate up to a certain output per man, and a higher rate (but still a piece rate) above that output. Applied to drilling, for example, the drill runner would be paid, say, 6 cents a foot up to a performance of 50 feet per day, and 8 cents a foot for every foot above 50. The helper might still be paid $2 a day straight, but it is wise always to give him also a contingent interest in the result of his work.

This system, which was devised by Mr. Frederick W. Taylor, is described in the following paragraphs.

General Plans on Which the Taylor Differential Piece Rate System Is Based.—There are two fundamental assumptions on which the layout of any extensive system of labor must be predicated:

I. A man can do his theoretical best if continually instructed and coached, but not otherwise.

II. A man will do his theoretical best if adequately remunerated, and not otherwise.

It is assumed in the expression of "theoretical best" that the right kind of theory is meant. A theoretical best that is founded on a lost theory is not here considered. The application of these assumptions depends upon the following fundamental principles of practice as outlined by Mr. Taylor:

1. A large daily task that must not be impossible.

2. Standard conditions, so that work can be accomplished with certainty.

3. High pay for success.

4. Loss in case of failure.

5. The task set must be so difficult ultimately that none but a first-class man can do it.

The first of these principles is based upon the fact of observation that if you give a man a specific thing to do in a definite amount of time he will do it more efficiently and more accurately than if you give him the same thing to do and he is supposed to take "any old time" to do it. This fact is so old and is so thoroughly grafted upon the minds of all men who do work that it seems unnecessary to argue in its favor; that it has not been more generally applied is due to the lack of appreciation of how easy it is to apply it. Hence, the rare and useful corrollary to this proposition—namely, that the duration of a special task, for the maximum efficiency, will be so short that a man can keep his mind continually concentrated upon the speed with which he is progressing, without becoming mentally exhausted. In practice it is sometimes possible to apply this principle without actually knowing what a reasonable task is by taking two men of about equal capacity and setting them to do the same kind of work in competition; then the task that each man has is to beat the other fellow, which, if he is gifted with ordinary red blood, he proceeds to do. In the course of a comparatively short time he finds out whether he can beat him, or not, and as soon as it is definitely settled which man can beat the other they both stop trying. It is possible, before they get through competing, to determine how fast they have been working, which is the really valuable point about competition.

Another method for ascertaining a man's possible output, and one which is mostly used in shop work, is to divide up the time of any process into its component parts. The process of rock drilling, for example, can be divided into the following component parts, starting with the drill all set up and ready for work:

1. Turning on the steam.
2. Drilling to the limit of the first bit.

3. Turning off the steam and picking up wrench.

4. Loosening the bit in the chuck, involving the unscrewing of two nuts and the turning of the chuck.

5. The raising of the chuck by hand to release the bit, assisted by the helper, who during the rest of the process is winding up on the feed screw.

6. Drawing out the steel from the hole.

7. Laying the steel down and picking up the pump.

8. Pumping out the hole.

9. Laying down the pump.

10. Picking up the next bit.

11. Dropping down into the hole.

12. Raising piston and slipping over the head of bit.

13. Picking up wrench.

14. Tightening nuts, involving ½ revolution of the piston about its axis.

15. Dropping wrench and turning on steam for the first five strokes.

16. Opening up throttle and slowly working drill up to full speed.

By the use of a stop watch a standard time for each of these processes, depending upon the conditions, can be obtained, and the total time, being the sum of these, will represent the entire cycle of the process. The problem consists in adding together the fastest times for each element to get the fastest possible time for the whole cycle. The results from such an investigation have never failed to be astonishing in the last degree.

1. In the process in which the mental effort required is large, care must be taken to allow a man a sufficiency of rest. For example, a man can "chin himself" on a horizontal bar quite rapidly for about ten revolutions, so to speak, but the next ten are a different matter.

2. The success of the Taylor method depends very largely upon standardizing conditions. To use the illustration of drill work, the time required to pick up and place in position a drill bit four feet long is considerably less than the time required to pick up and place in position a drill bit ten feet long, and the performance with the ten-foot bit cannot be accurately predicted upon observation with a four-foot bit. To use a still more pointed illustration, the time required to drill down two feet

through the different kinds of rocks varies greatly, and it also varies greatly in some of the rocks when a water jet is used. From the above it seems clear that the precise conditions should be known in all cases. Some of the conditions will be common to all similar classes of work and other conditions will depend upon the local features. The two illustrations mentioned in the paragraph above are taken from two different classes of conditions. The study of one means the study of drill work in general; the study of the other means the study of the work on the particular job to be attacked.

3. If a man is going to take orders and alter his way of doing work, doing it in a manner that is not only new but at first disagreeable, and when, involved with this, he is required to perform what seem to him a lot of unnecessary and rather ridiculous "stunts," he has got to have extra pay; if in addition to these other things he is required to exert himself to the utmost the extra pay will have to be very substantial. The whole proposition of the Taylor system is that under proper instructions with these conditions the amount of extra work that he will be able to do will be considerably more in proportion than the amount of the extra pay. The amount of extra pay that he must receive in order to do his best is from 30 to 100% more than what he originally was getting. There is a certain point at which still more pay will not result in the accomplishment of a corresponding increase in work for two reasons: In the first place, there is a limit to what a man can do, and in the second place, if his money comes too easily or he gets too much of it, he becomes lazy. Just here it is proper to observe that the result of work of this kind is to make a man more sober as well as more industrious for two reasons: He cannot drink much and hold the pace, and the effort and attention required to get his work done decrease his desire for alcohol. This statement seems rather remarkable, but it is a fact of experience.

4. If a man does not succeed in keeping up to the standard performance, one of two situations must obtain:

a. If his lack of success is due to special conditions, lack of instruction, lack of practice, or both, owing to break-downs of machinery or tools, or to irregularity in the material, or to the weather, it must not be counted against his future, but he should himself receive less money than he would if he had succeeded.

In other words he must try, and he must try successfully in order to earn his extra money.

b. If this failure to achieve extra money is because he is constitutionally unable to do what he ought to be able to do, then the only thing is for him to give place to a better man. Mr. Taylor has reduced the thing to the simple proposition of considering only two classes of labor—namely, the first-class man and the man who is not first-class. It is not difficult to determine which is which.

5. After months and years of development and instruction the pay can be made so high as to attract the very finest class of labor in the world and the task can be made so exceedingly difficult that none but the very highest class men can hold their jobs, and at this point it would seem that the ordinary limitations of the human machine had been reached. From a consideration of historical facts it does not seem as if there were any limit to what a man can accomplish industrially, but there is a limit to what he can do physically. Further improvement must depend upon methods, machinery, and special cooperation.

As Mr. Taylor expresses it, the differential piece rate not only pulls a man up from the top but it pushes him equally hard from the bottom. We quote from a paper entitled "A Piece Rate System," read by Mr. Taylor before the American Society of Mechanical Engineers in 1895: "The first case in which a differential rate was applied, during the year 1884, furnishes a good illustration of what can be accomplished by it. A standard steel forging, many thousands of which are used each year, had for several years been turned at the rate of from four to five per day under the ordinary system of piece work, 50 cents per piece paid for the work. After analyzing the job, and determining the shortest time required to do each of the elementary operations of which it was composed, and then summing up the total, the writer became convinced that it was possible to turn ten pieces a day. To finish the forgings at this rate, however, the machinists were obliged to work at their maximum pace from morning to night, and the lathes were run as fast as the tools would allow, and under a heavy feed. (Ordinary tempered tools 1 inch by 1½ inches, made of carbon tool steel, were used for this work.)

"It will be appreciated that this was a big day's work, both for men and machines, when it is understood that it involved removing, with a single 16-inch lathe, having two saddles, an average of more than 800 lbs. of steel chips in ten hours. In place of the 50-cent rate, that they had been paid before, they were given 35 cents per piece when they turned them at the speed of 10 per day, and when they produced less than ten, they received only 25 cents per piece.

"It took considerable trouble to induce the men to turn at this high speed, since they did not at first fully appreciate that it was the intention of the firm to allow them to earn permanently at the rate of $3.50 per day. But from the day they first turned ten pieces to the present time, a period of more than ten years, the men who understood their work have scarcely failed a single day to turn at this rate. Throughout that time until the beginning of the recent fall in the scale of wages throughout the country, the rate was not cut.

"During this whole period, the competitors of the company never succeeded in averaging over half of this production per lathe, although they knew and even saw what was being done at Midvale. They, however, did not allow their men to earn over from $2.00 to $2.50 per day, and so never even approached the maximum output.

"The following table will show the economy of paying high wages under the differential rate in doing the above job:

COST OF PRODUCTION PER LATHE PER DAY.

Ordinary System of Piecework.		Differential Rate System.	
Man's wages	$2.50	Man's wages	$3.50
Machine cost	3.37	Machine cost	3.37
Total cost per day	$5.87	Total cost per day	$6.87
5 pieces produced; cost per piece	1.17	10 pieces produced; cost per piece	.69

"The above result was mostly though not entirely due to the differential rate. The superior system of managing all of the small details of the shop counted for considerable.

"The exceedingly dull times that began in July, 1893, and were accompanied by a great fall in prices, rendered it necessary to lower the wages of machinists throughout the country. The wages of the men in the Midvale Steel Works were reduced at this time, and the change was accepted by them as fair and just.

"Throughout the works, however, the principle of the differential rate was maintained, and was, and still is, fully appreciated by both the management and men. Through some error at the time of the general reduction of wages in 1893, the differential rate on the particular job above referred to was removed, and a straight piece-work rate of 25 cents per piece was substituted for it. The result of abandoning the differential proved to be the best possible demonstration of its value. Under straight piece work, the output immediately fell to between six and eight pieces per day, and remained at this figure for several years, although under the differential rate it had held throughout a long term of years steadily at ten per day."

The most disappointing feature about the introduction of a system of management modeled after the Taylor plan is that such introduction always meets with the opposition of the "has beens." It seems that after a man has reached a certain age he becomes unwilling or unable to assimilate new ideas, and when he is confronted with the proposition that he has been doing work for 20, 25, or 30 years according to a method that was not and is not economic, the news strikes him with a shock that is painful. He objects, in the first place, that the new scheme cannot be right, because if it had been right he would have known all about it before; but, after it has been demonstrated beyond cavil that the new scheme is right, he is likely to work himself up into a stubborn and absolutely uncompromising policy of obstruction. The new scheme may be all right, but it is executed with a lot of "frills" which are not practicable; the new scheme involves too much superintendence and too many people who get well paid; the new ideas may have been tried out a few times lately with success, but his old ideas have been in use for a hundred years, and more people have earned their bread and butter by the old ideas than by the new ones; finally, with his back against the wall, having committed himself with absolute rigidity to the proposition that the new scheme must fail, he feels that he will stultify himself in the eyes of his employees and of his friends if the new scheme does not fail. This all results, in the worst cases, in a determined and absolutely uncompromising effort to make it fail. However, so far as the authors know, it never has failed, and it has been applied time and time again. How to treat the obstructiveness is a matter of individual tact and judgment that must be applied upon the merits of each case and does not come within the scope of this volume.

The differential piece rate should never be installed until after thorough time studies have been made of the work, so that a first-class man's capacity can be predicted with accuracy.

The Differential Bonus.—This is based on the same principle as the differential piece rate while guaranteeing to a man a fixed minimum of wages. We have applied it in drilling work, offering the men 2 cents per foot drilled for every foot above 70, and 3 cents for every foot above 80 per day, while at the same time paying them their regular rate of wages.

Task Work With a Bonus.—Mr. H. L. Gantt, one of Taylor's pupils, invented a system of differential payment known as "Task Work with a Bonus," which has been very successful in practice and has great flexibility of application under varying conditions. The workman under this system is paid his regular day's wages in any event and a certain lump bonus if he succeeds in accomplishing the standard task. The amount of this bonus is usually about one-third of his regular wages. Mr. Taylor says that this system is especially useful during the difficult and delicate period of transition from the slow pace of ordinary day work to the high speed which is the leading characteristic of good management. During this period of transition in the past, a time was always reached when a sudden leap was taken from improved day work to some form of piece work; and in making this jump many good men inevitably fell and were lost from the procession. Mr. Gantt's system bridges over this difficult stretch and enables the workman to go smoothly and with gradually accelerating speed from the slower pace of improved day work to the high speed of the new system.

The Premium Plan.—This is the term used by Mr. F. A. Halsey to describe what Mr. Taylor calls the Towne-Halsey system. It is based on the proposition of paying a bonus for achieving an estimated performance, the means to be employed and the methods being left to the ingenuity and initiative of the men, rather than to the management.

Principles Governing the Fixing of a Piece Rate or Bonus.—We are probably well within limits when we say that the average workman engaged on construction work under the wage system is capable of increasing his output 70% if given sufficient incentive to do so, and this without the least physical injury to himself. When it is desired to ascertain how much work men are capable of doing, one of the best plans is to conduct a contest between two or more men, or two or more groups of men, a substantial prize being offered for the best performance. Such a contest should usually extend over several consecutive days, so that it will not be a mere sprint, but a fair endurance test.

In Gillette's "Rock Excavation" are given the rate of progress and cost of driving the Croton Aqueduct tunnel. The men in one of the headings determined to "break the record" for one week's run, and drove 102 lin. ft. of heading in 7 days, at a total cost of $2.93 per cubic yard for labor, fuel, explosives and other supplies. The average weekly progress prior to that time was 47 lin. ft. and the average cost was $5.32 in the same material. In brief, these men doubled their average speed for a whole week when working with an incentive, although that incentive was merely pride in establishing a record.

Taking another example from the same book (page 360), we find that when miners in the War Eagle Mine, at Rossland, B. C., were paid by the lineal foot of drill hole, gangs of four men drove 97.5 lin. ft. of "drift" (or small tunnel), as compared with an average of 50.8 lin. ft. per month under the wage system. Under the wage system each miner earned $3.50 a day; while under the "hole contract system" (which is a piece rate system with lineal foot of drill hole as the unit), each miner earns $4.25 a day. Under the wage system the mining cost to the company was 86 cents per ton of ore, while under the "hole contract system" it is 48 cents per ton.

These examples are cited not only to show the wonderful possibilities of economic performance under any system whereby the men are paid according to their output, but to indicate in a general way what piece rate or bonus can safely be adopted to start with.

In the last case cited, it is the opinion of the authors that the mine managers did not give the miners as high a piece rate as they were entitled to receive. Surely when a man doubles his output without any change in the plant or tools, he is entitled to an increase more than 20% in excess of his previoius income.

If a competitive contest to disclose the workmen's abilities is not practicable, the authors assume that the output probably can be increased 60 to 70% over the output under the wage system, wherever the output depends mainly on the skill and strength of the workmen. In drilling rock, for example, if the average output of each drill is 60 lin. ft. under the wage system, then, in all likelihood, it can be increased to nearly 100 ft. under a bonus system. The driller who receives $3.00 a day under the wage system is really earning 5 cents for each of the 60 lin. ft. If it is planned that he shall increase his income 50%, he will receive $4.50 for the assumed 100 lin. ft. of hole. Hence his piece rate would be 4½ cents a foot, or his bonus would be $1.50 on 40 lin. ft. (60 lin. ft. being taken as the standard minimum performance), which is equivalent to a bonus of 3¾ cents per lin. ft. on every foot in excess of 60 ft. to be added to a daily wage of $3.00. At first sight it seems that the contractor gains only 1¼ cents per lin. ft. for the 40 lin. ft. on which a bonus is paid, or only ½ cent per lin. ft. on the entire 100 ft. The fact is that the contractor gains much more, not even considering the wages of the driller's helper, for the daily plant charges on the drill remain almost constant, regardless of the output. If fuel, fireman, interest, repairs, depreciation, foreman, etc., are $4.00 per day per drill, these fixed charges amount to 6.66 cents per lin. ft. of hole when the output is only 60 lin. ft. a day, as compared with 4 cents per lin. ft. when the output is 100 ft., or a saving of 2.66 cents per lin. ft. Wherever a plant of any considerable value is used, it is clear that it would be profitable to double the pay of the workmen if they could double the output of the plant, for the unit saving in plant charges alone would amount to a handsome profit. This is upon the assumption that the fuel bill remains practically unchanged by the increased output, and it seldom is materially affected by increased output on contract work.

How to Fix the Wage Rate.—When a piece rate or bonus rate is to be established it is of great importance that it be established with correctness, so that it will not be necessary to alter it subsequently, since nothing is likely to produce more dissatisfaction among the men than a change of base on the part of the management, which gives the men the impression that they are being imposed upon. A fairly safe rule is to pay a piece rate which will insure to the average workman under average conditions with average effort the ordinary wages which he could earn by the day. The trouble with this basis is that after the piece rate has been in operation a little while the earnings per man increase so much that the employer begins to think that the piece rate is too high, and then he attempts to readjust it with disastrous results. After long experience in this subject the only thoroughly satisfactory method of fixing the wage rate that we know of is to guarantee to the men not less than the "prevailing rate of wages," and preferably a little more than the prevailing rate of wages, as a daily or hourly or monthly rate, and on top of this to pay them extra for extra accomplishment. To make men do their level best, an increase of from thirty to forty per cent of this regular wage is necessary.

Mr. Harrington Emerson developed an excellent way of grading bonuses while reorganizing some of the work at the Toledo shops of the Atchison, Topeka & Santa Fe Railroad in 1907. Mr. Emerson first determines what a man's theoretical practicable efficiency is, and this he calls 100% efficiency. Thus, if a first-class man ought to be able under the standard conditions to make 100 pieces of a certain pattern per day, a man who succeeds in making 80 is rated at an efficiency of 80%. The bonuses are graded as follows: A man whose efficiency is 67% receives the regular rate of wages. If his efficiency is 80% he receives about 3½% of the regular rate of wages as a bonus. When his efficiency is 90% he receives a 10% bonus. At 100% efficiency he receives 20% bonus and from then on he receives 1% additional bonus for every per cent increase in efficiency. Thus if he can do 50% more work than the standard man or if his efficiency be 150% he gets 70% bonus.

It is well to avoid starting off on any fixed piece rate in outside construction work, as thereby it is possible to steer clear of a great many obnoxious preconceived notions of the men who may fear that the management is getting up a scheme to deprive them of their just compensation.

In applying any rule of this kind it is important to start off, as a rule, with one man, or small group of men, at a time, gradually expanding the system to include the whole job. Don't forget that the expansion must absolutely be gradual and at first very slow.

The "Stint" System.—Having decided the number of units of output that may be accomplished in a day or in a week, a "stint" or task may be assigned to an individual or to a gang, with the promise that when the "stint" is performed the workmen will be required to do no more that day or that week. By this method, the reward consists in a gift to the workman of all time that he may save by working vigorously. The authors have frequently found that a gang would finish its day's stint three hours before the regular quitting time, or that, if the "stint" was a week's work, the men would save 1½ to 2 full days. There are some advantages of this method over the ordinary wage system. For example, it gives spare time in which to make repairs to the plant while the workmen are not using it. It makes the men more cheerful and ambitious while working, for they look forward eagerly to the hours thus gained for recreation. Hence a large "stint" can be set and the men will do more units of work under it than under the regular wage system.

The "stint" system has the obvious disadvantage that it does not yield the workman an increased income. Therefore it is only a short step in the right direction. We mention it in this chapter principally because it is often a good method to adopt preparatory to adopting a bonus system, for it serves to show, in a measure, what the men are capable of doing, and thus acts as a guide in deciding what the bonus shall be.

CHAPTER IV.

MEASURING THE OUTPUT OF WORKMEN.

Difficulties of Measurement.—Before men can be paid according to their performance it obviously is necessary to devise methods of measuring the number of units of work done, but it is not always so obvious what units to select nor how to measure them readily after the selection of units has been made. Indeed, this difficulty accounts in large part for the slowness with which piece rate and bonus systems have been adopted.

Subdivision of Units into Other Units.—In engineering construction the cubic yard is a very common unit upon which contract prices are based, but the cubic yard itself is frequently a very uncertain unit of performance, for it is a composite of other units. Thus, in rock excavation there are several distinct operations involved, which may be enumerated as follows:

1. Drilling.
2. Charging and firing (or blasting).
3. Breaking large chunks to suitable sizes.
4. Loading into cars, carts, skips, or the like.
5. Transporting.
6. Dumping.

The important item of drilling depends largely upon the spacing of the drill holes, which varies in different kinds of rock, and in different kinds of excavation, trenches and tunnels requiring close spacing. Clearly, then, the lineal foot of drill hole is a unit of work that must be adopted by the rock contractor in measuring the output of his drillers, and not the cubic yard.

Transportation is largely a function of distance, hence the unit of transportation cost should be the ton (or yard) carried 100 ft. or 1 mile, and not the cubic yard without the factor of distance.

Our first rule to be applied in seeking units that truly express the amount of work done is as follows: *Divide the contract price units into sub-units, selecting the "foot-pound" of work as the sub-unit wherever possible.*

A foot-pound is the unit of work used in theoretical and applied mechanics. It is the amount of work required to lift 1 pound a height of 1 foot. All forms of work are capable theoretically of being expressed in foot-pounds, but it is often very difficult to do so in practice. For example, it is not an easy matter to ascertain how many foot-pounds of work a man performs in shoveling earth into a wagon, for there is not only the number of foot-pounds involved in lifting the earth but in pushing the shovel into the earth, in lifting the shovel, in lifting the upper part of his own body, and in overcoming the inertia of earth, shovel and body. However, the theoretical ideal unit is the foot-pound, and, in selecting the actual unit to be used, the effort should be made to secure a unit that is as closely proportional to the foot-pound as possible. Thus, in drilling, there are certain units of work done by the drill in pulverizing the rock in the drill hole, and this work is quite closely represented by the number of lineal feet of drill hole in any given kind of rock. Hence the most practical unit of work in drilling is the foot of hole drilled.

The second point to consider in selecting suitable units of work is the different processes involved. Each process on field contract work usually involves a different class of men. In rock excavation the six items above given usually involve six separate gangs of men. Although all contribute their part to the final contract unit upon which payment is received—the cubic yard—yet the work of each may be, and usually is, better measured in terms of some other unit. We already have seen that the lineal foot of drill hole—and not the cubic yard—is the unit to select for the drilling gang. The pound of explosive charged in the drill holes is a good unit by which to measure the work done by the blasting gang. The cubic yard of rock usually is the only practical unit of breaking large rock chunks. So, too, the cubic yard becomes the unit for loading and for dumping, whereas the yard-mile, or ton-mile, is made the unit of transportation. Still further subdivisions of some of these six processes are often desirable, yielding still other units that more closely approximate the foot-pound unit.

Therefore, our second rule is as follows: *Since construction usually is divided into processes, and since a separate gang usually performs each process, select sub-units based upon the work done by each gang.*

In order to apply this rule it frequently is necessary to reorganize the work so that each process is performed by its special gang. Where the work is not of sufficient magnitude to keep distinct gangs busy on each separate process, it is still often possible to work the same gang a few hours at one process and then shift it to another process, instead of working the same men in a heterogeneous fashion on two or more processes at the same time.

Units for Concrete Work.—The cost of a cubic yard of concrete varies between about $3.00 for cheap pavement subbase to about $20.00 for certain parts of a reinforced concrete building. A hasty generalization drawn from such variations as this has led many an engineer to scout the usefulness of cost data, particularly such data as have not been gathered by the individual who attempts to draw conclusions from them. However, when the cubic yard of concrete is divided into proper sub-units of cost, it is astonishing to note the fading away of all seeming difficulties, either in estimating costs of concrete or in securing data upon which to judge the efficiency of workmen.

The labor processes in concrete may be classified as follows:

1. Receiving and storing materials.
2. Delivering materials to the mixer (loading and hauling).
3. Mixing concrete.
4. Transporting concrete.
5. Placing concrete.
6. Ramming concrete.
7. Finishing the surface.
8. Framing the lumber for forms.
9. Erecting forms.
10. Shifting and cleaning forms.
11. Taking down forms.
12. Shaping the reinforcing steel.
13. Placing the reinforcing steel.

Some of these processes may be still further subdivided, and frequently it is desirable to do so. While the cubic yard of concrete is usually a satisfactory unit for items one to six, it is clear that the square foot or square yard is a unit that must be used for item 7. Items 8 to 11 should be expressed in terms of the 1,000 ft. B. M. as the unit, and it is usually desirable also to use the square foot of concrete surface covered by forms as another unit for estimating the cost of work on forms. Items 12 and 13 should be expressed in terms of the pound of steel as the unit, since the number of pounds of steel per cubic yard of concrete varies widely.

Two or More Units for the Same Class of Work.—As just indicated, it is frequently desirable to use more than one unit of measurement. The unit on which the contract price is based is usually a desirable one in which to express all items of cost. In addition to this, the cost of each item may be expressed in other units, such, for example, as the 1,000 ft. B. M. and the square foot of area for form work in concrete construction. Such units should be selected as will permit comparison not only of one day's work with another, but of one job with another, and frequently it is desirable to select units that may be used in comparing two entirely different classes of work.

Uniformity in Units of Measurement.—The economic importance of uniformity in units of measurement cannot be overestimated. To illustrate: The common unit of concrete work is the cubic yard, but it is customary to measure cement walks in square feet. Now this leads to many blunders, not only in estimating the cost of walks but in effecting reductions in cost. Not only does the thickness of cement walks vary widely, but the proportion of cement to sand in each layer of the walk is variable. Therefore, to say that it takes so many barrels of cement to make 100 sq. ft. of walk means next to nothing unless the plans and specifications for the walk are also given. For purposes of accurate estimating it is necessary to prepare tables of cost of mortars and concretes in terms of the cubic yard; then by remembering that 100 sq. ft. having a thickness of 1 inch are almost exactly 0.3 cu. yd., it is a simple matter to convert costs per cubic yard into costs per square foot.

Not only in computing costs of cement walks, and the like, but in reducing costs, does it aid us to use the cubic yard as the unit, for it enables us to make comparisons, and thereby discover inefficiency of workers. In Gillette's "Handbook of Cost Data" a case is cited where the labor cost of the face mortar for a concrete wall was out of all proportion to what it should have been. Had the contractor estimated the cost of this mortar in cubic yards, he would have discovered that it was excessive. The labor of mixing mortar should not be much greater than the labor of mixing concrete per cubic yard, nor should the labor of conveying the mortar in wheelbarrows be greater. The labor of placing it in a thin layer is obviously greater than for placing concrete in thick layers; but, in the case mentioned, the contractor was losing his money in mixing and conveying the mortar. He had not recognized the fact because he had not reduced the cost to dollars per cubic yard of mortar.

In like manner, one may often see money wasted in making and delivering mortar to bricklayers and masons, because the cost of the mortar itself, in terms of the cubic yard of mortar (not of masonry), has not been calculated.

The cost of labor on forms and falsework should always be recorded in terms of 1,000 ft. B. M., as the unit; for that is the common unit of timber work, and, being so, ready comparisons can be made only in dollars per M. ft. B. M.

It is surprising how few managers of men have realized the value of reducing the cost of each item of work to units that are comparable; and by this we mean units in terms of which entirely different classes of work may be compared. Thus, in a brick pavement there is grout used between the joints. This grout is a thin cement mortar, and it averages, let us say, 6 cents per sq. ft. of pavement. Now, what does it average per cubic yard of grout? Probably not one paving contractor in a thousand knows; but, until he does know, he cannot compare the cost of grouting with the cost of other kinds of cement work. Many a time have we had our eyes opened to unsuspected losses and inefficiencies only by reducing the costs of the elements of work to units comparable with the units of similar work in other fields.

The ton is a very convenient unit to use when comparing the cost of loading and handling materials of all kinds. The ton of brick, the ton of gravel, the ton of timber, the ton of cast-iron pipe, are loaded upon wagons by hand at a cost differing not so much, one from the other, as might at first be supposed. When reliable data are not available for estimating the cost of handling any given material, by reducing it to tons an approximate estimate can usually be made that will be satisfactory, at any rate far more reliable than a guess.

Units of Transportation.—On contract work, distances of transportation are usually so short that the percentage of time "lost" by cars, carts, etc., while being loaded, becomes a very large part of the total day's time. Hence the unit of transportation must not be simply a unit of weight, or of volume, transported a unit distance. For example, a wagon may be loaded with earth in 4½minutes, transported 100 ft., dumped and returned in 1½ minutes, or less; total, 6 minutes. Of this time less than 25% is spent in transporting the earth. On the other hand, if the haul is 6,000 ft., the time spent in transporting may be 93%. The cost per 100 ft. transported is almost four times as much in one case as in the other. Therefore, unless the hauls are so long that the time lost in loading and unloading is an insignificant part of the total time, it is essential to divide the work of transportation into three elements:

1. Time lost loading.
2. Time lost transporting.
3. Time lost unloading.

Often this third item is so small that it may be disregarded. On contract work it is often necessary to have a fourth item:

4. Time lost during the shifting of tracks, and other changes in plant location.

In brief, the lost time, of whatsoever nature, must be determined and deducted from the total time, before the number of units of transportation performance can be divided by the correct number of hours.

Transportation, therefore, must be divided into two main units of cost:

1. Non-productive (lost time loading, dumping, shifting plant, etc.).
2. Productive.

The total cost of the non-productive time is divided by the total number of yards or tons moved to get the unit non-productive cost of transportation.

The productive cost of transportation is the ton-mile, the cubic yard-mile, the ton-station (station = 100 ft.), or the like.

The distance of transportation is usually computed from a map, but it is often desirable to attach an odometer to one, if not all, of the wagons, locomotives, or the like.

Odometers of the kinds used on automobiles and bicycles can be advantageously used in a great many places on contract work, a few of which are as follows: On wagons, on wheel scrapers, on locomotives, on traction engines, on road rollers, on derricks (to record the number of swings), on hoisting engines, on cableway carriages, etc. Indeed, wherever a machine or tool has a revolving or reciprocating part, an odometer or counter can be used to record the number of reciprocations or revolutions, and from the data so recorded the amount of work can often be calculated with great accuracy.

Recording Single Units.—There are many classes of work in which the only practicable unit to be used is the single or individual unit itself; thus, the telegraph pole erected, the pile driven, the door hung, etc. Obviously records of units of this sort are so readily made as to require almost no comment.

A punch card is a convenient record of single units. Some contractors prefer a tally board on which each unit is marked or tallied with a pencil. Others use a board like a cribbage board, having holes in which plugs are put to record the number of units. Still others give out tickets to the men for each unit of work delivered.

Record Cards Attached to Each Piece of Work.—In doing machine-shop work it is often necessary to have one piece of metal pass through the hands of several different workers. For example, one man may drill holes of a certain size, another man may drill holes of another size, still another man may thread the holes, and so on. In such a case it is common practice, where careful cost records are kept, to provide a card that is attached to each piece or each lot of pieces. In blanks provided on the card, each worker enters his number, and the number of hours and minutes spent by him in doing a specified kind of work on the piece. A modified form of this method is to attach a card or a brass check to each piece, giving a serial number and letter to the piece. Each workman on the piece notes its number on his own record card, and opposite this number he enters the amount of time spent on the piece.

While this method of recording output cannot be as frequently used in engineering contract work as in machine shop work, it should not be overlooked by the general contractor. It might well be applied to timber work where one gang of men bores the holes, another gang saws and a third gang "daps" or adzes the sticks, and so on. It is desirable always to assign different kinds of work to different men, not only because the time usually lost in changing tools may be saved, but because men become more expert when they do one class of work only. The record card facilitates the differentiation of labor into classes, and is, therefore, a great aid in increasing the output of a given number of men.

Measurements of Length.—For a great many kinds of contract work the lineal foot is the best unit to use. Track laying, fence building, pipe laying, setting curb, etc., come under this head. Many other classes of work are commonly measured only in terms of the lineal foot, when, to permit of true comparisons, some other unit or units should also be adopted. Sewer work, for example, is commonly recorded only in terms of the lineal foot; but the amount of excavation varies greatly per lineal foot in different sewers and often in the same sewer; hence the excavation should be measured with the cubic yard as the unit.

Tunnel excavation should also be reduced to the cubic yard standard. A contractor has no very definite idea whether the "mucking" (loading of cars) in a tunnel is being done economically or not until he has determined how many cubic yards each man is loading daily.

Measurements of length are often best made by driving a line of stakes 100 ft. apart, calling each stake a "station." The starting point or station is called Station 0. The next station, 100 ft. from the start, is Sta. 1; the next station, 200 ft. from the start, is Sta. 2; and so on. Hence the mark on any given station stake gives the number of hundreds of feet from the starting point. Points intermediate—that is, between any two stations—are called "pluses." Thus, a point 40 ft. in advance of Sta. 2 is called "two plus forty," and is written Sta. 2 + 40, by which it is clear that it is 240 ft. from the start.

Having driven a line of station stakes, properly marked with their station number, a foreman or timekeeper can quickly ascertain the station and plus at which the day's work has been completed.

In many instances, measurements of length are best made by counting the number of pipe lengths laid, or the number of rail lengths.

Measurements of Area.—Paving, painting, roofing, plastering, and many other classes of construction work are best measured in terms of the square yard, square foot, or "square"

(100 sq. ft.) as the unit. Since areas are usually measured with ease, it is noticeable that area work is generally done with much greater economy than mass work, which is usually more difficult to measure and consequently not measured every day on most jobs. It is sometimes not easy to measure the number of thousand feet board measure in concrete forms, in which case it may be preferable to measure the area of concrete covered by the forms, from which, if desired, the amount of lumber can be calculated approximately.

Measurements of Volume.—This class of measurements is usually the most difficult to make for purposes of daily output reports. Excavation, for example, is not easily measured, as a rule, except by a surveyor. Of massive masonry the same is true. Hence there are few contractors who know accurately how many cubic yards of this sort of work should be accredited each day to each gang. Record should be kept of the number of car or wagon loads of excavated material; but, to derive much benefit from such records, care must be taken to have cars and wagons of uniform size uniformly loaded, or to keep record of the capacities of the different vehicles. Where daily measurements of volume are difficult to secure, some one or more of the following methods may be adopted.

Measurements of Weight.—Loaded cars or wagons can be weighed on track scales or on portable platform scales, and this can be profitably done far oftener than it is. Loaded skips and buckets can be weighed with spring balances attached to the hoisting rope of a derrick. It is sometimes very difficult to measure volumes of certain quantities in the field and it then becomes of advantage to weigh them. It is not easy to tell how much rock there is on a skip load without weighing the loaded skip either by placing it on scales or by putting a spring balance on the derrick. Spring balances of that character can be purchased of a capacity up to 2,600 lbs. and costing about $150. Another form of rock measuring apparatus is in the nature of a balance, costing about $115. A great advantage of a spring balance on a derrick is that it takes no extra time for handling, and, while the first cost seems rather high, the information obtained on a large piece of work is well worth its cost.

In a good many of the Hudson River Trap Rock Quarries the stone is handled in cars which are pushed along on the tracks for purposes of weighing and the men are paid for performance according to the weights on the cars. This is a very accurate and, where it is practicable, a highly satisfactory method of measuring output.

This method has long been in use at coal mines where every car is numbered, and is weighed before dumping.

On contract work, such as macadamizing, for example, each wagon load may be weighed, if the amount of the work warrants the purchase and use of platform scales. It is usually considered sufficiently exact, however, to measure the size of a few loads, and simply count the number of loads. However, loads often vary so greatly in size that this method of counting loads becomes very unsatisfactory. This holds true particularly of loads of quarried stone, of earth loaded by steam shovels, and the like. In such cases the contractor should seriously consider the advisability of weighing each load.

One of the most difficult classes of construction work to measure daily is rubble masonry. Yet we have found two very satisfactory methods of recording the work done by each derrick gang. One way is to use wooden skips that are loaded at the quarry with stone, put upon cars and transported to the work. Each skip is provided with a clip for holding a brass check. The checks are numbered serially, and the weight of stone corresponding to each number is entered in a book; for before delivery to the masonry derricks each skip is lifted by a derrick, placed on scales and weighed. It is sometimes preferable to provide a large spring balance for weighing, instead of using scales. The mason in charge of the derrick gang removes the brass check from the skip and keeps it, entering its number on a card which is turned over to the timekeeper at night, together with the brass checks. Thus it is possible quickly to ascertain the number of tons of rubble laid by each gang.

Functional Units of Measure.—Under this head we class all measurements of units that are functions of the desired units. Thus, in any given mixture of concrete, the number of barrels or bags of cement is a function of (i. e., it bears a definite relation to) the number of cubic yards of concrete. Hence a record of the amount of cement used each day will enable making a close approximation to the number of cubic yards of concrete.

In rubble or cyclopean masonry, a record of the number of buckets of mortar will enable making a close calculation of the yardage of masonry. If spalls are liberally used to reduce the amount of mortar, as they should be, then the number of buckets or skips of spalls should also be recorded.

The number of gallons of paint used is ordinarily a fair criterion of the area of surface painted.

By the use of packets for handling bricks, Gilbreth has developed a system of measuring the work done by each bricklayer, for count is made of the empty packets stacked up by each mason. Since each packet is loaded with a definite number of bricks, this gives an accurate record of each man's output.

Stockpile Measurements.—There are certain kinds of construction that are best measured indirectly by ascertaining what has been removed each day from the stock piles. Thus, in erecting a frame building, the different kinds and sizes of lumber can be piled in stock piles of regular size, easily measured. Rolls of paper, bundles of shingles, etc., can be stored in such manner that a daily inventory of stock on hand is readily made. By subtracting the amount shown by the inventory at the end of each day from the amount on hand the previous day, an accurate record is obtained of materials that have gone into the building. Since a carpenter's work is usually best measured in terms of the 1,000 ft. B. M., the square of shingles, and the like, it is evident that stock pile measurements can be used to great advantage in determining the number of units of certain kinds of work performed on a building.

The measuring of material is greatly facilitated by using a standard method of handling. Gilbreth's rule for cement (see his "Field System") is to place the bags one on top of the other in piles of fifty.

One of the most difficult of the materials to check regularly is the reinforcing steel for concrete. If this is handled in plain bars they can be weighed and wired in bundles of 100 lbs., this being a suitable size for two men to carry. The bundles are, of course, nearly always more or less than 100 lbs., and when the steel is wired it is a good plan to attach to each bundle a tag giving its weight, which tag can be left with the storekeeper for record as the bundles are removed to the work. The difficulty of obtaining these records is caused by the fact that the material is usually placed in a haphazard way wherever it happens to be most convenient for the men placing it without any systematic regard for its use on the work.

Key Units of Measure.—It is always desirable to relieve the foreman or timekeeper of the work of computing the number of units of work done daily, wherever such computation involves either many measurements or much labor in computing. A foreman can readily report the number of "stations" of road graded or macadamized, leaving to the office force the work of deducing the number of units of work performed.

A further step in the same direction is the use of key letters and numbers to designate sections of work whose dimensions the foreman may not know but which are recorded in the office, and from which the number of units of work performed can be readily ascertained. For convenience we call these units key units, since they are designated by key letters or numbers.

Key Units on Drawings.—Any given structure can usually be divided into "sections" identical in shape and character of work. Thus, in a concrete building, there are a number of columns of identical size, a number of beams also identical, a number of identical floor slabs, and so on. To each of these "sections" a key letter or number, or a combination letter and number, may be assigned and written on the drawing.

If numbers from 100 to 199 are reserved for "sections" on the first floor, and the letter C is used to denote columns, then C 100 will designate a particular kind of column on the first floor; while C 200 will designate a corresponding column on the second floor. Having assigned keys to all "sections," the foreman or timekeeper is furnished with blueprints on which the "sections" with their respective keys are marked. In some instances it is preferable to furnish only a few large blueprints containing many "sections" on each print, but it is usually desirable to supplement these large blueprints with small ones of notebook size, which, if preferred, can be punched and bound in a loose-leaf binder.

The foreman or timekeeper reports daily the number of each class of "sections" built by each gang, using the proper key to designate each "section." The office force, having computed the number of units of work in each section, is then able to record the total number of units of work done, with accuracy and with rapidity. If a full "section" is not completed, the foreman or timekeeper estimates the percentage completed, and reports accordingly.

Keys Marked on Separate Members.—On certain classes of work a modification of the above plan is preferable. Instead of providing the foreman or timekeeper with drawings having keyed "sections," a key number or letter is painted, or otherwise marked, on each separate member of the structure before it is put into place. Thus, each block of cut stone is measured in the stock yard and a "key" is painted upon it. Then, when the foreman reports that block A 105 has been laid in the wall, the office force can determine its volume from the recorded measurements. The authors have found this to be the most satisfactory method of recording cut stone work, for it is thus possible not merely to tell the total amount laid each day by several derrick gangs but to tell precisely what each gang has done, for each boss mason can be required to record the key number of every stone laid under his direction. The office work of computing the volume of each stone is insignificant in amount if tables are used for computation, such as Nash's "Expeditious Measurer" ($2.00). These tables give the volume of any block, progressing in size by inches up to 4 ft. 9 in. x 6 ft. 4 in. x 1 ft. 1 in. The tables also give surface areas, progressing by inches, up to 4 ft. 1 in. x 8 ft. 5 in. in size.

Structural steel members can be marked with key letters; so, too, can heavy timbers, movable sections of forms and falsework, and many other classes of materials used in construction work.

Conclusion.—Upon the ingenuity of the management engineer who devises ways of recording the daily output of work done rests the success or failure of any effort to introduce modern methods of management on complicated contract work. The problem before him is often one to tax his ability almost to the elastic limit, for it is not sufficient to devise a method of measuring daily output after a fashion. He must devise not only an accurate method but one that permits of application at the hands of men comparatively unskilled mentally, and under the varying conditions that characterize field construction work. Many a contractor has given up in disgust his attempt to install a modern system of cost keeping, and has charged his failure to the folly of "new-fangled notions." Such failures are usually the outcome of trying to teach old dogs new tricks without so much as hiring a competent teacher. Eventually, it will be recognized that management engineering is a science not to be picked up and mastered at one reading of any article or book, but that it requires study extending over a considerable period of time.

CHAPTER V.

COST KEEPING.

Objects of Cost Keeping.—The two primary objects of cost keeping are:

1. To enable a manager to analyze unit costs with a view to securing the minimum cost possible of attainment under existing conditions.

2. To provide data upon which to base estimates of the probable cost of projected work.

As a result of the analysis of unit costs, followed by a comparison of the items with corresponding cost items of similar work previously done, a manager may discover:

1. Excessive use of materials in erecting a given structure.

2. Excessive use of supplies (coal, etc.) in operating a plant, whether due to ignorance, carelessness or theft.

3. Inefficiency of workmen.

4. Inefficiency of foremen.

5. Padded payrolls.

6. Excessive loss of time due to: (a) plant break-downs, (b) plant shifting, (c) waiting for materials or supplies, etc.

7. Improper design of plant.

Cost keeping also leads to the introduction of piece-rate or bonus systems of payment, which may, in fact, be said to be one of the ultimate objects of cost keeping.

Cost keeping secures many incidental advantages, like the following:

1. Fewer "bosses" are required on certain classes of work, for the report card is a more persuasive stimulus than the eye of a taskmaster.

2. One skilled manager can direct many more men, and with much greater effectiveness than is possible where a cost keeping system does not exist.

3. Systematic analysis of costs leads inevitably to a study of reasons for differences in costs, and this study of reasons is

the first step toward inventing new machines and new methods for reducing costs.

Cost Keeping Defined.—For the purpose of the discussions in this book, a distinction must be drawn between bookkeeping and cost keeping.

Bookkeeping, as we treat it, is the process of recording commercial transactions for the purpose of showing debits and credits between different "accounts." These "accounts" may be individuals or firms, or they may be arbitrary accounts, the latter being an evolution in bookkeeping that came after individual accounts became so large or so complicated as to be insufficient to show the status of the business and the profits derived from any given transaction.

Cost keeping, as we treat it, is the process of recording the number of units of work and the number of units of materials entering into the production of any given structure, or into the performance of any given operation. To these units of work or materials, actual or arbitrary wages or prices may or may not be assigned. The object of cost keeping is primarily to show the efficiency of performance; hence actual money disbursements need not be recorded, as in book keeping. This distinction is vital, and will be discussed at greater length.

Differences Between Cost Keeping and Bookkeeping.—Bookkeeping was first devised and subsequently developed by merchants. Cost keeping was devised and developed by engineers. The merchant is a student of profits; the engineer is a student of costs. Although profits depend upon costs, there is a vast difference in the point of view of the merchant and the engineer.

In the study of costs, as we have previously pointed out, the aim of the engineer is to reduce all costs to a unit basis, selecting such units as most closely conform to the theoretical unit of work—the foot-pound. This study often necessitates the use of several different units for the same class of work. It necessitates the recording of conditions, and the making of measurements—all of which is more or less foreign to the fundamental idea of bookkeeping. Yet, in groping toward methods of cost keeping, it has become the practice of most contractors, manufacturers, railway companies, etc., to endeavor to develop a cost keeping system in the bookkeeping department. Hence we have today systems of bookkeeping that are wonderfully complex, and, withal, show very little that they attempt to show as to unit costs.

Take, for example, the accounting department of an American railway. Here we find skilled accountants loaded up with a mass of work called for in distributing the costs to different accounts. Calculating machines that carry the cost of railway spikes out to the third decimal place are clicking away from morning to night. A prodigious amount of figuring is done so that scores of distributions may be made, without the error of a cent in the balancing of accounts. Yet, with it all, what do these railway accounts show as to unit costs? Next to nothing worthy of the name of cost keeping. The authors have in their possession a mass of railway accounting records; some of it of great value, but most of it valuable only to show bookkeeping gone mad. The accounting department of the average railway has no true record of unit costs. The average railway engineering department is even worse off, as shown by the ridiculous estimates often submitted. After a structure is built, the auditor of the railway takes the superintendent of construction to account for having exceeded the engineer's estimate. The engineer is put on the rack and calls the superintendent inefficient—which is usually true. The superintendent retorts, in his letter to the accounting department, that the engineer does not know how to estimate correctly—which, also, is usually true. Figures, figures, figures, but not a single unit cost! This is typical of railway accounting costs today. We emphasize it because it is also typical of the accounting departments of many contracting firms. And we emphasize it again because it illustrates so well our contention that bookkeeping and cost keeping must be divorced if there is to be a simple, effective system of ascertaining the efficiency of workmen, and permit of such study of their performance as will result in greater efficiency.

Why Cost-keeping Records Should Be Kept Distinct From Bookkeeping Records.—Many contractors and engineers confound cost keeping with bookkeeping and attempts are often made to make a cost keeping system so elaborate as to be a bookkeeping system, thus burdening the bookkeeping with a great deal of material that is not germane to it and piling the cost keeping under an avalanche of details and figures that are destructive to its economic value.

Bookkeeping is an ancient art. Cost keeping is a development that is less than a generation old. Since cost keeping has resembled bookkeeping in some respects, it has been regarded as an evolution of bookkeeping, when, in fact, it was not originated by accounts nor developed as a part of accounting. We repeat that cost keeping has been evolved and developed by engineers, not by bookkeepers. It is an art and a science having objects differing radically from the objects of bookkeeping. Yet innumerable blunders have been made in the attempt to graft a cost keeping system upon a bookkeeping system. These blunders arise from a misconception of the functions of cost keeping and bookkeeping. Let us consider still further what bookkeeping is and wherein it differs from cost keeping.

Bookkeeping in its original and simplest form consists of a record of debits and credits. Its primary object is to show obligations between individuals or corporations. By an extension of this idea, arbitrary accounts were created, such as Bills Payable, Profit and Loss, etc.; but, in all cases, the accounts were kept in the form of debits and credits. Hence the general object of bookkeeping is to show debits and credits.

Now, what is the object of cost keeping? Primarily, its object is to show unit costs. These unit costs may be used as standards by which to effect reductions in costs, or as standards by which to estimate the cost of future work. Cost keeping, therefore, involves the use of standards of comparison, which do not enter into bookkeeping in its original form, nor can the use of standards be grafted upon bookkeeping without great confusion and complication. As above stated, perhaps the best example of the confusion and complication that follow such an attempt may be found in the bookkeeping of railway companies. Without discussing the matter at this time, we need but refer to the absence of satisfactory unit costs in the accounting records of railways and the great labor involved in digging out the data necessary to derive unit costs of the kind most useful to the engineer. The labor wastes that undoubtedly occur in railway construction and operation are attributable to the hybrid system of accounting which is supposed to be good bookkeeping and good cost keeping, without being good in either respect. Nor shall we dwell upon the inability of the chief engineers of railways to estimate costs accurately further than to point out that the accounting records are so involved as to be of little or no assistance to them.

We shall now give in concise form some of the various reasons why cost keeping records should be kept entirely distinct from bookkeeping records.

1. Since the primary object of *bookkeeping* is to show debits and credits, all accounts must be summarized in one book—the ledger. Since the primary object of *cost keeping* is to reduce costs, no book corresponding to a ledger is needed. Indeed it is often desirable to have cost records of different classes of work kept in different books, in different ways, by different men, in order to localize responsibility as well as to apply different units as standards of comparison.

2. *Cost keeping* should partake of the nature of daily reports by which a superintendent can gage the daily performance, and discover inefficiency at once. *Bookkeeping* accounts may not be, and usually are not, posted promptly or completely until some time subsequent to any performance.

3. *Bookkeeping* records must balance to a penny. *Cost keeping* records need not be kept with mathematical precision, except in so far as bonus payments to workmen are involved. The object of cost keeping is to show efficiency, and this may usually be shown by approximations fully as well as by hair splitting exactness. Hence cost keeping records may be devised that will require far less clerical work than is necessary when mathematically accurate bookkeeping is used.

4. *Bookkeeping* is a clerical function; *cost keeping* is an engineering function. It is a rule of successful management not to ask one man to exercise many functions, particularly when they are diverse in nature. An engineer is not interested in recording debits and credits, or in the rendering of bills—functions of the bookkeeper. On the contrary, a bookkeeper knows nothing about construction methods and not only has little interest in construction costs, but lacks the necessary engineering training to interpret cost records and to devise methods of reducing costs.

5. A contractor who has an effective and simple system of bookkeeping naturally objects to a change to a more complex

system, such as is necessary when cost keeping is added to the bookkeeper's duties. Gilbreth's "Office System" contains an admirable method of bookkeeping without books, which is kept wholly distinct from cost keeping.

6. When cost keeping is begun, it is well to start in a small way, taking some particular kind of work, like teaming, and applying a system of daily reports. When this phase of the work has been analyzed and organized, some other feature is taken up, and so on, thus developing a cost keeping system gradually. Resistance to change is bound to be encountered, and the way to overcome it is in this manner, a little at a time. Bookkeeping can not be changed a little at a time. A new system of bookkeeping means an entire revision all at once, for accounts are interdependent.

7. Cost keeping records should state conditions, such as weather, distance of haul, etc., which are essential to interpretation of results. Sketches showing design of structures should form part of permanent cost records. Such things are entirely foreign to bookkeeping, and, if placed upon bookkeeping records, simply serve to confuse them.

8. The bookkeeper enters bills for materials as they are received, crediting the firm that furnishes them. A barrel of spikes may be followed by a dozen picks on the bill. It is not the bookkeeper's function to trace the spikes to their place in the work, and, when the work is finished, to ascertain the total number of barrels of spikes used in a particular structure. That is the function of the cost keeper on the ground. The bookkeeper must show that John Smith Co. has been credited with the spikes. The cost keeper, on the other hand, cares nothing as to the particular firm credited. He is concerned only with the quantity of spikes and the use to which they have been put. It is hopelessly confusing to try to show in one set of records both credits, and unit costs.

9. In studying cost records to ascertain efficiency, it is often necessary to have several different units as standards. On reinforced concrete work, for example, the primary unit is the cubic yard, but there should be at least three other units, namely, the pound of steel (for comparing costs of handling and placing the steel reinforcement), the thousand feet B. M. (for comparing costs of forms), and the square foot of exposed surface (not only

for comparing costs of form work but costs of surface dressing). Cost records must be sufficiently detailed for these purposes, if not in every case, at least in some cases of concrete work. Bookkeeping records become hopeless of interpretation unless they are uniform, and, to be uniform, they must have few units of comparison. In brief, bookkeeping is not flexible. To generalize further, cost keeping costs must be divided by units of work done, so as to secure unit costs for comparison, which is a process foreign to bookkeeping.

10. Since cost keeping has as its primary object the reduction of costs, since comparisons of results secured by different men or different machines or different methods are necessary, it follows that standard wages and standard prices of materials must be used. It may happen that on one job the cement may be purchased at different times at prices ranging from $1.20 to $1.50 per barrel, and that common laborers may receive from $1.50 to $1.75 a day. In comparing unit costs a standard price of cement should be assumed, as $1.30 per barrel, and a common labor standard wage, as $1.50 per day. Then comparisons become possible. A bookkeeper cannot assume any rate of wage or any price; he must give the actual wage or price. A cost keeper usually finds it desirable to use standard wages or prices which approximate the average, or actually are the average.

Time Keeping Defined.—Time keeping, in its old fashioned sense, is a part of the bookkeeping system, and the time keeper is charged with the task of ascertaining what time each man has worked during the day, week or month, according to the arrangement under which he is employed, and what amount of money is due him on pay-day. The timekeeper was not concerned with how much work a man did or on what process his time was spent, so long as the general distribution of the work was obtained. Of late years the time keeper's distributions have become much more elaborate and now he is often charged with considerable cost keeping responsibility. When he does cost keeping work, the records should ordinarily be kept on separate blanks from the time keeping.

If a time keeper, unaided, attempts to distribute the labor according to the work done, his records become complex and are rarely reliable, for, due to his going from place to place, he must rely upon what others (like foremen) tell him as to the performance of different men. In his attempt to balance the statements made to him with the total time, he usually "fudges" his distributed records.

Daily Cost Reports, By Whom Made.—Daily cost reports may be made by: (a) individual workmen, (b) foremen, or (c) time keepers, or by all three of these classes of employees.

Individual workmen are not always competent to fill out reports properly, but, if the report is simple in form and relates to work done by "skilled workmen," it is usually possible to get very satisfactory results. Certainly the individual report is to be encouraged wherever it can be applied, for it heightens the individual's interest in his work.

On field contract work the foreman is the man usually required to make the daily reports. His constant presence on the work enables him to make a more accurate report than a time keeper can make, if the time keeper is required to cover considerable territory, as is usually the case.

In addition to his duty in keeping the time of the men for purposes of paying them properly, the time keeper is often able to attend to filling out the daily cost reports, or one or more special time keepers may be appointed for the special purpose of rendering daily cost reports. If the time keeper is not able to be present constantly where a gang is at work, it is often wise to prepare certain blanks upon which he receives reports from the foreman of the gang, and, from these foreman reports and reports of individuals, combined with his own observations and measurements, the time keeper is able to fill out the complete daily report.

No hard and fast rule can be laid down as to the best persons to whom report making is to be entrusted. The character of the workmen, the size of the job, and other conditions govern the choice.

Written Card vs. Punch Card Reports.—Daily cost reports are best made on forms or blanks, and these forms are preferably cards in which the blank spaces are marked either in writing or by punching holes with a conductor's punch. The written card possesses the following advantages over the punch card:

1. It is more flexible, because the punch card is limited in the scope of the record to what has been foreseen in the office

plus what can be written in a small space reserved for remarks. The pad and pencil are not so limited.

2. A man can usually go ahead filling out blanks in a written card without any previous directions, while he has to have some instruction in the use of the punch.

3. Erasures are possible with pencil and pad but not with a punch card. This is not always an advantage on the side of the written card, however.

The punch card possesses the following advantages over the written card:

1. By folding the card, or by superimposing one card on another, a duplicate record is secured without the use of the carbon paper necessary to secure duplicates with written cards. This duplicate record cannot be altered or erased, and one copy may be kept by the superintendent for his record in discussing the work with the home office, the other being sent in as a regular report to the proper department.

2. A dirty thumb can greatly interfere with the legibility of a written record. Moreover the average foreman or time keeper does not write a particularly clear hand. Punch card records are absolutely clear and legible.

3. It is sometimes expedient to have records from two or more men on the same card. By having no two punches alike on the job and having each man's punch charged to his name on the records it is possible to have a clear and complete record of who made the record without wasting time and space for signatures.

4. The hole made by the punch is usually less than one-eighth of an inch in diameter, and consequently a much larger number of facts can be recorded upon a small card by the punch than by writing, the number of groups of facts, however, being somewhat limited.

5. To punch a hole in a card takes much less time than to make the average pencil record, especially where duplicate records are made. Where a time keeper has to keep track of a large number of men this is a very valuable feature.

6. A hole can be accurately punched while riding on a hand-car, wagon or locomotive, when the vibration would greatly distort a man's handwriting.

7. Punch cards can be made on blue print paper from a

tracing, which is an advantage where a mimeograph is not available for making white cards to be filled in with pencil.

Time Cards that Show Changes of Occupation.—In field contract work there is usually more or less change of occupation constantly occurring. A gang of workmen may be engaged in grading for a while and then may be shifted to track laying; or at least some individual in the gang may be thus shifted from one class of work to another. Hence it is usually desirable to have daily report cards arranged so as to record the exact amount of time spent by each individual on each class of work. This may be accomplished in either one of two ways: First, by having a separate card for each workman; or, second, by having a gang card on which each workman's name or number appears, and so arranged that his time may be placed opposite or under the tabulated class of work that he has performed.

The individual card (a card for each workman) is often preferable when the bonus system, or its equivalent, is employed. On most contract work, however, the bonus system is not yet in operation, and gang cards, filled in by the foreman, will serve the purpose of showing the total performance of the gang and the times spent by the various individuals on different work. There are several ways of recording the individual times spent by men working in a gang, among which the following are typical.

Each employee is given a number, and the numbers are arranged in a horizontal line across the top of a time sheet, as shown in Fig. 1. The different classes of work are printed in a column at the left, one line being assigned to each subclass. If team No. 1 works from 7 to 9 A. M. plowing, the record is made by the foreman, who writes 7-9 opposite "Plowing" and under No. 1; since this is 2 hours' work, the figure 2 is subsequently written directly below the 7-9. If team No. 1 is then transferred to work connected with rolling subgrade, and is thus engaged from 9 to 11 A. M., this fact is indicated, as shown, by writing 9-11 under No. 1 and opposite "Rolling Subgrade."

Another method involves the use of "key letters" to indicate each class of work, the proper key letter being placed opposite the employee's name and under the nearest half hour when he began doing the class of work represented by the key letter. Fig. 2 shows that employee No. 1, whose name is Smith, began work at 7 A. M., the key letter A being under 7, and that he was engaged in excavation, since A is the "key" for excavation. He continued on excavation until 10:30 A. M., when he began back filling, as shown by the key letter C entered under 10 and in the

*Street*______________ *Date*______________*190*__ *City*______________

	No. OF EMPLOYEE	1	2	3	27	28	29	30	31	32	33	Total Hours
GRADING	Plowing	7-9 2										
	Excavating											
	Rolling Subgrade	9-11 2										
CONCRETE BASE	Hauling & Loading Concrete Gravel	11-12 1										
	Hauling & Loading Concrete Stone											
	Hauling & Loading Concrete Sand											
	Laying Concrete											
	Hauling & Unloading Cement											
BRICK	Hauling & Unloading	1-6 5										
	Laying Brick		7-8 1									
	Making Cushion		8-12 4									
	Hauling & Loading Cushion Sand											
	Culling Brick		1-3 2									
	Rolling Brick											
FILLER	Putting in Filler		3-6 3									
	Hauling & Loading Filler Sand											
	Putting in Expansion Joints											
SEWERAGE	Putting in Sewers & Inlets											
	Putting in Catch Basins											
	Putting in Manholes											
SAND	Screening Sand											
CURBING	Hauling & Loading Gravel or Stone											
	Hauling & Loading Sand											
	Hauling and Unloading Cement											
SUNDRIES	Hauling & Loading filling Gravel or Sand											
	Cleaning up											
	General											
MACADAM	Rolling Stone											
	Spreading Stone											
	Total Hours	10	10									
	Rate Per Hour	35	20									

All remarks must appear on the other side.

______________Foreman

Fig. 1.—Time Card Showing Changes of Occupation.

lower square. The upper squares indicate the even hour, and the lower squares indicate the half hour. At 3 P. M. he was transferred to concrete work, as shown by the key letter F under 3.

A modification of this last method is shown on page 194.

TIME SHEET, JOB No........ ...FROM...........TO...................
For instructions see reverse side.

TIME KEEPERS' CHECK COLUMN — See instructions

DISTRIBUTION (See instructions). SEC...................

No.	Name / See instructions	Dates							Total Hours	Rate	Total Amount $	c	Dates or Hours 7	8	9	10	11	12	1	2	3	4	5	6	A Excavation	B Sheeting	C Back Fill	D Surplus	E Centers	F Concrete	G Pipe Lay.	H C. Basins	I C. B. Con.	J House Con.	K	L	M
	Brought Fordard																																				
1	Smith												A			C					F																
	Totals												Total Hours																								
													Total Nearest Dollar																								
	Signed..												Total Cement Used (Bags)																								

Distribution and Pay Roll must check in $ and hours.

Fig. 2.—Time Card Showing Changes of Occupation by Means of Key Letters.

where it will be seen that the number of hours worked by each man on each class of work is recorded under a column headed with a combination of key letters that indicate the class of work.

On some classes of work, a gang of men is seldom split up, but the entire gang may be shifted from one class of work to another. A method of keeping a daily "log" of events, showing at the same time the number of units of work done, is illustrated on page 265.

Wherever men are being frequently shifted from one class of work to another, some method of recording the time of shifting, at least to the nearest half hour, should be used, as outlined in the different ways above given. If a foreman does not make an immediate record of such shifting, but relies upon his memory to fill in his report blanks at night, he is almost certain to make serious mistakes. Moreover, it is not unusual for a foreman to "fudge" the reports thus made, and even to falsify them grossly, for the purpose of showing a seemingly high efficiency of the men on certain classes of work; but, if a blank must be filled in during the progress of the work, and not at night, a foreman risks discovery of any attempted deceit, since his record card may be examined at an unexpected time of the day.

Gang Report Cards.—These are usually made by the foreman in charge of the gang. If the gang is always engaged on the same class of work, it is not necessary for the foreman to keep a time record of each man's occupation, in the manner just described; for the foreman can fill in the daily report card from memory. In this case the *time keeper* records each workman's name and hours of work, while the *foreman* concerns himself only with reporting the total number of men engaged on each class of work and their day's performance.

A gang report card should usually show most of the following things:

1. Number of contract.
2. Location of the job.
3. Character of the job.
4. Date of the report.
5. Kind of weather.
6. Name of the foreman.
7. Classification of work, or "key letters."

8. Total hours' labor under each class.
9. Rates per hour.
10. Total pay.
11. Number of units of each class of work done.
12. Units of material and supplies used.
13. Units of materials received.
14. Units of material in stock.
15. Delays, time and cause.
16. Time machines are actually working.
17. Kind of machine or tool used and its condition.
18. Remarks.

Obviously there are many classes of work that do not require a daily statement containing all these 18 facts; but in preparing a daily report card it is desirable to have this list at hand, to make sure that no omissions occur.

The space reserved for "Remarks" is usually so small that it is rarely used. Special conditions that would naturally be recorded under "Remarks" had better be recorded in a loose leaf diary kept by the foreman, of which more will be said later.

In designing a gang report card, the most difficult feature is the classification. This, however, is greatly simplified if done according to the following system:

1. Select for the general class heads the items upon which the unit contract prices are based, such as excavation (cu. yds.), macadam (sq. yds.), curb (lin. ft.).

2. Divide each of these pay items into the *operations* involved. Thus excavation involves (a) loosening, (b) loading, (c) transporting, and (d) dumping.

3. Divide each operation into as many subheadings as there are classes of workmen engaged upon it. Thus, the operation of loosening earth may involve (a) teams plowing, and (b) men holding plow.

Summing up we would have the following subclasses under the class Excavation:

Excavation—

Loosening: Men holding plow.
Teams plowing.
Loading: Men shoveling.
Transporting: Teams.
Dumping: Men.

The next thing to consider is whether the men are of the same class, receiving the same rates of wages; for, if they are not, there must be a further subdivision. For example, on cement curb construction, the classification would be as follows:

Curb—
Trenching: Laborers.
Placing cinders: Laborers.
Mixing and placing: Laborers.
Setting forms: Skilled laborers.
Finishing: Skilled finishers.
Helpers.

There are many kinds of pay items, such as macadam, that often involve processes that are performed at widely separated places. Thus, quarrying and crushing are processes far removed from spreading, rolling and sprinkling the macadam. Whenever this is the case, it is usually unwise to attempt to show all the processes on one report card. A good general rule to follow is to group together on the same report card only those processes that come directly and constantly under the eye of one foreman. Therefore one report card should show the quarrying and crushing, another should show the grading of the road; and possibly the spreading, rolling and sprinkling of the macadam should also be placed upon the same card with the grading, but not unless the grading gang is to be always a very short distance in advance of the macadamizing.

The commonest mistake in designing report blanks is to endeavor to reduce the number of the blanks. It is far better to have more blanks and to distribute the work of reporting, for it not only simplifies the blanks, but, by giving each foreman less to report, greater accuracy is secured. In fact, there are many operations that can best be reported by the workmen themselves. Thus, to continue the illustration of the macadam road work, each of the teamsters hauling broken stone should carry an individual report card which is punched or marked by workmen at each end of the trip.

We have said that the pay items should be analyzed according to the operation involved, but care must be taken not to select operations upon which men are engaged for but a few moments continuously. To illustrate: In mixing concrete by hand, there are usually the following operations—(a) loading wheelbarrows, (b) wheeling, (c) mixing, (d) loading, (e) transporting, (f) spreading and ramming. Some gangs are so organized that a few men are kept constantly busy loading wheelbarrows with sand and stone, while the rest of the gang spends a few minutes wheeling, a few more mixing, and so on. Clearly it would be foolish to subdivide the operations on the report cards where the organization is of this character, for most of the men are changing their operations so frequently that a foreman would have time for doing nothing but to record their changes.

We see that the designer of a report blank should know approximately what the organization of the gang and what the methods of operation are to be, before he can design a report blank that will be concise, and complete, but with no superfluous headings. Since there are almost innumerable methods of doing work, it is obviously impossible to furnish a set of printed report cards that will exactly serve all cases, unless the classification headings used are very general. However, the designing of a report card is a comparatively simple matter once the organization and methods of doing the work are known, provided the foregoing system is used.

A tentative report blank can be designed either by using some existing report card for similar work as a guide, or by referring to some book that gives, in detail, the costs of construction work similar to that for which the report blank is intended. From the items of cost given in published records, a classification can be prepared that will be of decided help in planning the report card.

In order to economize space on a report blank, it is not always necessary to print the classes or subclasses in full. Abbreviations and key letters may be used. Sometimes the mere recording of the rate of wages opposite a class will show the subclass. Thus, under the class of "Forms" (building wooden forms for concrete) if a wage of 20 cts. per hour appears, also a wage of 35 cts. per hour, it will be understood that the latter refers to the carpenter, while the former refers to the carpenter's helper.

Having decided upon the classification of operations and employees, the next thing to determine is the character of the performance report, which is usually to be recorded on the same card.

In Chapter IV we have discussed the difficulties of reporting daily performance, and have indicated ways of overcoming the difficulties. It is evident that a foreman or timekeeper should not be expected to report the number of units of each class of work performed if any considerable amount of difficult measurement is involved. Hence, it is usually futile to provide for a daily report of the number of cubic yards of earth excavated. On the other hand, the number of wagon loads, or car loads, may usually be reported, and the blank used for excavation should usually provide for such a report.

If some of the excavated material is shoveled directly into the embankment or hauled by scrapers, while some is hauled by wagons, it will be futile to provide for a daily report of loads hauled. In such cases, it is often advisable to report merely the number of lineal feet of work done daily. Thus, in road work, where the excavation is shallow and mostly from ditches, the report should show the station and plus up to which the grading is completed at the end of the day. It is then the function of the office force to determine the yardage from the office records.

The amount of concrete and cement work of all kinds can be reported with considerable accuracy by stating the number of bags of cement used during the day.

Chapter IV should be consulted for further hints on methods of measuring daily performance of gangs.

The amount of supplies, like coal, used each day, can usually be reported if some system be devised for recording consumption or for readily inventorying the stock on hand each night. It is generally wise to require coal to be measured in boxes or in wheelbarrows of uniform size, uniformly filled. Then each fireman reports the number of cubic feet (or boxes) of coal used during the day.

Empty dynamite boxes are often convenient for purposes of measurement, as they hold exactly ¾ cu. ft. each.

Individual Record Cards.—Wherever individual workmen are paid by the bonus or piece rate systems, it is usually best to provide a separate record card for each workman, for it is difficult to make a compact record on one card that will show not only the occupations of a number of men, but the performance of each man. This is particularly true where the men are repeatedly shifted from one class of work to another.

Where one man operates a machine, like a rock drill, it is usually wise to provide him with his own individual record card, upon which he is required to record his day's performance. A modification of this plan is to let the foreman carry the individual records of all the men, and fill in each card himself.

The engineman on a dinky locomotive should be required to make and fill in a daily report, showing the number of train loads hauled, time lost, etc., as shown on page 151.

A teamster should usually be required to carry a card whereon are recorded the times of arrival or departure at each end of each trip.

A steam roller engineman should be required to fill in a card report showing number of lineal feet of road rolled, and the number of miles travelled by the roller. The latter should be recorded by an odometer.

Kinds of Punches to Use.—If punch card reports are to be used, an ordinary conductor's punch will serve for small cards; but it is generally desirable to have large cards, which necessitates the use of a special punch having a 2 in. reach. Such special punches are made by L. A. Sayre & Co., of Newark, N. J., and by other railroad supply concerns.

Size and Kind of Daily Report Cards.—It is usually desirable to have report cards of a size that will be suitable for filing in the standard card index files. A size that will be found satisfactory for general use is 5x7¾ ins.

If reports are to be written and made out in duplicate, the report cards should be made up in pads of alternate thin and thick cards, so that a carbon paper may be inserted between a thin card and a thick one.

It is generally wise to have the cards tinted one color for the original and another color for the duplicate. It is also a good plan to designate the kind of report card by a key letter, or combination of letters, which may be stamped in red in one corner of the card. Thus the letter T may be used to designate the daily report card of teamsters. Instead of using mnemonic key letters, some contractors prefer to use different tints for different classes of report cards.

This works well when there are only a few classes, but becomes confusing when there are many, and is worthless as a means of distinguishing cards at a glance when there are very many classes.

Where a great deal of information must be crowded on one card, it is often desirable to provide for writing the report on both faces of the card. This is objectionable, however, because it makes it impracticable to produce a duplicate by the use of carbon paper. It is also inconvenient to examine such a card after it is placed in a filing case.

Foreman's Diary.— The foreman or the superintendent should always be required to keep a daily diary in which should be entered:

1. Verbal orders received from engineers and owners.

2. Verbal requests made to the engineers for grade stakes, etc.

3. Weather conditions.

4. Remarks as to hardness of digging, poor quality of materials and supplies, slowness of their delivery, general inefficiency of the men available, and such other conditions as bear upon the economic performance of the work but can not be shown in the daily report.

The ordinary field foreman will not keep a diary of much value unless its pages are inspected daily. This requires that it shall be a duplicate loose leaf diary, the original leaf being sent to the office with the daily cost report, and the duplicate, or carbon copy, being retained by the foreman and bound in a loose leaf binder.

Designing Punch Card Reports.—We have already enumerated the advantages of the punch card for certain kinds of daily reports. One of the earliest punch cards devised for this purpose is shown in Fig. 3, and was designed by one of the authors for recording the daily work done by each team in hauling broken stone for macadam. Each teamster carries a card which he presents for punching at each end of the trip. The diamond punch hole indicates that the loaded team left the crusher bin at 7:05 A. M. The cross punch holes shows that it dumped its load on the road at 8:20 A. M. A new card is issued to each teamster each day; but, if it is desired to provide one card that will serve for a full week, one may be easily designed.

Fig. 4 is such a team card for macadam road work. The punches on this card show:

1. That the team was No. 14.
2. That its pay was 35 cts per hour.
3. That the record is for the week ending July 12.
4. That the team was hauling 2½ in. stone for macadam.
5. That the haul was from Station 124 to Station 185.
6. That the first trip on Monday was begun at 7:05 A. M. and that the team reached the place where the stone was dumped at 7:30 A. M.

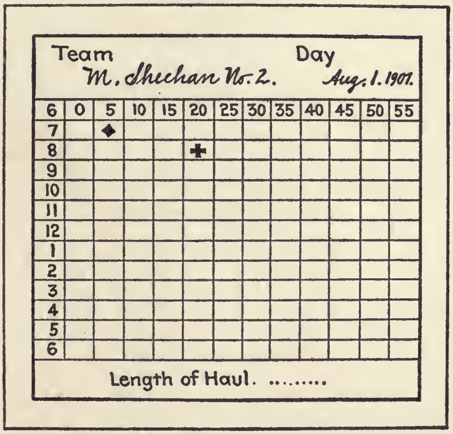


Fig. 3.—Punch Card, Team.

A more elaborate form of individual punch card is shown in Fig. 5 and is designed to show the daily performance of each rock drill in great detail.

The punch holes in this particular card show:

1. That the holes were spaced 4 ft. one way and 5 ft. the other.
2. That + bits were used.
3. That the drill was in good condition.
4. That the drill was No. 2.
5. That a 3 in. starting bit was used.
6. That 54 ft. of hole were drilled.
7. That there were 4 holes, Nos. 1, 2, 3 and 4, whose depths were 15, 14, 13 and 12 ft. respectively.

(Note: A hole, No. 0, is provided, in case a partly drilled hole of the previous day has to be completed, for, in that event, the number of feet drilled to complete the hole is punched above hole No. 0.)

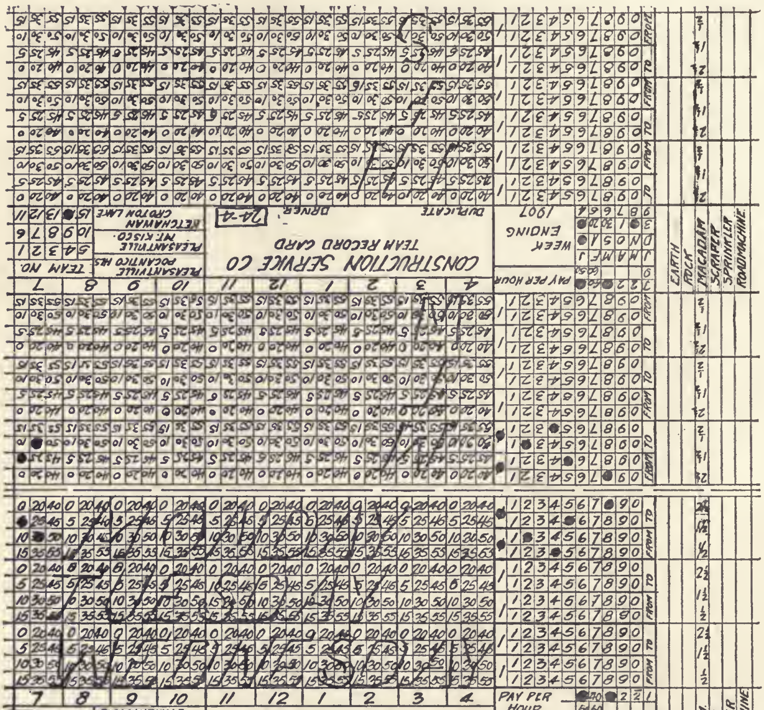


Fig. 4.—Duplicate Punch Card, Teaming (original size 5"x7¾").

7. That the date was July 16.

8. That work began at 7:02 A. M., and hole No. 1 was completed at 9:44; that work was stopped at 12 M. and begun

again at 1:00 P. M.; that hole No. 2 was finished at 1:18 P. M., hole No. 3 at 2:36, hole No. 4 at 4:52.

It is not usually necessary to record rock drill operations to

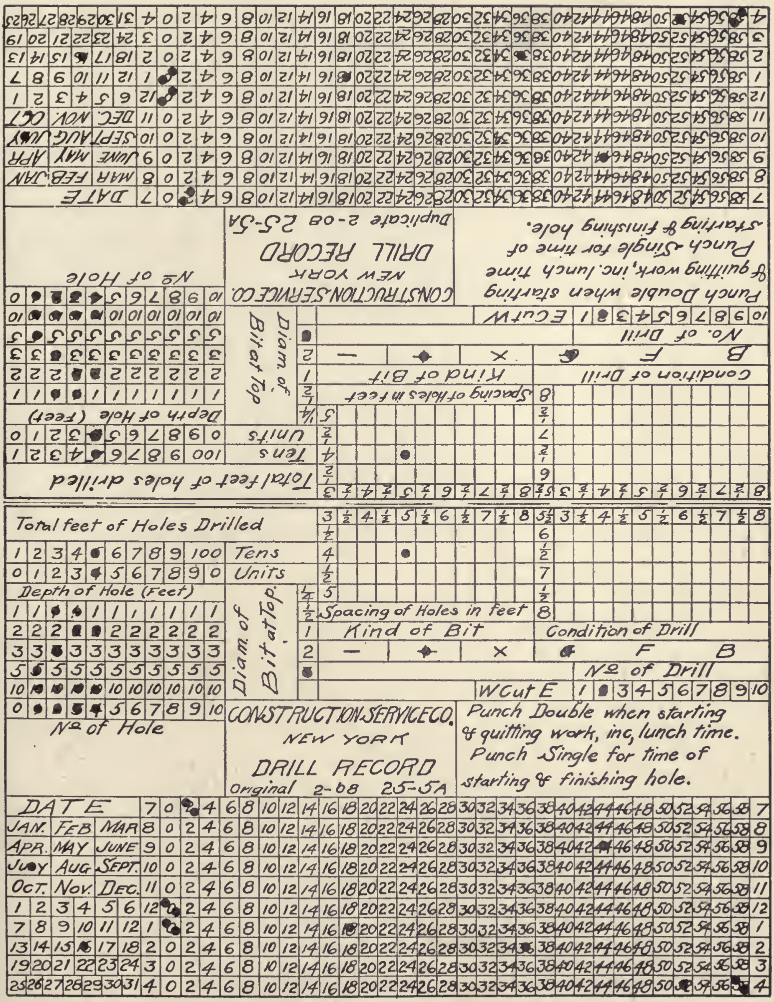


Fig. 5.—Duplicate Punch Card, Drilling.

the nearest even minute, as the nearest 5 minutes will ordinarily suffice; but it is sometimes desirable to have the drillers record the time of starting one hole and of starting the next hole. In that case this card, which provides for a time record on 2 min. intervals, is more satisfactory than one designed for 5 min. intervals. Drillers are often very slow in shifting drills from one hole to the next, which is well shown up if the time of finishing one hole and of starting the next is punched. Punching two holes in the card in one square (punching double), can be used to indicate time of starting a hole, while punching one hole indicates its time of completion.

Note that in designing punch cards, space can be economized by the arrangement shown in the upper left hand corner of Fig. 5,

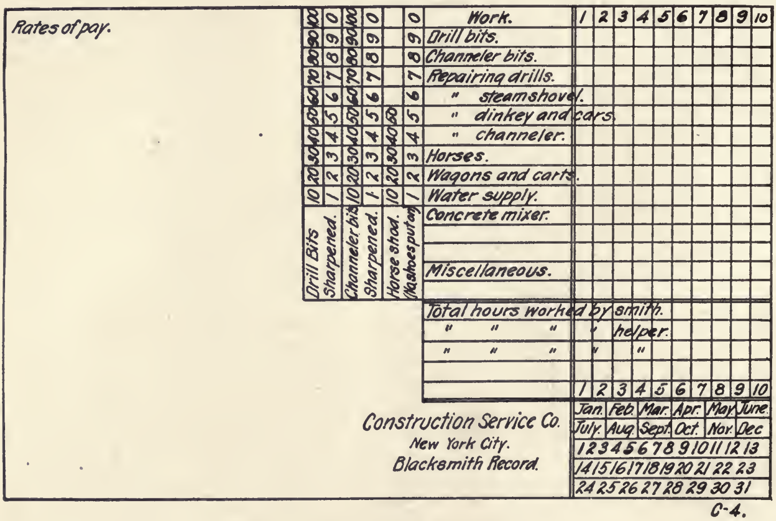


Fig. 6.—Punch Card, Blacksmith.

where the upper line indicates "tens" and the lower line indicates "units."

The punch card lends itself well to recording the work done by individual men, or by one skilled man assisted by a few helpers, as exemplified in the blacksmith report card, Fig. 6. Here, it will be seen, the blacksmith punches the number of hours spent at each class of work. The nearest half hour is designated by punching on the line between the two full hours. By punching a blank card for every bit sharpened, the smith keeps tally of the number sharpened, and, at the end of the day, punches the number on this report card.

On some classes of work, particularly shop work, it is often desirable to have a separate punch card for each class of work, instead of recording several classes of work on the same card. Fig. 7 illustrates such a card that has been used by the National Switch & Signal Co. and was described by Mr. Chas. Hansel and published in the "Complete Cost Keeper," 1903. Each workman perforates the five-minute time card for each job on which he is employed, simply piercing the card at the five-minute points most nearly representing his times of beginning and ending

TIME CARD

Workman's No........ Date............

Date Commenced ....

Order No.........................

Catalog No......................

Number Pieces ....

Operation No....................

Date Finished....................

H	Min.										
7	5	10	15	20	25	30	35	40	45	50	55
8	5	10	15	20	25	30	35	40	45	50	55
9	5	10	15	20	25	30	35	40	45	50	55
10	5	10	15	20	25	30	35	40	45	50	55
11	5	10	15	20	25	30	35	40	45	50	55
12	5	10	15	20	25	30	35	40	45	50	55
1	5	10	15	20	25	30	35	40	45	50	55
2	5	10	15	20	25	30	35	40	45	50	55
3	5	10	15	20	25	30	35	40	45	50	55
4	5	10	15	20	25	30	35	40	45	50	55
5	5	10	15	20	25	30	35	40	45	50	55
6	5	10	15	20	25	30	35	40	45	50	55

Approved

............................Foreman

Fig. 7.—Punch Card, Shop Work.

work on the job in hand, the appropriate order number being entered on the card by the foreman. When the workman enters the shop in the morning, he is furnished with one time card, which he hangs on the upper hook of his individual time board, after perforating it at his beginning time. If the foreman gives the workman a second job before the first is completed, he fills in the order number on a second card, and hangs this second card on the upper hook. Thus the workman may have any number of jobs before him, each order being given on a separate card. When any job is completed its card is transferred to the lower hook. The time cards on the lower hook are removed by the time keeper each morning, cards on the upper hook being left undisturbed.

Punch Card Showing Time and Occupation of Each Member of a Gang.—It is frequently desirable to record the amount of time spent by each member of a gang on each kind of work performed by him. Some ingenuity is required to design a punch card for this purpose, without making the card too large. Fig. 8 shows a punch card (for a rock channeling gang) that

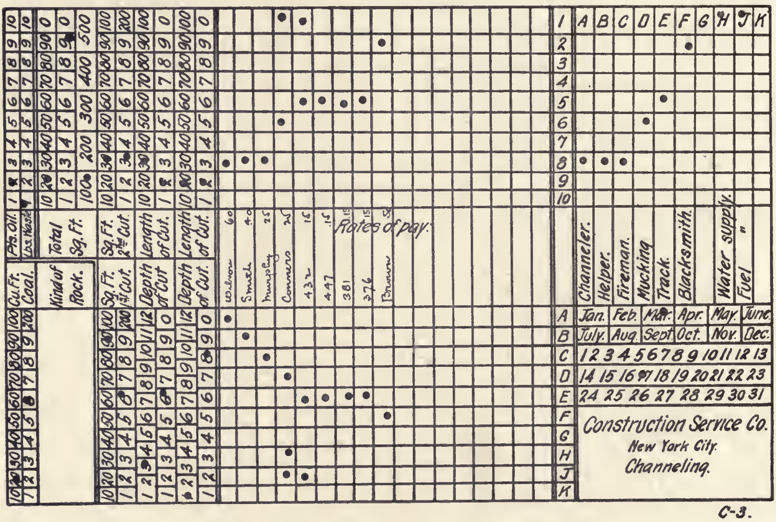


Fig. 8.—Punch Card, Rock Channeling.

provides for 17 men in a gang with 10 different occupations. The names or numbers of each of the men are written in the center of the card, with their rates of wages. All the rest of the data is punched.

It will be noted that Wilson, Smith and Murphy each has one punch mark above his name, and to the left of the figure 8. This shows that each of them worked 8 hrs.; but at what class of work? At the right of the figure 8 are three punch marks, under A, B and C, indicating channeler, helper and fireman. Which of these three men is the channeler? To find out, drop down to the lower half of the card, where the key letters A, B, C, etc., are found in a vertical column. Running the eye along the horizontal line from A to the left, we find a punch mark directly under Wilson's name, which shows that he is the channeler. In like manner, the punch mark under Smith's name, and to the left of B, shows that he is the helper.

The fourth man, Connors, has two punch marks over his name, one opposite 6, and one opposite 1. To the right of 6 we find a punch hole under D, which is in the column marked mucking; and, since there are no other punch holes opposite 6 and over the names of other men, it is clear that Connors spent 6 hours mucking. But it is not so clear at first glance what the punch hole above Connors's name to the left of the 1 means, for we find two punch holes to the right of 1, through H and J, indicating work in connection with water supply and fuel supply. On which of these classes of work did Connors spend the 1 hr.? Dropping down to the vertical column of key letters, let the eye travel along the line to the left of H until it comes under Connors' name; there we find a punch hole indicating that he worked 1 hr. on water supply. But we see still another punch hole below Connors' name and to the left of J; hence he worked another hour on fuel supply. This makes the total of 8 hrs. for Connors.

The men whose numbers are 432, 447, 381 and 376 each worked 5 hrs. at track laying; but man 432 has a second punch mark over his name, to the left of 1; we find what this 1 hr. of work was by looking for the punch marks below this man's number (432); for there we see that in addition to his having a punch mark to the left of E, which relates to his 5 hrs. on track work, he has also a punch mark to the left of J, which relates to his 1 hr. spent on fuel supply work.

This same scheme of indicating each man's work and the time spent upon it is susceptible of wide application, as will be seen by referring to the report cards in Chapter VIII.

In addition to the record of time spent by each man on the different classes of work, the card in Fig. 8 shows:

1. That the day was Mar. 17.

2. That 26 cu. ft. of coal were used by the channeling machine.

3. That 2 pts. of oil and 1 lb. of waste were used.

4. That the length of the first cut was 32 ft. and its depth 36 ins.

5. That the length of the second cut was 22 ft. and the depth 18 ins.

6. That the area of the first cut was 96 sq. ft., and that of the second cut was 33 ft.

7. That the total area was 129 sq. ft.

While the description of such punch cards sounds complicated, experience has demonstrated that any foreman or intelligent workman is easily taught how to use them.

The important thing to impress upon the man who is to make out the report is that every workman must have at least one punch mark above his name and one below it, and that there must be a third punch mark on the line to the right of the upper punch mark and directly under the key letter which shows the nature of the work done, and that the punch mark below the man's name must be on the line to the left of the same key letter —the three punch marks showing the time spent and the kind of work.

Duplicate Punch Cards.—It is often desirable to have a duplicate record of the daily report, one copy of which is sent to the office and the other retained by the man who makes the report. This is easily done with a punch card designed as shown in Fig. 9, so that, when folded along the center line, the duplicate half comes exactly below the original half.

The maintenance of way card, Fig. 9, shows the number of men employed on the various classes of work indicated, the time spent on each, and the location of each class of work. The first column of figures indicates hundreds, second column tens, and third column units, so that 999 is the largest number that can be punched.

The particular card illustrated gives the following information:

The work consisted of renewing ties and surfacing track and was located between telegraph poles 121 and 990. There were ten ties renewed and 260 feet track surfaced, and two hours were spent in traveling. There was a total of six men employed. All worked one hour on *D* (renewing ties), all spent two hours traveling, and all spent seven hours on *F* (surfacing track). Thus the work was distributed over *D, F, K,* as shown in the lower right hand corner, and all six men worked on each item. At this place is also shown the rates of pay. All the laborers received 14 cts. an hour and the foreman received $50.00 per month. The date was May 21, and the foreman's name was Applin.

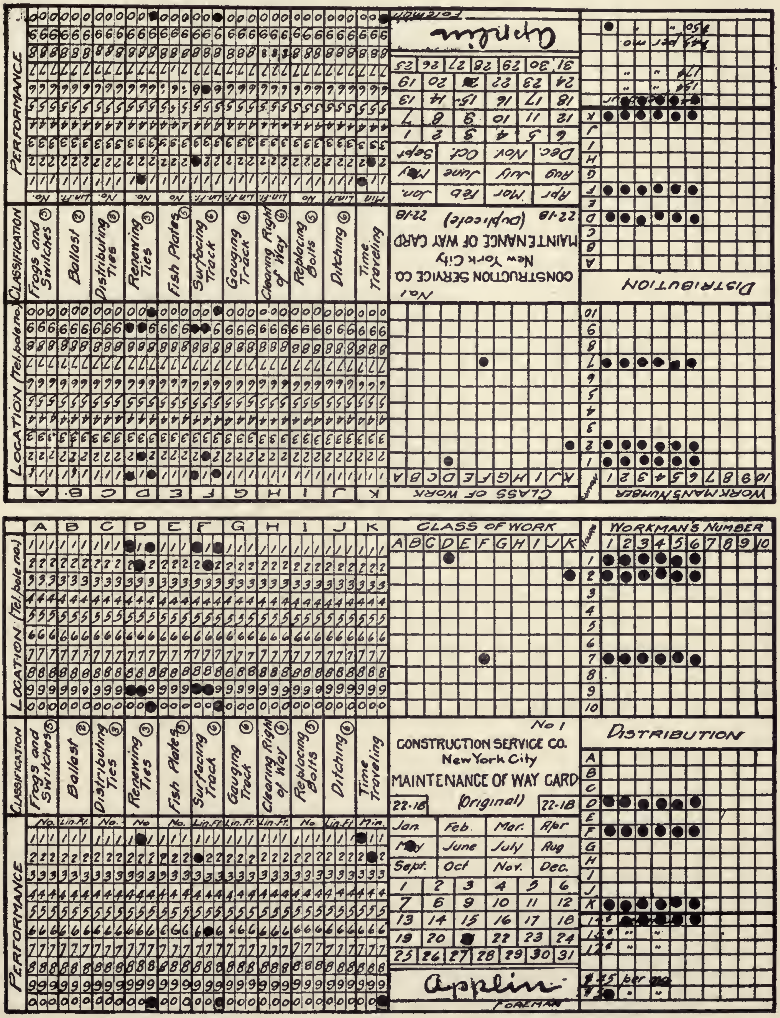


Fig. 9.—Duplicate Punch Card, Maintenance of Way.

It will be noted that while the original card will show clearly the number of units of work done, etc., the duplicate, which is retained for an official copy and is not much used, must be read backward.

Record Cards Accompanying Each Piece of Work.—In doing machine shop work, it is often necessary to have one piece of metal pass through the hands of several workers. For example, one man may drill holes of a certain size, another may drill holes of another size, still another may thread the holes, and so on. In such a case a record card may be attached to, or accompany each piece or lot of pieces. In blanks provided on the card, each worker enters his number and the amount of time spent in doing a specified kind and amount of work on the piece.

Using Several Record Cards, One For Each Piece of Work.—A method that is usually preferable to the one just described for shop work, is to give each workman several record cards. As each new piece of work comes to him, he enters its "order number" on a record card, and records the time he spends on the piece. When finished, he uses another record card for the next piece. Fig. 7 shows a punch card designed for this sort of record.

Store Keeper's Reports.—The store keeper's duties include the following:

1. He must receipt for and take charge of all material delivered for temporary storage.

2. He must see that all of this material is properly accounted for and none lost or stolen.

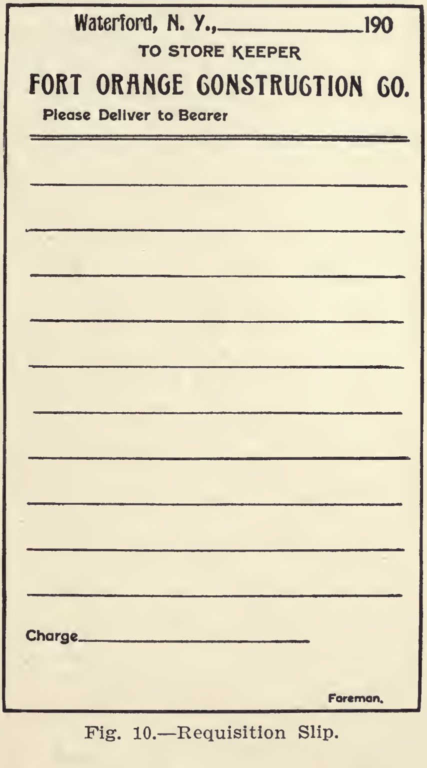
3. He must take charge of the issuing of materials and supplies to the men and see that they are issued in proper quantity and that there is no waste.

4. He should see that needed material and supplies are issued without loss of time.

To accomplish these objects it is necessary that some one be on hand at the store house at all times when material is likely to be delivered or called for. This includes the noon hour as well as other times. Considerable economy results from sending to the store house in the noon hour to obtain articles that are needed in the afternoon.

The second duty of the store keeper is often interfered with by men going to the store house for articles needed in a hurry and not leaving receipts for them. The only way then that the store keeper can account for his materials would be by periodical inventories, and then at the best there is nothing whereby the periodical inventory can be checked. The perfunctory inventory is generally useless. All the men in the field in the position of authority or who are likely to require to have materials issued to them should be provided with small requisition blanks similar to the one shown in Fig. 10, and the store keeper should require a requisition slip as a receipt for all material issued.

At the end of the month these receipts for material issued should tally with his inventory and list of material received.


Waterford, N. Y., ____________ 190
TO STORE KEEPER
FORT ORANGE CONSTRUCTION CO.
Please Deliver to Bearer

Charge ____________

Foreman.

Fig. 10.—Requisition Slip.

On some work it is customary for the store keeper to go around the job interviewing the different men who may need material and take charge of getting the material to them, taking a receipt for material from the messenger. These receipts then form part of the record. Another way is for the foreman of each gang every night to turn in with his report a statement of the material that he will need and when. The requisition part of the report can then be abstracted and turned over to the store keeper. This latter plan has the objection that, unless somebody works over-time, it is difficult for the store keeper to get the material as early as it is likely to be wanted. The rule of requiring receipts for material should be applied even to such large units as piles and timber generally. Although it seems at first glance an easy matter to keep track of such large units without the application of any particular system, it is found exceedingly difficult in practice.

After material and supplies have been issued by the store keeper they may remain upon the work for some time before being actually used. This applies particularly to such material as dynamite that is kept in magazines. The key of the magazine should be in charge of one man who should record the number of cases that he removes during the day. One of the best methods of getting this record is to have a card hanging by the magazine door and require the magazine tender to punch a hole in the card for every case of powder that he moves. This card can then be turned in to the store keeper each day, from which the records of powder used and powder on hand can be kept posted. The same method works very well for recording cement.

In general, when the material records are made by productive laborers in the field they should be made to the store keeper and be checked and handed out by him.

When no definite rule is established for the prompt obtaining of material on request the inability to obtain material promptly is used as a most prolific excuse for not getting work done. In a certain case in point some important work was delayed for a long time because a pump gasket blew out just after the requisition rule had been instituted on the work and before the store keeper realized the necessity of promptness in making deliveries or the directness of his responsibility.

Reports on Materials and Supplies.— Fig. 11 shows a requisition blank for materials, which is self explanatory.

Fig. 12 is a card for reporting supplies received. It includes the oil, waste, powder, caps and fuse supplied to the various field organizations, such as drillers, pumps, various steam shovels, dinkeys, cars, shovels, and also shows the amount remaining on hand. This is for steam shovel work in rock.

Fig. 13 is a material card designed to be used daily by the foreman on concrete work for recording the materials received. The size of various loads of cement, gravel, sand, screenings,

Nº 50 DANSVILLE AND MT. MORRIS R. R. MATERIAL
A. S. MURRAY, JR., RECEIVER
REQUISITION ORDER DANSVILLE, N. Y., ... 19
TO ....
....
PLEASE FURNISH THE FOLLOWING MATERIALS
....
....
....
....
....
....
....
DELIVER VIA. ....
.... D. L. & W. R. R. DELIVERY NOT ACCEPTED
APPROVED
.... GEN. SUPT.
.... Keep white copy in Dansville Office, mail others to Gen Mgr's Office. Blue slip is dealer's order for material.

Fig. 11.—Requisition Blank.

stone, and the number of feet board measure of lumber are shown on one half of the card, and on the other half are the amounts of glass, steel, lampblack, oakum, nails, etc. On the back of the card an entry is supposed to be made of all material sent away from the shop or remaining on the work at night, thus giving a check upon the quantity of materials used.

SUPPLY REPORT NO. 1. .... 190....

	Drillers.	Pumps.	No. 1 Shovel.	No. 2 Shovel.	No. 1 Dinkey.	No. 2 Dinkey.	No. 3 Dinkey.	Cars.	Shop.	Little Hill.	On Hand.
Cyl. Oil....											
Eng. "											
Blk. "											
Waste											
Powder....											
Dynamite.											
Exploders.											
Caps.......											
Fuse.......											

Fig. 12.—Blank for Reporting Supplies Received.

Checking the Accuracy of Reports.—Systematic checking of the accuracy of reports made by individuals or foremen is of paramount importance, for, unless this is done, there is apt to be gross falsification of the reports in order to make a favorable showing of performance. Thus, if a drill runner is not checked occasionally as to his report of number of feet drilled, he is apt to add several feet to his actual performance.

On one railway with which the authors are familiar, the master mechanic is in the habit of reporting the time of men spent in building new cars as if it were spent in repairing old cars. The object in doing this is to make a creditable showing

Job No. MATERIALS RECEIVED
Date 190 Foreman

Size or Brand		From Whom Received	Size or Brand		From Whom Received
bbls.	Cement		bbls.	Glass	
bags	"		bars	Steel	
lds.	Gravel		"	"	
"	Sand		"	"	
"	Screenings		"	"	
lbs.	Stone		lbs.	Lampblack	
"	"		"	Oakum	
lds.	Sand		"	Nails	
ft.	Lumber				

Fig. 13.—Blank for Reporting Materials Received.

of the cost of making new equipment. While it is true that this seems like robbing Peter to pay Paul, it must be remembered that there is usually great difficulty in determining just what is a reasonable cost of repairing a car, whereas there is no difficulty in fixing upon a reasonable cost of making a new car.

So many men are dishonest, particularly in ways that are not actually criminal, that implicit trust should not be placed in reports that are not verified by systematic investigation at unexpected intervals of time, if they are not subject to constant checking.

On construction work it should be the duty of some one to make reports that will check the reports made by individual workmen and by foremen. The time keeper is usually the man upon whom part of this checking devolves. Thus, the time keeper may be required to make certain measurements at the close of the day, from which a foreman's report of performance can be checked, as, for example, the number of drill holes and the depth of each. The time keeper may also be required to visit each part of the work frequently, noting the number of men engaged in each class of work at the time of each visit. Frequent visits are often made possible by providing the time keeper with a horse or a motorcycle.

Checking the distribution of the men of a gang, as well as observing the energy with which they are working, may frequently be done to advantage by means of a telescope or field glasses in the hands of an observer located in a tower or on some high point of ground.

By requiring different foremen and different individuals to report on the same performance, an excellent check can often be secured. Thus, a dinkey locomotive engineman should report the number of trains hauled, and either the dump foreman or the steam shovel engineman should render a similar report.

The monthly estimates of engineers should, of course, be used to check the daily reports of foremen, as far as possible; and on large jobs it is often desirable for a contractor to employ engineers to cross-section and measure the work once a week, if not more frequently.

Where the gang under a foreman is frequently shifted from one class of work to another, the foreman should always record the time that the change is made, in one of the ways already indicated. When this is done, the superintendent or walking boss should examine the foreman's record occasionally, during the day—not necessarily every day—to assure himself that the foreman is posting the record properly and at the time each change is made.

There should always be some system of recording the receipt of daily reports at the office. This is sometimes effected by having a tabular list of all the reports that should be received, and by placing a check mark opposite the name of each report (or each foreman or individual making the report) under the day of the month to which the report relates. A glance at such a tabulation shows whether any report is missing.

If it is the practice to plot or chart the returns shown by each report daily, then no further check may be needed to show that the report has been received.

One of the advantages gained by divorcing cost keeping from bookkeeping is the check thus obtainable on both. The aggregate weekly pay roll shown by the time keeper's report should check fairly well—not necessarily with great precision—with the aggregate pay roll deduced from the foreman's reports. Incidentally this check makes it more difficult for a time keeper to "pad the payroll:" that is, to enter fictitious names upon the payroll or to credit a man with more time than he is entitled to. Many a contractor has been robbed in this manner.

If the distribution of costs shown on the books corresponds with the distribution derived from the daily report cards, a fairly close check is obtainable.

It is generally wise to have accounts for each of the main items of materials and supplies, such as lumber, cement, coal, explosives, etc. Then the total consumption of coal, for example, as deduced from the foremen's daily cost reports, should check fairly well with the amount purchased, as recorded by the bookkeeper. Likewise the bookkeeper may divide the payroll into certain general classes of labor and assign an account for each class, which should check with the cost records turned in by the foremen. But, in our opinion, it is a serious mistake to encumber the bookkeeper with a multiplicity of accounts intended either to show detailed costs or to check the various details of cost deduced from the daily cost reports.

Cost Charts.—For showing relative performance or relative unit costs, no method is so satisfactory as a diagram or chart. A glance at the unit cost line plotted on a chart shows the manager whether there is cause for congratulation or alarm. The up and down waves of a cost line are far more impressive than columns of figures ever are.

A chart of daily performance has the incidental advantage of affording an automatic check as to whether all the daily cost reports have been turned in or not, for without the reports the lines on the chart can not be plotted.

The chart shown in Fig. 14 was 8½x11 ins.—a large enough size to show the unit costs with sufficient accuracy for comparative purposes.

It will be noted that three lines are plotted on the chart. The upper line, drawn in full, marked A, shows the total daily yardage of rock loaded by two steam shovels. The line C shows the cost per cubic yard. The line B shows the total daily operat-

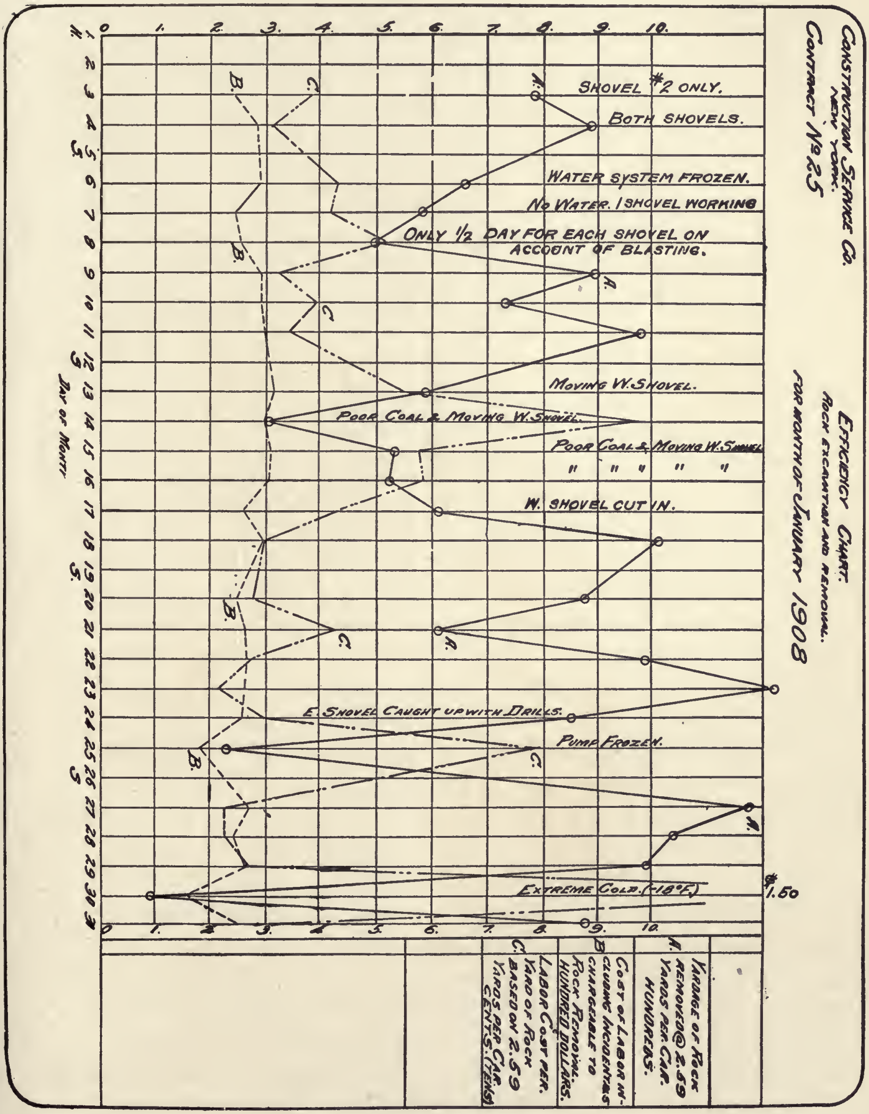


Fig. 14.—Efficiency Chart, Rock Excavation.

ing expense, including only the payroll and not the cost of fuel, dynamite and other supplies.

The unit cost line, C, is the only one that presents any difficulty in plotting. On most contract work, some of the men are paid by the month, and their wages go on whether it rains or shines. The number of working days in the month (excluding Sundays and holidays) divided into the total monthly payroll of these "steady pay" or "monthly pay" men gives the daily payroll of the "monthly pay" men, to which must be added the payroll of the men who work by the hour or by the day. On days when the weather is so bad that no work at all is done, the daily payroll of the "monthly pay" men would be divided by nothing, which gives an infinite unit cost, and therefore can not be plotted. But, if it is not plotted, and if there are several days in succession on which no work is done, the unit cost line ceases to show the true unit cost. This difficulty, however, is more imaginary than real, for the object of the chart of daily costs is not to show whether a profit is being made, but to show how well the work is being managed on those days when the weather is such as to permit any work to be done.

In plotting a chart of costs, the performance can be plotted each day in pencil and can be inked in at the end of the week on tracing cloth and blueprinted. As many copies as desired may then be sent to the home office.

Referring to Fig. 14, we see that conditions of weather, accidents, etc., can be recorded on the chart. The full history of the work shown by this chart is as follows:

The shovels did not work on the 1st or 2nd of the month, but one shovel started on the 3rd, making a record of 780 yards, which was the highest point that had been reached for several months. The cost of operation of both shovels was $240, making a unit cost for the output of one 38 cts. On the next day the other shovel worked, but the total output of both was only 885 yards, and, while the total cost rose to $285, the unit cost dropped to 31½ cts. On the 5th of the month, being Sunday, no work was done. On the 6th the work was badly interfered with, because the water pipe, which supplied water to the work, was frozen, and the output of the shovels fell to 660 yards, while the total cost was raised slightly to $290, making a much higher unit cost of 43½ cts. On the 7th one shovel worked in a crippled condition for the whole day, while the other worked only a half day because of the short supply of water. The performance dropped still further to 580 yards, on account of the fact that one entire pit and dump crew was laid off for half a day, and the unit cost fell to 42 cts. On the 8th both shovels were held up for nearly half a day because of poor blasting in front of them and the necessity of drilling and blasting in the shovel pits. Because of the likelihood of starting at any time the crew could not be laid off, so the total expense was kept up to about $260, making the unit cost jump to 51½ cts. On the 9th both shovels were working in good shape and produced an output of 890 yards with a complementary reduction in unit cost, since the total labor cost was increased but little. On the 10th the performance dropped slightly, but on the 11th it again rose, reaching 975 yards. The total labor cost for this day was higher than it had been any time during the month, while the unit cost was about 34½ cts. The 12th was Sunday and no work was done, and on the 13th but one shovel was working, as the other shovel was moving back in the cut. The high total labor cost maintained caused a very steep rise in the unit cost line. On the 14th one shovel was still moving back while the work of the other shovel was badly delayed because of trouble with poor coal both on the shovel and on the dinkey locomotives hauling dump trains. This difficulty was overcome to some extent on the 15th and 16th, but the output was still very low even for one shovel. On the 17th the second shovel cut in, but owing to a very shallow cut and frequent moves necessary, a very small output was obtained. The next day, however, both shovels were working well and got out 1,020 yards. The 19th was Sunday. On the 20th the output was maintained at rather a high figure, being 875 yards; on the 21st the output dropped because of rain;* rose again on the 22d and went still higher on the 23rd, reaching on that day 1,230 yards, which was the highest daily output of the month, and on that day the lowest unit cost is also shown. On the 24th the output fell because one shovel was delayed by having to wait for drilling, and on the 25th only 230 yards were taken out because neither shovel worked more than a few hours because the water supply was shut off by the freezing up of the pumping

*Weather and some other conditions mentioned here are not shown, but are mentioned by way of explanation.

station. The 26th was Sunday and no work was done, but on the 27th the output jumped to a high point, reaching 1,180 yards, and the unit cost fell to 23½ cts. The next day the output was 130 yards less, but the total labor cost was also much less and the unit cost was maintained at 23½ cts. The performance fell a little lower on the 29th, but was still well above the average, but on the 30th fell to less than 100 yards because the weather was so extremely cold (minus 18° F.) that the men could not work. In this case the fixed charges of the shovel raised the unit cost of the 90 yards taken out to about $1.50. When work was resumed on the 30th 875 yards were removed at a cost of 30 cts. a yard. The jagged nature of the lines on this chart is due to the character of the weather. It will be noted that the general trend of the unit cost line was downward.

The channeler chart, Fig. 15, shows only the performance and unit cost of the work done. This record is also for the month of January. Work began on the 2nd, the performance being but 160 feet of channeling done by two crews. The performance fell from that point to 85 feet on the 5th and rose to 185 feet on the 6th and again fell and remained low until the 9th. These bad records were due to the presence of nigger heads in the rock being channeled which made fast work absolutely impossible. On the 9th the performance rose to 160 feet, and kept on increasing until the 11th, when 200 feet was reached. On the 13th, 14th, 15th and 16th the performance was low because of poor track. The track was fixed by the 17th, when performance again rose and was maintained at a figure slightly above the average until the 24th, when, because of the extreme cold, one crew deserted its post and allowed the pipes feeding the machine to freeze. On the 29th the performance fell slightly, due to the clogging of the channeler by earth sliding into the cut, and the unit cost rose because it was necessary to put on an extra force to clean out this earth. On the 30th but little work was done owing to the extreme cold, but on the 31st the high record of the month was made, 370 feet being channeled.

Progress Charts.—It is generally desirable to record graphically the progress of each particular class of work on a contract. This is best done by means of a progress chart similar to that shown in Fig. 16, which is a modified form of the chart shown on page 184.

This chart relates to excavation. The first column is a percentage column. The second column gives the length of the excavation (trench, ditch, or the like). The third column gives the number of cubic yards. The fourth column gives the estimated cost. The fifth column gives the actual cost; a sixth

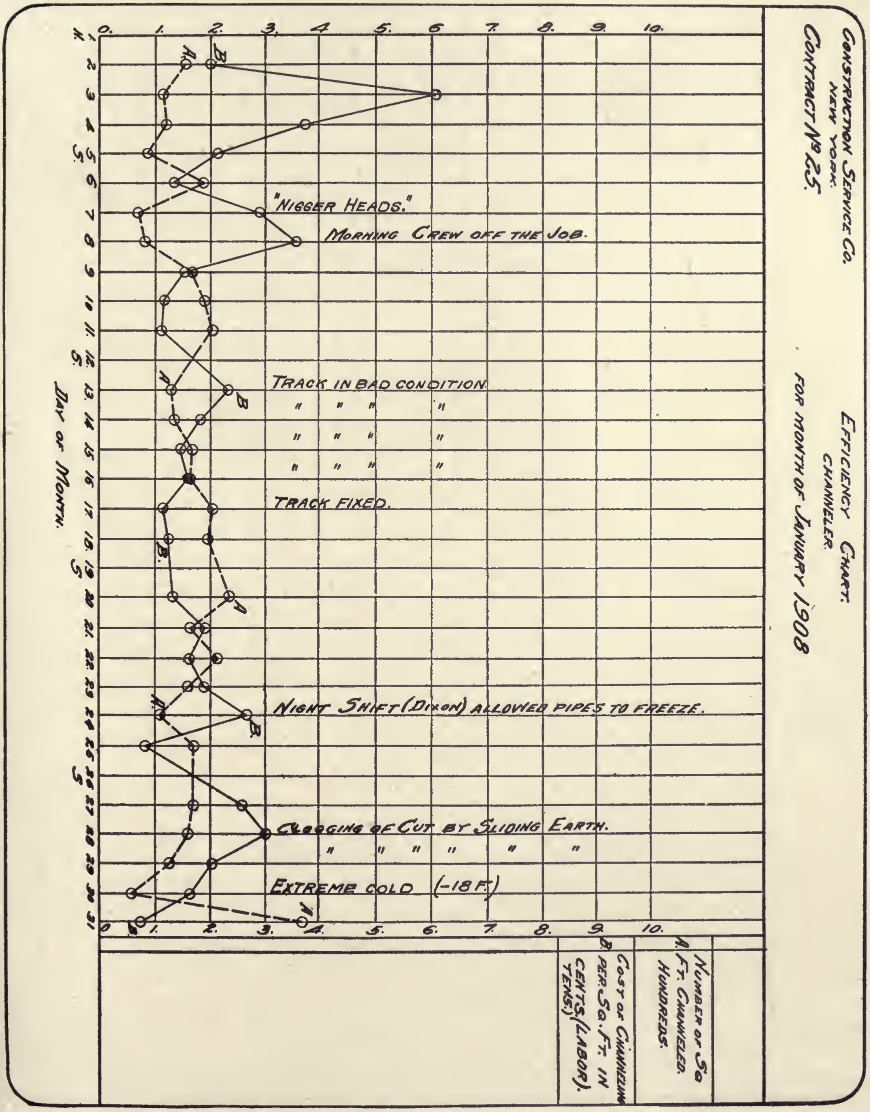


Fig. 15.—Efficiency Chart, Rock Channeling.

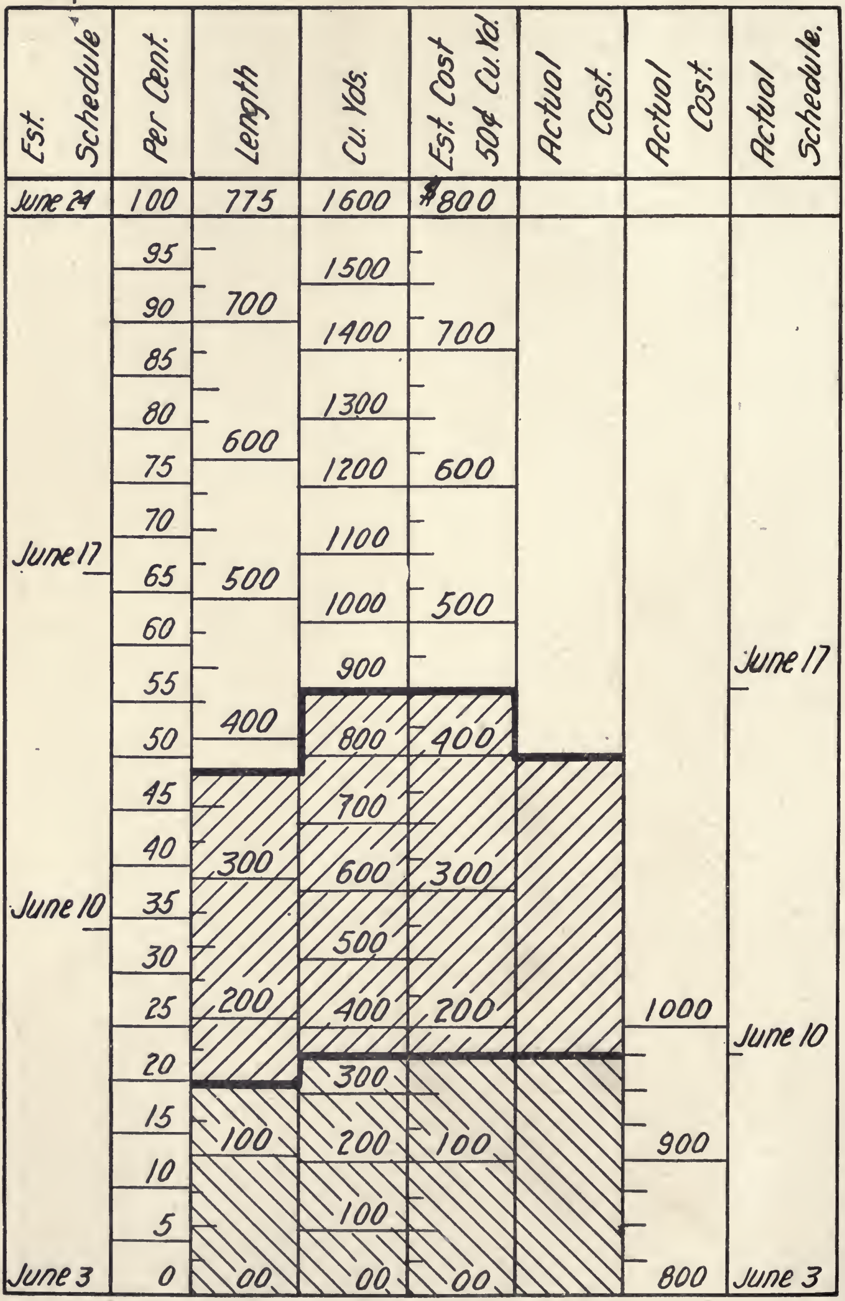


Fig. 16.—Progress and Cost Chart, Trench Excavation.

column of actual cost is provided in case it overruns the estimated cost. The total length of the excavation to be done is 775 ft., which is written opposite the 100%. Then the length column is divided into 7¾ parts, each representing 100 ft., or a "station."

The total yardage in this length of 775 ft. is 1,600 cu. yds., which is also written opposite the 100%. Then this yardage column is divided into 16 parts, each representing 100 cu. yds. The work has been estimated to cost 50 cts. per cu. yd., therefore the total cost of the 1,600 cu. yds. should be $800, which is written opposite the 100%; and the estimated cost column is divided into 8 parts, each representing $100.

This work on section of excavation is scheduled to begin June 3, as indicated in the space to the left of the percent column and at the bottom; and it is scheduled to be finished in three weeks, as indicated.

The work is begun on schedule time, June 3, as indicated by the entry to the right of the last column, and at the end of the first week (beginning of the next), June 10, the progress and cost are shown by the hatched portion below the heavy black line. It will be seen that the excavation has been completed to station 1 + 50 (= 150 ft.), as shown in the second column; and that 350 cu. yds. have been excavated, as shown in the next column. The estimated cost of the 350 cu. yds. is $175, as shown in the fourth column. The actual cost has been proved to be the same as the estimated cost, or $175, as shown in the fifth column. The yardage completed up to June 10 is 22% of the total, as seen by comparing the first, or percentage, column with the third, or yardage, column; whereas, to have lived up to the estimated schedule, 33% of the yardage should have been excavated by June 10.

The performance of the next week is similarly shown by the heavy black line opposite June 17, which shows that 375 ft. of length (reaching therefore to Sta. 3 + 75) and 900 cu. yds. have been completed. The total actual cost is now $400, as compared with an estimated cost of $450, showing that the work is being handled satisfactorily.

If the chart is plotted on tracing cloth, blue prints are readily made. Instead of cross-hatching the performance area of each week, paints of different tints may be used.

On jobs of long duration, a similar chart showing progress by months is usually desirable, in addition to a weekly progress chart. Then it is often desirable to paint the area on the monthly progress chart, using the following colors of paints to designate the different months:

January	Chrome Yellow
February	Carmine
March	Payne's Gray
April	Deep Chrome
May	Prussian Blue
June	Burnt Sienna
July	Sepia
August	Emerald Green
September	Cobalt Blue
October	Vermilion
November	Indian Red
December	Sap Green

Charts of this sort should be prepared for each of the different classes of work, and, if the job is large, it should be divided into sections, each having its own progress chart. Finally, the manager should have a chart showing the progress of the job as a whole. To prepare such a chart, it is generally sufficient to reduce all the units of work done to the common unit of the dollar. To do this take the estimated costs, given in the fourth columns of all the weekly charts, and add them together. The sum will give the total amount of work done, based on the estimated unit prices. Then do the same with the actual cost columns. Plot these totals for the entire job, in columns side by side, as shown in Fig. 17.

This summary chart, Fig. 17, shows that the estimated cost of the entire job was $20,000 (indicated by $20M opposite 100%). It shows that the work was scheduled to begin June 1, and to be finished Oct. 31. As a matter of fact it was finished Oct. 10 and its actual cost was $21,000.

On July 1, the total number of units of work done multiplied by their respective estimated unit costs amounted to $3,500, as shown in the second column; while the actual cost was $4,000.

On Aug. 1, the total work done, at estimated unit prices, was $7,000, and its actual cost was $6,800. Only 35% of the work was finished, although the time schedule calls for 40%.

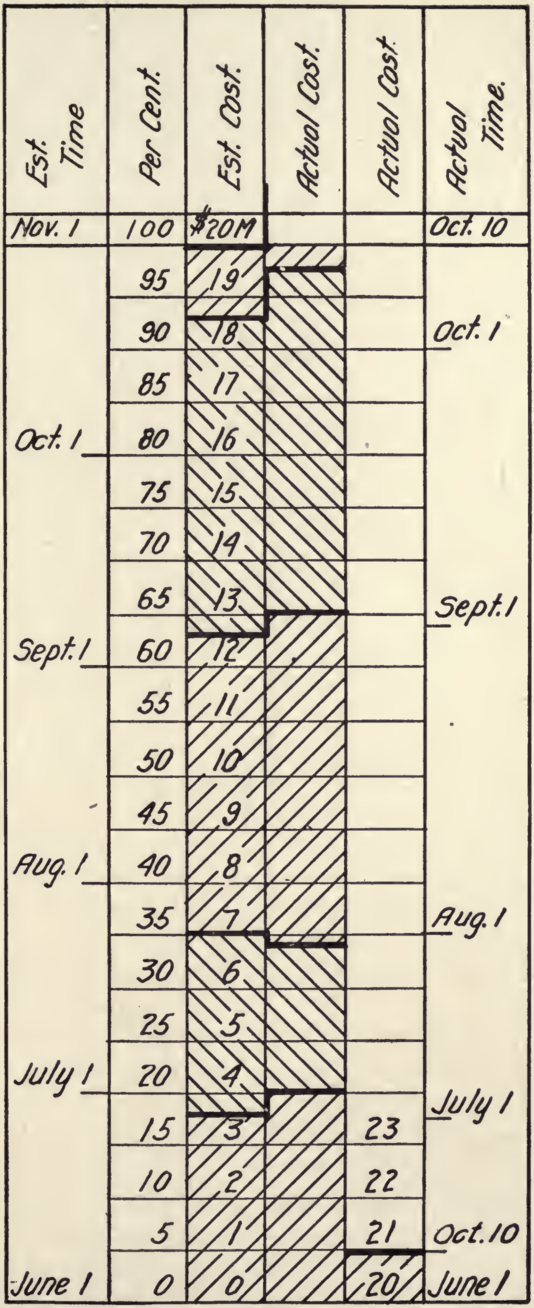


Fig. 17.—Progress and Cost Chart. Entire Job.

On Sept. 1, however, the work is ahead of the scheduled time, and it also shows a greater cost than was estimated.

A similar condition exists on Oct. 1.

The work is finished Oct. 10, and since its actual cost overruns the estimated cost, it is necessary to plot the actual cost in the fourth column, where it is seen that it amounts to $21,000.

In preparing a time schedule, the first step is to take the time limit, as specified in the contract, and use this as the basis for planning the performance. A study of the plans and local conditions will determine what classes of work and what sections must be first started. Time schedules should be prepared for each of these, due allowance being made for the time required to deliver and install the plant, which is often an important consideration. If there is much plant to install, it is obvious that the intervals in the time schedule will not be evenly proportioned as in Fig. 17; but the schedule of performance for the first month or more will be much less than for succeeding months.

Once a time schedule has been carefully prepared, every effort should be made to live up to it, not only in toto but in every section, in order to prevent disorganization of the work. The function of the progress chart is to show how well the plans are succeeding.

History and Sketches of the Work.—As the work progresses, a brief—but not too brief—history should be kept of its progress, like the log of a ship. The organization of the forces, the number, kind and location of the machines should be recorded. Sketches should be made to show plant layout and local conditions. Sketches should also be made to show the types of construction. Large working drawings are usually too cumbersome to be of much value in any historical outline of the methods of construction.

Finally, when the work is completed, a complete history should be written in as condensed form as is consistent with a clear understanding of its governing features. This should be typed and bound in a loose-leaf binder, together with the sketches and photographs that illustrate it.

Too much emphasis can not be laid upon the importance of such a written history, for memory, at best, is defective, and it often takes but a few years to render bare figures of cost almost worthless even to the man who gathered them. There is a further consideration—namely, that the employee who was most familiar with the work may resign or die, leaving the construction company with a mass of data that would possess great value if accompanied by a full sketch of conditions encountered and methods used, but which are more or less useless without such a sketch of conditions and methods.

CHAPTER VI.

OFFICE APPLIANCES AND METHODS.

There are many appliances which can be used in the office for the compiling of records gained in the field and which recommend themselves to general office systems.

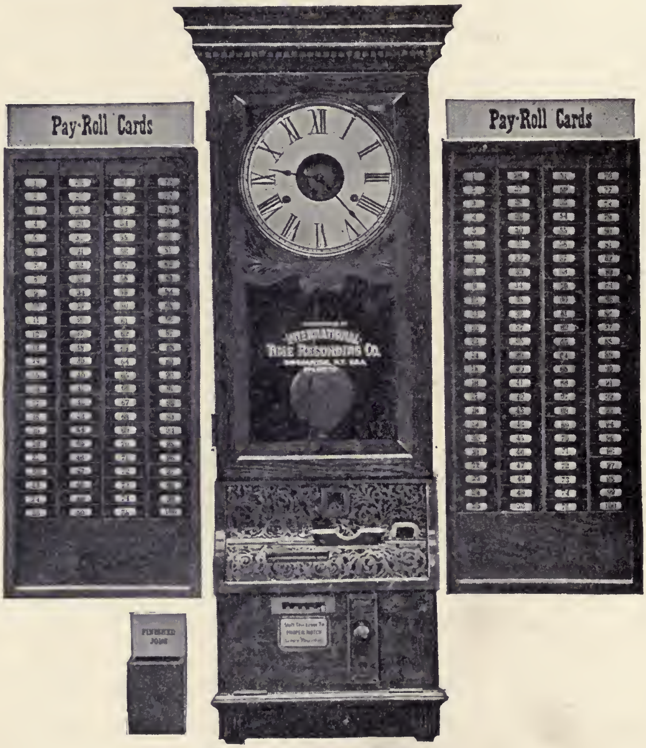


Fig. 18.—Time Clock.

Time Clocks.—Such an appliance which may not, in general, be used in the field, but which is of immense value in the office and particularly in a shop, is the time clock. Various forms of time clocks are in common use, two types of which are illustrated. Fig. 18 is a time card recorder, which is a clock so made that it will automatically stamp on a card inserted in a slot in the clock by the workman the time of his arrival and of his departure. The cards are made to hold a record covering the pay period and need no attention from a timekeeper or clerk until the termination of this period. The record of the men's time can then be compiled very readily by one who need not be a skilled mathematician or time clerk.

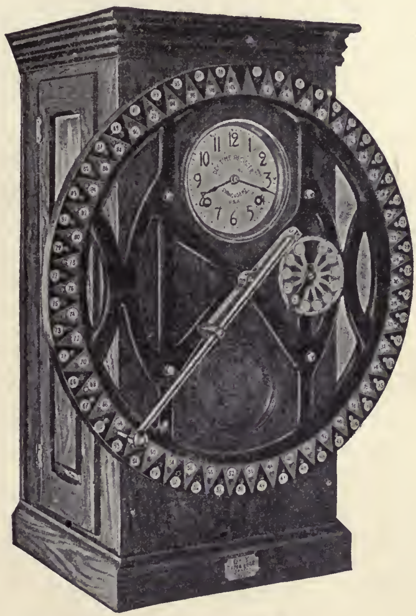


Fig. 19.—Time Clock.

The time clock system has been developed very highly in shops for keeping track of time used in completing any job by workmen, but as this in a way is not in the realm of field cost keeping, it will not be entered into here.

Another form of time clock, shown in Fig. 19, has the numbers of the employees fixed on the outer edge of a disk or ring and a record is made by the employee who shifts a revolving arm and punches his number upon entering the office and leaving.

The working up of the employees' time then becomes simply a matter of computation from printed figures. These two types are made by the International Time Recording Co. of New York.

An automatic time stamp, Fig. 20, is of inestimable value in a well regulated office. Such a stamp can be placed upon any sort of a paper received in the office and shows the hour and minute both morning and afternoon and date of receipt, and, in a machine with various refinements, the name and address of the

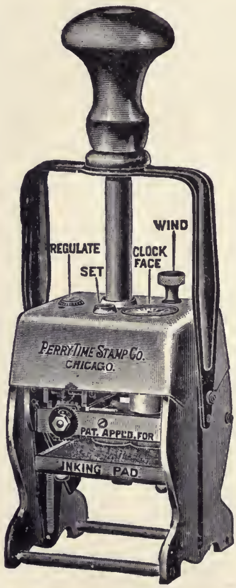


Fig. 20.—Time Stamp.

owner, the classification of the matter received, and a mark indicating the person who received it. In the case of orders issued to field employees or reports received from them, such an accurate stamped record as this machine will give might avoid serious controversy in case of delay from any cause. The exact time of receipt of a report is shown or the exact time of the issuing of an order, and, if the order is not promptly obeyed, the man to whom the order is issued cannot plead the excuse that the order was not issued until after a time too late for its effective execution. Such a machine can be purchased for from $20.00 in its simplest form to $100.00, embodying all refinements.

Rubber Stamps.—A full equipment of ordinary rubber stamps will be found decidedly useful in an office. Not only is much writing saved by their use, but accuracy is insured.

Mimeograph.—In its simplest form the Edison mimeograph consists of a frame for holding a stretched sheet of paraf-

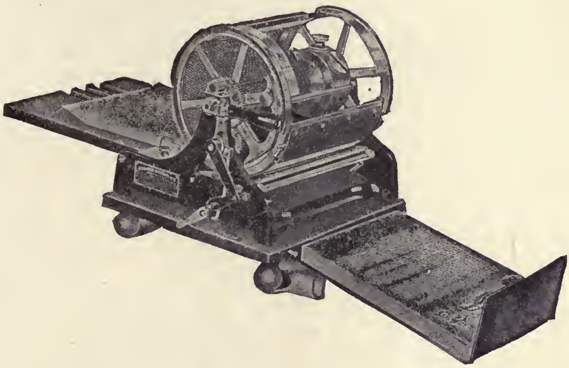


Fig. 21.—Mimeograph.

fined paper, and a block of steel that has been cross-ruled with very fine lines. The paraffined paper is laid on this block, and a stylus, or pen, having a blunt steel point, is used for writing or drawing on the paper. The stylus is pressed rather hard on the paper, and the little sharp teeth of the steel block cut minute

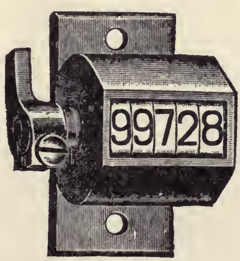


Fig. 22.—Counter.

holes through the paper. Having written or drawn as much as is desired, the steel block is removed, and for it is substituted the card, or paper, that is to receive the impression. A small roller, inked with printer's ink, is then run lightly over the paraffined paper. The ink passes through the small holes in the paraffined paper and prints on the card below. Then another card is substituted, and printed, and so on indefinitely. The mimeograph is really a sort of printing press that can be used by anyone.

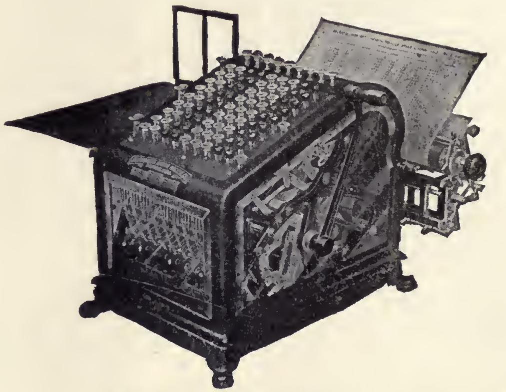


Fig. 23.—Adding Machine.

There are various sizes and kinds of mimeographs. Fig. 21 shows one whose price is $45. Others that are cheaper and others that are more expensive are obtainable.

The authors have used the mimeograph extensively for making report blanks, as well as for issuing orders. On any

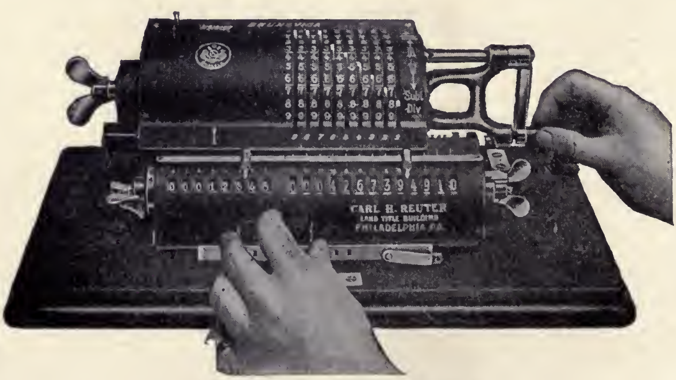


Fig. 24.—Multiplying Machine.

new class of work, it is generally wise to use mimeographed report blanks, for changes in the methods of doing the work and in the organization are likely to occur, and such changes frequently necessitate alterations of the report cards. A new report card can be quickly designed and hundreds struck off with a mimeograph, without any delay in waiting for printers.

The mimeograph is made by The A. B. Dick Co., New York and Chicago.

Counters.—Fig. 22 shows a Veeder counter (price $1), which may be attached to the form of mimeograph shown in Fig. 21, for recording the number of cards printed. Such a counter can be made to serve many useful purposes in the field,

Fig. 25.—Adding and Multiplying Machine.

for recording revolutions or reciprocations of machinery. The Veeder counter is made by Veeder Mfg. Co., Hartford, Conn.

Adding Machines.—Where there is any considerable amount of office work, an adding machine should certainly be used. Fig. 23 shows a Burroughs adding machine, which records the column of figures on a strip of paper and adds them at the same time. This machine is made by The Burroughs Adding Machine Co., Detroit, and costs from $175 to $850.

Multiplying Machines.—The Brunsviga machine, Fig. 24, for multiplying and dividing is extensively used in railway accounting departments. It is very rapid and perfectly accurate.

This machine is listed at $300, and is made by Carl H. Reuter, Land Title Bldg., Philadelphia.

Another machine that is extensively used for multiplying is the Comptometer, Fig. 25. It is also used for adding, but has the disadvantage that it does not print the figures, as does the Burroughs machine. Its price is $200 to $315 and it is made by Felt and Tarrant Mfg. Co. of Chicago.

Slide Rule.—It is of course understood that the slide rule is not a multiplying machine that is accurate beyond certain limits. Within those limits—which depend on the kind and size of the rule—it is perfectly accurate. For purposes of estimating and for making ordinary designs, the slide rule gives results that are close enough. A 10-in. rule—the size most commonly used—costs $4.50. Any dealer in civil engineering instruments will furnish slide rules.

Planimeter.—The planimeter, like the slide rule, is so well known as scarcely to require mention here. For figuring the areas of irregular cross-sections, the planimeter is a great labor saver; but its absolute accuracy depends largely upon the scale to which the cross-section is plotted. The commonest error in the use of a planimeter is the plotting of cross-sections to a small scale.

There are many styles and sizes of planimeter, ranging in price from $16 to $100. A good instrument for ordinary use can be had for $30.

Wage Tables.—A great help to the contractor's office is a wage table. This table gives the amount of pay due for each quarter of an hour worked at rates from 5 cts. up, for eight, nine and ten hours worked per day. If the rates of pay on the work are irregular, no small amount of time can be saved by the use of such a table, and, in any case, the liability of error in computing wages is almost entirely eliminated. One such book of tables is got out by the International Time Recording Co. and sells, bound in cloth, for $1.50.

How to Systemize the Office.—We are indebted to Mr. Frank B. Gilbreth for the following notes on how best to systemize a contractor's office. They were first presented in a paper, read before the American Public Works Association in 1908:

In this paper I have endeavored to give a description of the lessons that we learned during the years of evolution of the present system in our office. Systematizing a department, an office, or a business, is accomplished by one, or both, of the two following methods: (1) By efforts of the members of the organization, (2) By efforts of professional systematizers.

For the original idea of system in our office, I desire to acknowledge my indebtedness to my friend, the late Wm. H. McElwain, the possessor of one of the master commercial minds of America. The success of his whole tremendous business was, to use the words of his own statement to me, *"Due to having his entire system in writing."* Mr. McElwain's further advice was to carry the systematization of our business as far as possible by our own efforts before calling in the professional systematizer—that is, to use both methods suggested above in the order given. After a system has been put in writing and perfected along simple lines by the men who have built up the business, it is easy for the professional systematizer to understand instantly the methods in use at the time he undertakes his task. He can then suggest changes and improvements, which can be adopted with no shock to the business.

When experts attempt to install system for a concern that has not been systematized by its own organization, a shock is bound to occur. If it is desired to introduce expert advice before any attempt is made to systematize by the organization itself, there is no such protection against shock as to take the precaution of carrying on the old system at the same time that the new system is being installed and tried out. Keep the old system in a separate building if necessary, but keep it in operation until the new system has proved itself, by actual use, to be superior to the old. The expense of temporarily maintaining a duplicate accounting department, for example, is very little compared with the protection, speed, order, rivalry and value of actual comparison.

As a result of our own experience, we believe that the best way to systematize a contractor's business is along the lines suggested by Mr. McElwain. We believe that the fundamental laws governing systemization are clearly defined. They can be used and adapted to any line of business by the men in that business.

The procedure in systematizing by the evolution method is as follows:

(1) Have each member of the office put in writing a description of the way he actually does his work. Not at first of the ideal way that the work should be done, but of the real way, the way in daily use. If an attempt is made at first to write down the ideal way, the entire benefit of the scheme will be lost. The rules must be historical, descriptive and no nearer perfect than are the members of the organization. The rules must be in such form that they can and will be obeyed without having perfect human beings to fill each position. These written descriptions should be put in the form of rules for the next clerk below, who needs description, instructions and guidance as to the work he is eventually to do.

(2) After each member of the organization has submitted his rules describing the way he actually does each part of his work, have the entire collection typewritten. A complete copy should be handed to the head of each department for correction and improvement. The corrected copies should be then inspected by the general manager.

(3) During the various inspections of the rules, it will usually develop that some members of the organization have not been able to express their ideas well. It will also develop that some one clerk has a talent for wording rules particularly well. Select this clerk to revise and arrange in proper order the entire collection of rules. If an announcement is made at the time the rules are first written that the clerk submitting the best set of descriptive rules will be made "System Clerk," better offerings from all employees will result, and a higher standard will be secured. The system clerk should see that each rule describes the easiest way to accomplish the act that it describes. Few people realize that a simple system that can be enforced easily is much better than an ideal system that is difficult to enforce. Only simple system is good system. Have the rules expressed in the simplest, most concise manner possible.

(4) Have the revised rules typewritten again, and give a complete copy to each member of the office force. Also distribute notices of prizes that will be given to those who suggest improvements that are adopted. We have found that $1 for each suggestion adopted, and three special prizes of $2, $3 and $5 each for the best suggestions during the month will bring in many improvements. Clerks will use every effort to discover improve-

ments not only for the prizes, but also for the promotion that always rewards a clerk who can constantly suggest better ways of doing work.

Our experience proves that immediately after all of the clerks have received a complete copy of all the rules governing all other departments as well as their own, all hands will discover and suggest eliminating rules requiring unnecessary labor. Suggestions for improvements will then come thick and fast. The $6 boy will understand the work of the $12 boy. He will consider himself lucky to fill the place of the $12 boy above him for $9. The $12 boy will be able to do the work of the young man who is getting $24 per week. It means a raise of pay and more earning power for every member of the office organization. This process will extend up to the heads of departments, who can spend their time more profitably on new work that requires judgment, leaving routine work to be handled by the clerks under them.

Too much stress cannot be laid upon the importance of receiving, rewarding and incorporating suggestions from any and all members of the organization. It encourages all clerks not only to make the best use possible of their own experience, but also to investigate what is going on in other organizations and to read magazines of "Short Cuts" in business. This reading brings the organization into sympathy with the best work of system experts and labor saving devices, and paves the way for the successful entry of the professional systematizer into the office. Such reading of short cuts and improved business methods also stimulates the interest in "Motion Study."

This "Motion Study" is an object of particular interest to us, and is put into practice by us on all of our work, both office and field. It consists of observing and noting the motions used to do any piece of work, of eliminating the unnecessary motions, determining how the work may be done with the least possible number of motions, and, finally, of reducing the necessary motions to the shortest possible distance in feet and inches.

In the office this study involves the discovery of the form, methods, etc., that will save motions of each and every clerk. In our office we make use of every device that we know of to save motions. For example:

(1) "Eye saving" devices.

(a) Different forms, especially manifold sheets, made of different colored paper, the color showing to which special destination each copy of the form is to be sent. It is obviously quicker to collect or file, say, all the blue copies than to read the destination directions on each sheet.

(b) Distinguishing numbers or initials on the lower corner of form—T. L. (tool list), U. C. R. (unit cost report), to save reading of the entire forms.

(c) On all typewritten letters a list of articles to be enclosed or sent under separate cover is placed at the lower left hand corner. This makes it needless of the mail clerk to read the entire letter to see what is to be enclosed.

(2) "Hand saving" devices.

(a) Printing on forms all wording that is in continual use to save pen motions.

(b) Several phrases or sentences on such forms as telephone blanks, etc., all but one of which may be crossed out when form is used.

(c) General use of self-inking rubber stamps. These save the motions of inking on a pad. The place for the thumb is cut off flat to save the motions of turning the stamp right side up, as well as to save taking the eyes off the work. It is attached to a weight that will carry it back into place when it is not in use.

(3) "Foot saving" devices.

(a) Placing all files and furniture so as to have the shortest possible distance, measured in feet and inches, for the travel of the clerk who uses them.

(b) A definite place for every piece of paper that is handled in the office both before and after it is filed.

(4) "Memory saving" devices.

(a) Each file plainly labeled.

(b) All similar files labeled in the same sequence.

(c) Daily calendar made out ahead, an automatic memory of date of events, etc.

These are only a few of the many examples that might be cited.

It is impossible to go further into detail in this paper. In our business the written system for the office work has grown into systems for the various departments. For work in the field, the written system has evolved into a field system, a concrete system, a bricklaying system, etc.

The general benefits that are sure to come from this evolutional form of system are:

(1) There is no general upheaval, nor the slightest shock to the business. The installation of the system has cost nothing.

(2) All members of the organization are working understandingly toward the same desired end.

(3) A corps trained on the duplicate plan system is evolved simultaneously with the system.

(4) Clerks can be instantly shifted to accommodate the business, for vacations, illness, promotions and immediate demands of any or all departments and to sudden increase of business.

(5) From its beginning the system will be popular with the clerks. Every one of them profits by it. It reduces their labor. It fits them for constant promotion, and gives them continued opportunity to win prizes. It provides places for the advancing young man, also for the faithful routinist.

(6) Competitive spirit is always active, yet "Team work" is assured.

(7) The resulting system is exactly suited to the particular office in which it is evolved, as it is the outgrowth of that office, and its particular requirements.

(8) Growth is an integral part of the conception, and therefore the system will be elastic and adapted to great fluctuations in the amount of business in hand.

After the evolutional system has been installed and is successful, it is time to call in the professional systematizer. There is hardly a business that is not large enough to warrant the advice of a system expert. This expert, having made system a life study, will surely be able to bring from his experience and observations behind the scenes of the inside workings of fifty offices some points that will be of great value to the fifty-first. He will find in that office an organization to appreciate his study, and on the alert to receive his suggestions. His improvements will correct and improve the growing system with no resulting check to the growth.

This is the age of System Scientific Management. Such men as Frederick W. Taylor, ex-president of the American Society of Mechanical Engineers, and his co-workers have done more than install systems. They have also installed entirely new methods of operation, founded upon lifetime study of the fundamental laws of management. They are now ahead of their times, but the general awakening of the industrial world is coming. Their methods, which are the only solution of the struggle between capital and labor, will be generally adopted because they reduce production costs and increase wages simultaneously.

There are three obstacles which the man who undertakes to systematize his office must overcome.

The first obstacle is the fear one naturally has of being called theoretical instead of practical, of being called "a dreamer" instead of "a doer." When it is realized that that man who can manage the details of his work by putting in writing a description of the simplest and the swiftest routine is best fitted to handle large undertakings in a business-like way, all such criticism will die.

The second is, thinking that his system can ever be complete. By its very nature the system of a growing business is a growing thing. It must be constantly adapted, constantly increased, constantly improved.

The third obstacle is so called "red tape," and the fear of it. No good system is ever "red tape." In fact "red tape" is simply bad system, system that has never been tackled by all the individuals of a loyal and interested organization determined to answer the following questions:

(1) How can we simplify?

(2) How can we eliminate?

(3) How can we condense?

The whole secret of success is in a *constant* endeavor to answer these questions. This *constant* attention can be given only by the organization itself. The innovations of an expert who can, necessarily, give his whole attention to the business for a limited time only, are not to be underrated. But the best man to keep a system going and growing is the man who is vitally interested in the business and who has brought it to the point where it can successfully compete with its competitors.

Order System by Means of a Card Index.—This system, which was used by a large contracting firm, was described by

Mr. C. Arthur Worden in Engineering-Contracting, June 3, 1908, as follows:

Each order is made out in triplicate. The original, Fig. 26, is mailed to the firm or party from whom the material is ordered. At times, the list of material is too large to be put on the regular order form and in that case the words "kindly furnish us with material as per list attached to and forming a part of this order" are substituted. The list is then made in triplicate, and one copy is attached to each copy of the order.

Order No. *2510* Date *April 25/08.*

James Goodnow, Esq.,
143 Liberty St.,
New York City.

JOHN DOE CO.
Engineers and Contractors
N. Y. City.

Please furnish us, without delay, the following material:
(*a*) *150 feet Monarch sash chain at 3 cents per ft.*
(*b*) *10 kegs 20d wire nails at $2.50 per keg.*

Send Bill of Lading and itemized invoice to us on day of shipment.
Always put order number on invoice.
No boxing or crating paid for unless specified on order.

Ship via *N. Y. C. & H. R.* F. O. B. *NewYork*
Ship to *John Doe Co.,*
c/o Frank Miller,
Albany, N. Y.

JOHN DOE CO.
By *C. A. Worden.*

(Detach and return to us.)

________________190___

JOHN DOE CO., New York:
We have this day completed shipment on your order No. ________, same going forward via____________ R. R. Co. Express Co.

(Detach and return to us.)

ACKNOWLEDGMENT SLIP.

________________190___

JOHN DOE CO., New York:
We acknowledge receipt of your order No.________ and will ship from ____________on____________
(Give definite date of shipment.)
This order will be executed in accordance with conditions stated.

Fig. 26.—Order Blank.
This and the blanks shown in Figs. 27, 28 and 29 are much condensed.

The "Office and Purchase Record," Fig. 27, is retained in the Home Office, while the "Receiving Department" copy is mailed to the Field Office having that particular contract in charge.

Fig. 26, as will be noted, gives the forwarder of material all information in regard to shipment, manner of rendering invoice, etc. Attached to this slip are two stubs: the first, or acknowledgment slip, is to be returned to the contractor immediately, stating probable date of shipment; the second slip is returned as soon as the order is completed, and should have attached the itemized invoice and Bill of Lading.

The "Office & Purchase Record," Fig. 27, is printed on a light weight card, suitable for filing in a small vertical file. The order number, date, and name of party to whom order is given, appear in the extreme upper left hand corner, thus giving easy access to the record in the file when desired. In the upper right hand corner, blank spaces are given in which are to be noted the amount of freight, express or cartage paid by the Field Office, date of delivery, name of party paying transportation charges and party checking the material upon receipt. This information

Order No. *2510* Date *Apr. 25/08.* *James Goodnow, Esq.,* *143 Liberty Street,* *New York City.*	Office and Purchase Record JOHN DOE CO. N. Y. City. Freight \$*1.34* Transp't'n p'd by *J.D.* Cartage \$ *.25* Date Rec'd *4/3/08* Express \$ Checked by *J. D.*
(*a*) *150 feet Monarch sash chain at 3 cents per ft.* (*b*) *10 kegs 20d wire nails at \$250 per keg.*	Charge *a* to *Doors and Windows* " *b* to *Timber* " to
Ship via *N. Y. C. & H. R.* F. O. B. *New York* Ship to *John Doe Co.* *c/o Frank Miller,* *Albany, N. Y.*	Order completed *4/1/08* Bill Checked by *O. K.* Date *4/5/08* Voucher No. *374*

Fig. 27.—Office and Purchase Record Blank.

will be noted on the Record as soon as the receiving slip is received from the Field Office, and will be needed in checking the invoice. In the lower right hand corner is given the item in the cost data to which material covered by order is to be charged, date of completed shipment, name of party checking invoice, date of checking and the voucher number. The voucher is very seldom used for information, as the Office and Purchase Record will show all that is ordinarily required.

The "cost data" to which reference is made may be described as follows:

A book is provided in which each contract is subdivided into various items, such as excavation, concrete forms, concrete, timber work, doors and windows, etc. Labor and material are charged under these headings in separate columns, so that, at any time, the cost to date of either or both may be ascertained, and at the completion of the work the contractor may see not only the total profit or loss on the job, but also how the actual costs of the various items compare with the estimated costs.

The "Receiving Department" copy, Fig. 28, is used on the job in checking material when received. In all cases the freight, express or cartage charges, if any, should appear on this slip before mailing to Home Office. This copy when received at Home Office is attached to the Office and Purchase Record bearing same number, and filed until the invoice has been checked, when it is attached to same, thus giving a complete record of the transaction in the voucher.

Order No. *2510* Date *Apr. 25/08* *James Goodnow, Esq.,* *143 Liberty Street,* *New York City.*	RECEIVING DEPARTMENT JOHN DOE CO. N. Y. City. Freight *$1.34* Transp't'n p'd by *J.D.* Cartage $ *.25* Date Rec'd *4/3/08* Express $ Checked by *J. D.*
(*a*) *150 feet Monarch sash chain at 3 cents per ft.* (*b*) *10 kegs 20d wire nails at $2.50 per keg.*	Charge *a* to *Doors and windows* " *b* to *Timber* " to
Ship via *N. Y. C. & H. R.* F. O. B. *New York* Ship to *John Doe Co.,* *c/o Frank Miller,* *Albany, N. Y.*	Check up all goods as soon as received, and return this slip to Home Office at once, using back of same for detailed statement, if necessary.

Fig. 28.—Receiving Department Order.

The order file should be provided with three guide cards, thus:

(1) Marked "Ordered," behind which the Office and Purchase Record should be filed as soon as made out.

(2) Marked "Received." When the "Receiving Department" copy is returned, it should be attached to the Office and Purchase Record and filed behind this guide card, preparatory to checking the invoice.

(3) Marked "Checked." This is a final file for the Office and Purchase Record as soon as invoice has been checked.

In all cases cards should be filed numerically.

Section 1 of this file can easily be converted into a follow-up file by putting in guide cards of a different color from the one marked "ordered," and numbered from 1 to 31. Order No. 2,510, say, was promised on the 29th. The Office and Purchase Record bearing this number is filed under the 29th and the order clerk in going over his records on that date will find this card and follow up the shipment.

Fig. 29 shows a card system for following up, which, while more complicated, gives far more satisfactory results. This

Order No. *2510* Placed with *James Goodnow* Date *3/25/08.*
Completed *4/1/08.*
Cont. No. *752* Tel. No. *2900 John* Address *143 Liberty St., N. Y. C.*
Order by *C. A. W.* Correspondent *Mr. Goodnow*
Material *Sash Cord—Nails*
Followed up | *3/28 phone* | *3/30 letter* | | | |
Date acknowledgement slip *3/28* Freight Express
Shipment asked for *immediate shipment from stock*
" promised *3/29*

Complete or Partial	A	B	C	D	E	
Date of Shipment	*4/1/08*					
" Ship'g Papers	*4/1/08*					
Due at Destination	*4/3/08*					
Request for Tracer	✓					
Material Received	*4/3/08*					

Form 5, see other side for Memorandum.

Fig. 29.—Card System for Follow Up.

card may be filed in a "daily reminder" file under date of promised shipment, and all information can be noted thereon instead of on the Office and Purchase Record.

This card explains itself.

CHAPTER VII.

BOOKKEEPING FOR SMALL CONTRACTORS.

Simplicity Essential.—Most articles and books describe complex bookkeeping systems which are impossible for the average contractor who must depend on a moderate priced bookkeeper, or even a stenographer with a slight knowledge of bookkeeping. While today most firms in this class are still able to do business with poor records because their small awards are obtained from friendly sources or through "pull" of some kind, competition is day by day making inroads on this field. That these firms are aware of the danger of their position is clearly indicated by the increased number of inquiries received by accountants and engineering cost specialists regarding simple accounting systems. It is with these contractors in mind that this chapter is written.

Let us suppose that the office force of a small contracting firm largely engaged in building work, for which we are about to design a bookkeeping system is made up of two owners, one of whom acts as Manager and the other as Chief Engineer, the former attending to the business end and the latter the construction end, supervising the designing and estimating and acting as superintendent; an estimator who also does whatever drafting there may be; a stenographer who looks after the correspondence, the files and the telephone; a bookkeeper who is responsible for the records; and an office boy.

With such a limited force available for the work, it is clear that simplicity must be the keynote, even if the results obtained are not theoretically accurate at some points.

Partnership agreements often contain a clause which states that each partner is to receive a salary, naming the amounts. Although this makes no difference in the total amount received from the business by each partner, it aids in making up the cost records; and we will assume that such an agreement has been entered into by the partners of the business under consideration.

For the sake of clearness we will first outline the various accounts to be kept, then discuss the methods of gathering the data and finally describe the method of distribution.

Fundamental Divisions of Cost.—In order to make the discussion clear, Chart No. 1 has been inserted. The subdivisions shown are only illustrative, and are not complete, since it would be futile to attempt to make a complete outline that would apply to any contracting firm. Keeping books is writing the history of business transactions; hence, it is obvious that no outline of the "history" can be made until the "events" are known. Even though two firms are in the same line of work, these "events" are never of quite the same nature in both concerns. Therefore, it is clear that before an outline of the records of a concern can be made, that particular concern must be studied to learn the nature of all its transactions. For this reason no general discussion of the methods of keeping accounts for any line of business can hope to be more than thoroughly suggestive.

Every source of expense to a contracting business contributes to the total cost of the contracts carried by the firm. A certain proportion of the Office Rent, the Legal Expenses in connection with law suits, the cost of making unsuccessful tenders, etc., are just as much a part of the cost as wages paid to carpenters and bricklayers. To allocate these various costs seems a difficult problem, but the first step is simple, for each item can be readily classified under one of the following two divisions:

1. Direct Expense.
2. Overhead Expense.

Direct Expense includes all expenditures that pertain to only one contract, and that can be charged to that contract without subdivision or apportionment.

Overhead Expense includes all expenditures that pertain to all the contracts carried, and that cannot be charged to the individual contracts without subdivision or apportionment.

Analysis of Direct Expense Account.—The Direct Expense Account is divided into two parts:

1. Field Expense.
2. Sub-Contract Expense.

Field Expense includes all items which can be directly charged to the work in the field.

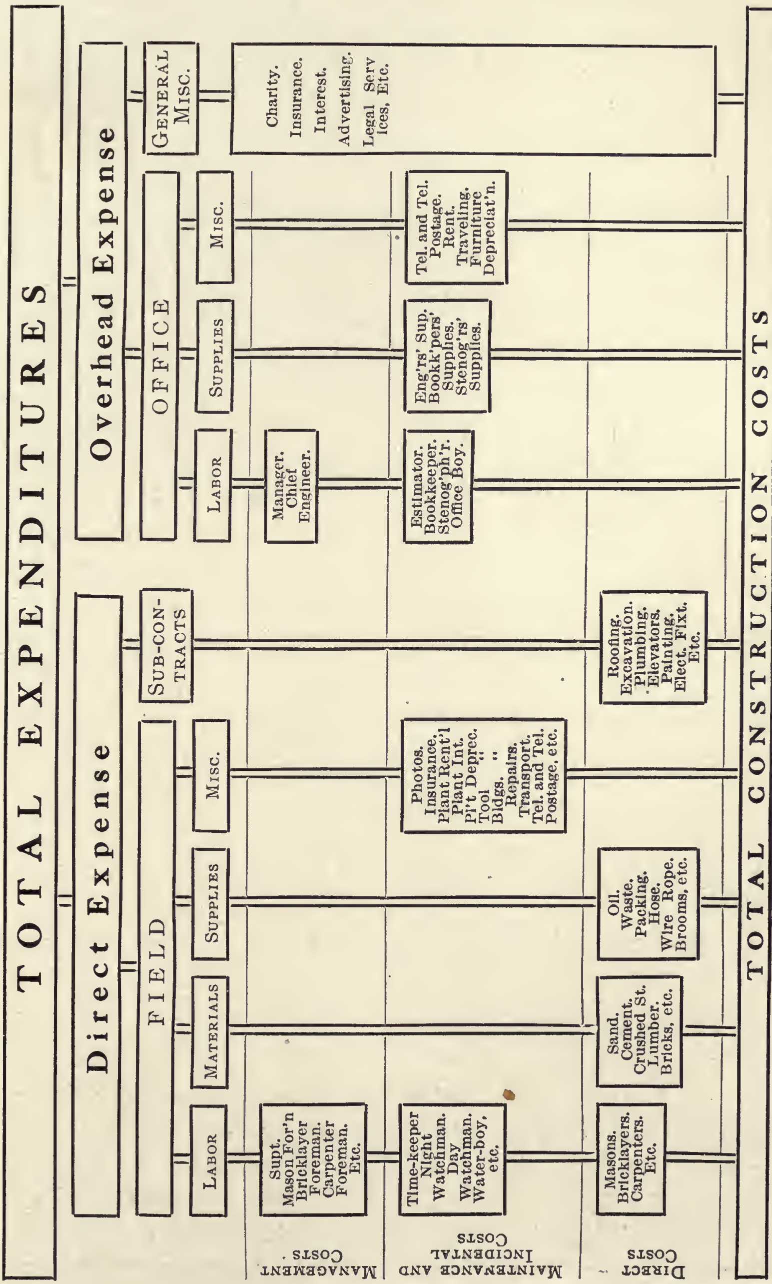

TOTAL EXPENDITURES
Direct Expense
Overhead Expense
FIELD
SUB-CONTRACTS
OFFICE
GENERAL MISC.
LABOR
MATERIALS
SUPPLIES
MISC.
LABOR
SUPPLIES
MISC.
MANAGEMENT COSTS.
MAINTENANCE AND INCIDENTAL COSTS
DIRECT COSTS
Supt. Mason For'n Bricklayer Foreman. Carpenter Foreman. Etc.
Time-keeper Night Watchman. Day Watchman. Water-boy, etc.
Masons. Bricklayers. Carpenters. Etc.
Sand. Cement. Crushed St. Lumber. Bricks, etc.
Oil. Waste. Packing. Hose. Wire Rope. Brooms, etc.
Photos. Insurance. Plant Rent'l Plant Int. Pl't Deprec. Tool " Bldgs. " Repairs. Transport. Tel. and Tel. Postage, etc.
Roofing. Excavation. Plumbing. Elevators. Painting. Elect. Fixt. Etc.
Manager. Chief Engineer.
Estimator. Bookkeeper. Stenog'ph'r. Office Boy.
Eng'rs' Sup. Bookk'pers' Supplies. Stenog'rs' Supplies.
Tel. and Tel. Postage. Rent. Traveling. Furniture Depreciat'n.
Charity. Insurance. Interest. Advertising. Legal Services, Etc.
TOTAL CONSTRUCTION COSTS

Chart No. 1.

Sub-Contract Expense includes all amounts paid for work done by sub-contractors.

Under Field Expense we have four subdivisions:

1. Labor.
2. Materials.
3. Supplies.
4. Miscellaneous.

All expense for labor (except when sub-contracted) employed in the field is charged under *Labor.*

Expenditures for materials which are found in the completed structure, and which are paid for according to the contract, are charged under *Materials;* e. g., Cement, Sand, Crushed Stone, Bricks, etc.

Supplies include all such items of material as are necessary to the carrying on of the work, but which are partially, or wholly, destroyed in the process of construction; e. g., Oil, Waste, Coal, Rope, Hose, etc.

General items of expense which do not come under any of the first three classifications, but which can be directly charged to the Field Account of a contract, come under *Miscellaneous;* e. g., Plant Rental, Plant Depreciation, Telephone and Telegraph, Postage, etc.

Analysis of Overhead Expense Account.—There are two main divisions under Overhead Expense:

(1) Office Expense.
(2) General Miscellaneous Expense.

Office Expense includes all items which cannot be charged directly against the field and which are due to maintaining an office.

Three subdivisions can be made under Office Expense, namely:

(1) Labor.
(2) Supplies.
(3) Miscellaneous.

All expenses incurred for *Labor* through the office force, including everybody housed in the office from the Manager down to the Office Boy, are classed under Office Labor. In the case of a large business it will pay to subdivide this account rather minutely, the degree of analysis depending upon the magnitude of the business. In a small firm, where a man is called upon to do several classes of work, time of the individuals will have to be divided and charged to several classifications. This matter will be taken up again later.

Supplies include all expenditures for materials used by the office force, and include such items as Engineer's Supplies, Bookkeeper's Supplies, Stenographer's Supplies, etc.

Expenditures which are due to the maintenance of the office and which cannot be classed under either Labor or Supplies, being general in nature, are charged under *Miscellaneous Expense.*

General Miscellaneous Expense includes all expenditures which are so general in nature that it is impossible to charge them against either the Field or the Office and which are due to the maintenance of the business in general.

The various items of the subdivisions under Field, Sub-Contract and Office Expense are divided into three classes:

(1) Management Costs.

(2) Maintenance and Incidental Costs.

(3) Direct Costs.

Management Costs include all expenditures for labor doing work of a managerial nature, involving discretionary powers.

Maintenance and Incidental Costs include all expenditures incurred by the Office and Field for labor, material, supplies and miscellaneous items necessary to the maintenance of the business, but incidental as regards the actual construction.

Direct Costs include all expenditures for labor, materials, supplies and sub-contracts directly necessary in carrying out the main contract.

Attention is called to the fact that the Total Expenditures are equal to the Total Construction Costs. Hence, when unit costs are worked out, their total should check reasonably close with the difference between Total Expenditures and Sub-Contracts, or they are too much in error to be of use. Just what "reasonably close" means depends on the class of work and on the elaborateness of the system of accounts, which in turn depends on the size of the business. On one large contract the total of the unit costs as made up from distributions checked within 1% of the costs according to the books. This work was done by a large firm with a newly installed cost department.

Gathering Data.—Field Labor data for Field Labor expense come weekly from the Timekeeper in the form of the

CONT. No. 115 — CONSTRUCTION LABOR. — Sheet No. 20

WEEKLY PAY ROLL FOR WEEK ENDING Jan. 9 1909

	Name. (Write last name first.)	Trade.	Hours. Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Thur.	Total Hours	Rate.	Amount Dollars	Cts.	Trade Total Dollars	Cts.	Remarks.
1	Murphy, Patrick	Mason	8	4		8	6	$7\frac{1}{2}$	8	$41\frac{1}{2}$	0.55	22	83			
2	Sullivan, James	"	8	4		7	6	8	8	41	0.55	22	55			
3	Oliver, Patrick	"	8	4		8	6	8	8	42	0.55	23	10			
4	Williams, Robert	"	8	4		8	6	8	8	42	0.55	23	10			
5	White, Walter	"	8	4		$7\frac{1}{2}$	6	8	8	$41\frac{1}{2}$	0.55	22	83			
6	O'Neil, Clarence	"	8	4		8	6	8	8	42	0.55	23	10			
7	O'Connel, Frederick	"	8	4		8	6	4	8	38	0.55	20	90	158	41	
8	Smith, James	Mason's Helper	8	4		$7\frac{1}{2}$	6	8	8	$41\frac{1}{2}$	$0.22\frac{1}{2}$	9	34			
9	Jones, John	" "	8	4		8	6	8	8	42	$0.22\frac{1}{2}$	9	45	18	79	
10	Smith, John	Bricklayer	8	4		8	6	8	8	42	0.55	23	10			
11	Quirk, Samuel	"	8	4		0	6	8	8	34	0.55	18	70			
12	Russel, Walter	"	8	4		8	6	8	8	42	0.55	23	10			
13	Glass, Charles	"	8	4		7	—	—	—	19	0.55	10	45			P.R.U. 510
14	Green, James	"	8	4		8	6	8	8	42	0.55	23	10			
15	Willets, Joseph	"	8	4		4	4	8	8	36	0.55	19	80			
16	Rubinstein, Isaac	"	8	4		8	6	8	8	42	0.55	23	10			
17	Dexter, James	"	8	4		8	6	8	8	42	0.55	23	10			
18	Butler, John	"	8	4		8	6	8	8	42	0.55	23	10			
19	Keog, George	"	8	4		8	6	8	8	42	0.55	23	10			
20	Kellogg, Frank	"	8	4		8	6	8	8	42	0.55	23	10			
21	Cole, John	"	8	4		8	—	—	—	20	0.55	11	00			P.R.U. 511
22	Coleman, James	"	8	4		8	6	8	8	42	0.55	23	10			
23	Brown, Frank	"	8	4		7	6	8	8	41	0.55	22	55			
24	Franklin, Joseph	"	8	4		8	6	8	8	42	0.55	23	10			
25	Haring, Frederick	"	8	4		8	6	8	8	42	0.55	23	10			
26	Thomas, George	"	8	4		8	6	8	8	42	0.55	23	10			
27	James, John	"	8	4		8	6	8	8	42	0.55	23	10			
28	Conners, James	"	8	4		8	6	8	8	42	0.55	23	10	405	90	
29	Murphey, James	Bricklayer's Helper	8	4		8	6	8	8	42	$0.22\frac{1}{2}$	9	45			
30	Carber, John	"	8	4		9	6	8	8	43	$0.22\frac{1}{2}$	9	68			
31	Lucas, James	"	8	4		8	6	9	8	43	$0.22\frac{1}{2}$	9	68	28	81	
32																
33																
34																
35																
36																
37																
38																
39																
40																
	Sheet Totals.											611	91	611	91	

Posted to Distribution Sheet.
U.S.N. Le 100
S.T.N. H. — Book keeper

This account is correct.
James S. Smith — Time Keeper.
Approved [illegible] — Supt.

Form I.

Weekly Pay Roll. Form I is that used for the Construction Labor. For Field Management and Incidental Labor the same form is used, with the exception that the words printed at the heads of the sheets are the names of those accounts.

It will be noted that the week ends on Thursday night. This is to give the Timekeeper Friday and Saturday in which to make up his accounts and get his money ready for payment on Saturday night. Anyone who has been through those week-end periods knows that this is not allowing any too much time.

CONTRACT No. *115* P. R. V. No. **510**

WEEKLY PAY ROLL VOUCHER

Class of Work *Bricklayer* Date *Jan. 6* 190*9*

Name *Chas. Glass* No. ~~~

Fri.	Sat.	Sun.	Mon.	Tues.	Wed.	Thur.	Total Hours	Rate	Amount	
8	4	—	7	—	—	—	19	0.55	10	45

RECEIVED OF THE REAL ESTATE CONSTRUCTION COMPANY

~~~~~~~~*Ten*~~~~~~~~ $\frac{45}{100}$ DOLLARS

Chas. Glass
Workman's Signature

CORRECT *James S. Smith*
Time Keeper

APPROVED *A. B. Minns*
Superintendent

Form II.

The men are listed according to trades, and the total amount paid for the week to each trade is entered in the "Trade Total" column on the line opposite the last name in that list. When starting to list a trade on a sheet partly filled, take a new sheet if there is not room for the whole trade in the remaining space.

When a man is discharged and paid during the week a voucher such as shown by Form II should be obtained and the voucher number entered in the "Remarks" column of the weekly pay roll. (See Form II.)

All of these forms should be made up into books of convenient size with alternate pages printed on tissue paper, and a
~~~~~~~~

carbon sheet used to make a copy on the tissue. The original sheet is perforated near the binding so that it can be readily torn out and forwarded to the Office. A copy of all records is thus left in the book for reference on the work.

Later, under the discussion of distribution, the further handling of these data will be taken up.

Office Labor.—The time of the owner who attends to the business end will be divided between soliciting new business, purchasing materials, interviews with owners and architects, legal matters and various other things too numerous to mention. To be able to tell just how much each of these items costs the business might be very interesting, but the value of such data would not justify its expense and trouble in collecting. Hence, his wages will be charged each month without being analyzed.

In the case of the other owner it would seem advisable to distribute the time over Estimating, Designing and Superintendence. The division is simple and inclusive; and the information gained is of value, because it helps to keep the constructive accounts of Superintendence and Estimating accurate. As the major part of the time will be charged to Superintendence, the additional work will be slight.

Monthly wages paid to the Estimator, Bookkeeper, Stenographer and Office Boy can be readily charged to their respective accounts each month.

Field Materials.—Wise purchasing of material is as dependent upon effective Material Accounts as efficient management of labor is on Labor Accounts. The partner whose duty it is to purchase materials might succeed in getting good prices, but without some system he would be unable to follow up each purchase to see that the quality and quantity that he contracted for were delivered, that the materials were billed but once, and that the price as billed was the same as the agreed price. But the average man would not be able even to get good prices, because successful purchasing, like the letting of contracts, is not a question of picking the lowest bidder, but of carefully comparing values. Good judgment is a prerequisite; and with such a vast amount of detail, it is impossible to bring good judgment to the problem without some aid to the memory. For example, if coal is to be purchased, some of the questions which the purchaser should be able to answer are:

Of whom have we purchased coal before?

What were the prices?

Was the quality of coal delivered satisfactory?

Was the quantity as ordered?

Was the service prompt?

With such an important item as coal it may be easy to remember the leading facts. But there are thousands of items to be dealt with, and no one is able to remember the detail necessary to good judgment in purchasing in such a wide field. The return in savings on purchases will more than pay for the extra cost of keeping what the small contractor may consider too elaborate a system of Material Accounts.

Purchasing.—First, let us outline the various steps in purchasing; and in order to make the outline general, let us take the case in which the Purchaser must be notified of the need of material. For example, the hoisting engineer reports to the Timekeeper that he needs oil for his engine. The latter makes out a Purchase Requisition for the oil,—which is a notice that certain quantities of that material are needed,—and sends it to the Purchaser after it has been signed by the Superintendent. On receipt of the Requisition the Purchaser selects a Dealer and issues a Purchase Order for the oil. A copy of this is sent to the Timekeeper, who checks off the items when the material is received. By means of a Receiving Slip he notifies the Purchaser that the goods ordered have arrived. In general this is the method of making purchases.

Stock forms for the work outlined above can be purchased of firms dealing in office records. They will serve the purpose quite well; but, of course, it is always more satisfactory to have special forms printed when possible, because the stock forms are of necessity general and cannot meet the special demands peculiar to the business.

Purchase Requisition.—Purchase Requisitions should give such information as Contract Number, Requisition Number and Date, Point of Delivery, Quantity and Description of Material, Proposed Use, Date Wanted, Timekeeper's and Superintendent's Names. Also, space should be provided for the Purchaser's record of the firm from which the material was ordered and the number of the Purchase Order. They should be made in duplicate so that the copy may be kept on file at the job. Until a copy of the Purchase Order arrives this duplicate serves as a reminder that the materials needed have not yet been ordered. If, for any reason, the order is not placed promptly, the delay will be shown by the Requisition File, and a note of it made in the Daily Letter will correct the fault. This is a letter to the Office written each night by the Timekeeper and signed by the Superintendent, and should contain a statement of progress made during the day and any items of special interest to the Office.

Purchase Order.—Purchase Orders should give such information as Contract Number, Order Number, Date, Purchase Requisition Number, Dealer's Name, Place of Delivery, Proposed Use of Materials, Method of Shipment. They should be made in triplicate. The original goes to the Dealer as his authority for shipment, and gives him the identifying number to place upon his shipments and bills. In cases where the order arises out of a requisition, as in the case cited above, the duplicate goes to the department which made the requisition to give notice that the materials needed have been ordered. This leaves the triplicate for the Purchaser's record. It is usual to make these three copies of different colors, so that the department from which a paper comes may be told at a glance. Thin paper is used for the original and duplicate, and the triplicate is on a regulation card for filing. Hence, all three copies can be made at one time by the use of carbon sheets. By having thirty-one numbers printed horizontally along the top of the card the day of promised delivery may be indicated by attaching an adjustable tab showing the month at the point where the date of delivery is printed. This enables the Purchaser to tell at a glance what orders are overdue, and thus avoid delays.

It is not advisable to put the price on the Order. In the case of most of the small purchases the price is not known, the Purchaser relying on the past fair dealing of the Dealer for a reasonable figure. Before he pays for the goods he will, of course, determine whether the price is right or not; but if he waited to find out the price before ordering, his work would be seriously delayed to the detriment of the business.

Receiving Slip.—Receiving Slips should give such information as Contract, Order and Receiving Slip Numbers, Date of Receipt of Materials, Shortage or Mistake, Quantity and Description of Materials. They should be made out in duplicate, the original going to the Purchaser to notify him of the receipt of the materials that he ordered, and the duplicate remaining on the job. In case several shipments are necessary to make up the order, each separate delivery should be immediately reported on one of these slips; and on receipt of the final shipment, a note to that effect should be made on the slip reporting the receipt of the materials. As the several Receiving Slips come in, the Purchaser attaches them to the copy of the Purchase Order which authorized the shipment of the goods received. When the final Receiving Slip comes in he records on the Order the prices that have not already been recorded and "O. K.'s" it ready for checking the bills. If the Dealer does not deliver promptly the Purchaser will be notified of the fact by the Purchase Order which will be in his file of unfilled orders without a final Receiving Slip.

Duplicate Bills.—Duplicate bills bearing the Purchase Order number may be demanded of vendors in certain cases. One is filed alphabetically and the other numerically, so that a bill can be found as readily when only the number is known as when the name of the vendor is known.

Combined Purchase Requisition and Order.—There is a modification of the purchasing system outlined above which, if the conditions are favorable for its adoption, will save considerable time. The Purchase Requisition and Purchase Order are combined into one sheet, so that when the Requisition comes to the Purchaser he has simply to fill in the name of the Dealer. By the use of carbon sheets the Timekeeper makes five copies. One of these copies remains in the book for reference on the job and the other three, with the original, are forwarded to the Purchaser. The latter enters the name of the Dealer on the four sheets by means of carbon paper and sends the original to him as his authority for the sale. One of the copies goes back to the source of the demand to give notice of the purchase, and the other two copies remain with the Purchaser for alphabetical and numerical filing. As the materials purchased arrive, Receiving Slips are sent to the Purchaser, and when the final shipment is received, the copy of the Order sent to the job by the Purchaser is returned to him with a note stating that the final delivery has been made and calling attention to faulty material or shortages.

Price Records.—As these accounts are designed for a small contractor, it is safe to presume that he confines his activities to a few cities, or even to one city. If this is the case, his purchases are made among a certain limited field of dealers. Hence, it will pay him to keep record cards showing the comparison of quotations on different staple articles. In this way he will be able to determine accurately the best place to purchase.

The quantity and quality of each class of Construction Materials will be determined from the drawings and specifications by the engineering department, who will inform the Purchaser as to what is necessary. These materials offer the big opportunity for saving in purchasing and will have to be handled by the Purchaser himself. The method of purchasing has already been described.

Field Supplies.—Many of the purchases of Construction Supplies will find their origin in a Purchase Requisition from the job. But it is necessary, in order to avoid great loss through delays, that the Timekeeper be authorized to make out Purchase Orders for such supplies as Nails, Rope, Brooms, Hose, etc., for immediate delivery. All such Orders should bear a distinctive mark and a serial number and be approved by the Superintendent. The method is the same as already outlined for regular purchases through the Purchaser. In this case, however, a copy of the Order goes from the job to the Purchaser, instead of from the Purchaser to the job.

If the contract is very large it will pay to maintain a Storeroom on the job, with a Storekeeper in charge. He should keep as careful records of the materials received and disbursed as the work will allow. This in itself is a topic for elaborate discussion and space cannot be given to it in this chapter.

Tool Record.—A Tool Record of some kind should be kept by every contractor no matter how small the job. Even if it is only an approximation to a correct record it will serve a good purpose, for if there are signs that records are being kept, the workmen will not know how accurate they are and will hesitate to appropriate tools for fear that the records will show their misdeeds. Just a simple record charging tools sent to the job and crediting those returned to the Storehouse or transferred to another job will save a great deal of money. If a Purchase Requisition comes in calling for tools of a certain sort and the

Tool Record shows that a normal number have already been supplied to the job, the fact can be called to the attention of the Superintendent and a reason demanded for the necessity of such a large supply.

Office Supplies.—Whether the firm be large or small, it is advisable to leave the purchasing of drafting and stenographic supplies to those departments, with the occasional supervision of the regular purchasing head. No one knows so well as the persons doing the work in these departments just what particular kind of material is needed. Also, when special technical knowledge is of value in making a purchase it is wise to allow the proper department to place its own order. But for every purchase there should be a Purchase Order issued by the Purchaser or somebody authorized by him.

Plant Depreciation.—Whether a contractor's plant is in use or in storage it is depreciating in value. Even the moment an article is purchased its value drops, because the article immediately becomes second-hand. If the loss in value of plant due to depreciation is not taken out of the gross profits and either put back into the business or used to establish a fund with which to purchase new plant when that now in use must be discarded, the capital is being impaired and the business ruined.

Until recently it was customary to charge out a certain percentage of the value of the plant at the end of the year in the Profit and Loss Account; but this method does not give the correct cost of each separate piece of work, because each job has the use of certain plant and should bear a proportion of the total depreciation.

One modern method of handling this account is to credit the Equipment Account and charge an Equipment Depreciation Suspense Account, with the estimated amount of depreciation for the coming year. Then the value of the business for the coming year is estimated, and as each contract is completed it is charged with a part of the total depreciation for the year determined by the ratio of the value of the contract to the estimated business for the year, and the Equipment Depreciation Suspense Account is credited with the same amount.

This scheme presents several difficulties. In the first place, the amount of plant that will be carried during the year is unknown, and hence the per cent. for depreciation cannot be accurately determined. Also, the amount of business which will be done during the coming year is an unknown quantity. Again, if you charge a certain proportion of the depreciation on all plant to a contract, whether the total of that proportional part of the entire plant was used on the job or part was used and part was in storage, the amount of depreciation which you charge to a contract this year when business is dull will be quite a different amount from what you would charge for the same piece of work next year when all your plant is in use. In other words, if this method is used the records will lose their value for comparisons.

It may be argued, as above, that it costs a contractor the total amount of the depreciation to maintain his business, and that as he does so much business with that amount as one of the items of expense, each part of the business done costs its proportion of the total depreciation. Nevertheless, what it costs a contractor to maintain his business and what it costs him to perform the contracts of the year are quite different. For example, if he obtained no contracts at all for a year he would still have a considerable item for Equipment Depreciation, and this would have to be charged to maintaining his business. When his plant is not all in use, that part of the depreciation which is on account of plant in storage is a part of the expense of maintaining his business and not a part of the cost of performing the contracts in hand. The reason why some advocate this proportional method is that they confuse the point of view; they look at the question from the point of view of an outsider, rather than that of the contractor. An outsider knows that a contractor must at least make enough on his contracts to cover the total expenses, and that if work is being done the owner is going to help to pay those expenses. Thus, to the outsider, a ratable proportion of the expense for depreciation will be charged to the work being done for him, and it will be; but the contractor wants his accounts to tell what it costs for the depreciation of the plant actually used in the completion of the contract, so that the figures will be useful in estimating on future work; also, what it costs to carry idle plant in order to remain in business.

This information can be readily obtained if the proper method is followed. Some record of the equipment on the work and in storage must be kept in any event. Also, a schedule of depreciation rates for the different items of plant must be made out, if anything like an accurate charge for depreciation is to be made. If the monthly depreciation rate is entered opposite each plant charge to the different jobs and storage accounts, this can readily be multiplied by the time during which the item of plant remains charged and the amount of depreciation entered in the column next to the rate. The total of the amount column can then be charged to the job in case the plant is in use, or it can be carried into a Profit and Loss Account in case the plant is in storage. This method is even simpler of operation than the first one described.

It is, of course, obvious that if plant is carefully repaired its life may be indefinitely extended, and hence the rate of depreciation lowered. Just how much a certain piece of plant will be repaired cannot be predicted; but if we should credit out the cost of all repairs except those due to accidents, unforeseen break-downs, etc., against the charges for depreciation, we would practically charge off depreciation at this modified rate. If we charge depreciation at some arbitrary rate and then also charge the business with repairs which counteract the effect of depreciation, it is clear that we are overloading with expense, because we are charging depreciation at an excessive rate. But there are so many difficulties in separating the expenses for repairs into those that should be credited in the Depreciation Account and those that should be charged against Repairs, that it seems better for the small contractor to charge all against Repairs. In handling the account in this way he is, at least, on the safe side financially.

Interest on Plant.—Contractors doing work on the cost-plus-a-fixed-sum or the cost-plus-a-percentage, basis are anxious —and justly so—to include among the items of cost the interest on the money invested in the plant used on the work. By following the usual method of simply charging off among the Overhead Expenses a certain percentage of the total capital as interest, the interest on the money invested in plant is finally charged against the several contracts because it swells the percentage charge for Overhead Expense. But the amount which is charged to each job is not based on the ratio between the plant used on the job and the total plant owned by the contractor; hence the charge may be unjust and open to objection on the part of the person for whom the work is being done. If it is true in this case, it is also obvious that the contractor doing work on the ordinary contract basis is not arriving at its true cost if he follows this method of charging interest.

If a column is provided next to that for depreciation in the scheme outlined above for handling Depreciation, the charge for interest can be entered as easily as that for depreciation, and the total charged off against the job.

Interest on capital in other forms necessary to the business will have to be charged off through Overhead Expense. The amount of this charge will be equal to the difference between the interest on the total capital and the total of the plant interest charged to the several jobs.

Electricity Purchased.—In case steam and electricity are bought from outside concerns we will have bills coming in for steam and electricity in addition to those for water. A note of the reading of each meter should be made periodically on a job Purchase Order and forwarded to the main office as if a purchase had been made.

Employees' Insurance.—Insurance on employees is figured on the weekly pay roll, and a Purchase Order should be made out for the amount when the pay roll comes into the office. Timekeepers' Bonds and all other items of expense of a similar nature, the amount of which is definitely known before the bills come in, can be handled in the same way. When the bills are received they can thus be checked in the same way as for purchases, and there will be no danger of paying the same bill twice.

Miscellaneous Office Expense.—The items that go to make up the Miscellaneous Expense Account are comparatively few in number. Their nature is such that they do not lend themselves to the methods already outlined for collecting items of expense. As the bills come in for Rent, Telephone and Telegraph, Insurance, etc., they are referred to the proper persons for their "O. K.," and a glance at the account books, contracts, leases and other papers will establish the justness of the claim.

Such small items as Postage and Car Fares can best be handled through a Petty Cash Account. A certain amount of cash, to be determined by the previous experience of the business, is turned over to one in charge of this account and is charged on its records. All expenditures are credited to the account and vouchers obtained. Either periodically, or when the cash on hand reaches a certain low figure, the vouchers are turned in and cash to the amount of their total paid into the Petty Cash Fund. This amount plus the cash on hand should always equal the original amount assigned to the account.

Sub-Contracts.—The amount of expense due to parts of the main contract being sub-let can, of course, be obtained from the contracts.

General Miscellaneous Expense.—What has been said of the items under Miscellaneous Office Expense applies equally well to those found under General Miscellaneous Expense.

Distribution of Expenditures.—We have now described the various accounts and discussed the methods of gathering the data for them. But only a small percentage of the value of these data could be realized if the accounting work were dropped at this point. It still remains for us so to group and arrange these data that they will show at a glance the expense of the different divisions of the work.

Columnar ruled Distribution Sheets afford the best solution of the problem of distributing expenditures. (See Form III.) These are simply sheets headed with the names of the general accounts to be charged and ruled with vertical columns for the amounts to be entered under the subdivisions of the general accounts. At the extreme left hand side is a column for the date, the smaller column to the left of each amount column is for the number originally put on the Purchase Order, and the very narrow column to the right of each amount column is for tick marks in checking.

In the following Schedule for Distribution of Expenditures the items found in the second subdivisions and marked (1), (2), (3), etc., will be the headings for distribution sheets; e. g., Field Management, Field Incidental, Construction. Items found in the third subdivisions and marked (a), (b), (c), etc., will be headings for the columns; e. g., Superintendent, Assistant Superintendent, Mason Foremen, etc.

When a bill is checked and ready for payment it should show on its back the total expenditure distributed over the various items of which it is composed. By using a system of symbols, such as shown to the right of the schedule on page 145, we are able to designate with little labor both the account to which an item should be posted and also its location in the records.

CONTRACT No. 115. CONSTRUCTION FIELD MATERIALS DISTRIBUTION SHEET. · FL

DATE.	1 LUMBER.			2 CEMENT.			3 SAND.			4 CRUSHED STONE.			5			Total.
	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	Purchase Order No.	Amount.	√	

Form III.

SUMMARY SHEET.
OVERHEAD EXPENSE.

Date.	OFFICE EXPENSE																					GEN'L MISCELLANEOUS EXPENSE.							Total Overhead Expense.
	Office Labor.								Office Supplies.					Office Miscellaneous.						Total Office Expense.								Total General Miscellaneous Expense.	
	Manager.	Chief Engin'r.	Estimator.	Bookkeeper.	Stenographer.	Office Boy.	Etc.	Total.	Engineers' Supplies.	Bookkeeper's Supplies.	Stenographer's Supplies.	Etc.	Total.	Tel. and Tel.	Postage.	Rent.	Traveling.	Etc.	Total.		Charity.	Insurance.	Interest.	Advertising.	Legal Services.	Etc.			

Form V.

SCHEDULE OF DISTRIBUTION OF EXPENDITURES.

I—Direct Expense.

- (A) Field Labor.
  - (1) Field Management 115-FF
    - (a) Superintendent 115-FF-1
    - (b) Assistant Superintendents 115-FF-2
    - (c) Mason Foremen 115-FF-3
    - (d) Bricklayer Foremen 115-FF-4
    - (e) Carpenter Foremen 115-FF-5
    - etc.
  - (2) Field Incidental 115-FI
    - (a) Time Keeper 115-FI-1
    - (b) Night Watchman 115-FI-2
    - (c) Day Watchman 115-FI-3
    - (d) Water Boy 115-FI-4
    - etc.
  - (3) Construction 115-FL
    - (a) Masons 115-FL-1
    - (b) Bricklayers 115-FL-2
    - (c) Carpenters 115-FL-3
    - etc.
- (B) Field Materials.
  - (1) Construction 115-FM
    - (a) Lumber 115-FM-1
    - (b) Cement 115-FM-2
    - (c) Sand 115-FM-3
    - (d) Crushed Stone 115-FM-4
    - (e) Brick 115-FM-5
    - etc.
- (C) Field Supplies.
  - (1) Construction 115-FS
    - (a) 115-FS-1
    - (b) 115-FS-2
    - (c) 115-FS-3
- (D) Field Miscellaneous Expense.
  - (1) Incidental 115-FX
    - (a) Photographs 115-FX-1
    - (b) Insurance 115-FX-2
    - (c) Plant Rental 115-FX-3
    - (d) Plant Interest 115-FX-4
    - (e) Plant Depreciation 115-FX-5
    - etc.
- (E) Sub-Contracts.
  - (1) Construction 115-FU
    - (a) Roofing 115-FU-1
    - (b) Excavation 115-FU-2
    - (c) Plumbing 115-FU-3
    - etc.

II—Overhead Expense.

- (A) Office Labor.
  - (1) Management .... OD
    - (a) Manager OD-1
    - (b) Chief Engineer OD-2
    - (c) Estimator OD-3
    - (d) Book Keeper OD-4
    - (e) Stenographer OD-5
    - (f) Office Boy OD-6
    - etc.
- (B) Office Supplies.
  - (1) Incidental .... OS
    - (a) Engineers' Supplies OS-1
    - (b) Book Keeper's Supplies OS-2
    - (c) Stenographer's Supplies OS-3
    - etc.
- (C) Miscellaneous Expense.
  - (1) Incidental .... OX
    - (a) Telephone and Telegraph OX-1
    - (b) Postage OX-2
    - (c) Rent OX-3
    - (d) Traveling OX-4
    - etc.
- (D) General Miscellaneous Overhead Expense XX
    - (a) Charity XX-1
    - (b) Insurance XX-2
    - (c) Interest XX-3
    - (d) Advertising XX-4
    - (e) Legal Services XX-5
    - etc.

Hence once the distribution has been written on the back of the bill, the remaining work is merely mechanical; for, by simply glancing at the back of the bill, the bookkeeper is able to turn immediately to the column in which the amount is to be entered.

In this system the first number is that of the contract to which the charge goes. Of course, this number will not appear in the symbols of the accounts under Overhead Expense, as these are not directly chargeable to the individual contracts. The method of handling these accounts will be made clear when we come to discuss the Profit and Loss accounts. Following the contract number are two mnemonic symbols which show the subdivision of the accounts under which the item comes, and the distribution sheet on which it is to be charged. The number following indicates the column in which the amount to be charged to the sheet should be entered.

To illustrate, let us suppose that a bill has come in for—

200 ft. ⅝ in. wire rope, at 10c	$20.00
50 lbs. "Slip Easy," at 3c	1.50
50 window weights, at 15c	7.50
	$29.00

On the back of the bill the bookkeeper would write:

115-FS-3	$21.50
115-FM-12	7.50
	$29.00

When he was ready to post these amounts he would turn to the Field Supplies Sheet for Contract 115 and enter $21.50. Then he would post $7.50 in column 12 of the Construction Material Sheet for Contract 115. The accounts with Field Supplies and Construction Materials are subdivided, so as to give data on the various supplies and materials. Subdivision of this kind depends entirely on the particular needs of the work, and the business of each firm has to be studied before they can be made.

From week to week, as the pay-roll statements come in from the Timekeeper, the Trade Totals are transferred by the Bookkeeper to their respective summary sheets, as shown by Form IV, page 147. After each entry the total to date is written in small figures with red ink under the entry. The Trade Totals for the week are added and the result placed in the Weekly Total column. This amount is then added to the Grand Total for last week, which gives the total cost to date. This method of handling

Contract No. 115 CONSTRUCTION LABOR DISTRIBUTION SHEET. F.L.

Sheet Nos	Week	1 Masons.	2 Masons' Tenders	3 Bricklayers	4 Bricklayers Tenders	5 Carpenters	6 Plasterers		7 Riggers	8 Pipe Fitters	9 Pipe Fitters Tenders	10 Laborers	11 Etc.	12	13	14	Weekly Total	Grand Total
1-2	Oct. 16 1908 to Oct. 23 1908					115 18			33 10			213 17					361 45	361 45
2-3	" 23 1908 to " 30 1908					120 40			39 31			290 80					450 51	811 96
3-4	" 30 1908 to Nov. 6 1908	175 10	10 80	223 15	10 80	180 85			51 08			356 16					1007 94	1819 90
4-5	Nov. 6 1908 to " 13 1908	228 40	21 60	460 90	21 60	193 10			90 42			374 09					1390 11	3210 01
5-6-7	" 13 1908 to " 20 1908	225 65	21 60	590 10	21 60	210 40			87 69	68 92	10 80	325 10					1561 86	4771 87
7-8-9	" 20 1908 to " 27 1908	235 80	21 60	630 25	32 40	230 03			89 43	75 45	10 80	350 02					1675 78	6447 65
9-10-11	" 27 1908 to Dec. 4 1908	235 20	21 60	638 40	33 08	255 89			95 62	89 60	10 80	359 10					1739 29	8186 94
11-12-13	Dec. 4 1908 to " 11 1908	230 54	21 60	633 05	32 40	245 92	58 92		87 50	93 87	10 80	365 08					1779 68	9966 62
13-16	" 11 1908 to " 18 1908	238 45	25 40	628 40	32 40	250 98	43 60		89 63	85 32	11 95	360 89					1767 02	11733 64
16-17-18	" 18 1908 to " 25 1908	234 90	21 60	575 10	21 60	249 60	57 89		87 12	84 92	10 80	358 92					1702 45	13436 09
18-19-20	" 26 1908 to Jan. 2 1908	215 70	23 50	509 35	21 60	247 53	45 10		86 39	89 39	12 30	369 88					1620 74	15056 83
20-21-22	Jan. 2 1908 to " 9 1908	158 41	18 79	405 90	28 81	145 03			98 42	43 10	10 80	250 79					1160 00	16216 83
23	" 9 1908 to " 16 1908			150 05	10 80				95 33	25 02	10 80	187 39					479 39	16696 22
24	" 16 1908 to " 23 1908								52 89			115 43					168 32	16864 54
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	
	190 to 190																	

Form IV.

the accounts makes it possible to tell on Monday morning how much has been expended on any contract for Construction, Incidental and Management Labor up to the preceding Thursday night; it tells how much these items cost for any week; and it gives the total amount paid for any single item of labor for any week, for any number of weeks, or to date.

On the Sub-Contract Distribution Sheet a column is assigned to each contract. As payments are made for the value of the completed work less a percentage, the net amounts are entered in their respective columns. The total amount of the contract is entered in the heading of the column. Knowing the percentage, it is an easy matter to tell at any time how a contract stands. To those who are inseparably attached to debits and credits this may sound childish because of its simplicity; but it is a very practical method in use on large contracts.

Summary Sheet.—Every month the totals from distribution sheets of each contract are posted to their respective Summary Sheets. Column headings for such sheets are shown by Form V, page 144. By writing the totals of each column in small figures under each entry we are able to read the totals to date for each column as well as the monthly totals.

Profit and Loss Accounts.—As stated before, it is impossible to charge the items under Overhead Expense directly to the contracts. If we knew how much business we were going to carry during the year we could charge off against each contract a proportion of the Overhead Expense determined by the ratio of the contract price to the total amount of the year's contracts. Unfortunately there is no way of determining this unknown variable. And even if we could, the result obtained by the method just outlined would not be correct, because some of this expense is due to the contracts handled and some to maintaining the business. Should no contracts be carried for a year, the entire amount of this expense would have to be charged against maintaining the business, for there would be no contracts to charge it against.

The only way to handle the Overhead Expense Account is to close it into a Miscellaneous Profit and Loss Account. Depreciation of plant in storage should also be closed into the account. This account will show a big loss, as the only credit will be Discounts Gained and some small miscellaneous items.

Field and Sub-Contract Costs are added together for each contract and these totals closed into a Contract Profit and Loss Account. In this case the credit side will be large and a big gain will be shown, which should more than offset the loss in the other account.

Finally, these two Profit and Loss Accounts are closed into a Surplus Profit and Loss Account, which shows the loss or gain for the month.

In making up the unit costs as the work progresses, a certain percentage of the Field Costs can be added for Overhead Expense. The percentage for this approximation can be determined from the previous experience of the business.

It would be necessary to devote an entire book to the subject of contractors' accounts in order to treat of it fully. Even with such an amount of available space, the discussion could not hope to be more than suggestive, because each individual business must be studied in order to design accounts to meet its particular needs. Hence, it is clear that this short chapter is only an outline. Many points have been barely touched upon and some have been omitted altogether, but if the discussion has made it clear to the small contractor how he can improve his accounting work it has accomplished its purpose.

CHAPTER VIII.

MISCELLANEOUS COST REPORT BLANKS, AND SYSTEMS OF COST KEEPING.

Following the sample cost report cards given in the fore part of this chapter will be found reprints of a number of articles describing various cost keeping systems.

Construction Service Co.
Contract # 40
Steam Shovel Record.

Location South Cut Weather Clear Date June 1-1909

Nº	Work.	Work Done.	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
1	Engineer		10	.30			3.00		.006
1	Craneman		10	.30			3.00		.006
1	Fireman		10	.20			2.00		.004
1	Pit Foreman		10	.40			4.00		.008
3	Pitmen		10	.15			4.50		.009
								16.50	
	Blacksmith								
	Incidental								
	Water Supply								
	Fuel "	1 1/3 tons coal at $3.00 delivered						4.00	.008
	Total								

Name & Nº of Shovel Vulcan Cap. of Bucket 1 c.y.
Width of Breast Ft. above track at which mat'l dumped
Nº of Moves Total feet moved up.
Delays, From to Cause
Haul 1000 ft.

Coal used Oil Waste
Repairs & supplies needed
Total cars or carts loaded Cap. of car or cart 3 c.y.

Fig. 30.—Daily Report, Steam Shovel.

As previously explained, it is rare that a report card for any given class of work will exactly meet the requirements of all contractors doing that class of work. Hence, the report cards that follow are intended to serve merely as guides. Regarding the cost keeping systems, however, there are many features that may be profitably adopted in their entirety by other contractors. Hence we have deemed it wise not to condense the original articles.

A Cost Keeping System and Its Application to Street paving.*—The acccompanying illustrations show the set of

Construction Service Co.
Contract #
Dump Train Record.

Location Weather Date

No. & Weight of Engine

Runner Brakeman

Trip	Left Shovel	Left Dump	Cars	Trip	Left Shovel	Left Dump	Cars

Engine inspected by Date

Repairs needed

Condition of engine Cars Track

Length of haul

Coal used Oil Waste Other supplies.

No. of Cars used Cap. of car Aver. wt. of empty car.

B-4

Fig. 31.—Daily Report, Dump Train.

blanks used by Kaumeier Bros., general contractors, Port Huron, Mich., for the purpose of keeping records of their paving work. Figure 58 shows a blank used for a daily curbing report. This work is always in charge of a separate foreman and consequently a separate report is made. Figure 59 shows the blank used for

*Engineering-Contracting, June 10, 1908.

a daily time sheet. Stiff folders, with a loose binder so that the cover folds back straight, are used to hold these blanks. The blanks are taken out by the foremen onto the work, and whenever a man is changed from one class of work to another the foremen simply mark the time under its proper classification, and when the blank is turned in at night the number of hours worked is put on in ink, as shown in columns 1 and 2 of Fig.

Construction Service Co.
Contract #
Blasting.

Gang Nº. Location. Weather Date

Nº	Work.	Work Done	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.		Unit. Costs.	
	Foreman.										
	Loaders.										
	Clean'g Holes.										
	Carry'g Powd'r										
	Cleaning Up.										
	Totals										

Nº Holes loaded & depth Kind of Powder - % & make & amount

Nº of Holes sprung

Exploders Kind & Nº used

Material needed and when

Supplies " " "

Kind of Rock Spacing of Holes

- G-1

Fig. 32.—Daily Report, Blasting.

59. It will be noticed in Fig. 59 that employe No. 1 worked from 7 to 9 at plowing, from 9 to 11 in rolling subgrade and so on. It takes the foreman but a second to note the time, as he always has his folder handy. All other clerical work is done at the office.

Figure 60 shows the blank used for a daily report. This daily report is a recapitulation of all work performed during the day, as well as of all material received. This report must be filled out by the foreman each night as to the amount of work performed and material received. All other work, such as cost data, is figured out in the office. Under this method it can be observed each day as to whether the foreman is getting efficient work out of his men or not, and is a good way of demonstrating to him where they are falling behind and where an improvement can be made.

Construction Service Co.
Contract #
Channeling

Location Weather Date

No.	Work	Work done	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
	Channeler								
	Helper								
	Fireman								
	Water Supply								
	Fuel "								
	B'smith								
	Total								

Length of cut Depth sq. ft.
" " " " "
Kind of Rock Total sq. ft.
Condition of Track Condition of machine
Delays from to cause

Coal used Oil Waste Other supplies
Repairs & supplies needed

Fig. 33.—Daily Report, Channeling.

The card shown in Fig. 61 is a teaming card, and one of them is given to each teamster. The letter "O" is used to note the time of arrival of the team and the letter "X" the time of departure. The letter "S" is used to indicate that the team drew a load of stone; the letter "G" indicates a load of gravel and the letters "Sd" a load of sand. In the card shown in Fig. 61 it will be observed that the team arrived at 7:10 and departed at

7:16, arriving back on the second trip at 8:04 and departing at 8:12. This card should be left with the teamster so that he can call the checker's attention to it on each trip. If this is not done the checker is apt to mark the card wrong, but with the teamster carrying the card there will be no trouble about its being marked each trip, for he will naturally be anxious to get in his right number of trips.

Construction Service Co.
Contract *
Drill Gang Record.

Cut Nº Location Weather Date

Nº	Work.	Work done	Reg. Hours	Reg. Rate	Extra Hours	Extra Rate	Total	Total Am'ts.		Unit Costs
	Foreman.									
	Runners.									
	Helpers.									
	Mucking.									
	Nippers									
	Pipe Fitting.									
	Blacksmith.									
	Waterboy.									
	Watchman.									
	Power Sta.									
	Totals.									

Oil consumed	Make and size of machines
Coal „	
Other supplies	Dia. of starting bits
Mat'l needed & when	
Kind of rock	Spacing of Holes
Remarks	

B-1

Fig. 34.—Daily Report, Rock Drilling.

Inspector's Daily Report on Paving.—In Engineering News, April 2, 1908, Mr. M. G. Hall has described the report shown in Fig. 62. Each inspector was required to record the number of men and their occupations once an hour during the day.

A Flexible Cost Keeping System and Its Application to Building Construction.*—Mr. Sam. W. Emerson, of Cleveland,

*Engineering-Contracting, June 13, 1906.

has contributed to the science of cost keeping a description of an ingenious system which has great flexibility and can be applied to many classes of work. In some respects the system lacks completeness of detail, but when time is lacking to devise special blanks it has great usefulness. Mr. Emerson's description is given below:

The work is all done by the time-keeper, who in addition to

Construction Service Co.
Contract #
Blacksmith Record.

Location Weather Date

Work	Work Done.	Reg. Hours.	Reg. Rate.	Extra Hours	Extra Rate.	Total.	Total Amts.	
Drill bits								
Channeler „								
Repair Drills								
„ Stm Shovel								
„ donkey & cars								
„ channeler								
Horses & Carts								
Water Supply								
Conc. Mixer								
„ Plant								
Miscel.								
)								
Total								

Coal on hand Quality.

C-4

Fig. 35.—Daily Report, Blacksmith.

his regular time-book carries a small note-book. An engineer's transit-book answers admirably, or books may be made up with ruling similar to the illustration. A number of columns are ruled on the right hand page, one for each rate of wages paid on the job and one for the totals.

Figure 63 shows the system applied to building construction, the cost of each class of work being kept separately on each building. On the left hand page is given the location and class of work.

The time-keeper making his rounds in the morning, notes in the column corresponding to the proper date the number of men doing each class of work. Four trips are made over the job each day, on each of which any changes in the distribution of men are noted. On the last trip the total number of hours worked on each class of work is put down in the proper column.

Construction Service Co.
Contract #
Derrick Record

Location Weather Date

No.	Work.	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Work Done.	Unit Costs.
	Engineman								
	Tagman.								
	Load Buck't								
	Dump'g "								
	Setting Up Derrick.								
	Taking Down Derrick.								
	Placing Anchors.								
	Foreman.								
	Total								

Guy or peg-leg derrick. Height Length of boom

Kind of bucket or skip Capacity

Kind of material moved Quantity

Coal used Oil Waste

Other supplies used

A-7

Fig. 36.—Daily Report, Derrick.

The small figures in the upper and lower left hand corners of the small squares indicate the number of men working in the morning and afternoon. The large figures give the total number of hours worked, which, multiplied by the rate at the head of the column, gives the cost in dollars and cents in the right hand (total) column.

The sample page shows that on April 10th. eight bricklayers at 60 cents, one foreman at 70 cents and ten laborers at 22½ cents, each worked eight hours on Building *A*.

On the same building ten carpenters at 30 cents and one foreman at 35 cents worked nine hours, four of them putting in half a day setting window frames while the balance of the work consisted in laying roof sheeting.

No concrete was placed on this date, but the cost of hauling

Construction Service Co.
Contract #
Mixing Concrete.

Location Weather Date

No.	Work.	Work Done.	Reg. Hours.	Reg. Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Unit Costs.
	Sand Handle to Mixer								
	" Stone "								
	" Cement "								
	" Water "								
	Mixer								
	Hoisting								
	Wheeling								
	Placing and Ramming								
	Finishing								
	Sprinkling								
	Foreman.								
	Repairing Reinforc't								
	Placing "								
	Total								

Bags cement Cu.yds Sand Cu.yds stone
Batches mixed " " mixed
Mixture Kind of mixer Kind of Hoist
Floor worked on.
Bags of cement on hand Steel on hand

C-5

Fig. 37.—Daily Report, Concrete Mixing.

gravel, moving the mixer and bailing sacks is given. The number of loads of gravel hauled is stated and if any concrete had been mixed the number of sacks of cement used would have been shown.

From the above it will be seen how easy it is with this system to learn the cost of special items, such as moving a mixer, setting up a derrick or repairing a breakdown, etc., which would ordinarily be merged into some general account.

At the end of each week the distribution book was checked with the pay-roll. The difference between them seldom exceeded a dollar or two on pay-rolls of $1,000 to $1,500, and even this error could have been avoided by checking with the time-book every day.

Construction Service Co.
Contract #
Pipe Laying

Location Weather Date

Nº	Work.	Reg. Hours.	Reg Rate.	Extra Hours.	Extra Rate.	Total.	Total Amts.	Work Done.	Unit Costs.
	Excav. Trench								
	Digging bell holes								
	Sheeting & Bracing								
	Laying Pipe								
	Handling & Pouring Lead								
	Calking								
	Backfilling								
	Ramming								
	Distributing Materials								
	Miscel.								
	Foreman.								
	Total								

Lumber used

Pipe (no. of lengths) Laid from ⊙ to ⊙

Valves Hydrants

Lead Yarn

Special Materials

Miscellaneous

A-8

Fig. 38.—Daily Report, Laying Water Pipe.

To get the time of changes in the distribution of men, made during his absence, the time-keeper depends on the foremen or on the men themselves. Whenever convenient to figure progress, estimates should be prepared each week and unit costs determined.

Weekly estimates are easily made by anyone who can read drawings, for brick work, laying roof sheeting, siding and earthwork. Daily estimates can be made with even less trouble for pile driving, making ties, laying pipe, curbing, pavements, etc., and any work which progresses in a straight line. Concrete can

No.	Classification	Hours	Rate	Extra Hours	Extra Rate	Extra Pay	Total Pay	Total Work Done	Unit Cost
	Loading Bucket								
	Signalman								
	Hooking on Bucket								
	Dumping Bucket								
	Driving Sheeting								
	Bracing								
	Chuting Mat. to Cars								
	Engineman								
	Fireman								
	Waterboy								
	Foreman								
	Total								

Construction Service Co.

Contract No. — Trenching by Cableway

Date — Foreman's Daily Report

Material	Amount used today	Amount on Hand	Amount Needed	When Needed
Coal				
Oil				
Waste				

Rush following material, previously ordered

Remarks

Weather

B-10

Fig. 39.—Daily Report, Trenching With Cableway.

always be roughly estimated from the number of sacks of cement used.

On large jobs, where material is handled in buckets by derricks or cableway or in cars, it pays to have a boy count the loads, and his record should show the amount handled each half hour as well as the total for the day.

No.	Classification	Hours	Rate	Extra Hours	Extra Rate	Extra Pay	Total Pay	Total Work done	Unit Cost
	Pavers								
	Loading barrow								
	Wheeling "								
	Spreading Sand Cushion								
	Ramming								
	Trimming								
	Load'g Sand+Cement								
	Loading Brick								
	Hauling Sand+Cement								
	" Brick								
	Grouting								
	Foreman								
	Total								

Construction Service Co.

Contract No. Brick Pavement

Date Foreman's Daily Report.

Material	Amount used today	Amount on Hand	Amount Needed	When Needed
Brick				
Sand				
Cement				
Gravel				

Rush following material previously ordered

Remarks

Weather

C-12

Fig. 40.—Daily Report, Brick Paving.

For the office records a loose-leaf cost ledger should be used. The loose-leaf ledger has many advantages over bound books, one of which is that if an improvement in the arrangement or classification presents itself, the change can be made at once, with at worst no more than copying a few pages. And it is only by making changes and adopting improvements as rapidly

No.	Classification	Hours	Rate	Extra Hours	Extra Rate	Extra Pay	Total Pay	Total Work done	Unit Cost
	Excavation								
	Loading								
	Cinder fill								
	Staking & Setting forms								
	Mix. & Plac. Concrete								
	" & " Finish								
	Troweling								
	Waterboy								
	Hauling Mat. to Job								
	" " from "								
	Moving Plant								
	Foreman								
	Totals								

Construction Service Co.

Contract No. Cement Walk.

Date Foreman's Daily Report

Material	Amount used to-day	Amount on Hand	Amount Needed	When Needed
Cement				
Sand				
Gravel or Stone				
Cinders				
Lumber				

Depth of Excavation	Rush following material previously ordered
Width of Walk	
Cinder fill from ○ to ○	
Concrete Placed Mix.	
Finish Placed Mix.	Remarks.
Finished Walk from ○ to ○	
Length of Haul	
	Weather

C-9

Fig. 41.—Daily Report, Cement Walk.

as their merit is demonstrated that a first-class system for any particular business can be obtained.

It will simplify the work greatly to have special sheets made up for this ledger wider than can usually be found in stock, say

15 in. or 18 in. wide and having a large number of vertical columns.

The use of this ledger is shown in Fig. 64. All charges are

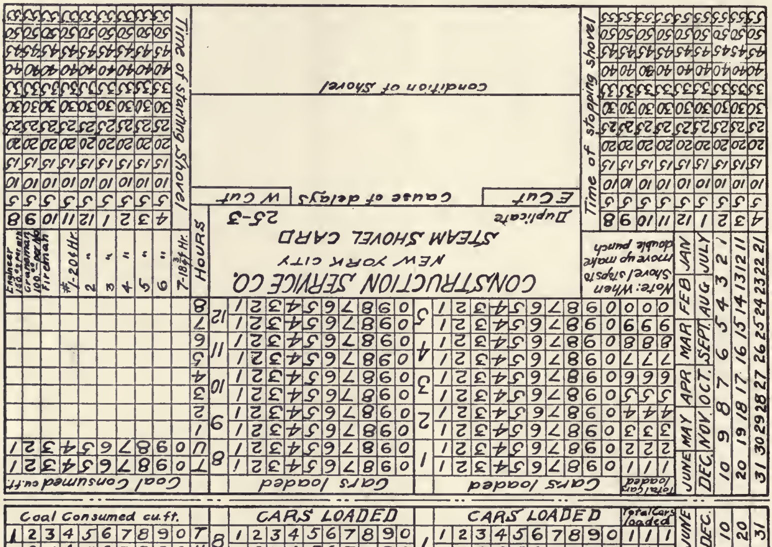


Fig. 42.—Duplicate Punch Card, Steam Shovel.

entered under the proper heading and the totals can be obtained at any time by merely adding up the columns.

A separate sheet is used for each class of work at each point, the cost of which is wanted independently of the rest of the job.

Thus for a bridge substructure job consisting of three piers and two abutments, five pages would be used to cover the concrete work, one sheet for each foundation.

The cost of the excavation and pile driving would be kept in the same way and from a comparison of these sheets valuable data would be obtained as to the efficiency of foremen and methods.

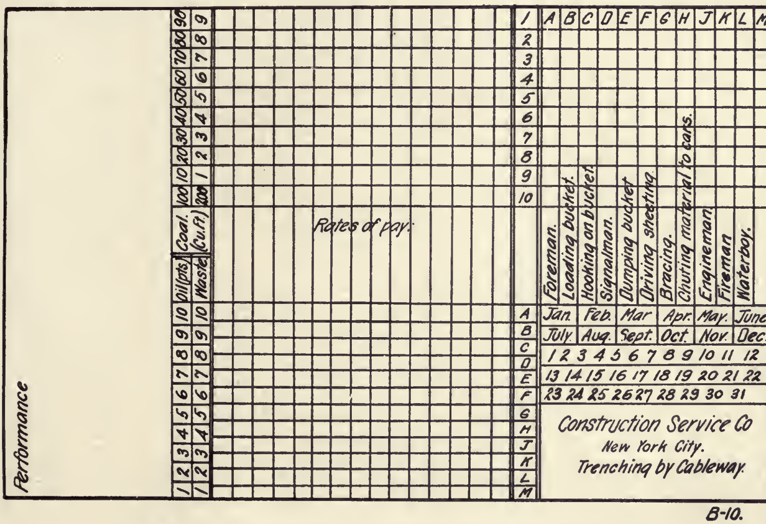


Fig. 43.—Punch Card, Trenching With Cableway.

In order to show the cost of work as it progresses, only materials used, not those on hand should be charged in the ledger.

To accomplish this, materials are charged to suspense accounts as received, the charge being transferred to the ledger account as the material is used. To the suspense account should also be charged the cost of unloading and storing the materials.

To illustrate: on a job where cement costs $1.40 per barrel, unloading from the cars 4 cents by contract, and the cost of cement sheds, storing, loss of sacks, etc., is estimated at 7 cents, the cost of the cement sheds and all labor of unloading and storing is charged to the cement account. The cement as used is then charged to the work at $1.51 and credited to the cement account at the same rate.

Other materials are treated in the same way, and at the end

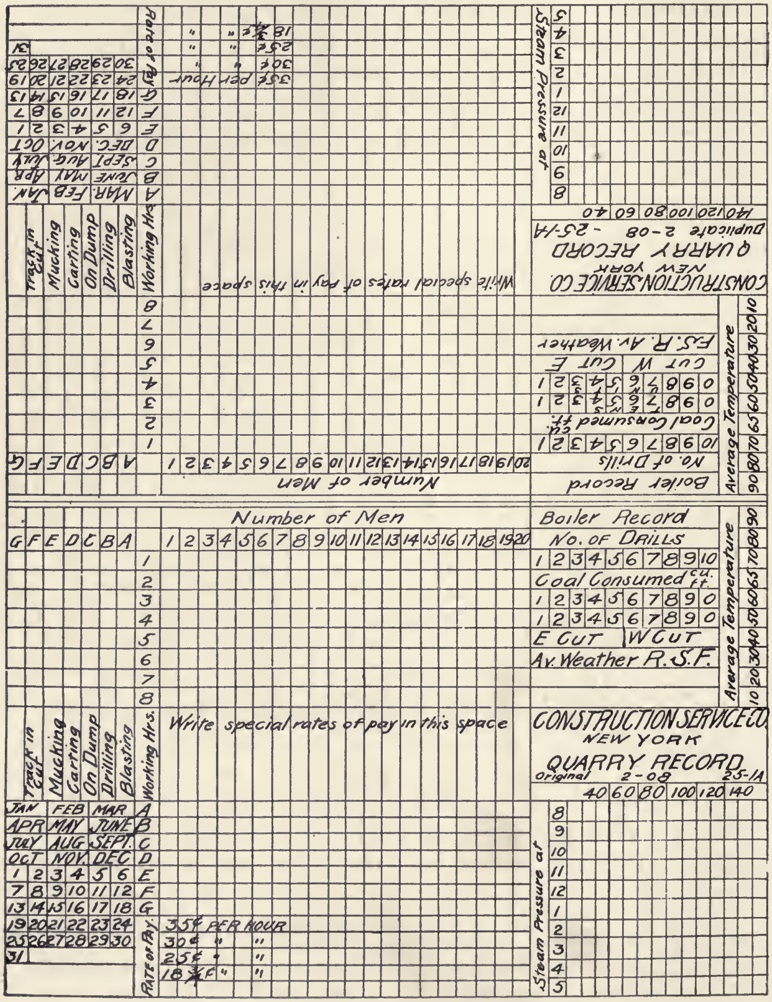


Fig. 44.—Duplicate Punch Card, Quarrying.

of the job any small errors in the estimated cost of unloading and storing can be distributed.

Credits may be shown on the ledger when necessary by using red ink.

On the completion of the job the valuable data contained in the ledger should be worked up into brief tables and filed away on cards for convenience of reference, while the ledger sheets themselves are taken from the holder and stored away in a transfer binder.

The habit of using a card file should be cultivated as it is by far the most convenient method of filing cost records, quotations on machinery and materials, addresses of foremen and one hundred and one other things which will suggest themselves.

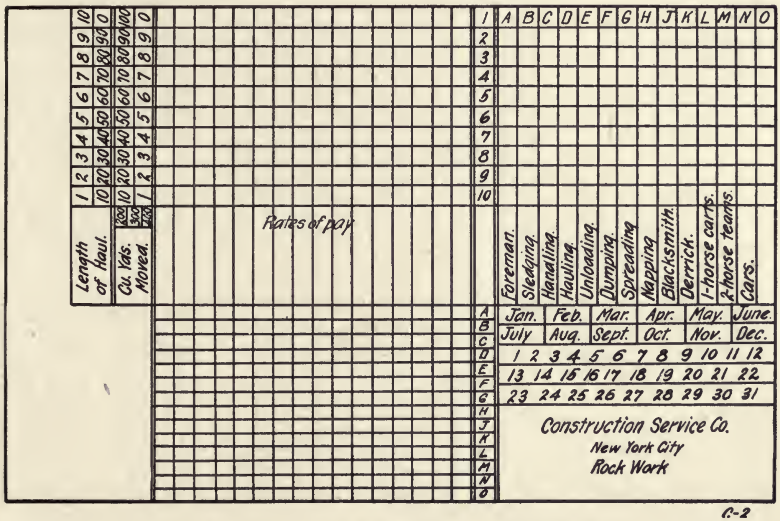


Fig. 45.—Punch Card, Handling Crushed Rock.

In the writer's experience the cost ledger has always been kept on the job, under the direction of the superintendent. Where it is to be kept at the general office, report blanks should be used ruled like the distribution book. On to one of these the record could be copied from the distribution book and mailed to the office every evening.

From the daily reports containing an exact statement of cost and at least an approximate estimate of the work accomplished the office could keep in pretty close touch with the work.

A Cost Keeping System and Its Application to Sewer Work.*—The system of collecting cost data herein explained

*Engineering-Contracting, January 13, 1909.

is that used by the Moore-Mansfield Construction Company and the Mansfield Engineering Company, associated companies, maintaining an engineering designing and general contracting office at

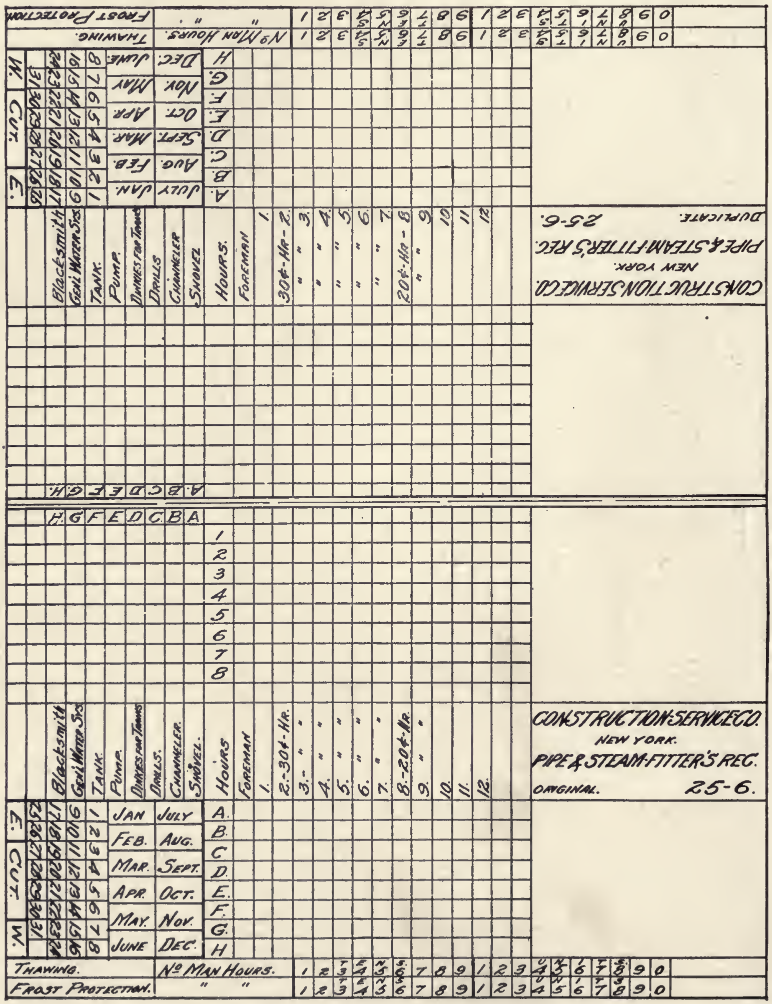


Fig. 46.—Duplicate Punch Card, Pipe Fitting.

Indianapolis, Indiana. The character of the work done by them covers almost the entire field of engineering and architectural construction and it has been the effort of their Mr. Moore, who gives his time very largely to the estimating and cost record department of the organizations, to prepare a system which may be used uniformly through their work and which may be used for

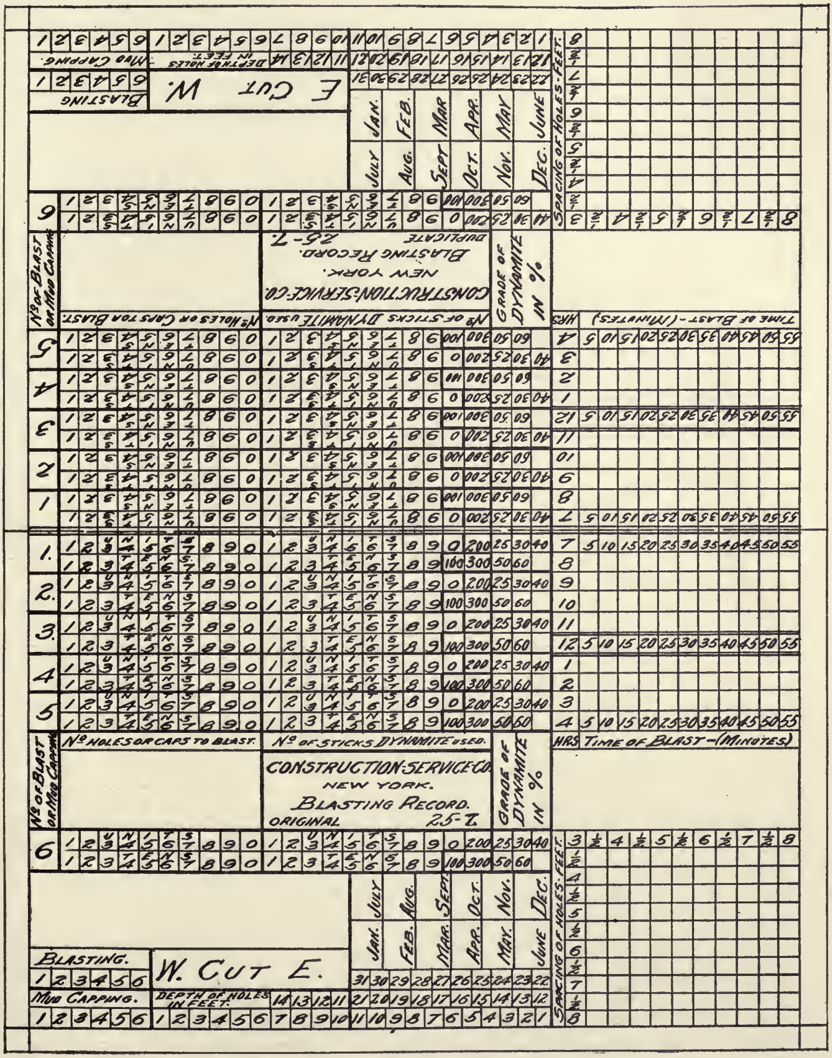


Fig. 47.—Duplicate Punch Card, Blasting.

the different character of the work done, with only minor changes and modifications for each job.

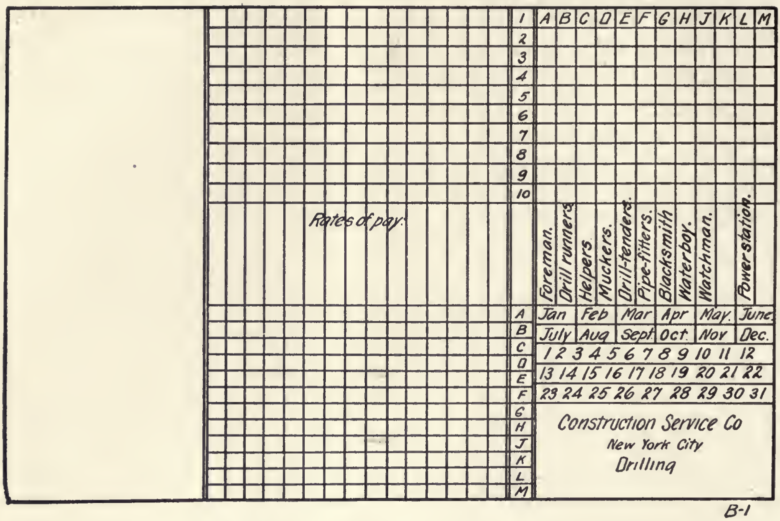


Fig. 48.—Punch Card, Rock Drilling.

The essential and fundamental feature of the system depends upon the form of the time sheet used (see Fig. 65, front view of time sheet, and Fig. 66, back view). The time sheet is folded when in use by the timekeeper and carried in a cover,

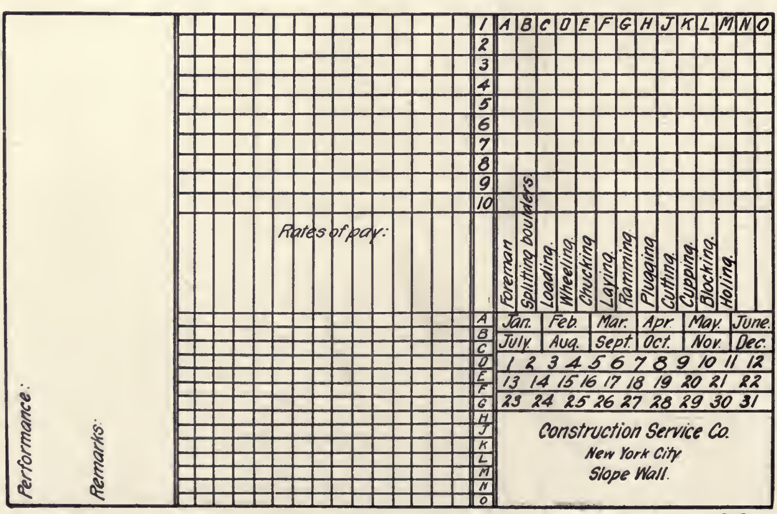


Fig. 49.—Punch Card, Slope Wall.

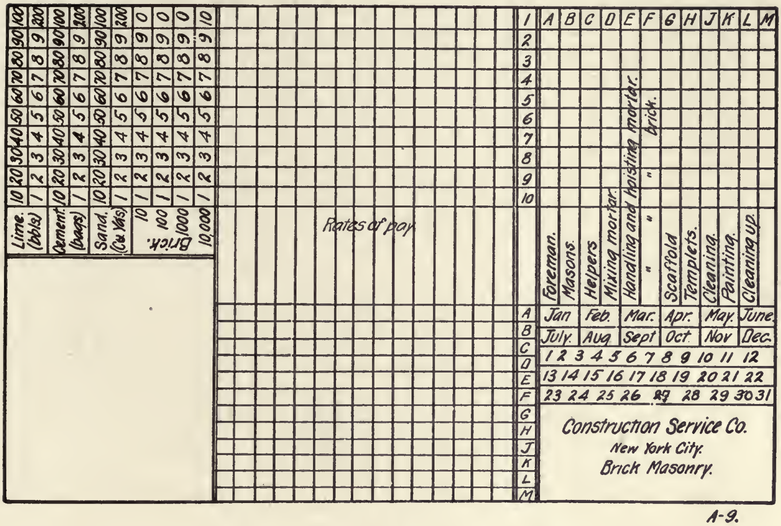


Fig. 50.—Punch Card, Brick Masonry.

making the same of book size, and practically the same form as the ordinary time book. On the left hand side of the front appears the time sheet in the usual form. This time sheet is arranged so that it may be used for a gang reporting time weekly,

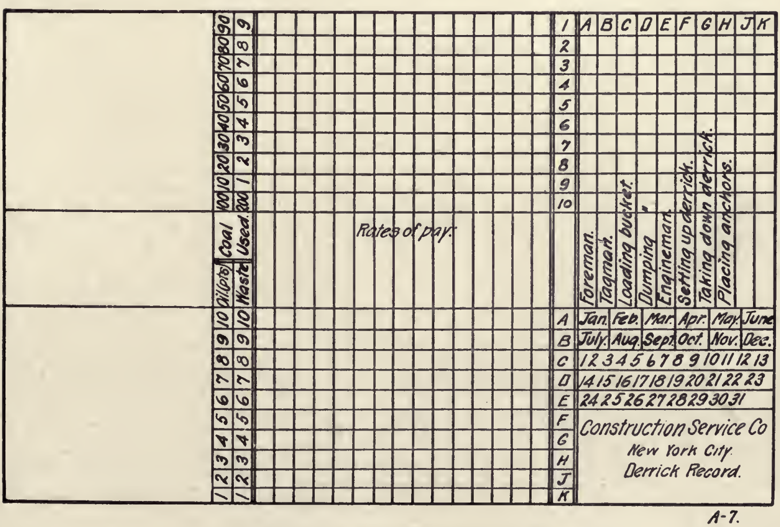


Fig. 51.—Punch Card, Derrick.

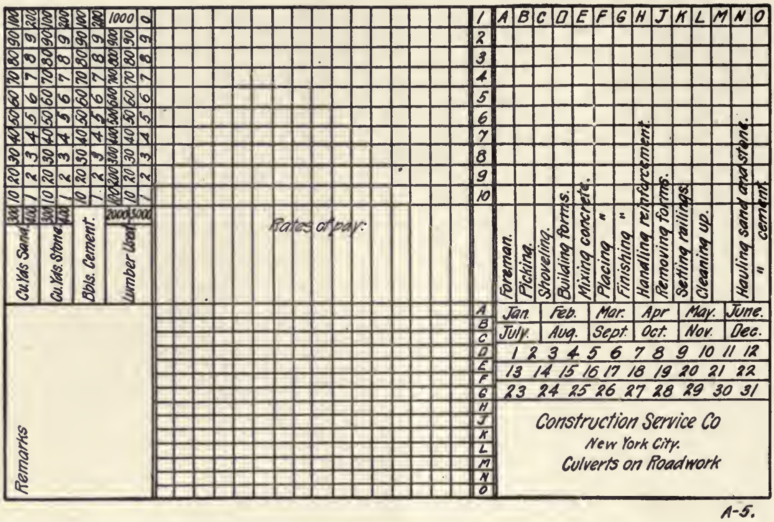


Fig. 52.—Punch Card, Road Culverts.

and is also used where the time sheet is turned in each day, in which latter case the lines under the column dates are ignored and the time placed in the total hour column. On the left hand side appears first the timekeeper's check column. The instructions

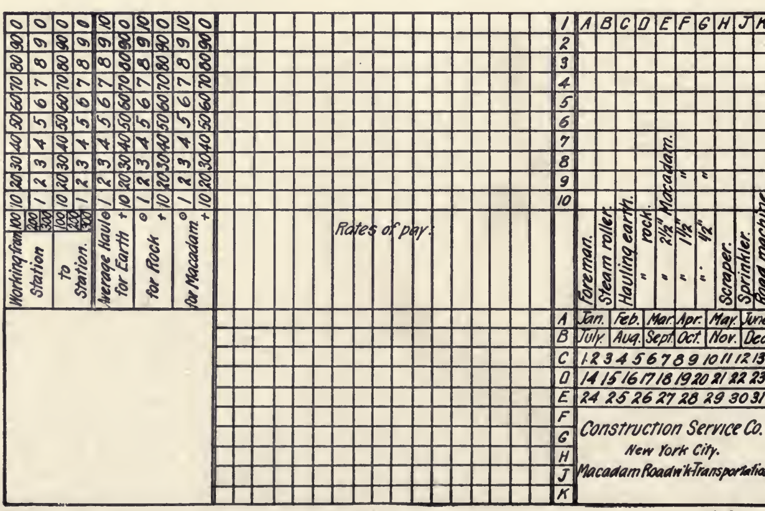


Fig. 53.—Punch Card, Roadwork.

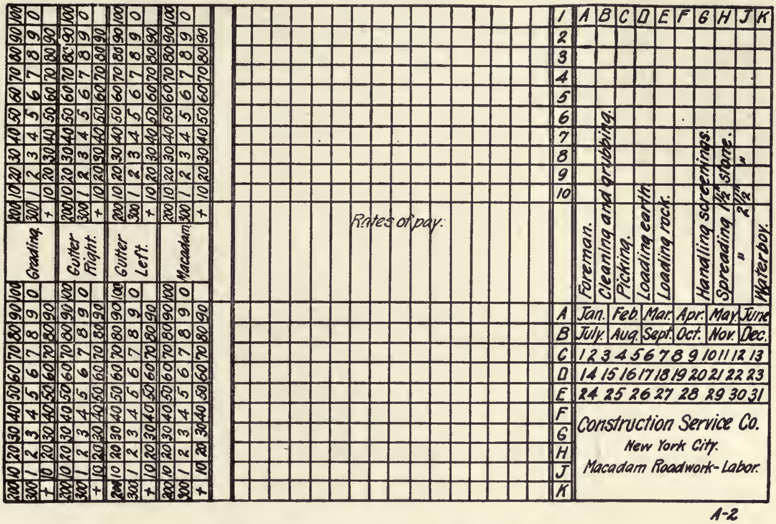


Fig. 54.—Punch Card, Macadam.

to the timekeeper on the back of the sheet (Fig. 66) are probably sufficiently clear, although it might be added that where the time sheet is used as a weekly report, as is generally the case, where the gang is small or where the work is unimportant, the time is

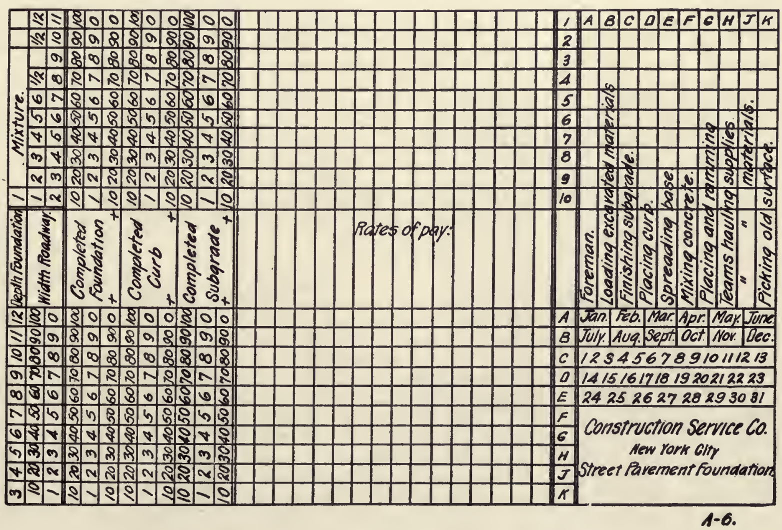


Fig. 55.—Punch Card, Street Pavement Base.

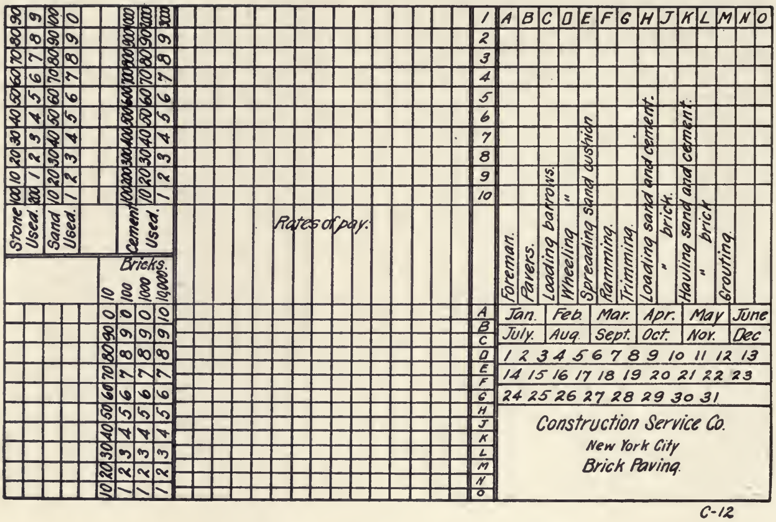


Fig. 56.—Punch Card, Brick Paving.

checked and divided by means of the four squares under each date and opposite each name, each square thus representing one-fourth of a day. In the case of the time sheet as illustrated, the distributions shown are for a sewer job and the particular distri-

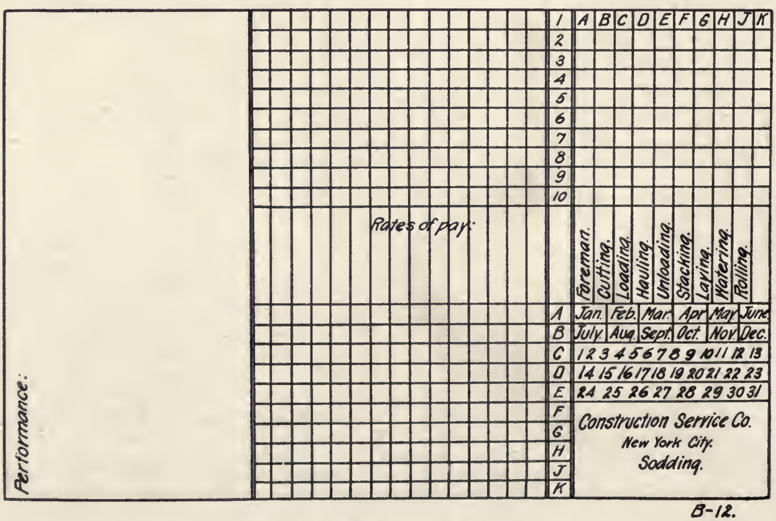


Fig. 57.—Punch Card, Sodding.

butions required are shown printed in by means of a rubber stamp. Each distribution thereby for this job shows a particular key letter although the same letter may not mean the same thing on any two jobs, but reference is made to the rubber stamp heading on each contract to determine the meaning of such letter.

*City of*____________________*Street*____________________*Date*__________________*190*__

NO. OF EMPLOYEE																								Total Hours
Digging Trench																								
Filling & Tamping foundation																								
Setting Stone Curbing																								
Setting Form for Cement Curbing																								
Constructing Cement Curbing																								
Setting Forms for Curb & Gutter																								
Constructing Curb & Gutter																								
Removing Forms																								
Constructing Headers																								
Hauling and Unloading Cement																								
Sundry Teaming and Labor																								
Backing up Curbing																								
Total Hours																								
Rate Per Hour																								

CEMENT

No. Sacks on hand A. M____________________

No. Sacks received____________________

No. Sacks used____________________

No. Sacks on hand at night____________________

No. Empty sacks returned____________________

GRAVEL, STONE AND SAND.

No. Loads concrete Gravel received____________________

No. Loads concrete Stone received____________________

No. Loads concrete Sand received____________________

No. Loads filling Gravel received____________________

No. Loads filling Sand received____________________

No. Loads concrete Gravel used____________________

No. Loads concrete Stone used____________________

No. Loads concrete Sand used____________________

AMOUNT OF WORK PERFORMED

No. Feet of Trench, complete____________________

No. Feet of Trench for Cement Curb and Gutter, complete____________________

No. Feet of Form set____________________

No. Feet of Stone Curbing set____________________

No. Feet of Cement Curbing laid____________________

No. Feet of Cement Curb and Gutter laid____________________

No. Feet of Cement Headers laid____________________

____________________Foreman.

All remarks must appear on the other side.

Fig. 58.—Curb Report (See p. 151).

In the case of the daily report of a job in the timekeeper's check column, each principal column under the "Dates" is counted as two hours or each single column is counted as one hour.

Each small square opposite each name in such column indicates a thirty minutes check. By this means, automatically a man's time is checked by thirty minute intervals extending over a fourteen hour day. In using a checking system of this sort, it is

Street__________ Date__________ 190__ City__________

	No. OF EMPLOYEE	1	2	3	27	28	29	30	31	32	33	Total Hours
GRADING	Plowing	7-9 2										
	Excavating											
	Rolling Subgrade	9-11 2										
CONCRETE BASE	Hauling & Loading Concrete Gravel	11-12 1										
	Hauling & Loading Concrete Stone											
	Hauling & Loading Concrete Sand											
	Laying Concrete											
	Hauling & Unloading Cement											
BRICK	Hauling & Unloading	1-6 5										
	Laying Brick		7-8 1									
	Making Cushion		8-12 4									
	Hauling & Loading Cushion Sand											
	Culling Brick		1-3 2									
	Rolling Brick											
FILLER	Putting in Filler		3-6 3									
	Hauling & Loading Filler Sand											
	Putting in Expansion Joints											
SEWERAGE	Putting in Sewers & Inlets											
	Putting in Catch Basins											
	Putting in Manholes											
SAND	Screening Sand											
CURBING	Hauling & Loading Gravel or Stone											
	Hauling & Loading Sand											
	Hauling and Unloading Cement											
SUNDRIES	Hauling & Loading filling Gravel or Sand											
	Cleaning up											
	General											
MACADAM	Rolling Stone											
	Spreading Stone											
	Total Hours	10	10									
	Rate Per Hour	35	20									

All remarks must appear on the other side

__________ Foreman

Fig. 59.—Daily Time Report, Paving (See p. 151).

not necessary to write the letter indicating the distribution in each square. Suppose that, in the first square in the first column, a man is checked in at 7:00 as working on excavation, distribution *A*; no further letters or checks are made until this man changes the nature of his occupation, which we will assume is done at 10:30, in which case a check is made in the bottom square under the ten hour column. Suppose, in this case, the man changes his work to distribution *C*, indicating back fill. This distribution is

City of ______________ *Street* ______________ ______________ *190*

Weather Condition A. M. ______________ *P. M.* ______________

CONCRETE BASE (Cement)	Amount		No. Hrs.	Rate	TOTAL		Cost per M	Cost per Sq. Yd.	Cost per Cub. Yd.	Cost per Lin'l Ft.
No. Sacks cement on hand A. M.										
No. Sacks cement received										
No. Sacks cement used										
No. Sacks cem't on hand at night										
No. Empty sacks returned										
No. Sq. yards concrete laid										
GRAVEL, STONE & SAND										
No. Cub. yards concrete gravel received										
No. Cub. yards concrete stone received										
No. Cub. yards concrete sand received										
No. Cub. yards filling gravel received										
No. Cub. yards cushion sand received										
No. Cub. yards Grouting sand received										
GRADING										
No. Loads of Dirt hauled										
No. Loads of cobble stone hauled										
No. Loads of rubbish hauled										
BRICK										
No. Brick unloaded										
No. Sq. yards laid										
FILLER										
No. Sq. yards laid										
No. Sacks cement received										
No. Sacks cement used										
No. Sacks cem't on hand at night										
SEWERS										
No. Feet Tile received										
No. Common Brick received										
No. Feet Tile laid										
No. Inlets set										
No. Catch Basins, completed										
No. Manholes, completed										
SUNDRY ITEMS										
Amount of Coal received										
Tools & Supplies received										
Name & No. cars unloaded										
Overhaul No. loads from and to (State exact points.)										

Submitted ______________ Foreman.

All remarks must appear on the other side.

Fig. 60.—Foreman's Daily Report, Paving (See p. 152).

then carried until we assume that the man changes his time again at 3 p. m., which is indicated by the 9th column, and the letter *F* indicates that he has been placed upon the concrete gang, and we will assume that he so continues until the completion of the day. By even a casual observance of this man's time for the day, it is evident that he spent 3½ hours upon back fill (taking an hour for noon), and assuming that the gang quit at 6:00 p. m. that he spent 3 hours upon concrete, making a ten hour day. This system has been found to work satisfactorily, either upon a weekly report basis or upon a daily report basis, and being used uniformly on all contracts, whatever the size of the job or character of the work, the office work has been greatly simplified.

On the back of the time report are shown all of the matters ordinarily appearing in the life of any contract. A complete car

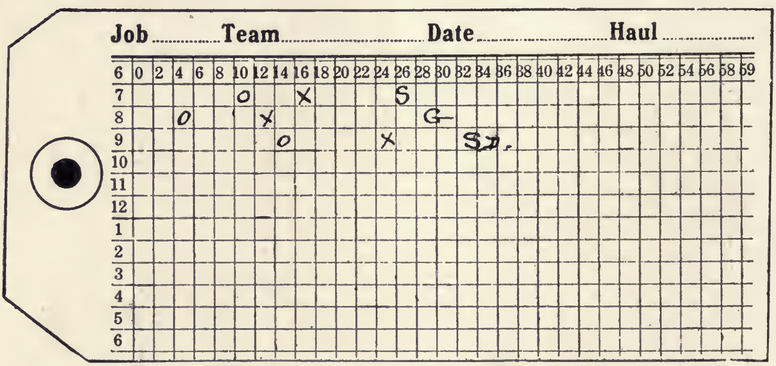


Fig. 61.—Team Card (See p. 153).

report is made; also items of expense and amount of cement used. In the latter case, the opportunity is also given for the dates when the cement was used and where used. On the right hand side a complete report of the job is given. The manner in which this is done is apparent from the form given; but especial attention is called to the fact of the opportunity to check up current work with past work; and also to compare the total amount of work done to date. The items are printed in the same order by rubber stamps in the item column the same as they appear upon the reverse side of the sheet under the distribution. If the timekeeper is unable or not competent to make a report of the amount of work accomplished, one of the supervising engineers co-operates with him to secure this information, so that the report may be a complete one.

In the matter of the office work, complete pay rolls are prepared from the time sheet side and the cost of the work is posted in the cost record book. This cost record book, however, is not essential, but only as a matter of permanent record, as the sheets

Inspector's Daily Report.

Date...*Weather*..........

Street...

....

....

Condition of Street—dry, wet, etc.......................................

....

....

GRADING.

Hour of day	8	9	10	11	12	2	3	4	5	6	Total
Graders											
Wheelers											
Wagons											
Plows											
On Dump											
Foreman											
Water Boy											
C. Y. Graded											

ROLLING.

Rolling Sub-grade											
Rolling Brick											
Men on Roller											
Sq Yds. Rolled											

CONCRETE.

Hand Mixers											
Wheelers, R & S.											
Wheelers, Concrete											
Men on Mixer											
Engineer											
Concrete Wagons											
Spreaders											
Tampers											
Foreman											
Water Boy											
Teams—Hauling Rock											
Teams—Hauling Sand											
Teams—Hauling Cem.											
Sack Cement used											
Sq. Yds. Spread											

BRICK LAYING.

Hour of day	8	9	10	11	12	2	3	4	5	6	Total
Brick Wheelers											
Brick Layers											
Others											
Foreman											
Water Boy											
Sq. Yd. Layed											

SAND CUSHION.

Men											
Sq. yd. Cushion made.											

FILLER.

Screening Sand											
Mixing, dry											
Mixing, wet											
Sweepers											
Wheelers											
Foreman											
Water Boy											
Teams Hauling S.											
Teams Hauling C.											
Sq. yds. Filled											
Sacks Cement											
Yds. Sand											

EXPANSION JOINTS.

Men.											
Bbls. Pitch											

BUILDING CURB.

Graders											
Setting Forms											
Foundations											
Mixers, hand											
Mixers, at machine											
Wheelers, sand											
Wheelers, cement											
Concrete wagons											
Concrete wheelers											
Tampers											
Finishers											
Removing Forms											
Backing up											
Sacks Cem.											
Linear feet built											

General progress of work ....

Any unusual or important matter to report? ....

....

....

Signed...
Inspector.

Fig. 62.—Inspector's Report, Paving (See p. 154).

Tuesday, Apr. 10-'06.	$17\frac{1}{2}$	20	$22\frac{1}{2}$	30	35	50	60	70	
Building "A"									
Brickwork.									
Bricklayers							$^{8}_{6}64$	$^{1}_{1}8$	\# 44.00
Laborers.			$^{10}_{8}80$						18.00
Carpenter Work.									
Sheeting				$^{10}_{6}72$	$^{1}_{1}6$				23.70
Setting Frames.				$_{4}18$	3				6.45
Building "C"									
Concrete.									
Hauling Gravel (74 Loads)	$^{4}_{4}40$				$^{4}_{4}38$				20.30
Moving Mixer	$^{5}_{5}50$			$^{1}_{1}10$	2				12.45
Bailing Sacks (Finished 2 30 P.M.)	$^{2}_{2}14$								2.45
Building "D"									
Excavating.	$^{15}_{5}150$								29.25
Superintendent.									5.00
Timekeeper – Waterboy									3.25
									\$ 164.85

Left Hand Page. *Right Hand Page.*

Fig. 63.—Timekeeper's Book, Building Work (See p. 155).

themselves show total cost to date at all times of each item of work.

This form of timekeeping would be of value because of the system of uniformity alone, even if no regard were given to the other features mentioned, although the above companies using this report are satisfied that they are securing more valuable data by this form than they would have ever been able to do by

A, B & C Shops.	Concrete Foundations. – Bldgs.											
Date		Cement	Sand	Stone	Form Materials	Supplies Fuel		Erecting Plant.	Forms Labor	Mixing	Placing	Teams
Apr. 24	Pay Roll Apr. 13–19								130 50	190 30	80 75	42 00
"	Cement. 300 bbls. @ 1.51	453 00										
"	Stone 300 cu. yds. @ 1.00			300 00								
"	Sand 120 " " @ 0.60		72 00									
"	Lumber 10 M @ 20.00				200 00							
Apr. 26	6" Belt 30' @ 0.20					6.00						
May 2	Pay Roll Apr. 20–26								140 00	125 00	95 50	21 00
	ENG.-CONTR.											

Fig. 64.—Loose Leaf Ledger Sheet (See p. 162).

TIME SHEET. JOB NO.................FROM...........TO...................
For instructions see reverse side.

No.	Name See instructions	Dates							Total Hours	Rate	Total Amount $	c
	Brought Forward											
	Totals											
	Signed..											

Distribution and Pay Roll must check in $ and hours.

TIME KEEPERS' CHECK COLUMN See instructions Dates or Hours											
7	8	9	10	11	12	1	2	3	4	5	6
A								F			
			C								
Total Hours											
Total Nearest Dollar											
Total Cement Used (Bags)											

DISTRIBUTION (See instructions),
SEC...................

A Excavation	B Sheeting	C Back Fill	D Surplus	E Centers	F Concrete	G Pipe Lay.	H C. Basins	I C. B. Con.	J House Con.	K	L	M

Fig. 65.—Front of Time Sheet (See p. 168).

previous forms used. The value of the uniform time sheet lies in the education of the timekeepers, resulting in a more efficient working force. Under the old system with individual time sheets, prepared especially for each job, the forms of the time sheets were many and various, and, for this very reason timekeepers presumed to incorporate their own ideas and make changes and innovations, resulting in a bunch of data that required hours, and generally the personal attendance of the timekeepers, to work out.

Passing from the time sheets, Figs. 65 and 66, pay rolls, Fig. 67, and the cost record book, the next feature of the system of information or cost data consists of progress charts. These of course, will vary with any job according to the character of same, and, as they are used by nearly every large construction company, it will only be necessary to say that blue prints are prepared (generally blue line prints) upon which the timekeeper is able to color in the work completed each day of the week, marking dates thereon and turning such charts into the office. These progress blue prints thus form a permanent record of the progress of the work and also form the basis for the determination of the amount of work accomplished from time to time.

In connection with these progress charts, however, Mr. Moore has a unique summary progress chart upon which is carried forward and maintained a continuous record of the job, the information being obtained from the summary report of the time sheet. One of these summary progress charts is shown by Fig. 68. The essential idea of this summary progress chart is to have at all times a condensed, complete history of the work, not so much with reference to the detail unit cost of each item of work, but more especially with reference to a comparison between the estimated total cost and the actual total cost. This comparison allows an intelligent idea to be made of the portion of the work done, and indicates at once whether the actual cost is less than the estimated cost or exceeds it. The general form of this summary sheet is a standard, but of course will vary with each job as to the number of items making up the complete contract. Referring to Fig. 68, the chart illustrated is being used in connection with a sewer contract, and a brief description will be given of the manner of the use of this chart. In this case, the sheet is ruled so as to cover two classes of work only; namely, excavation and concrete. Under each one of these

FREIGHT AND CAR REPORT

Car		Loading		Received		Unloaded	
Initial	Number	Kind	Amount	Place	Date	Place	Date

EXPENSE

Name	Items	Amount	

CEMENT USED (BAGS)

Dates	Where Used					
Total						

REPORT OF WORK. JOB NO..............FROM..............TO.........

SEC........ Item	Previous Report			This Period			Total to Date.		
	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost
Excavation, cu. yds.									
Sheeting, lin. ft.									
Back Fill, cu. yds									
Surplus, cu. yds.									
Centers, lin. ft.									
Concrete, cu. yds.									
Pipe Lay, lin. ft.									
C. Basins, No.									
C. B. Con., lin. ft.									
House. lin. ft.									

Signed

INSTRUCTIONS.

It is intended that this sheet shall be used for all jobs, whether timekeeper makes report to pay-roll clerk daily, weekly, or monthly, and is to be used also for making summary reports. In using this time sheet side, always place date at head of column, and when marking out summary sheet place daily dates in the name column. In using the distribution side, the column marked "Timekeeper's check column" must have dates placed at the head corresponding to the time sheet side, and each column represents one day, the distribution being taken four times per day and marked inside of the four little squares, using distribution letter. However, for daily sheets, each vertical column represents one hour, and separation of time must be checked to the hour. Distribution columns will be headed by rubber stamp for each job and each man's time must be distributed under the proper columns and the totals reduced to dollars and shown at the foot of sheet, except that for summary sheets, total for each day will show opposite same. Timekeepers and engineers will co-operate to insure that summary sheets are correct as to time distribution and amount of work done. Daily time sheets must be turned in to the office at the close of each day; weekly time sheets each Thursday evening, and bi-monthly or monthly sheets will be separated and turned in at least once each week. No change of rate of pay will be allowed between pay-roll periods.

No deviation from these instructions will be allowed on any job.

Fig. 66.—Back of Time Sheet (See p. 168).

headings, the first column is a percentage column. In using the sheet, the length of the section is platted in the column marked length so that the complete length corresponds to the 100% line; the same is done with the estimated amount of cubic yards of material to be handled corresponding to such length. The estimated cost is then platted in dollars, the total, however, being made to correspond with the 50% line in the percentage column.

Now, as the work proceeds, the actual cost is platted on the same scale as the estimated cost and shows at all times the relative proportion. No matter what the total length of the job or the total length to be handled, if the scale upon which same is platted is so made that the length corresponds with the 100% line, the general manager is able to tell, at all times, just where any one section of the job stands. For instance, on the chart used for section A of the sewer, above mentioned, the 100% line equals in the length column 1,265 ft. = 3,186 cu. yards = an estimated cost of $733.00, the latter point being opposite the 50% line. Now, for instance, on the first day of August, the actual feet of sewer constructed was colored in the length column as about 610 ft.; immediately upon the percentage scale line, we see that this amounts to about 47%, and in the yardage column, this gives us 1,550 yards. Upon the estimated cost scale the amount to be expended for this amount of work was about $375.00. As an actual fact in the case mentioned, the actual cost to the date corresponded exactly to the amount of $375.00. At once, by casual observation, the general manager or superintendent is able to tell from very meager information just where the job stands. Given the length, the cubic yards and estimated cost for the section may be read off the chart and the actual cost compared. If the record is made in number of cubic yards, and so platted, the corresponding length may be read off. In either case, the percentage of completed work may be compared with the percentage representing the actual cost and in turn compared with the percentage indicating the estimated cost.

The chart is also of great value on any section, especially where the work is of a character that is continuous in its operation and continues in the repetition of certain units of work, in that the timekeepers or superintendening engineers can read directly from the chart the data necessary to complete the report of work done on the reverse side of the time sheet.

THE MOORE-MANSFIELD CONSTRUCTION CO.
INDIANAPOLIS
PAYROLL

From....190.. To............190..

Contract No. (........)..........................At........................
(Contracting party) (Location)

(......) Gang No. (....) At.. ..)
We hereby acknowledge receipt of the amounts set opposite our names as payment in full of all claims to date.

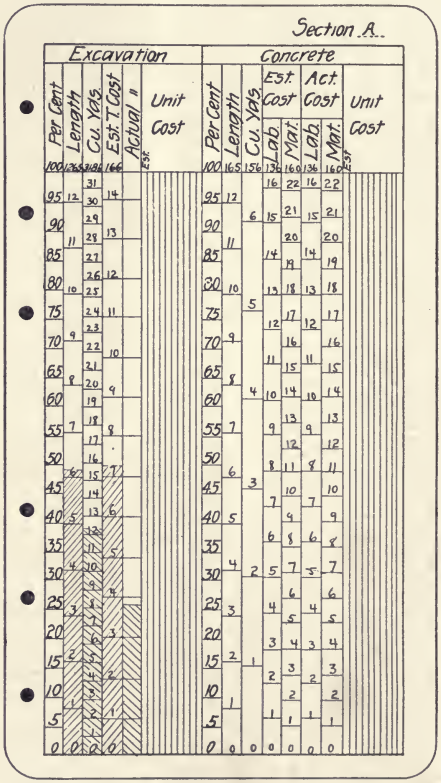
No.	Man's No.	Names	1	2	3	4	5	6	24	25	26	27	28	29	30	31	Total Hours	Rate	Total Amount Pay roll	Deductions									Net Am't Due	Paymaster's Memora'dum of Method of Payment	No.
																				Co. Board	Co. Supplies		Cash Advances		Miscellaneous					
																					Item	Am't	In favor of	Am't	In favor of	Item	Am't			
1																														1
2																														2
3																														3
4																														4
5																														5
6																														6
7																														7
8																														8
22																														22
23																														23
24																														24
25																														25
26																														26
27																														27
28																														28
29																														29
30																														30
31																														31
		Totals																												

Correct .... Pay Roll Clerk.
Correct .... Supt. Const.
Approved .... Treasurer.
Paid........................190..
.... Paymaster.

Fig. 67.—Payroll (See p. 180).

In the particular chart shown, various lines were also drawn for unit cost, so that at various times during the progress of the work, the fluctuating unit cost might be readily compared. This, however, is not essential, and, in fact, it is but seldom used.

In connection with the particular sewer job referred to above, in as much as the sewer itself was of various sizes and



Eng.-Contr.

Fig. 68.—Progress Chart (See p. 180).

to be built under varying conditions, the general progress blue print was made as shown by Fig. 69. Attention is called to the fact that each individual size of the sewer or change of conditions is indicated as a section and all reports are made upon the basis of such sections. Where the general character of the work is the same, and the work is to be handled by the same methods, a letter is used as indicating a general division and numerals added to indicate the sub-sections.

The costs of work, however, and amounts of work accomplished are kept by sections and sub-sections, so that when the

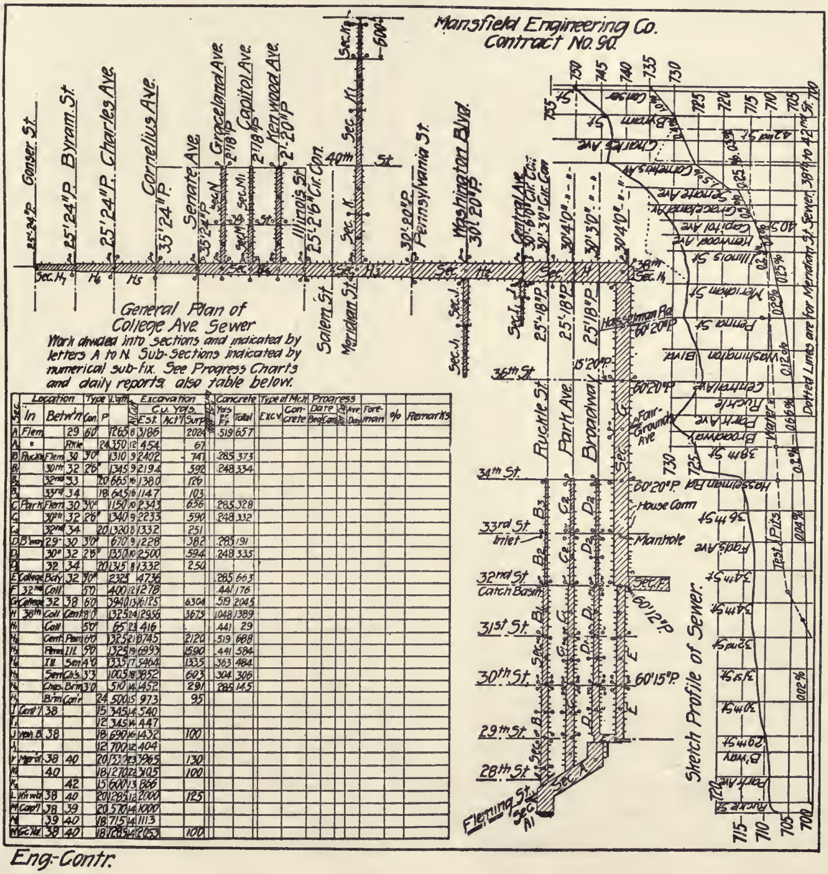


Fig. 69.—General Progress Blue Print.

job is completed the cost of each size sewer under the conditions met with can be readily determined. In the particular case mentioned, the principal item being excavation, concrete, or pipe, the summary progress charts as just described are kept only on these particular items of work, although the miscellaneous items of work always appear and are carried forward upon the time sheet distribution and reports of work done.

The particular contract referred to above consists of about seven miles of main sewer, of which four miles is all concrete construction, three miles of pipe work, and there are also some four miles of miscellaneous pipe work, making in the aggregate eleven miles. The same system of cost recording is being used at this time to keep in tab with the construction of bridge work, the construction of a boulevard, embankment work, and also for the construction of several reinforced concrete buildings.

FOREMAN'S DAILY PAY ROLL REPORT.

Location....*14th Avenue*....*No. 2*....*96" Sewer*..................Date,....*August 7, 1907*..............

Itemized Pay Roll.					Work Done.		Pay Roll Distributed.	
Foreman *1* days at	*4*	*00*	*4*	*00*	*General Night Watchman and Water Boy*........		*2*	*25*
Engineer *1* " "	*3*	*50*	*3*	*50*	Excavation completed to station	*18.40* Cost	*19*	*25*
Labor *1* " "	*3*	*00*	*3*	*00*	Sheeting " " "	*18.30*	*8*	*25*
" *27.4* " "	*1*	*75*	*47*	*95*	Foundation pl'nk " " "	*18.00*	*2*	*63*
" *11.8* " "	*1*	*50*	*17*	*70*	Backfilling " " "	*16.90*	*3*	*00*
" ...... " "	......	......	......	......	Sheeting Pulled " " "	*17.10*	*2*	*62*
Carts *1* " "	*3*	*00*	*3*	*00*	Concrete Invert " " "	....	......	......
Teams *2-10* " "	*6*	*00*	*1*	*20*	Brick Invert " " "	....	......	......
Hoister *1* " "	*2*	*00*	*2*	*00*	Concrete Sides } " " "	*17.48*	*29*	*62*
Water boy *1* " "		*75*		*75*	Concrete Roof } " " "	....	......	......
					Steel Bars set " " "	*17.48*	*3*	*50*
					Forms set to station	*17.48*	*7*	*25*
Total day's pay					Forms, Pipe laid to station		......	......
roll	......	......	*83*	*10*	Manholes built to-day		......	......
					Other items ....*Pump*			*53*
					Teams working ......*Cement*	*17.48*	*1*	*20*
					Carts working ....*Gravel*	*17.48*	*3*	*00*
					Total day's pay roll		*$83*	*10*
					Signed——*L.—W.*—— ....Foreman.			

Fig. 70.—Cost Keeping on Sewer Work—Blank for Daily Report of Foreman.

(The blank was $8\frac{1}{2}$ in. long by $5\frac{3}{4}$ ins. wide. In the reproduction words in *italics* and figures are shown to illustrate use of blank in a specific case.)

Cost Keeping on Sewer Work.*—Mr. Keith O. Guthrie has contributed an excellent article, which we reproduce here:

The report cards, Figs. 70 and 71, shown below were designed to gather detailed cost records from scattered sections without increasing the ordinary clerical force. They have been used on a large sewer contract in charge of the writer, producing records in handy shape for daily and semi-monthly comparison, easily compiled into compact totals for future reference. The entire extra expense of the working system has only amounted to the first cost of printing.

*Engineering-Contracting, Oct. 23, 1907.

It is common practice, and properly so, on cost reports to print the desired items of distribution and adhere to them throughout. Otherwise it is the tendency to increase the number of special items ad infinitum, making comparison difficult. However, on these reports, three extra lines were left to cover special conditions, such as pumping, laying sub-drain, etc., occur-

FOREMAN'S DAILY MATERIAL REPORT.

Location *14th Avenue No. 2 96″* Date, *August 7, 1907*

Full cement bags on hand last night		*84*
" " " received to-day		*160*
Total		*244*
Full cement used to-day on conc. invert		
" " " " " brick "		
" " " " " conc. sides }	*156*	
" " " " " " roof }		
" " " " " manholes		
" " " " " pointing up, etc.	*1*	*157*
Balance on hand to-night		*87*
Empty cement bags on hand last night		*7*
Full bags used to-day		*157*
Total		*164*
Empty bags sent in to-day		*140*
Empty bags balance on hand to-night		*24*

Materials received.	From.	Amounts.
		47—4 x 6—16-ft.
		12—4 x 6—14-ft.
Lumber	E.——— N.———	*1120′ ⅞″ roofers.*
Steel Bars	*Car No. P R R 7284*	*120—⅞—15* ft.
		120—¾—19-ft.
		75—⅝—30-ft.
Sheeting and bracing left in place	*None*	
	L.——— W.———	Foreman.

Fig. 71.—Cost Keeping on Sewer Work—Form for Foreman's Daily Material Report.

(The blank was *8* ins. high by *5* ins. wide. In the reproduction the words in *italics* and figures are shown to illustrate use of blank in a specific case.)

ring only on one or two sections. It is often difficult to secure, on daily reports, an accurate statement of the amount of work done. This is easily obtained on sewer work by referring everything to the stations or "grade-boards." This method obviates everything and the daily distances check up when totaled for any period of time. Indeterminate items, like teams, can be arbitrarily coupled with some suitable item, such as Excavation or Arch.

To get an accurate distribution of a payroll it is necessary, of course, to have the amount of the pay-roll. That the foreman may find this readily, and, in part as a reminder, the different classes of labor are tabulated on the left.

Toward the end of the day the foreman first jots down the stations of completed work, then from his time-card, having simply the check numbers, rates and hours worked, he draws off his day's pay-roll, finding it to be, as in the case taken, $83.10. He now distributes first the minor items, which is readily done from memory. For example, the Bracer and his three helpers worked on "Sheeting"; the two men on "Backfilling" car; the three who "Pulled Sheeting" for five hours; the two bending and setting "Steel Bars"; the two carpenters and one laborer on "Forms," and so on, until there is left only Excavation and Concreting. As a rule the men who have been in the ditch can be readily counted up, and Concrete Invert, or Arch, gets the balance of the pay-roll. The last item, of course, gets some of the odds and ends, but that is better and far safer as a basis for future estimating, than heaping them into a "Miscellaneous" item by themselves.

These reports are daily collected by the general timekeeper and checked up by him as to correctness of pay-roll amount. They can then be used for comparison between different sections, or between different days on the same section, without further tabulation. At the end of a half month it takes not more than an hour to foot up the totals of a section and post on the same card, which is then ready to file in a card cabinet as a permanent record.

The "Material" Report, Fig. 71, was gotten up to catch the elusive cement empties and to follow the quantities used on different parts of the sewer. By checking with the storekeeper's records, the loss of bags or waste materials can be learned soon enough to take advantage of it.

Cost Keeping Blanks for Building Construction.—We are indebted to the late Chas. J. Steffens of New York City for an excellent description of a simple system which is susceptible of wide application. It appeared in *Engineering-Contracting,* July 4, 1906, and is given below.

The Guarantee Construction Company use on their small contracts a form of report, illustrated herewith, Fig. 72, which,

DAILY REPORT

GUARANTEE CONSTRUCTION CO., NEW YORK

Job 765 Date 5/22/06

Number of Men	Earth Excavation	Rock-Excavation	Pumping	Concrete	Forms	Waterproofing	Brick Masonry	Stone Masonry		Heavy Timber Raising	Heavy Timber Framing	3-in. Flooring	2-in. Flooring	1-in. Flooring	Roof Sheathing	Sides and Partitions Heavy	Sides and Partitions Light	Heavy Studding	Light Studding	Doors and Windows and Trim	Machinery	Roofing	Painting	Hardware						Extra Work Stable	Extra Work	Extra Work	Foreman	Gen. Exp.	Repairs to Plant	Total Hours	Rate	Amount
16	55			95	10																															160	17½	28 00
18				40	20						80																			40						180	33⅓	60 00
2			20																																	20	25	5 00
1																																	10					4 00
Total	961		5 00	30 00	8 41						26 66																			13 33			4 00					9700 97 00 75
					25¢																			50¢													0 75	97 75
Cash Expenses of To-day					Twine																			Expansion Bolts												Total Expenses		

Weather Clear

NOTE.—Keep each kind of extra work separate.

APL Foreman.

Fig. 72.—Daily Time Report, Building Work.
(Actual size 6¼ ins. x 13 ins.)

while requiring but little time to prepare, yet supplies all the essential information for a detailed cost record. The report is of course sent to the office daily.

The first column gives the number of men, the same horizontal line being used for all men receiving the same rate per hour. Thus, in the report illustrated, there were 16 men at 17½ cents per hour, distributed as follows: Excavation, 55 hours; forms, 10 hours; concrete, 95 hours. The total hours at this rate are shown at the right of the sheet, namely, 160 hours; the rate, 17½ cents, making a total cost, for this rate of wages, of $28.00.

The men paid at other rates are entered in a similar manner and the vertical column of totals is footed up. The horizontal column for totals, near the bottom of the sheet, shows the cost for the day of the various parts of the work, as, for instance: Excavation, $9.61; concrete, $30; forms, $8.66; etc. This column is also footed up and the two footings made to check.

In the column of "Cash Expenses of To-day" appear all such items as carfare, etc., which the foreman pays himself. These are entered in the vertical column to which they are chargeable, as, for instance, in the case of twine secured for use in construction of the forms, the cost of twine appears under forms. These expenses are footed up and added to the total already found, giving the grand total as shown. Upon this daily report must appear all charges for which the foreman expects to receive payment on the fortnightly payroll.

When the report reaches the office it is immediately checked to ascertain if it is correct, and if so the proper entries are made on the daybooks under the contract covered by the report. Thus on Tuesday afternoon our books show the cost of each contract or of any particular item of a contract up to the end of Monday's work.

All material is ordered by the triplicate order system, by which three copies of each order are prepared, one being forwarded to the firm from whom the material is purchased, another sent to the foreman on the work, and the third retained for an office copy.

As soon as material is delivered on the job the foreman checks such material and if he finds it correct sends the copy of the order which he holds back to the office, marking it O. K. and giving the date on which material was received. When this returned copy reaches the office, the material covered by the order is at once charged against the contract under the proper distribution of forms, concrete, etc.

The books in which these cost records are kept are of the loose leaf type. A number of the pages are headed with the name and number of the contract and one page is allowed for each item of distribution and is headed forms, concrete, etc. Should more than one page be required for any item the additional sheets may be inserted at any time. The pages are ruled with a column at the left for the date, then a head space for the description of the order. Beyond this is a column for the order number and two columns, one for entry of cost of material and another for entry of labor cost. The manner of ruling these pages is shown above.

At the end of each month, or whenever desired, these columns may be footed up showing the cost up to the previous night on any item of distribution of any contract and subdividing such cost into material and labor. A monthly data sheet is prepared for each contract showing the estimated costs of the various items and the actual cost to date. At the completion of the contract another sheet is prepared showing the estimated costs and actual costs as well as the estimated unit prices and the actual unit costs.

In connection with these reports another form is used which is also illustrated herewith, Fig. 73. This has, as will be seen, spaces provided for reporting material received, material required, material which the foreman has found it necessary to order and such other information as he considers it advisable to communicate to the office.

The report blanks are furnished to the foremen in the form of pads with alternate sheets punched with small holes along the top close to the binding. These sheets are torn out and sent to the office, while the next sheet, on which a carbon copy of the report appears, remains in the book or pad for the foreman's record.

It has been found that the use of these reports with spaces provided for the above purposes will tend to call to mind the various matters when the foreman prepares his report in the

GUARANTEE CONSTRUCTION CO.
NEW YORK CITY

Job 765 Date 5/22/06

The following material received to-day: Bolts etc on order #1087 — Timber on order #1093
Cement on order #1081

Please order the following material: 1/3 doz 12 qt galv. pails. — 150 ft 3" dia. rope.

Please hurry material covered by requisition No. #1067 — #1069

I have ordered the following material to-day:

MATERIAL	CHARGE TO	NAME OF FIRM	PRICE	
3 kegs 10 d. wire nails	Hardware	Cronley Co.	2	30

Do not report on this sheet the purchase of any material you have paid for.

Remarks: Earth excavation will be completed tomorrow — Forms are all constructed and cost on this will in future be simply for moving from place to place

A.P.L. FOREMAN.

Fig. 73.—Material Report.
(Actual size 6¼ ins. x 13 ins.)

evening, and matters which otherwise would be forgotten are called to the attention of the office.

The Cost Keeping System of the Alberthaw Construction Co.*—The following is an abstract of an article by Mr. Leonard C. Wason, president of the Aberthaw Construction Co., of Boston.

In order to have an intelligent understanding of the meaning of the figures hereinafter given, the method of collecting data will be described. When making up an estimate of the cost of a building, in scaling the plans, it is found convenient to take off the volume of excavation and backfilling, the cubic feet of footings, foundation and wall, the square feet of forms for walls of foundations and above grade, the lineal feet of belt courses, moldings, cornices, etc., also the size of special features of exterior treatment. Similarly the superficial areas of column and floor forms are measured by themselves. Concrete of each different mixture is scaled off in cubic feet and totaled separately. Steel of each kind is taken off in pounds; granolithic finished surfaces in square feet, and so on in detail every item is measured. As the work progresses it is desired to know weekly how the actual experience compares with the estimate and at completion to compile correctly the costs of each item to compare with estimate and to aid in obtaining the true cost of future structures of a similar kind. The method of accounting was developed to fit the estimate.

In the year 1898 daily time reports were designed having a number of columns for ease in sub-dividing the time of the workmen. At the head of each column the timekeeper puts index numbers or letters to show the kind of work being done, and below, the actual time the men worked. On blank spaces at the extreme right of the report the timekeeper inserts in writing the amount of each kind of work done and the amounts of the principal materials used. The experience of eight years has required no change whatever in the principles first adopted. The only change in the forms has been to increase the number of vertical columns so that a larger number of sub-divisions can be used without troubling the timekeeper to re-write the names on another sheet. At the present time ten vertical columns (Fig. 74) are used for recording time, with the names of the

*Engineering-Contracting, Jan. 13, 1909, and March, 1906.

JOB No. 747 LOCATION, *Attleboro, Mass.* ALBERTHAW CONSTRUCTION CO., BOSTON

DATE, *Aug. 1, 1906.* DAILY REPORT

Name of Workman	Time *Ofs*	Time *Maef*	Time *Maew*	Time *Maec*	Time *Maof*	Time *Maow*	Time *Mef*	Time *Meaf*	Time *Ceak*	Time *Meaw*	Office Rate	Amt.		Put at head of proper column or against each name index of work performed.
1 *Closby* Foreman...	9½										30 00		5.28	State each kind of work done. Amount of Cem. and Materials used.
2 *MacIntire*........	9½										15.00		2.64	Weather
3 *Cook, John*.......	9½										.41		3 89	Temperature: 7 A. M.
4 *Angwine*..........			5				4½				.37½	*Maef*	19.38	1 P. M
5 *Blanchard*........		7	2								37½	*Maew*	49.43	5 P. M.
6 *Cameron*.........			9								.28	*Maec*	3.11	
7 *Clough*..		7		2							37½	*Maof*	3 27	
8 *Cook, James*... ..		4				5					.41	*Maow*	9.03	
9 *Dunne*......					3	6					.37½	*Mef*	11.41	
10 *Dupont*...		5	4								.37½	*Meaf*	12.34	
11 *Emmons*..			5				4				.37½	*Ceak*	3.88	*Ceak—Motor Shaft.*
12 *King*.			9								.37½	*Muaw*	3.61	
13 *Lambert*... ...			4			5					37½	*Meaw*	2.75	
14 *Leminx*.... ...					3	1			5		25	*Water-boy*	.50	*Meaf 630 c. f.*
15 *Lovejoy*....											37½		130.42	*Meaw 46 " (46" th)*
16 *O'Connell*..... ..		6	9	3							.37½			*" 11.6 " (10 ")*
17 *O'Hara*.		6		3							.41			*" 21 " (21 ")*
18 *Parrus*		9									.28			
19 *Peterson*....			9								34			*140 bags cement used.*
20 *Proulx*.....			9								.37½			
21 *Robarge*..		9									37½			
22 *Sanford*....			2								.37½			
23 *Spittle*..			9								37½			
24 *Steeves*:			7							2	.37½			
25 *Turnbull*.. . .			2						7		.37½			
26 *Valignette*.. ..			8								.37½			
27 *Riley*.							9		*Muaw*		.28			
28 *Phelan*..									9½		.25			
29 *Martin*....			3			6					.20			
30 *Johnson*...			9								.20			
31 *Spenser*.			5				2	2			.20			
32 *Lawson*.								9½			25			
32 *Geaudaux*. ...								4½	5		.22½			
34 *Russ*..........	*Waterboy* 9										.05⅝			
35 71... ...			5					4½			.23			
36 651......			5					4½			.20			
37 652......			5				1½	3			.20			
38 653.....			5				2	2½			.20			
39 676....						7	2½				.20			
40 677... ...			5				4½				.20			
41 678...					5		4½				.20			
42 681.... ..							4½			5	.20			
43 682....			5				4½				20			
44 684....			5					4½			20			
45 685...			5					4½			.20			
46 688....... ..			5					4½			.20			
47 690....... ...			5		2		2½				20			
48 692...			5					4½			.20			
49 696..........			5					4½			.20			
50 697........... ..								4		5	.20			
Work performed.														Approved

Fig. 74.—Daily Time Report.

workmen at the extreme left, two columns being left at the right for the rate per hour and the total amount. At the beginning of a job written instructions are given as to how the work is to be subdivided into items in the reports. A standard method of classification has been adopted as follows:

The principal sub-divisions are given a capital letter. Thus, everything whatsoever relating to concrete masonry is given the index letter *M;* excavating of all kinds, including work incidental thereto, the letter *D;* all work connected with plant the letter *P,* and so on, there being only six or seven sub-divisions to indicate every building operation. To indicate the kind of work vowels are used. Thus, the vowels beginning with *a* all relate to form work, as: *a,* centering complete; when done by separate operations *aa* is making, *ae* is setting, *ai* is straightening up or bracing, *ao* removing after being used, and *au* cleaning up and handling ready to be used again. All labor connected with mixing and placing concrete or with handling materials for same goes under the head of *e;* all work in connection with plant, receiving, erecting, taking down, shipping and repairing, is indicated by the vowel *i.* Thus *i* means receiving and setting up plant ready to work, *ia* taking down, removing and shipping, and *ie* repairing. The consonants are used to indicate different parts of a structure in which certain work is done. Under classification *M, b* stands for footings, *c* columns, *d* foundations, *f* floors, *g* stairs, etc. Under classification *P, f* stands for boiler, *g* for horizontal engine, *h* for vertical hoisting engine, *l* for elevator, *m* for mixer, etc. Thus our timekeeper places at the head of a column when he is reporting concrete floors, for the placing of forms *Maaf,* for concrete *Meaf.* If a mixer is being set up ready to work the report would read *Pim* and later if it was repaired it would be reported under *Piem.*

This is not so complicated to use as it may appear to read, and experience has proved that every man who knows enough to keep time can use the system with a few days' experience. The principle is to make the least amount of clerical work to the timekeepers on the job, as they have plenty of other work to do. In addition to sub-division of time as above set forth, it is the duty of the timekeeper to report the number of barrels of cement mixed in a day, which is usually done by the man in charge of the mixer counting the empty bags, and in addition the actual volume of concrete measured in place. From this, knowing the proportions, it is a very simple matter to obtain the amount of sand and stone used and also to see if the right amount of cement is being used.

Carpenter work on forms is reported by the number of square feet of surface in contact with the concrete erected. Thus walls are measured two sides without deducting doors and windows, as it is usual to let the form work run straight across these unless it is impossible on account of mouldings, in which case the framing of the opening will cost as much as the form work omitted. Beam floors are measured around the perimeter of the beam and the flat surface of the panel and around the perimeter of girders. No deduction is made for the loss of area by the intersection of beams and girders, and small openings in the floor are not deducted. Anything as large as an elevator or stairway is usually deducted. Form work for columns is measured for entire area of surface contact between wood and cement, all four sides.

These reports are made out on the job daily and sent to the office. The bookkeeper works these reports up into units of measurement, as cost of labor per cubic foot of concrete and number of cubic feet of concrete per barrel of cement, number of square feet of form work erected, etc., and from this it is easy to obtain the unit costs hereinafter given. The bookkeeper can take the reports of four or five jobs, employing in the aggregate 500 or 600 men, and in a single day work up the complete report for a week's time; thus it will be seen that there is really little extra labor involved in the subdividing of reports into a useful form over merely reporting the time so that the payroll can be accurately made.

The system employed has appeared of sufficient value to others to warrant its being briefly outlined in Gillette's "Hand Book of Cost Data," pages 14, 15, and 19, and a description of it also appeared in *Engineering-Contracting* of March, 1906.

Materials received on the job are reported on cards especially printed for the purpose, listing the principal materials which are reported, in order to save work of the timekeeper in reporting materials accurately.

When a job is entirely completed and the ledger account is closed, a master card is worked out giving the complete history of the cost. On one side of the card are written the items which went into the original estimate, such as excavation, backfilling, footings, foundations, columns, floors, walls, stairs, etc., etc. In parallel columns are placed the actual amount of the estimate with the actual experience, reduced to cost units, such as cubic feet, square feet of form work, etc., and the percentage of profit or loss between the estimate and actual results. On the reverse side of the card the principal items are worked out more in detail. Thus form work is reduced to cost of labor, lumber and nails, wire or other sundries used in the forms per square foot of surface. Concrete is itemized into the superintendent's general labor, labor of mixing and placing, cost of cement, sand, stone; miscellaneous expenses such as teaming, plant and other general items, reduced to cubic feet measurement, which makes the total cost of the concrete in place in each division of the building itemized for ready reference when making up future estimates on work of a similar character. An example of this form is given by Fig. 75.

It is well known that the costs of materials and labor in different parts of the country vary somewhat. Having the unit

Job No. 747.
Date May 24th, 1906. Mill, Tappan Bros., Attleboro, Mass.

	Proposal.	Actual Cost.	Per. Cu. Ft.	Profit.	Loss.	Per Ct.
Total	$35,164.55	$31,330.48	......	$3,834.07	$.......	11
Excavate	790.00	823.18	.021	....	33.18	..
Footings and Fr.	1,738.00	1,033.57	.137	704.43	....	..
			Per sq. ft.			
Exterior walls	1,955.00	2,162.02	.190	....	207.02	..
Wall and Fr. centers	1,520.00	3,630.08	.125	....	2,110.08	..
Floors, 6⅜" thick	8,883.00	6,542.16	.339	2,338.84	....	..
Roof 5¼" thick	2,869.00	1,713.51	.237	1,155.49	....	..
			Per l. ft.			
Columns, 20x20"	832.00	676.65	1.470	155.35	....	..
Stairs	883.00	910.35	.912	....	27.35	..
			Per sq. ft.			
Tool surface	469.00	636.53	.056	....	167.53	..
Ornaments and cornice	348.00	164.33	....	183.67	....	..
Ventilators on roof	44.00	35.64	....	8.36	....	..
			Each.			
Set windows and door frames	852.00	729.99	2.19	122.01	....	..
			Per sq. ft.			
Interior partitions	1,770.25	1,656.35	.189	133.90	....	..
Bolts and iron work	253.00	257.06	....	....	4.06	..
Stair railing and grill	387.00	654.00	....	....	267.00	..
			Per M.			
Screens and setting	1,086.00	835.12	52.17	250.88	....	..
2" Spr. plank and laying	2,839.00	1,431.69	33.30	1,407.31	....	..
7-8" Maple plank and laying	1,738.00	1,788.88	89.44	....	50.88	..
Motor shaft	379.50	533.19	98.89	....	153.69	..
Motor shaft found	98.00	70.07	.....	27.93	153.69	..
Roofing and conductors	1,255.00	1,026.06	.....	288.94	....	..
			Per sq. ft.			
Paving	1,009.00	647.54	.094	361.46	....	..
Retaining wall—						
Centers, per sq. ft.	....	......	.211	....	....	..
Concrete, per cu. ft.	429.00	316.90	.175	112.10	....	..
Painting	400.00	375.00	....	25.00	....	..
Steel footings and walls	300.00	218.91	....	81.09	....	..
Plant frt., etc	1,860.00	2,271.73	....	....	411.73	..
Bond	100.00	120.00	....	....	20.00	..
Extras	77.80	67.97	....	9.83	....	..

Fig. 75.—Master Card Giving Summary of Cost.

items all sub-divided, as above stated, into their elementary parts. it is an easy matter after determining the cost of materials in any locality to make the exact corrections to the results obtained on a previous job. Similarly, when a difference in the rate per hour for wages is known, if the same efficiency is obtained from the men it is very easy to make a correction, or if the efficiency varies, judgment must be applied to determine the correct rate to use. It has been the writer's experience that although the rate of wages and cost of materials vary somewhat in different parts of the country, the variations frequently offset one another so nearly that the sum total of the unit cost obtained in one place may be used in another, very seldom needing correction. For instance, within one month, after careful investigation, a bid was made up on a structure at San Juan, Porto Rico, using the same unit costs as for a building in Boston.

The following appeared originally in *Engineering-Contracting,* March, 1906:

We give here a full set of the record blanks used by the Aberthaw Construction Co., of Boston, builders of the Harvard "Stadium" and other reinforced concrete structures.

The Aberthaw Construction Co. requires its foremen to make daily reports on cards. The foreman has a time-book (printed especially for the Aberthaw Construction Co.), week ending Thursdays, leaving additional space sub-divided. This time-book is his original record, which he copies on the daily report card. The foreman does not enter the rate of wages on the card; that is done in the office, the idea being to keep the clerical work of the foreman down to an absolute minimum. On large jobs the time-book is kept by a time-keeper; but with less than 20 men the foreman keeps the time.

The standard size of report card is 4 x 6 ins. These cards are printed on heavy paper, which weighs about 160 lbs. to the ream of 500 sheets, each sheet measuring 25 x 38 ins. Cards of different colors are used to assist in rapid and certain classification. For example, the daily report cards, Fig. 76, are printed on yellow stock and on green stock. The yellow cards are used for the regular contract work, and the green cards for extra work. All the reproductions of the cards shown herewith are three-quarters the actual size.

The blank is printed on the back of the card just as on the front, except that the Job No., Location, Date, etc., are not repeated. Hence on the face and back of the card there is room for the names of 27 men. It will be noted that this particular day's record related to concrete work, namely the building of a reinforced concrete fence. The number of bags of cement used in each class of work is recorded, opposite the corresponding number of "beams," "bases," "shafts," etc. On the back of the card is given the "Index" letter for each class of concrete work. For example, we see that the "Index" for "beams" is *BE.* We see, on the front of the card, that workman No. 3 worked 9 *BE,* that is, 9 hrs., on beams. We also see that he was a carpenter, for his time is entered in the column for carpenters. We see that he was paid 30 cts. an hour. In the column headed Am't., is given a summary of the labor cost of all the carpenter work done on "beams" *(BE),* "shafts" *(S),* "bases" *(BA),* etc. In the similar column on the back of the card is the summary of all day labor cost of the beams, shafts, etc.

In many kinds of contract work there is a certain amount of general work, which cannot be charged directly against any one item. This general work is given the Index letter *G.* There is often a certain amount of lost time, due to break-downs of plant, delay in receiving materials, etc., which it is well to charge against an item called Delays, indexed *D.* In this particular work of concreting on Soldiers' Field no such item is provided for, because the work was of such a character and so handled that delays were too brief to be worth recording. However, a contractor should always require his foreman to keep a record of every important delay, and assign a cause for it. This can be done very nicely by using index letters; thus, *DM* would indicate a delay waiting for materials; *DB* would indicate a delay due to a breakdown of some part of the plant; and so on. If a breakdown were to delay certain men in their work for an hour, then opposite their names would appear 1 *DB,* and 8 *BE,* for example.

Regarding the record of the quantity of work done each day, there is always a possibility of error. To reduce this error, the Aberthaw Construction Co. requires a supplementary report every Thursday, showing the total work of the week, and the condition of the job. In this way errors of estimated progress tend to balance up.

The foreman does not do the computing necessary to fill in the columns in Fig. 76 headed "Am't." This is done by the office force. All the foreman is required to do is to record the hours worked by each man, the class of work done by each man, the amount of cement used in each class of work, and the like. The office accountant knows just how many cubic feet or cubic yards of concrete are contained in each beam, each base, each shaft, etc.; and can compute the amount of work done by simple multiplication.

Job No. 370 Location Soldiers Field ABERTHAW CONSTRUCTION CO., BOSTON.
Date Sept. 20 1900 Daily Report

Name of Workman	Time Carp.	Time	Time Concrete	Time	Time	Rate	Am't	Put at head of proper column or against each name index of work performed.	
1 Thorne Foreman				10			\$4.07	State each kind of work done. Amount of Cem. and Glass used.	
2 Henderson		3^{C}	6^{C}			0.30	C 0.90	Weather	
3 Jack		9^{BE}				"	BE {6.30 2.00	Temperature	
4 Finnion	9^{S}					"	S {5.40	Put in	Cement
5 Dunn	9^{F}					"	2.52	2 beams	18 bags
6 Davis		9^{BE}				2.00	BA {5.40 2.52	8 bases	15 "
7 Deboy		3^{BE}	6^{S}			0.30	2.70	2 Pile caps	9 "
8 Glover	9^{S}					0.28	F {2.00 3.30	55 ft. shaft	26 "
9 Sullivan		9^{BE}				0.30	C 1.80	6 shaft caps	6 "
10 McDonald		9^{BA}				0.28	1.33	Picked 3 bases	39□'
11 Monroe		9^{BA}				0.30	S {1.80 2.25	" Shaft	414□'
12 Murphy			9^{S}			0.25	4.00 4.80		
13 O'Leary			9^{S}			0.20	53.09	Approved	

LAWMAN & ERBE MFG. CO., ROCHESTER, N. Y.

Front of Daily Report.

Name of Workman	Time Carp.	Time	Time Concrete	Time	Time	Rate	Am't	Remarks	
14 Phelan			9^{S}			2.00	53.09 2.77	Work	Index
15 Ring				Clean S 9		1.65	PC 1.28	Beams	BE
16 McCue			9^{F}			"	BE {2.87 3.00	Bases	BA
17 Charly			10^{PC}			2.50		Shaft	S
18 Mahoney			4^{PC}	5^{E}	Pump 1	1.65	BA {2.11 5.70	Cap	C
19							0.22	Pile Caps	PC
20 P. McCarthy				10^{E}		2.00	PA {3.60 3.30	Foundations	F
21 Burgess			9^{F}			2.00	E {4.44 6.05	Picking Pace	PA
22 Laughlin			9^{F}			1.65	Fill in {3.20 3.30	Excavate	E
23 Carley			Plaster 9			1.65	Clean S 1.65	General	G
24 No. 10			$10\frac{1}{2}^{BE}$			0.25	Ver pick 1.28		
25 " 98			6^{C}	1^{PA}	2^{G}	2.00	Plaster {2.00 1.20 1.65		
26 " 12			$9\frac{1}{2}^{BA}$			2.00	G {45 40		
27 " 13			$9\frac{1}{2}^{BA}$			0.20	3.45 107.51		

Fig. 76.—Back of Daily Report.

To quote from a letter by Mr. Leonard C. Wason, president and manager, Aberthaw Construction Co.:

"All the figuring up of pay-rolls and summarizing of the weekly summaries is done by the office force, which takes two men about one day, and the book-keeper a second day, each week, for all the work we have running. We have two comptometers for mechanical figuring, which saves vastly in the time

Job No. 370 WEEKLY SUMMARY Location Soldiers Field Fence.

From September 14, 1900 to Sept. 20, 1900

DATE	Fore.	CARP. Shaft	BE	BA	F	S	CONCRETE BE	C	BA	PC	F	PA	Etc.	G
Sept. 14	$3.67	7.92	7.40	7.92	5.16	16.15	8.43		5.80	4.70	9.55	7.05	17.74	12.08
" 15	3.67	5.22	9.20	7.92	6.78	16.15	11.50	5.22	5.02	5.62	7.20	5.25	12.15	14.95
" 17	4.07	7.92	15.50	5.22	7.19	12.05	8.90		2.00	7.63	9.55	4.65	13.81	14.65
" 18	2.85											0.55		1.48
" 19	4.08	5.22	12.80	5.22	8.00	9.85	8.55	5.15	5.34	4.25	3.02	5.80	14.21	13.50
" 20	4.07	8.82	8.30	7.92	8.00	12.85	5.87	3.13	7.81	4.05		7.12	16.99	12.58
	22.41	35.10	53.20	34.20	35.13	67.05	43.25	13.50	25.97	26.25	29.32	30.42	74.90	69.24

Kind of Work	Fore	Amt. Performed	Labor Cost per Unit.	Cement Used	
Shaft	7.40	244 lin. ft	$0.168	29 bbls	15 ft. per bbl.
Beams	4.71	20	2.40	45¾ "	2.29 bbls per Beam
Caps	1.34	24	0.62	6 "	0.25 " " Cap
Bases	2.91	35	0.825	15 "	0.43 " " Bases
Pile Caps	2.91	10	2.916	11½ "	1.15 " " Pile cap
Foundation	3.14	7	4.67	13½ "	1.93 " " foundation
PA		24.74 □'	0.015		

YAWMAN & ERBE MFG. CO., ROCHESTER AND BOSTON 26224Q 1M-2'06

Fig. 77.—Weekly Summary.

and energy of the clerical force. The item of cost of keeping these records is so infinitesimal that we have never attempted to separate it from the general office expenses."

The office force makes a weekly summary, compiled from the daily report cards. An example of such a summary is shown in Fig 77, which is printed on a white card. This particular weekly summary gives the cost, in dollars and cents, of shafts, beams, bases, etc.

Figure 76 gives the time and cost of work done Sept. 20, and it will be noted that the carpenter work on beams *(BE)* cost \$6.30 plus \$2.00, or \$8.30; this \$8.30 is entered in the weekly summary, opposite Sept. 20 and in the column headed *BE*. In

Job No. 370
Date June 30, 1900 Fence Soldiers Field.

			Proposal		Actual Cost		per Unit	Result Profit		Loss		%
Total			27815									
Excavating			1115		883	26	c.f. .016	231	74			
Piles			1188									
Pile Caps			1351									
Foundations			2378									
Bases			1699									
Shaft			4038									
Beams			6896									
Caps			367									
Caps of Gate Posts			75									
Iron Railing			8708									

Front of Master Card.

Beams

	Cost	per beam		1900		
Carpenter	368.90	1.91	Work begun	7	9	194 Posts
Foreman	47.04	0.24	" finished	10	31	193 Beams
Concrete	448.26	2.32				
Picking	148.30	0.77				347 Piles
General	130.27	0.68				
Timekeeper	22.23	0.12				55,872 c.f. Exc.
Cleaning	34.88	0.18				
Plastering	110.53	0.57				1455 lin. ft. Shaft
Cement	907.83	4.70				
Agg.	479.38	2.48				
Steel	439.98	2.28				
Lumber	209.53	1.09				
Team & Lunches	291.55	1.51				
Profit						
		18.85				
			Other Parts of work are figured in same manner			

Fig. 78.—Back of Master Card.

like manner all other summaries are entered in their respective columns, as shown in Fig. 77. The second column of this blank, headed "Fore," contains the daily wages paid to the foreman. The lower half of the card is devoted to a summary of the total number of units of work done and the labor cost per unit, exclusive of the carpenter labor, but inclusive of the foreman's wages. For example, the total labor cost of beams *(BE)* for the week was $43.25, and the percentage of the foreman's wages charged to beams is $4.71, making a total of $47.96, or prac-

Job No. MATERIALS RECEIVED ABERTHAW CONRTRUCTION CO., BOSTON.

Date 190 Foreman

SIZE OR BRAND	FROM WHOM RECEIVED	SIZE OR BRAND	FROM WHOM RECEIVED
bbls.	Cement	bbls.	Glass
bags	"	bars	Steel
lds.	Gravel	"	"
"	Sand	"	"
"	Screenings	"	"
lbs.	Cr. Stone	lbs.	Lampblack
"	"	"	Oakum
lds.	N. Sand	"	Nails
"	Ipswich Sand		
ft.	Lumber		

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y. 45006

Fig. 79.—Daily Material Report.

tically $48, exclusive of carpenter's labor. Now, there were 20 beams built during the week, so that the labor cost was $48 divided by 20, which is $2.40 per beam. It will be seen that 45¾ bbls. of cement were used in making these 20 beams, or 2.29 bbls. per beam.

We have seen how the daily report card is filled in, and how the weekly report is made up in the office from the daily reports. We now come to the final report card, or the "master card of costs," as shown in Fig. 78. This card is printed on white stock, and its face and back are ruled as shown. The proposal

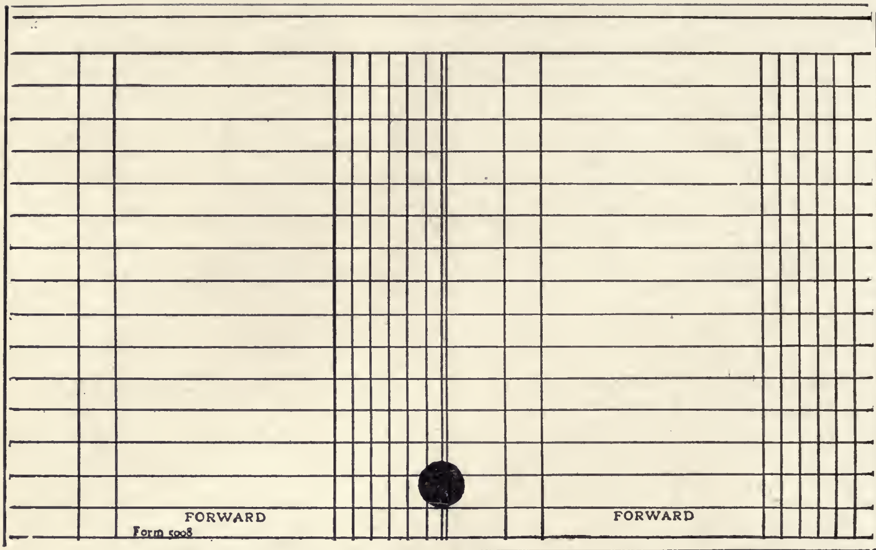


Fig. 80.—Front of Loose Leaf Ledger Card.

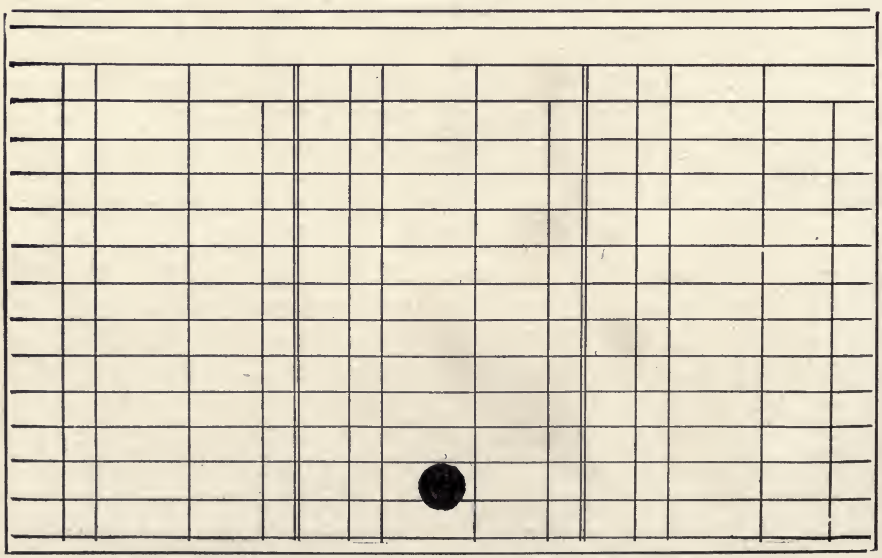


Fig. 81.—Back of Loose Leaf Ledger Card.

price, the actual cost, and the profit or loss on each item, as well as on the total work, are entered on the face. Then, on the backs of these cards, are entered the itemized unit costs, as illustrated.

It will be noted that all the cards are provided with a small circular hole in the lower center of the card. This is for filing the cards in the standard filing cases.

Fig. 79 is the daily report made by the foreman, showing what materials have been received during the day, and

ABERTHAW CONSTRUCTION CO., BOSTON.

EXPENSE ACCOUNT WEEK ENDING

Name				Name			
Day	Item	Amt.	Job	Day	Item	Amt.	Job

Approved

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y.

Fig. 82.—Expense Account Report.

what materials have been shipped away. On the front face of this card, as shown, are entered the quantities of different materials received. On the back face of this blank the entries are made of materials shipped away. This card is printed on blue stock for the regular contract work, and on green stock for extra work.

Even the ledger accounts are kept on cards, the cards for this purpose being Figs. 80 and 81. They are printed on white stock, and each card is printed on both front and back faces.

Fig. 82 gives the expense account of each foreman or other employee who incurs expenses in behalf of the company. This

Pay Order

ABERTHAW CONSTRUCTION CO.
7 Exchange Place, Boston, Room 52

Scratch out one { Original / Duplicate

Date The bearer

is entitled to dollars ($ 00)

in full payment for wages and expenses as per statement below.

Foreman.

Date	F	S	M	T	W	T	Total	Rate	Amount
Job No.									
Time									
Expenses									

Foreman will give every man discharged an order which will be cashed after Friday noon.

Mail duplicate to office immediately.

LIBRARY BUREAU A 46960A

Fig. 83.—Pay Order.

INFORMATION WANTED. **ABERTHAW CONST. CO., BOSTON**

Note Reply to the following inquiry on this card at the earliest possible moment and return to the writer. The writer will keep a carbon copy.

Date Mr. Re

Signed

Date Answer

Signed

LIBRARY BUREAU A46960

Fig. 84.—Information Wanted.

blank is printed on the front face only, and on salmon-colored stock.

Fig. 83 is a "pay order" card, and is printed on the front face only, on white stock.

Fig. 84 is an "information wanted" card, and a carbon copy is kept by the man who fills out this card. This carbon copy is printed on thin paper, alternate leaves of the "information wanted" pad being printed on thin paper, so that a piece of carbon paper can be slipped between the thin paper

Pattern No.	**Order No.**	**Cast Stone**	**ABERTHAW CONSTRUCTION CO., BOSTON.**	
Article		**Date**	**Volume**	**Cu. Ft.**
Remarks				

YAWMAN & ERBE MFG. CO., ROCHESTER, N. Y. 117419

Fig. 85.—Cast Stone Record.

and the card paper, thus giving a duplicate of all pencil writing. During the busy season the office force is out at different times, and the men may not meet one another for several days. These "information wanted" cards are then very useful. The carbon copy saves the need of remembering the question asked, and is used as a follow up if the reply is slow in coming.

We may note, in passing, that the use of carbon copies is becoming much more common than it once was. It not only saves the labor of copying a record, but in case of the loss of a record in the mails, or otherwise, the carbon copy is available.

Quotation Subject

7 Exchange Pl., Boston. Mass.

Messrs.

Dear Sirs :- Please quote hereon your lowest price f. o. b.
for the goods mentioned below and ***return this card to us*** and oblige,

Yours truly

ABERTHAW CONSTRUCTION CO

Per

Quantity	Article	List	Quotation
		Sign here	

Fig. 86.—Price Quotation.

In many instances it is wise to keep all records in triplicate. This is easily done by having two thin sheets to each thick sheet, two pieces of carbon paper being used when filling in the blank.

Fig. 85 is an example of a triplicate record blank. One copy is kept at the shop, and the other two at the office. One of the office records is filed by serial number, and the other is filed by the subject of which the cost has been itemized.

When it is desired to secure a quotation on materials, machines or products of any kind, Fig. 86 is used. A carbon

PRICE. LIST

Article

Date	Firm's Name		Price	Terms	Remarks

LIBRARY BUREAU. 77437

Fig. 87.—Record of Prices Quoted.

copy of this card is kept so that a firm which is slow in replying can be promptly followed up. This card is printed on blue stock, one side only.

Fig. 87 is used for recording quotations on the same article as given by different firms. It is printed on salmon-colored stock, one side only.

A record is kept of every telephone message and every call message; separate sheets 4 x 5½ ins. being used to record

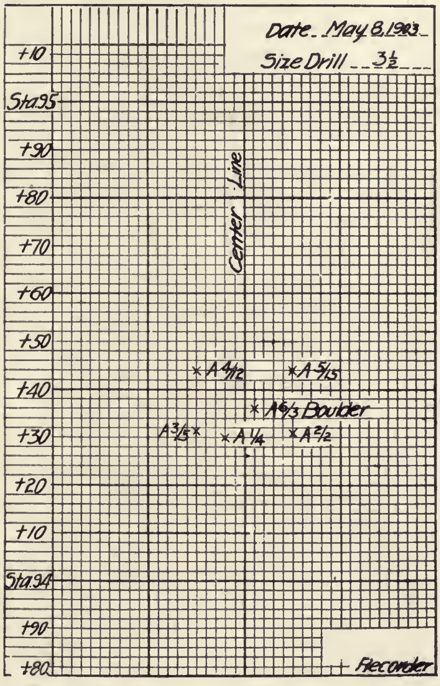


Fig. 88.—Chart For Recording Location of Drill Holes.

each message, giving time of day, name, telephone number, and message.

To many contractors of the old school, who have trained themselves to carry most of their business knowledge under their hats, it may seem that any system of recording facts and figures on cards or blanks is largely a waste of time. With this opinion we cannot agree. The very marked success of such firms as the Aberthaw Construction Co. is ascribed by their own officials as being due largely to the completeness of their cost keeping system. Mr. Leonard C. Wason, M. Am. Soc. C. E., the president of the Aberthaw Construction Co., has given us several specific examples of "leaks" discovered by virtue of his daily report records. Then, too, every employee feels that with such a system of daily reports, his output is bound to come under the eyes of the head of the firm. Each employee feels, consequently, that not only will laziness and inefficiency be discovered, but that merit will also be recognized and ultimately rewarded.

Cost Keeping on Rock Drill Work.—We give below some sample charts from *Engineering-Contracting,* Oct. 23, 1907, to be used in connection with the record cards to be found elsewhere in this book.

The charts show the location of the drill holes and the key letter that identifies the man who drilled them, as well as the depth of the hole in feet.

Two kinds of charts are shown, each adapted for a different class of work. Fig. 88 shows a chart for use on railroads, canals and other engineering work that is laid out with a center line as a base for measurements. The ruling is the same as that for ordinary cross-section paper, used by engineers, each square representing a measurement of 2 ft. each way. Any one wishing to adopt this form can have it printed or can buy cross-section paper and make his own forms.

A word of explanation will show how this chart is used in connection with the form for recording explosives shown in Fig. 89. The work is being done on a new grade of a railroad in a cut that runs from Sta. 92 to Sta. 98, 600 ft. long. A stripping of 3 or 4 ft. of earth has been taken from the top of the cut by scrapers, leaving exposed a ledge of rock 12 to 15 ft. deep to sub-grade, shown in cross section taken at Sta. 95 + 50 in Fig. 90.

The two short vertical lines in Fig. 90 running through the ground surface show the position of slope stakes set by the engineer. On these stakes are marked the cutting and the station number. Some engineers also mark on the stake the distance out from the center. If this is not done the contractor should have some one do so. With this distance known it will always be possible to locate the center line, by measuring out from

RECORD OF EXPLOSIVES USED May 8, 1903.

From Sta. No. 94+30 to Sta. No. 94+50. In Cut No. 95.

Hole No.	Depth Ft.	Springing: Dynamite Lbs.	Springing: Powder Lbs.	Springing: Judson Lbs.	Springing: Caps or Fuses	Springing: Fuse Ft.	Blasting: Dynamite Lbs.	Blasting: Powder Lbs.	Blasting: Judson Lbs.	Blasting: Caps or Fuses	Blasting: Fuse Ft.	Cu. Yds Moved
A-1	4	1			1	5	8			1	5	
A-2	2						4			1	3	
A-3	5	3			2	10	12			1	6	
A-4	12	7	25		4	30	1		$137\frac{1}{2}$	1-14		245
A-5	15	23			$1\frac{3}{14}$	22	1		$162\frac{1}{2}$	1-14		
A-6	3						$3\frac{1}{2}$			1	3	84
Totals		34	25		$1\frac{10}{14}$	67	$29\frac{1}{2}$		300	$2\frac{4}{14}$		249

Correct ________ Foreman

Fig. 89.—Record of Explosives.

several slope stakes. For this purpose, as well as for other uses, every foreman should be provided with a metallic tape line. One of the authors has also provided his foreman with a half-dozen steel pins like those used by land surveyors. These pins can be made by any blacksmith, and should be about 10 ins. long. Through the ring at the top a piece of red flannel should be tied so they can be easily seen and thus save them from being lost. The pins are not only useful in marking places on the ground, but a foreman, by their aid, can make any measurement he desires, without assistance. He can stick a pin through the ring on his tape and make measurements without taking a man from his work to help him.

In this way he can make his measurements on the ground to locate drill holes, and put them on the chart as shown in Fig. 88. In this case a driller, whose key letter is *A*, has been

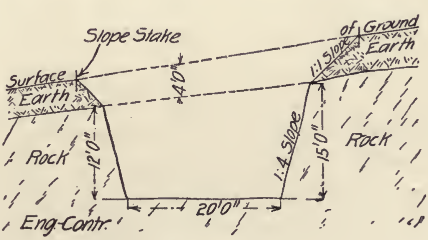


Fig. 90.

assigned to work in the cut in question. He starts by drilling a 4 ft. hole 4 ft. to the left of the center line at Sta. 94 + 30. Then he drills a 2 ft. hole 10 ft. on the right at + 31, following this with a 5 ft. hole 10 ft. on the left at the same station. These holes are drilled to "breast up" the cut at Sta. 94 + 32, and while these holes are being loaded and shot, and the muckers are cleaning up the blasted material, two holes are being drilled for a large blast: Hole No. 4 at 10 ft. on the left, 12 ft. deep; and hole No. 5, 10 ft. on the right, 15 ft. deep, at Sta. 94 + 44. After this blast is made a boulder is thrown in the way of the workers and the drill is set up to put a 3-ft. hole in it for blocking. This is hole No. 6, and notation is made on the chart to show that it was drilled in a boulder. This record can be made up by the foreman or timekeeper, from the pegs left in the holes by the driller, these pegs having burnt on them the driller's letter.

The blank filled out in Fig. 89 shows how these holes were shot, and gives a record of the explosives used. Hole No. 1 was sprung once with 2 sticks (1 lb.) of dynamite, and then shot with 8 lbs. Hole No. 2 was not sprung but shot with 4 lbs. of dynamite. Hole No. 3 was first sprung with 1 lb. of dynamite, and again sprung with 2 lbs., being shot with 12 lbs. All of these holes were exploded with cap and fuse, as the record shows.

Hole *A*-4 was sprung 4 times, first spring being with 1 lb. of dynamite, second with 2 lbs., and the third spring with 4 lbs. The fourth spring was made with one keg (25 lbs.) of black powder. Powder was used to develop a seam that was opened up at the bottom of hole by the other springs. The springing of No. 5 was done with dynamite, four springs being made with respectively 1, 2, 6 and 14 lbs. The last spring was shot with an electrical exploder or fuse. The small amount of fuse used in springing is caused by the fact that for the first springs only a piece of fuse 3 or 4 ft. long was used tied to a stick of dynamite, and after being lit it was dropped into the hole. This can be done when the hole is not ragged. These two holes were shot with Judson powder, the blasts being put off simultaneously with a battery. It will be noticed that the fuses used are recorded both as to number used and as to length.

Hole No. 6 in the boulder was shot with dynamite with a cap and fuse. The column for the yardage moved can be filled in by the superintendent or some one able to calculate the approximate quantity of rock loosened. No yardage is recorded

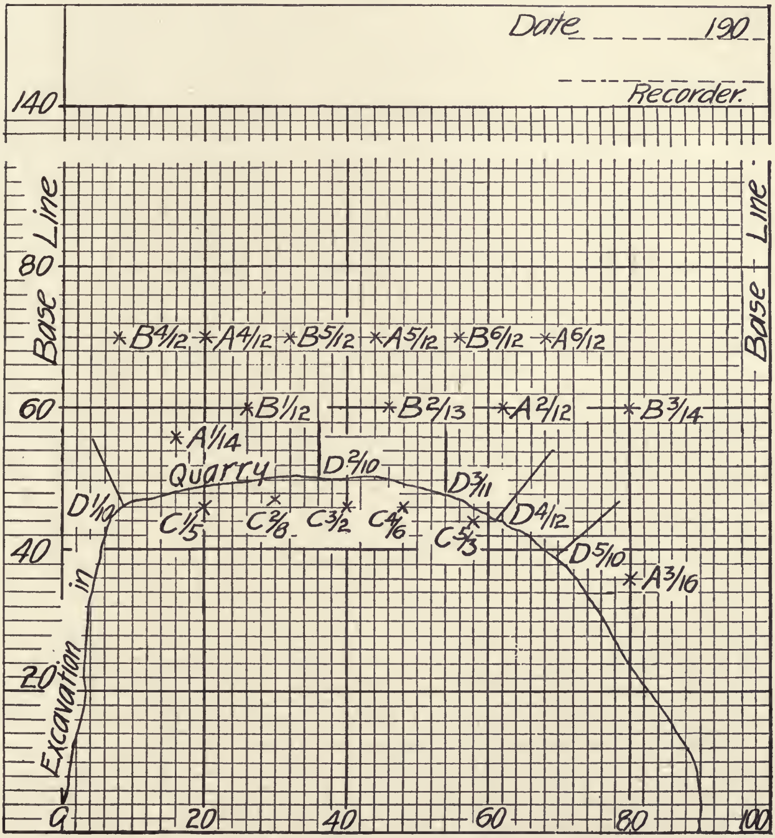


Fig. 91.—Chart of Drill Holes in a Quarry.

with the first three blasts, as these blasts are chargable against the yardage moved by the last heavy blast made in the cut.

A separate sheet which need not have the springing columns on, can be used for blasting boulders, and in a column for remarks can be noted the method used in breaking them up, such as "block-holing," "mud-capping" and other methods.

The blasts here recorded are not given as economical ones, but rather as examples of actual blasts, in which there is nearly always used more explosive than necessary to loosen the rock. Contractors prefer to shoot rock in this way, as it is extremely expensive to loosen and break up rock after an unsuccessful blast.

The records shown on the chart and explosive sheet, should be copied upon permanent records in the contractor's office. The office chart, for showing location of the holes drilled, should be a long sheet of cross section paper, showing, on the same scale as the small chart, the entire line, except the embankments. The totals from the explosive sheet should be recorded in a book made up for that purpose, which should also have columns for the drilling records, the work done by the muckers, and the transporting of the excavated material.

Fig. 91 shows a chart to be used in a quarry. A base line can be run on each side of the excavation to be made in the quarry, and from these base lines any point in the quarry can be located, for recording on the chart. These records can be transferred to an office chart that can be on a larger scale, if desired.

From the chart shown here, it will be seen that four drills are working in the quarry. Drills *A* and *B* on top of the ledge of rock, and *C* and *D* down on the breast. C is a small drill putting down shallow holes, while *D* is a large drill snaking in holes on the breast as indicated by the long lines drawn from the face inward.

A sheet similar to the one illustrated in Fig. 89 can be used in a quarry to record the explosives used. An accurate estimate of the yardage may be difficult to obtain at times; but it is usually possible to approximate the yardage very closely by calculating the cross-section along each line of drill holes and the distance between the lines of holes.

In some tough rocks it is frequently necessary to drill a foot or two below grade, in order to be sure to break all the rock to grade. In such cases, due allowance should be made when estimating the yardage of "pay rock" broken. In other cases, the rock breaks one or more feet beyond the outer line of drill holes, and allowance for this should be made also. But, in any given kind of rock, the foreman or time-keeper will soon learn how much to allow for these factors, and can then estimate the yardage of "pay rock" accurately from the chart of drill holes. In this manner it is possible to make a very close report of the yardage of rock broken every day, without the necessity of cross-sectioning with an engineer's level. *The rock-drill does the cross-sectioning.*

Forms for Recording Well-Drilling Costs.*—These forms are gotten up by the Cyclone Drill Co., of Orrville, Ohio, and are furnished to their customers for keeping records of drilling done by machines bought of them. The first blank illustrated in Fig. 92 is meant to record a day's work of well drilling or

REPORT OF CYCLONE DRILL.

No..................
For..Shift
....190....
Number of feet drilled..............................
Number of hours worked..............................
Driller..hrs....
Helper..hrs....
From........to..feet
....

Paid for coal.............. Paid for oil..............
Paid to move....................
....
....
....Driller

Fig. 92.—Report of Well Driller.

deep holes for blasting. From it the cost of drilling per foot can be calculated, showing in detail the labor cost, coal and oil and cost of moving.

The form shown in Fig. 93 is meant to be used for prospecting drilling, especially where a core is taken for record. The form is printed on the two sides of the sheet. It gives a time record, depth drilled, record of delays, materials and bits used, expense account for the day and a record of the drill holes showing cores taken and the depth and thickness of the strata drilled.

A Report Card System for Dredging Work.†—In the June 13, 1907, issue of *Engineering News,* in an article descriptive of the Bush Terminal R. R. Co.'s dredge "Independent," men-

*Engineering-Contracting, Nov. 20, 1907.
†Engineering News, August 22, 1907.

tion was made of a report card system in use on that dredge and possessing features of some novelty. The system was devised by Mr. William H. Arnold, M. Am. Soc. C. E., who was, prior to June 1, Chief Engineer of that company. Mr. J. A. Warner,

DAILY DRILLING REPORT.

Date......................1905.
Contract No.....Hole No....Day of Week..........
For Whom..
Address...
Hole located near or at...........................

TIME RECORD.

	Name	Began Work Hr.	Began Work Min.		Quit Hr.	Quit Min.	
Driller,	....	....	....	..M	....	....	..M
Helper,	....	....	....	..M	....	....	..M
Helper,	....	....	....	..M	....	....	..M
Machine,	Class.... No	....	....	..M	....	....	..M

DRILLING RECORD.

	Feet	Inches
Depth last Report........	......	......
Amount drilled today........	......	......
Present depth of Hole........	......	......

RECORDS OF DELAYS OR DIFFICULTIES.

....
....
....
....

MATERIAL RECORD.

Kinds of Core Barrel Used.	Length of Cutting Element, whether Barrel or Bit. Time Used Hr.	Time Used Min.	Before Ft.	Before In.	After Ft.	After In.
Standard........	......	......	....	....	....	....
Plain........	......	......	....	....	....	....
Bit........	......	......	....	....	....	....

Shot used pounds......................
Anything used in place of shot. ......

EXPENSE RECORD.

Paid Whom.	For What.	Amount	
....	....	......	....
....	....	......	....
....	....	......	....
....	....	......	....

SUPPLIES NEEDED.—HOW TO BE SHIPPED.—WHERE.

....
....
....

RECORD OF DRILL HOLE.

Kind of Strata Drilled Today.	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
....	......	......	......	......
....	......	......	......	......
....	......	......	......	......
....	......	......	......	......

To the Treasurer: I vouch for the truth of this report.

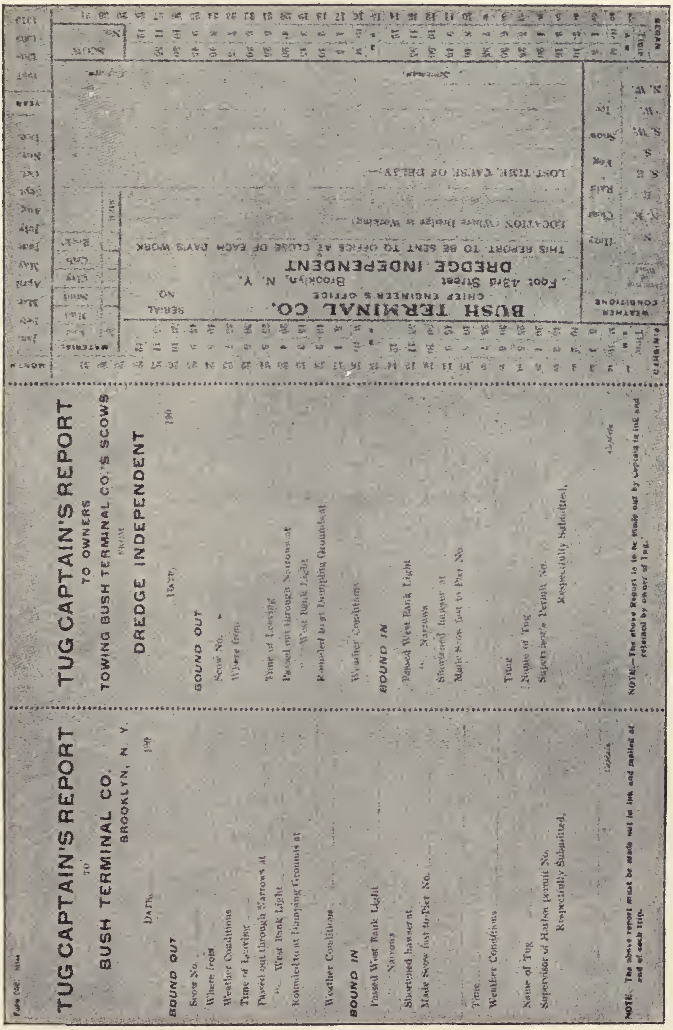
Signed..........................
P. O. Address..................

Fig. 93.—Report of Prospect Drilling (Calyx Core Drill).

General Superintendent of the company, furnished samples and data from which the following description was prepared.

The complete report cards are made up in three sections, perforations allowing the sections to be detached for use. Figs. 94 and 95 show both sides of a complete card. All of the information required concerning the loading of a scow is printed on the card, and such information as applies to the loading of any one scow is indicated by a punch mark opposite such information.

Fig. 96 shows the portion of the card on which the punch records are made, as filled out. On this portion of the card, the serial number indicates the consecutive number of scows loaded; for example, the serial number 250, shown in Fig 96,


TUG CAPTAIN'S REPORT
TO
BUSH TERMINAL CO.
BROOKLYN, N. Y.
DATE 190
BOUND OUT
Scow No.
Where from
Weather Conditions
Time of Leaving
Passed out through Narrows at
" West Bank Light
Rounded to at Dumping Grounds at
Weather Conditions
BOUND IN
Passed West Bank Light
" Narrows
Shortened hawser at
Made Scow fast to Pier No.
Time
Weather Conditions
Name of Tug
Supervisor of Harbor permit No.
Respectfully Submitted,
Captain.
NOTE.—The above report must be made out in ink and mailed at end of each trip.

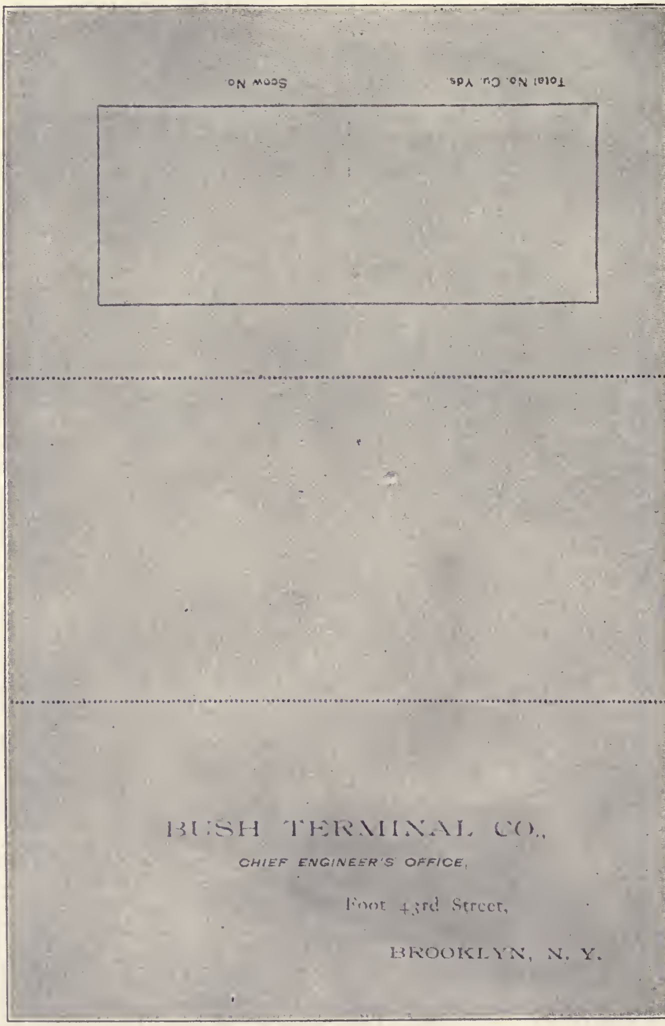
TUG CAPTAIN'S REPORT
TO OWNERS
TOWING BUSH TERMINAL CO.'S SCOWS
FROM
DREDGE INDEPENDENT
DATE, 190
BOUND OUT
Scow No.
Where from
Time of Leaving
Passed out through Narrows at
" West Bank Light
Rounded to at Dumping Grounds at
Weather Conditions
BOUND IN
Passed West Bank Light
" Narrows
Shortened hawser at
Made Scow fast to Pier No.
Time
Name of Tug
Supervisor's Permit No.
Respectfully Submitted,
Captain.
NOTE.—The above Report is to be made out by Captain in ink and retained by owner of Tug.

BUSH TERMINAL CO.
CHIEF ENGINEER'S OFFICE
Foot 43rd Street Brooklyn, N. Y.
DREDGE INDEPENDENT
THIS REPORT TO BE SENT TO OFFICE AT CLOSE OF EACH DAY'S WORK
LOCATION (Where Dredge is Working)
LOST TIME, CAUSE OF DELAYS
SERIAL NO.

Fig. 94.—Front of Dredge Tug Report.

indicates that the scow covered by that report is the 250th scow loaded since the dredge began operation.

Provision is made to show the date, hour and minute at which the loading of the scow was begun and completed. The weather conditions, the kind of material handled, the location


Scow No. Total No. Cu. Yds.

BUSH TERMINAL CO.,
CHIEF ENGINEER'S OFFICE,
Foot 43rd Street,
BROOKLYN, N. Y.

Fig. 95.—Back of Dredge Tug Report.

where the dredge worked, and any delays that may have occurred, are also provided for.

The amount of material loaded in the scow is indicated by a percentage system. In the sample card which has been filled out—see Fig. 96—the loading was 60% sand, 35% crib and 5% rock. The percentage, of course, is based on the carrying capacity of the scow, which in the case of the Bush Terminal R. R. Co. is 800 cu. yds.; hence, as indicated, 60% of the 800 cu. yds. was sand.

On the back of this portion of the card is a diagram representing the six pockets of the scow; this diagram is shown in

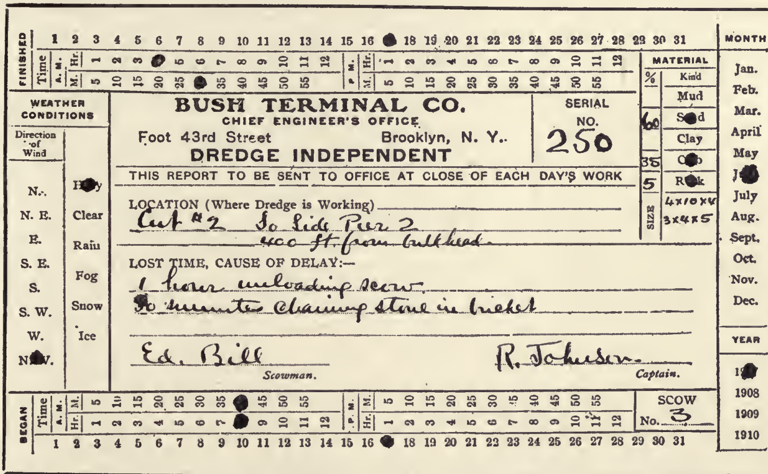

FINISHED Time A.M. Hr. M. P.M.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
MONTH: Jan. Feb. Mar. April May June July Aug. Sept. Oct. Nov. Dec.
MATERIAL: % Kind: 60 Sand, 35 Crib, 5 Rock; Mud, Clay
SIZE: 4×10×4, 3×4×5
WEATHER CONDITIONS
Direction of Wind: N. N. E. E. S. E. S. S. W. W. N. W.
Hazy Clear Rain Fog Snow Ice
BUSH TERMINAL CO.
CHIEF ENGINEER'S OFFICE
Foot 43rd Street Brooklyn, N. Y.
DREDGE INDEPENDENT
SERIAL NO. 250
THIS REPORT TO BE SENT TO OFFICE AT CLOSE OF EACH DAY'S WORK
LOCATION (Where Dredge is Working) Cut #2 So. Side Pier 2 400 ft. from bulkhead
LOST TIME, CAUSE OF DELAY:— 1 hour unloading scow 30 minutes clearing stone in bucket
Ed. Bill Scowman. R. Johnson Captain.
YEAR 1907 1908 1909 1910
SCOW No. 3
BEGAN Time A.M. Hr. M. P.M.

Fig. 96.—Dredge Report (Punch Card).

Fig. 95. When this portion of the card is filled out, notations are made in each of the six spaces in this diagram, showing how many of the pockets are full and how many partly full. Where the pockets are not filled, the shortage is indicated by the number of feet and tenths of feet that each pocket is short-filled; *i. e.,* if five of the pockets were full and the sixth 0.5-ft. short-filled, the spaces representing the full pockets would contain the word "Full," and in the short-filled pocket would be made simply the notation "0.5." In the case of an 800-cu. ft. scow, then, that would indicate that pocket No. 6 was filled to within 6 ins. of the top of the coaming, and the total yardage for that scow would be 792.5.

The other two portions of the card, as shown in Fig. 94, are filled out by the captain of the tug which tows the scows to sea. They are given the same serial number as that given to the report of scows loaded. The addressed section is mailed to the Bush Terminal Co. and the unaddressed section sent to the owners of the tug towing the scow, for their information in rendering bills for towage.

The serial number of each scow is shown on the towing company's bill, thus enabling the towing company and the Bush Terminal Co. to agree without dispute upon the amount of any towing bill.

A System for Recording Costs of Dredging and Dredge Maintenance.*—The following, by Mr. Magee Fisher, is an article with blank forms describing a system which will appeal to many for its simplicity. It will be noted that this is more of a book-keeping than a cost-keeping system proper.

Accounts divide themselves into two classes: First, accounts of original entry, such as "time books" and "purchase books," in which employes' time and purchases of various sorts are entered when made; and, secondly, accounts of final entry, to which are copied the items previously recorded in the books of original entry; the accounts of final entry are known as the "ledger." If the accounts of original entry can be so arranged that only footings have to be copied to the "ledger" an immense amount of work and inaccuracy is thereby avoided. Such an arrangement is doubly profitable, for it obliges the accountant to decide beforehand just what accounts he will and will not keep; then, having decided, it is a very simple matter to make all the original entries chargeable to any given account on a page by themselves; then at the end of the week only the sum total of the page need be copied to the ledger; and, if the loose-leaf system is used, all pages of original entry chargeable to that account, from the time book and purchase books, can be gathered together. But loose-leaf books have been a constant source of bother, the pages either tear out or some special kind of punching and paper have to be purchased. Fortunately, however, there have recently appeared for sale substantial clutch binders

*Engineering-Contracting, August 14, 1907.

capable of holding unpunched paper of any kind and in such shape that the whole outfit may be handled as conveniently as a bound book.

Accounting is not an easy subject to write about intelligently, but the writer thinks that if any one interested will study the sample pages of accounts shown herewith he will be able to

No purchases to be entered on this page except those chargeable to

Cost and Maintenance of Dredge.

Purchases entered by John Smith.

Date 1905	Items.	Check Nos.	By Check.	In Curr'cy.	On Acc't.	Ledger Transfs.
Oct. 16	American Steel & Wire Co., cable........	201	$31.00			
17	Novelty Iron Works, bill to date.........	203	70.17			
17	From materials charged to Stock Acct. 2-7" x 16" x 32' timbers.............					$30.00
20	Lamb Auto Co., acetylene lantern........			$20.00		
21	Nevine Hardware Co., Crosby clamps.....			2.50		
Total....	Week ending October 21, 1905...........		$101.17	$22.50		$30.00

No purchases to be entered on this page except those chargeable to

Operation of Dredge.

Purchases entered by John Smith.

Date 1905	Items.	Check Nos.	By Check.	In Curr'cy.	On Acc't.	Ledger Transfs.
Oct. 16	Nissen & Jacobson, 12 yds. oilcloth.......			$3.80		
18	Standard Oil Co., 5 gallons cylinder oil....			3.88		
18	E. N. Woodbury & Co., gaskets..........			.78		
20	Lamb Auto Co., acetylene...............			2.00		
21	Smith & Sons, carload coal, No. 13347....				$78.40	
Total....	Week ending October 21, 1905...........			$10.46	$78.40	

Fig. 97.—Purchase Book Sheets.

acquire the salient points. The illustration taken is the cost account of a dredging operation which the contractor not only wished to keep separate from his other operations going on at the same time, but to sub-divide so as to ascertain separately the cost of setting up, of operating and of maintaining the plant.

No time to be entered on this page except that chargeable to

Operation of Dredge and Maintenance of same.

Time kept by John Smith. Week ending October 21, 1905.

Initial.	Name.	Charge to.	S.	M.	T.	W.	T.	F.	S.	Hours Operation	Hours Maintenance	Rate.	Amount Operation.	Amount Maintenance.
Roy	Long, foreman, night	Operation	5	10	10	10	10	10	15	70		30	$21.00	
Henry	Steffensen, foreman, day	Op.		10½	11½	11½	11½	11½	10½	67		30	20.10	
Burt	Shaw, engineer, day	Op.	10	10	11	11	11	11	10	74		20	14.80	
John	Scott, day	Maintenance			10	10	10	10	10		50	17½		$8.75
do	do	Maintenance	10	10						20		do	3.50	
Harry	Thompson, day	Op.		10½	10½	10½	10½	10½	9	61½		17½	10.76	
Arthur	Dawley, fireman, night	Op.		10½	10½	10½	10½	10½	9	61½		17½	10.76	
Harry	Breher, day	Maintenance			10	10	10	10	10		50	17½		8.75
do	do	Op.		10						10		do	1.75	
Ed	McCaul, day	Op.		10½	10½	10½	10½	10½	9	61½		17½	10.76	
James	Clarke, engineer, night	Op.		11½	11½	11½	11½	11½	11½	80½		30	24.30	
Ernest	Douglas, fireman, night	Op.		12½	12½	12½	12½	12½	14½	89		20	17.80	
J. W.	Duncan, night	Op.		11½	11½	11½		5½		51		17½	9.00	
										646	100		$145.53	$17.50
	Shifts			2	2	2	2	2	2	12				
	Hours actually running, day shift			4	9	5	8	8	7	41				
	Hours actually running, night shift			6	9	4	6	7	7	39				
	Day finished up No. 13347 and No. 768 cars coal			—	—	—	—	—	—	—				
	State of weather, day			Fair	Fair	Cloudy	Rainy	Fair	Fair					
	State of weather, night			Fair	Fair	Rainy	Fair	Cloudy	Fair					
	Cu. yds. earth moved			—	—	—	—	—	—	1200				

Fig. 98.—Time Book, Dredging.

For this purpose he decided on two accounts as sufficient, one entitled "operation" and one "cost and maintenance."

First, in the "purchase book," Fig. 97, were entered all the purchases, which, for the benefit of the bookkeeper, were classified into "check," currency," "account" and "leager transfer" purchases. Secondly, in the "time book," Fig. 98, were recorded the time of the employes, the state of the weather, the actual time operating, the progress of the work and other items of import. Then each week the sum totals were carried to the two ledger accounts, Figs. 99 and 100, where all functions of the work could be analyzed week by week. Observe the separate columns for each function—one for coal burnt, one for shifts worked, one for man-hours, one for cubic yards moved, one for labor cost and one for material cost.

The contractor's confidential bookkeeper also week by week posted off from the "time" and "purchase" books all cash items to his cash book and all "accounts" and "ledger transfers" to their proper places in the "ledger," thus completing a balanced or so-called "double entry" ledger.

Then when the work of dredging was finally finished the contractor abstracted the cost for future reference, Fig. 101, thus completing his record.

Many engineers might find it convenient to keep similar cost abstracts of work valuable to them in a small card index, which would hold such records for a lifetime and yet never be bulky. It seems as though printed matter and other records accumulate so fast that the average individual is completely "swamped" and gains no benefit from his records, whereas, if the essential points were abstracted in compact form he could have them always at hand.

As illustrated above, the cost of any given piece of work is ascertained by adding together the various items, such as the cost of the labor, of the material, of the depreciation on the plant, of rent, of traveling expenses, etc. The amount of the work may be measured in units such as cubic yards of earth excavated, lineal feet of road built, or in per cents of completion, as in the case of a house where the architect specifies that it is 40 per cent completed.

If the contractor has spent 50 per cent of the money doing 40 per cent of the work, he is apt to have the cold shivers. As

Ledger for
Cost of Maintenance of Dredge.
Page 2.

This account opened at commencement of Building of Dredge, June 15, 1905.

Date 1905.	Items.		Days to Build.	Man Hours.	Debits.		Credits
					Cost Labor.	Cost Supplies.	
	Forwarded			1,951	$436.22	$913.57	
Oct. 21	Pay roll for week ending Oct. 21			100	17.50		
21	Purchases, by check					101.17	
21	do currency					22.50	
21	do ledger transfers					30.00	
Footing—week ending Oct. 21			30	2,051	$453.72	$1,067.24	

Fig. 99.—Ledger Sheet.

Ledger for
Operation of Dredge.
Page 3.

This account opened at commencement of operation, July 15, 1905.

Date 1905.	Items.	Tons of Coal.	Shifts Worked	Man Hours.	Cu. Yards Moved.	Debits.	
						Cost. Labor.	Cost Supplies.
	Forwarded	58	144	10,085	13,781	$2,215.36	$1,209.15
Oct. 21	Pay roll for week Oct. 21		12	646	1,200	145.53	
21	Purchases, currency						10.46
21	do on acct						78.40
21	Cars of coal No. 13347—No. 768	32					
Footing—week ending Oct. 21		90	156	10,731	14,981	$2,360.89	$1,298.01

Fig. 100.—Ledger Sheet.

(Abstract of Cost.)

Earthwork—Dredge Operation. 1905.

Location—Mississippi Valley.
Nature and extent—Railway embankment 2,000 feet long and 12 feet high; borrow pit along side and parallel with same.
Material—Sand and silt of Yankee River Delta.

Total yards moved	14,981
Shifts worked (ten-hour)	156
Cu. yards per shift	96
Total cost	$5179.86
Cost per yard—total	34.6c.
do. —operation wages	15.8
do. —operation coal	1.7
do. —operation repairs	7.0
do. —cost of plant wages	3.0
do. —cost of plant material	7.1
Pounds of coal burned	180,000
Pounds per yard moved	12
Average rate of wages per hour	22c.

Fig. 101.—Final Abstract of Cost, Dredging.

frequently happens, he does not discover this until the facts have become ancient history.

This is one wrong way of cost keeping. He might better have not kept any accounts at all, for what good were they?

I have taken a house as an illustration, but many of my readers can bring to mind some railroad or other large undertaking that has come to grief from the same cause. Too much stress cannot be laid on the importance of entering all items of expense instanter and of keeping the accounts up to date.

Another wrong way of cost keeping is to keep too many cost accounts, the resulting work being so vast as to be a burden. Many persons fail to realize the amount of work involved in accounting; and this work is apt to be greatly increased unless the books are carefully checked and balanced at frequent intervals.

Estimating is almost the reverse of cost-keeping. The work to be estimated is measured up into suitable units and tabulated. This is called "taking off." The estimated cost of each unit is then applied and the amount in dollars set out in the cost column. This is called "extending." This, then, is the engineer's estimated cost of the work to which the business department adds various amounts for overhead cost, profit, insurance against accidents, interest, etc. Many business men are said to add a liberal per cent for underestimating on the part of their engineer. Experience in paying the bills of underestimated work is a sure but costly road to accuracy in estimating.

Cost Keeping Blanks for Dredging.*—The port of Portland, Ore., has two hydraulic dredges at work deepening and widening the channel of the Columbia and Lower Willamette rivers. One of these dredges has a capacity of 8,000 cu. yds. per day in sand, and the other has a daily capacity of 20,000 cu. yds.

The dredges work under the direction of the chief engineer of the Port, Mr. J. B. C. Lockwood, M. Am. Soc. C. E., and he uses the following forms in keeping a record of the work done and in obtaining the costs.

In Fig. 102 is shown the blank for the leverman's report. On this report the measurements are given from which the yardage dredged can be calculated. Also a record is kept of passing vessels and all delays to the dredge.

In Fig. 103 is shown the report of the chief engineer of the dredge. From this report the delays are taken so that it can be a check on the leverman's report. As to causes for delay,

*Engineering-Contracting, May 26, 1909.

THE PORT OF PORTLAND

LEVERMAN'S LOG

*Date*____________________

*Dredge*____________________ *Location*____________________

*Shift No. 1*_______________ *No. 2*_______________ *No. 3*_______________

Time	Gage	Bells	Depth	Width	Depth	Time and Cause Each Delay	Other Vessels Passed

Fig. 102.—Leverman's Daily Report, Dredging.

the leverman shows the reason for all causes other than those occurring in the engine room, the causes for the latter delays being given on the engineer's report. This report also shows the amount of fuel used. The dredges for this work burn saw-

THE PORT OF PORTLAND

ENGINE ROOM LOG

Date ______________

Dredge ______________ *Location* ______________

Shift No. 1 ______________ *No. 2* ______________ *No. 3* ______________

Total running time ______________

" lost " ______________

Revolution counter No. ______________

Blowed boilers at ______________ and at ______________

" stacks " ______________ and at ______________

Fuel received. Scow No. ______________

Quantity on scow ______________

Quality ______________

Time and cause of delays in engine room ______________

____

____

CHIEF ENGINEER

Fig. 103.—Engineer's Daily Report, Dredge.

dust and shavings, the quantity being measured and estimated in cubic feet.

In Fig. 104 is shown the blank used for the captain's report. The other reports are meant to show some details for each shift, there being 3 shifts of 8 hours each, while in this report all the work is grouped for the 24 hours. This report is evidently

THE PORT OF PORTLAND

CAPTAIN'S DAILY REPORT

*Dredge*__________

At __________

*For 24 hours of*__________ __________*190*__

Character of material

Length of pipe line

Height of discharge

Pontoon pipe in use. No.

Shore " " " No.

Moved ahead Feet Total for month Feet

Depth dredged below zero

Average width of cut

" depth " "

Yards excavated Total for Month

No. hours run " " "

Lost time " " "

Revolution counter " " "

Fuel received. Scow No. " " "

" quantity Quality

Rubber sleeves failed. No.'s

" " installed. No.'s

Hauled for vessels No. Total for Month

Other vessels passed No. " " "

CAPTAIN

Fig. 104.—Captain's Daily Report, Dredging.

made from the two previous blanks and also from data collected by the captain, or under his direction.

In Fig. 105 is shown the cost analysis sheet, gotten up each month by the chief engineer of the Port. This form is at once a summary and also an analysis showing the cost per day, the cost per cubic yard, the average time worked per day, with average work done. This report is made up from the daily

THE PORT OF PORTLAND *No*______

ENGINEER'S MONTHLY REPORT

*Dredge*______

*At*______

*For*______ *Inclusive*______ *190*___

Character of material			
Length of pipe line			
Height of discharge			
Pontoon pipe in use. No.			
Shore pipe in use. No.			
Moved ahead	Feet. Average per day		Feet
Depth dredged below zero			
Average width of cut			
Average depth of cut			
Yards excavated		Average per day	Yards
No. hours run		" " "	Hours
Lost time		" " "	"
Revolution counter		" " "	
Fuel received. Scow No.		" " "	Load
Fuel, quantity	Quality		
Rubber sleeves failed. No's			
Rubber sleeves installed. No's			
Hauled for vessels. No.		Average per day	No.
Other vessels passed. No.		" " "	"
Total cost at $ per calendar day	$		
Cost per cubic yard	cents		

____
CHIEF ENGINEER

Fig. 105.—Engineer's Monthly Report, Dredging.

reports of the captain and also from the timekeepers' sheets or pay-rolls. We regret that we cannot reproduce a copy of these forms. In all cases there should be blank forms, showing the number of men worked on each shift, their positions and rates of wages.

Special attention is also called to the analysis sheet, as this is a weak point in many cost-keeping systems; that is, the lack of an analysis sheet. From such a sheet it is possible, at any time, to learn of the efficiency of the work being done, and at the end of any job the average cost is quickly calculated. This is not possible when daily sheets only are kept, without a great deal of labor, and when a large number of daily reports have accumulated it frequently happens that it is never done. Thus the greatest value of cost-keeping; namely, showing the efficiency of the work done, is not obtained.

A Cost Record System Used on Flood Protection Works at Grand Rapids, Mich.—The following system was described by Mr. C. S. Keating in a paper read before the Illinois Society of Engineers and Surveyors.

The administrative department of this work consisted of a superintendent and the writer. The former had charge of the men and of the direction and arrangement of the work. The writer had charge of the engineering and business portions. He had also the purchasing of all machinery, supplies, materials, fuel, etc.; looked after the various plants, keeping them in repair and good running order, and attended to the renting of all grounds, machinery, etc., and the direction of the teams.

The writer arranged and installed a cost account system. This included a general distribution sheet for the bookkeeper's use, cards for each division of the work (showing the amount of work done each day and the labor cost of same), and cards for recording minute observations for use in arranging men and teams to the best advantage. The writer kept the time personally, so as to keep a more efficient account of the work and check up the distribution from the cards each night with the time for that day. He found that by keeping the time he became familiar with the face and dress of each man, and when watching the work, could readily tell the position of each man and the work he was doing. This was a great help where a large number of men were employed.

The cards used for this work were the ordinary blank filing cards, 8 x 5 ins., and were ruled and marked by the writer as fast as they were needed.

The general distribution sheets were 38 x 24 ins., ready ruled horizontally, and ruled vertically in the office to correspond to the various headings, as shown in Fig. 106. A tracing was made of the heading of the sheet and blue-prints made, which were

FLOOD PREVENTION FUND

Date	Superintendence and General	Engineering		Coffer-Dam				Pumping								Quarrying Stone																							
				Construction		Maintenance		Plant			Operation					Plant																	Cleaning	Blasting				Moving	
									Installation					Repairs		Air Compressing								Drills & Piping											Material				
																	Installation		Operation						Installation		Operation												
																						Repairs					Labor			Repairs									
		Labor	Car Fare	Labor	Mat'l	Labor	Mat'l	Cost	Labor	Mat'l	Labor	Coal	Oil & Waste	Labor	Mat'l	Cost	Labor	Mat'l	Labor	Coal	Oil & Waste	Labor	Mat'l	Cost	Labor	Mat'l	Drilling	Sharp'g	Mat'l	Labor	Mat'l	Tool, Carts etc.		Labor	Dynamite	Fuses	Battery	Labor	Mat'l
	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

GRAND RAPIDS, MICH. 1905-6.

Crushing																		Wall																						Stone Sold		Totals
Plant								Operation										Excavation										Concrete														
Crusher			Engine			Bins		Engine					Crushing	Moving to and Feeding		Storage		Earth		Rock								Mixing				Concrete in Place						Forms				
	Installation			Installation							Repairs			Repairs						Drilling			Blasting					Mixer					Material									
																								Materials																		
Cost	Labor	Mat'l	Cost	Labor	Mat'l	Labor	Mat'l	Labor	Coal	Oil & Waste	Labor	Mat'l	Labor	Labor	Mat'l	Labor	Mat'l	Labor	% Tools	% Compr.	Labor & % Drills	% Tools	Labor	Dynamite	Fuses	Battery	Moving	Cost	Install'n	Operat'n	Labor	Labor	Cement	Sand	Gravel	Mis'ls	Rock Filling	Mat'l	Labor	Weighing	Hauling	
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	

Fig. 106.—General Distribution Sheet.

carried by the city engineer and the writer to use for reference in writing orders for material, etc. One of these sheets was used by the bookkeeper and one by the writer. The bookkeeper's sheet was used for all accounts, and the writer's sheet for pay-rolls only. At the end of each week, the pay-roll was totaled and checked with the distribution for that week, tabulated on the sheet, a list made out to correspond, and sent to the bookkeeper with the time-book and tabulated on his sheet. Order blanks were used when buying materials, etc., and the distribution numbers put on each item. These were in duplicate, one going to the seller and the other to the office. In this manner the bookkeeper had no trouble in keeping his accounts correctly distributed.

Referring to the accompanying sketch of this general sheet (Fig. 106) under the heading of superintendence and general,

Daily Report of Coffer Dam Construction

Month of ....February........1906.

Days.	Sections Put In.	Sections Filled.	Length in Feet Finished	Men Building	Men Placing	Men Filling	Material				Men Digging Clay	Men Digging Sand
							Lumber	Clay Del.	Sand Del.	Bags.		
Thur. 22nd	0	5	80	0	0	4-1.75 3-2.00		4 Teams			3 @ 1.75	

Fig. 107.—Daily Report, Coffer Dam.

was charged the superintendent's salary, carfare, cost of office, the lighting, watchman's time and part of the bookkeeper's time. To engineering was charged the writer's time and carfare, and the time and carfare of the field party giving lines, grades and taking cross-sections. The remaining headings are self-explanatory.

Taking the cards in sequence, to correspond to the general sheet, the first is the daily report of coffer-dam construction (Fig. 107). This example gives the card as it appeared for Feb. 22, 1906. No new sections were built or put in place, 5 sections were filled, making a total length of 80 ft. finished. Men filling: 4 at $1.75, 3 at $2; 4 teams at $5 hauling clay, and 3 men at $1.75 digging clay and loading. In connection with the heading "Men Placing" it may be explained that it took a number of men to bring the sections to place (which was done by the use of ropes), on account of the current in the river and

Daily Record of Pumping.

Month of February 1906.

Days	Nº of Pumps	Nº of Engines.	Rent of Pumps.	Rent of Engines.	Nº of Engineers	Total Wages	Coal Lbs.	Oil Gals	Waste Lbs.	Nº Hrs. Run.	Pumping for Wall.	Pumping for Quarrying
Thur. 22nd	2 Hand	0	0		3-$1.25	$5.25				10 Each	20 hours.	
	1 Cent.	1	50¢	$1.00	2-$2.00	$5.00	500	1/4	1/2	24		24 hrs.

Fig. 108.—Daily Report, Pumping.

the swirl around the end of the section already in place. The time for these men, which would be but a few minutes for each section, was kept by the foreman making note of the work from which each man was taken. In making up the distribution each night, the time for placing was deducted from the work as indicated by the foreman's report. The bags used on this work were old grain sacks and were obtained from the various milling companies in the city at a cost averaging about $6.50 per 100.

The first example given on the "Pumping Record" (Fig.

Daily Report of Compressor Operation.

Month of February 1906.

Days.	Hours Run.	Steam Pressure	Air Pressure	Coal Lbs.	Nº of Drills Running	Feet Drilled	Oil Gals.	Waste Lbs.	Repairs. Labor.	Engineers Salary

Fig. 109.—Daily Report, Air Compressor.

108) is actual, the other is merely for illustration. The amounts of coal, oil and waste used were obtained by dividing the quantity received at that pump by the number of days run to exhaust the supply. The hand pumps were used for the wall only and the steam pumps for the quarry only.

The daily report of compressor operation (Fig. 109) is self-explanatory. The sections of "drills running" and "feet drilled" were used on this card for comparison. In the daily drill record card (Fig. 110) the operation of 5 drills necessitated the

Daily Drill Record.
Card Nº 1.
Month of February 1906.

Days.	Drill Nº 1.						Drill Nº 2.						Drill Nº 3.					
	Nº of Holes.	Depth in Feet.	Total Feet.	Nº Bits Used.	Hours Drilling	Operating Expenses	Nº of Holes.	Depth in Feet	Total Feet	Nº of Bits Used.	Hours Drilling	Operating Expenses	Nº of Holes.	Depth in Feet.	Total Feet.	Nº Bits Used	Hours Drilling	Operating Expenses

Fig. 110.—Daily Report, Rock Drills.

Daily Report of Blasting.
Month of February 1906.

Days.	No. of Blasts.	Lbs. of 40% Dynamite.	No. of Caps	No. of Feet of Hole.	Cu. Yds. Displaced	Labor Blasting	Lost drill time		Lost Labor time		Lost team time	
							Hrs.	Am't	Hrs.	Am't	Hrs.	Am't
Thur 22nd	2	24	12	120	32	4 0 0	0	0	0	0	0	0

Fig. 111.—Daily Report, Blasting.

use of two cards to keep the record. The number of bits used for each drill, each day, was generally 8, there being 4 bits in a set, and usually two sets were dulled in a day's running. The last column is to receive the wages paid the drill runner and helper.

The daily report of blasting was kept as shown in Fig. 111. The number of cubic feet displaced was measured on the surface, and multiplied by the depth of the exposed face. The last three headings for lost time are for time lost in leaving the quarry

Daily Report of Moving Stone.
Month of February 1906.

Days.	Teams Hauling to		Men Loading Wagons.	Men Unloading Wagons	Men loosening and Breaking.	Cu. Yds. Moved to		Total Cu. Yds.
	Storage	Crusher				Storage	Crusher.	

Fig. 112.—Daily Report, Hauling Rock.

while blasting, but as most of the blasting was done at quitting time, noon and night, there was very little of this to account for.

The report of moving stone needs no explanation further than the headings on the card, Fig. 112.

The blacksmith's report is shown in Fig. 113. As to the "drill bits sharpened," when the bits became too dull to do efficient work, they were heated, driven into a die and tempered. As to "upset and cut," after a bit had been sharpened a few times it became so small across the base as to bind in the hole,

Daily Report of Black-Smith.
Month of February 1906.

Days.	Hours Worked.	No. of Drill Bits				Repairs to Drills.		Barrows Repaired	Picks & Bars Sharpen'd	Coal Lbs. Used	Wages.
		Sharpened	Upset & Cut	Made	Lbs. Steel	Labor	Mat'l.				

Fig. 113.—Daily Report, Blacksmith.

Daily Report of Crushing. Month of February 1906.								
Days.	Engineer	Coal. Lbs.	Oil. Gals.	Waste. Lbs.	Men Feeding	Cu. Yds. Crushed	Lost Time	
							Amount	Reason
Wed. 21st	[illegible]	340	½ Eng. ½ Cyl.	½	[illegible]	40	3 hrs.	Repairs.

Fig. 114.—Daily Report, Rock Crushing.

then it had to be upset, the leaves cut in and sharpened. The blacksmith made all the new bits needed.

On the crusher report, Fig. 114, the number of cubic yards crushed was obtained by tallying the number of yards in the bins, the amount hauled to storage, sold, and that used in the wall.

On the report of wall work, Fig. 115, the figures given are for illustration and are not actual. The amount of cement used was obtained by tallying the bags as they were used and checked

Daily Report of Work on Wall. Month of February 1906.									
Days.	Bbls. of Cement	Cu Yds. of Sand.	Cu. Yds. of Stone	Men Mixing	Men Placing	Men Building Form	Material Forms.	Material Placing	No. Cu. Yds. in Place.
Wed. 21st	26.5	9	21.5	6-[illegible]	[illegible]	[illegible]	449 Ft. B.M.	128 Ft. B.M.	21.5

Fig. 115.—Daily Report, Concrete Wall.

by counting the empty bags at night. The lumber was measured in the forms each night by the writer. The concrete was measured in the forms and the work of each day lined out on the outside of the forms.

The "minute observations of drilling and moving stone" (Figs. 116 and 117) were made occasionally to get the most out of the drills. Also to get the best distribution of men for loading and unloading stone, so as to cut the time lost while the teams were standing to as small an amount as possible, while

Minute Observations of Drilling.

Drill No.__________ Kind.______________________ Size.________

Runner.________________ ___¢ per hr. Helper.________________ ___¢ per hr.

Date	First Bit.			Second Bit.			Third Bit.			Fourth Bit			Moving and Setting Up.	Remarks.
	Change	Down	Pump	Change	Down	Pump.	Change	Down	Pump.	Change	Down	Pump.		

Fig. 116.—Minute Observations, Drilling.

Minute Observations of Moving Stone.

Weather ------------------ Condition of Road ------------------

Length of Haul ---------- to ---------- Men ---- $ per hr. Team ---- $ per hr.

Date	Loading				Hauling	Unloading			Return to Load	Lost Team Time	No. of Yds. in Load	Cost per Yd. in cts.					Total Cost
	Size	No. of Men	Time	Total Time		No. of Men	Time	Total Time				Loading	Hauling	Unloading	Return	Lost Time	

Fig. 117.—Minute Observations, Hauling Rock.

at the same time working the men to advantage. For example: When the number of men loading or unloading brought the price per cubic yard above the price of a preceding observation and the corresponding decrease in lost team time was not sufficient to balance it, it was evident that there were too many men loading or unloading and the force was decreased accordingly. The observations of drilling were taken to get the best results

Material Received and Accepted.

Week Ending Wednesday ------ 1906.

Order No.	Date	Received from	Quantity	Items.	Price	Amount	Distribution No.

Fig. 118.—Material Received.

from the drills and keep the men from loafing when making new set-ups or changing bits.

Under the head of loading on the stone card (Fig. 117), the "size" gives the dimensions of the wagon box; the "time" is the number of minutes and seconds taken to load, and the "total time" is the time multiplied by the number of men. "Hauling" is the time taken in going from the point of loading to the

City Engineers Office.

No. -------- Grand Rapids, Mich. ------------ 190 --

Bought of ----------------------------------

	Price	Amount

For Work of ------------------ ---------------- City Engineer

Per ------------------

Fig. 119.—Order Blank.

point of unloading and returning. The sub-headings under "unloading" are the same as for "loading." The number of yards in the load is taken from the size of the wagon box, and the cost is figured by dividing the total time multiplied by the rate of wages, by the number of yards in the load. The total cost will be the sum of the costs per yard multiplied by the number of yards.

The "material received" card (Fig. 118) was used merely as an additional check on the orders and to prevent any firm from charging up rejected material, and to keep a record of orders filled in part.

BOARD OF PUBLIC WORKS. NO....7081

ENGINEERING DEPARTMENT.

Limestone	...Building....	....Broken.....	" Screened	....	Boulders........	" Broken	....	Load—1 Cu. Yd....	" 1¼ "	" 1½ "	" 1¾ "	" 2 "	" 2¼ "	" 2½ "	Total Wt.........	Tare	Net Wt..........	Where Weighed	....

	Hour					
A. M.	5	10	20	30	40	50
	6	10	20	30	40	50
	7	10	20	30	40	50
	8	10	20	30	40	50
	9	10	20	30	40	50
	10	10	20	30	40	50
	11	10	20	30	40	50
P. M.	12	10	20	30	40	50
	1	10	20	30	40	50
	2	10	20	30	40	50
	3	10	20	30	40	50
	4	10	20	30	40	50
	5	10	20	30	40	50
	6	10	20	30	40	50
	7	10	20	30	40	50

Sold to..

Ground. Loaded. Delivered to..

RECEIPT to be signed by Purchaser and returned by Driver to Quarry. .... *Driver.*

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1906	1907	1908	1909	1910	PUNCH
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31							

LOADED	L
DELIVERED	D
RETURNED	R

Fig. 120.—Stone Record and Team Card.

The order blank (Fig. 119) was used in general by the engineer's office when purchasing materials or supplies.

The stone slips (Fig. 120) were printed for this work and served the double purpose of a sales slip and tally on the time the teams were taking in making the deliveries. At the top is the kind of stone, the size of the wagon, the weights, and the scales used. Along the right-hand end are the hours from 5 a. m. to 7 p. m, and the minutes (by tens) for each hour. As the team was loaded, unloaded and returned the time was marked with the letter of indication, shown at the bottom, in the minute square opposite the proper hour. At the bottom, the month, day and year are indicated by punching. The body of the slip is used for the purchaser's name, the place of delivery and the driver of the team. The words "ground" and loaded" were used to designate respectively whether the stone sold was loaded from stone piled on the storage ground or loaded from the quarry.

From these cards and slips, taken together, the unit cost of any piece of work or any part of the work can be obtained. This is done by assembling the various items included in the work, from the card for that work and the items on the cards for any other division of work that may be chargeable to that work, in whole or in part.

For example: The cost of the crushed stone used in constructing the wall will be derived from the cost of crushing and quarrying. The quarrying in turn will include pumping, compressor operation, interest, depreciation and maintenance, drilling and moving stone, the blacksmith's work chargeable to drilling and tool repairs, the blasting, and the cost of coffer-dam. The record of the number of men or teams or both, at work on any piece of work for each day, gives more concise data regarding the working conditions of the work, than would be the case if merely the total amount of time for the day were recorded.

By filing these cards, with a table for each showing the amount of work accomplished each day, together with the average cost per day, covering any convenient length of time or obtained after the completion of the work, excellent data would be kept for use in making estimates on work of the same character, making due allowance for the varying conditions.

Forms for Breakwater Construction, Including Quarrying, Concrete Work and Dredging.*—It should be stated that these blanks were not used by the contractors, but by the Government engineers who wished to secure a record for their own use. Now, it is obvious that a Government engineer is not particularly concerned about the daily output of each worker or each small group of workers, for it is not his province to devise a system that will make the men more efficient. In spite of this fact, these blanks have some good features that will serve as suggestions to contractors and to engineers who are doing similar

*Engineering-Contracting, Feb., 1906.

BUFFALO BREAKWATER CONSTRUCTION

CONTRACT OF HUGHES BROS. & BANGS.

DAILY REPORT OF OPERATIONS

CANADIAN QUARRY.

....190......

RUBBLE STONE SHIPPED.

NO. OR NAME OF VESSEL.	TONS.	NO. OR NAME OF VESSEL.	TONS.
....	....	....	....
....	....	....	....

CAPPING STONE SHIPPED.

NO. OR NAME OF VESSEL.	TONS.	NO. OR NAME OF VESSEL.	TONS.

FORCE.	NO.	PLANT.	NO.
Superintendent	....	Locomotives	....
Timekeeper	....	Large Flat Cars	....
....	....	Small Flat Cars	....
Foreman	....	Dump Cars	....
Drillers	....	Coal Cars	....
Drill Helpers	....	Boxes or Skips	....
Hoist Engineers	....	Stationary Boilers	....
Firemen	....	Skeleton Hoist'g Engines	....
Laborers	....	Hoist'g Engine with Boiler	....
Engine Drivers	....	Incline Engine and Boiler	....
Blacksmiths	....	Large Steam Drills	....
Blacksmiths' Helpers	....	Medium Steam Drills	....
Machinists	....	Pony Steam Drills	....
Carpenters	....	Steam Pumps	....
Water Boys	....	Derricks	....
Watchmen	....	....	....
Teams	....	....	....
....	....	....	....
....	....	....	....

Remarks: Weather, Sea, Delays, etc.

Once a week measure each stone on one scow load of capping stone and note same in detail on back of report.

Inspector.

Fig. 121.—Daily Report, Quarry.

work. Those who have written articles on cost keeping have usually been engineers, and not contractors. Hence they have had a point of view quite different from the point of view of the contractor. The engineer wants records of cost, principally to furnish assistance in estimating costs of similar work in the future. Incidentally, he wants records that can be used in case of claims for payment for extra work, and for use in presenting

BUFFALO BREAKWATER CONSTRUCTION

Contract of Hughes Bros. & Bangs.

Daily Report of Operations Stone Breakwater

....190......

DECK AND DUMP SCOWS.

RUBBLE STONE.

KIND OF STONE PLACED.	TONS.	SEC.	RANGE. L.	H.	BETWEEN STATIONS.
Small Rubble					
Ordinary Rubble ..					
Leveling					
TOTALS,					

NUMBER OR NAME OF VESSEL.

FORCE.	NO.	PLANT.	NO.

GRAVEL.

NO. OR NAME OF VESSEL.	CU. YDS.	SEC.	RANGE. L.	H.	BETWEEN STATIONS.

FORCE.	NO.	PLANT.	NO.

Remarks: Weather, Sea, Delays, etc.

Inspector.

Fig. 122.—Daily Report, Breakwater.

testimony in possible lawsuits between the contractor and the owner or company whom the engineer represents. The contractor, on the other hand, should keep cost records principally with a view to reducing his costs, and incidentally with a view to making safe bids on future work. Therefore, the contractor who says it does not pay to employ men to keep costs for him,

BUFFALO BREAKWATER CONSTRUCTION

Contract of Hughes Bros. & Bangs.

Daily Report of Operations Stone Breakwater

....190......

DERRICK No.............

CAPPING STONE.

KIND OF STONE PLACED.	NO.	SEC.	RANGE.	BETWEEN STATIONS.
H. Footing Angle				
H. Revetment . .				
H. Capping . .				
H. Top Angle . .				
L. Footing Course				
L. Revetment . .				
L. Capping . . .				
L. Top Angle . .				
Center Fillers . .				
TOTALS,				

RUBBLE STONE.

KIND OF STONE PLACED.	TONS.	SEC.	RANGE. L.	RANGE. H.	BETWEEN STATIONS.
Small Rubble . .					
Ordinary Rubble .					
TOTAL,					

FORCE.	NO.	PLANT.	NO.
Foreman		Derrick No.	
Hoist Enginemen . . .		Tugs	
Swing Enginemen . . .		Scow No.	
Asst. Foremen		Scow No.	
Stone Pickers			
Stone Setters			
Laborers			

Remarks: Report invariably the weather, wind and sea. Also delays, etc.

Inspector.

Fig. 123.—Daily Report, Breakwater Masonry.

simply exposes his own ignorance of what is the fundamental object of cost-keeping.

Let us now consider the blank records used on the work of constructing the Buffalo Breakwater. This work involved the quarrying of rubble stone and capping stone for the breakwater; conveying this stone in scows from the Canadian quarry to the breakwater; placing the stone; making and placing con-

BUFFALO BREAKWATER CONSTRUCTION

Contract of..

DAILY REPORT OF OPERATIONS

CONCRETE SUPERSTRUCTURE

....190......

MANUFACTURE OF CONCRETE BLOCKS AT

KIND OF BLOCKS MADE.	NO.	MATERIALS USED.	NO.
Lake Face	....	Cement . . ..Bags.	....
Harbor Face	....	Broken Stone.........C.Yds.	....
Interior Wall	....	Gravel . . ..C.Yds.	....
Cross-Wall Parapet . . .	....	....	....
Cross-Wall Banquette . .	....	....	....
Special			
TOTALS,			

FORCE	NO.	PLANT	NO.

Remarks: Weather, Sea, Delays, Brand of Cement, etc.

Inspector.

Fig. 124.—Daily Report, Breakwater Concrete.

crete blocks for a superstructure; drilling and blasting out the channel in the harbor; and dredging the blasted material.

To obtain the cost of this work the Government engineers devised a set of daily report blanks, seven in number, which are reproduced herewith, two-thirds size. Each blank is 3½ x 8 ins., which is a size convenient for filing.

BUFFALO BREAKWATER CONSTRUCTION

Contract of..

DAILY REPORT OF OPERATIONS

CONCRETE SUPERSTRUCTURE

....190......

PLACING BLOCKS AND BUILDING SUPERSTRUCTURE AT

KIND OF BLOCKS SET.	NO.	SEC.	BETWEEN STATIONS.
Lake Face	....	....	....
Harbor Face	....	....	....
Interior Wall . . .	....	....	....
Cross-Wall Parapet . .	....	....	....
Cross-Wall Banquette . .	....	....	....
Special			
TOTAL,			

MASS CONCRETE PLACED.

LOCALITY.	SEC.	CU. YDS.	
Lake Face Wall	....	....	....
Banquette Deck	....	....	....
Rem. Harbor Wall, etc.	....	....	....
Parapet Deck	....	....	....
Steps, etc. .	....	....	....
TOTALS,			

MATERIALS USED.

Cement, Bags . .	....	....	....
Broken Stone, Cu. Yds.	....	....	....
Gravel, Cu. Yds	....	....	....

FORCE	NO.	PLANT	NO.
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....
....	....	....	....

Remarks: Weather, Sea, Delays, Brand of Cement, etc.

Inspector.

Fig. 125.—Daily Report, Breakwater Concrete.

Fig. 121 gives the daily record at the quarry, including the force employed, the plant employed, and the output of stone shipped away. While this blank would serve well enough for the determination of costs at the end of the month, it is of little use to a contractor, unless the stone that is quarried is shipped on the day that it is quarried. If not shipped on

IMPROVEMENT OF ____

CONTRACT OF ____

Daily Report of Operations—DREDGING.

____ 190__

DREDGE ____

SECTION ____ CUT ____ STA. ____

TUG ____

NUMBER OR NAME OF SCOW	LOADING		KIND OF MATERIAL			
	BEGAN	FINISHED				

TIME ACCOUNT				CHARACTER OF DELAYS
BEGAN WORK	STOPPED WORK	HOURS WORKED	HOURS DELAYED	

Weather	WIND		SEA	WATER GAGE READINGS			
	DIRECTION	FORCE		A. M.	NOON	P. M.	MEAN

FORCE	NO.	FORCE	NO.
ENGINEMEN			
CRANESMEN			
FIREMEN			

REMARKS:

INSPECTOR,

Fig. 126.—Daily Report, Dredging.

the same day, the record of daily output of the quarrymen cannot be determined from this blank. The stone was weighed by the water displacement of the scows, giving an accurate measurement of the total quarry output over any considerable period of time; but, if asked, what was the exact output of the quarrymen on Tuesday of a certain week, no answer can be obtained from such

IMPROVEMENT OF ____________________

CONTRACT OF ____________________

Daily Report of Operations—DRILLING and BLASTING ROCK.

____________________ 190__

DRILL BOAT ____________________

SECTION __________ CUT __________ STA. __________

TUG ____________________

NUMBER				DEPTH TO ROCK	DRILLING HOLES BLASTING ROCK				DEPTH OF HOLE	EXPLOSIVES LBS.
POSITION	ROW	HOLE	DRILL		BEGAN	FINISHED	TIME DELAYED	TIME WORKED		

Weather	WIND		SEA	WATER GAGE READINGS			
	DIRECTION	FORCE		A. M.	NOON	P. M.	MEAN

FORCE	NO.	FORCE	NO.
FOREMAN		FIREMEN	
DRILLERS		LABORERS	
BLACKSMITH			
" HELPER			

REMARKS:

INSPECTOR.

Fig. 127.—Daily Report, Subaqueous Drilling.

a record. The record is, therefore, incomplete for the purposes of a contractor, although satisfactory for the purposes of the engineer.

Fig. 123, on the other hand, is much more complete, for it gives the daily output of the gang working on each derrick. Figs. 124 and 125, for recording the concrete work, are also sat-

BUFFALO BREAKWATER CONSTRUCTION.

CONTRACT OF HUGHES BROS. & BANGS.

DAILY REPORT OF OPERATIONS.

CANADIAN QUARRY.

....190....

FORCE. STATE OPPOSITE WHERE EMPLOYED.	Quarry.	Loading Dock.	Track.	Shops.		Total.	Rate.	Amount.
Superintendent.....								
Timekeeper.........								
....								
Foreman............								
Drillers............								
Drill Helpers......								
Hoist Engineers....								
Firemen...........								
Laborers............								
Engine Drivers.....								
Blacksmiths........								
Blacksmiths' Helpers								
Machinists..........								
Carpenters.........								
Water Boys........								
Watchmen.........								
Teams.............								
....								
....								

Remarks: Weather, Sea, Delays, etc.
Once a week measure each stone on one scowload of capping stone and note same in detail on back of report.

RUBBLE STONE SHIPPED.

NO. OR NAME OF VESSEL.	TONS.	NO. OR NAME OF VESSEL.	TONS.
....	....	....	....
....	....	....	....

CAPPING STONE SHIPPED.

NO. OR NAME OF VESSEL.	TONS.	NO. OR NAME OF VESSEL.	TONS.
....	....	....	....
....	....	....	....

PLANT.

Locomotives...............		Large Steam Drills........	
Large Flat Cars............		Medium Steam Drills.......	
Small Flat Cars............		Pony Steam Drills.........	
Dump Cars................		Steam Pumps..............	
Coal Cars..................		Derricks..................	
Boxes or Skips.............		....	
Stationary Boilers.........		....	
Skeleton Hoisting Engines..		....	
Hoisting Engine with Boiler		....	
Incline Engine with Boiler..			

Fig. 128.—Daily Report, Quarry.

isfactory. A contractor, nowever, would need a space for the name of the foreman in charge of each separate gang.

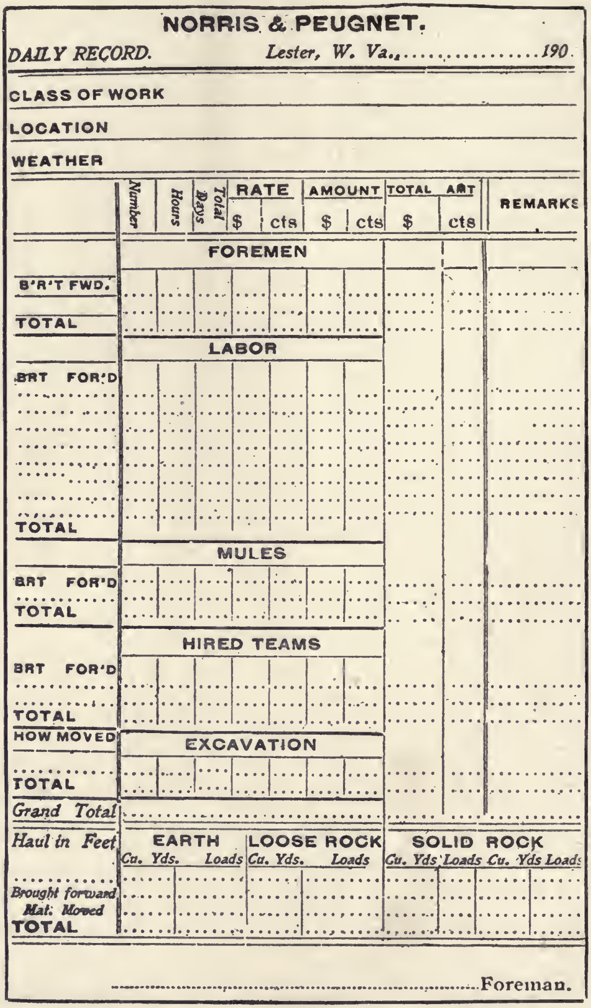
Note especially that on Fig. 125 there is a column for entering the numbers of the stations between which the concrete was deposited. The stations were 100 ft. apart, as in railroad work. This recording of the exact location of the work done each day is usually omitted by the contractor who has not had experience also as an engineer. It is a serious omission, for the progress of all such work should be plotted on a map or profile kept in the office, so that the contractor can tell at a glance what work has been done each day, and where it has been done.

Coming now to Fig. 127, we find a blank that gives more detail than any of its predecessors. We note, for example, that each row of drill holes is numbered, and that each hole in the row also has its number. This, when accompanied by a sketch showing the spacing and position of the holes, gives an accurate record of the drilling work. The depth of each hole is recorded and the number of pounds of dynamite charged in each hole. These holes were drilled under water, hence one column is reserved for entering the depth to rock.

We are indebted to Mr. Emile Low, M. Am. Soc. C. E., for these blank reports, which were prepared by him while in charge of the Buffalo Breakwater construction. As a result of his experience with the keeping of records, he suggests that it would be wise to make the blanks 7 x 8½ ins. in size, as indicated in Fig. 128, which is the same as Fig. 121, except for certain changes in arrangement and certain additional columns. Fig. 128 can be folded in the middle so as to form two pages of a note book, each 4¼ x 7 ins. Then the sheets can be made up into a time-book containing 31 sheets, or one for each day in the month. However, if it were desired to send in the sheets each day, as would be the case where a contractor is keeping the records, the same sheets could be used and folded in the other direction, making a folded sheet 3½ x 8½ ins.

Cost Keeping on Railroad Construction.*— In railroad construction it is more difficult to secure proper supervision of workmen than on many other kinds of engineering work. This is due to the fact that the men are distributed along the line of the

*Engineering-Contracting, Sept. 25, 1907, and Nov. 6, 1907.



NORRIS & PEUGNET.

DAILY RECORD. *Lester, W. Va.,* .... *190* .

CLASS OF WORK

LOCATION

WEATHER

	Number	*Hours*	*Days*	*Total*	RATE $	RATE cts	AMOUNT $	AMOUNT cts	TOTAL AMT $	TOTAL AMT cts	REMARKS
	FOREMEN										
B'R'T FWD.											
TOTAL											
	LABOR										
BRT FOR'D											
TOTAL											
	MULES										
BRT FOR'D											
TOTAL											
	HIRED TEAMS										
BRT FOR'D											
TOTAL											
HOW MOVED	EXCAVATION										
TOTAL											
Grand Total											

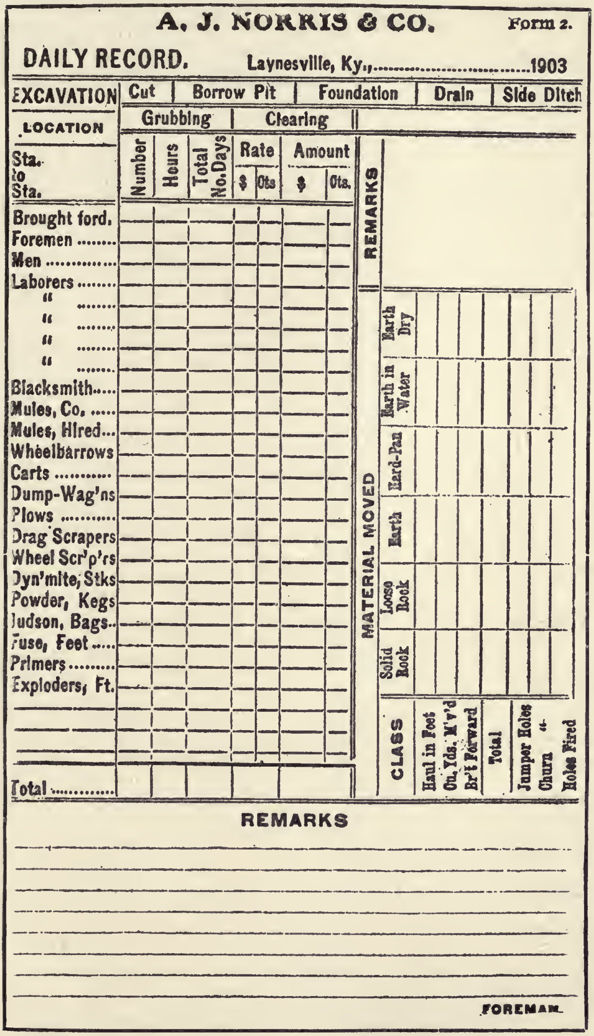
Haul in Feet	EARTH *Cu. Yds.*	EARTH *Loads*	LOOSE ROCK *Cu. Yds.*	LOOSE ROCK *Loads*	SOLID ROCK *Cu. Yds*	SOLID ROCK *Loads*	SOLID ROCK *Cu. Yds*	SOLID ROCK *Loads*
Brought forward Mat. Moved								
TOTAL								

....Foreman.

Fig. 129.—Daily Report, Railroad Grading.

road, a contractor's forces being scattered over many miles. Under such circumstances the keeping of cost records of work done is essential to efficiency.

Figs. 129 and 130 show two daily reports for open cut work. They both go somewhat into details, but No. 130 more so than No. 129. The latter has no spaces for explosives, blacksmith or feet of holes drilled, while No. 130 has spaces for these.


A. J. NORRIS & CO. Form 2.

DAILY RECORD. Laynesville, Ky.,..............................1903

EXCAVATION | Cut | Borrow Pit | Foundation | Drain | Side Ditch

Grubbing | Clearing

LOCATION Sta. to Sta.	Number	Hours	Total No. Days	Rate $	Rate Cts	Amount $	Amount Cts.
Brought ford.							
Foremen							
Men							
Laborers							
"							
"							
"							
"							
Blacksmith.....							
Mules, Co.							
Mules, Hired...							
Wheelbarrows							
Carts							
Dump-Wag'ns							
Plows							
Drag Scrapers							
Wheel Scr'p'rs							
Dyn'mite, Stks							
Powder, Kegs							
Judson, Bags..							
Fuse, Feet							
Primers							
Exploders, Ft.							
Total							

REMARKS

MATERIAL MOVED

CLASS	Haul in Feet	Cu. Yds. M'v'd	Br't Forward	Total	Jumper Holes	Churn "	Holes Fired
Earth Dry							
Earth in Water							
Hard-Pan							
Earth							
Loose Rock							
Solid Rock							

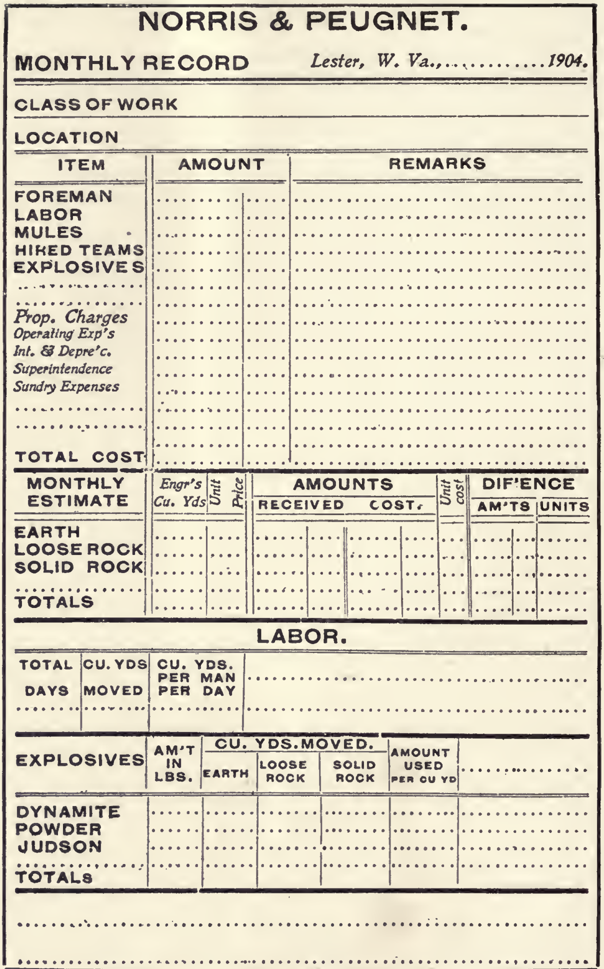
REMARKS

FOREMAN.

Fig. 130.—Daily Report, Railroad Construction.

These reports are made out by each foreman for the gang working under him, and a contractor should have but little trouble in judging quickly if any one gang is not being handled properly.

Figs. 131 and 132 are blanks for making a monthly resume of the daily reports. The value of the foreman's estimate of the amount of work done during the month on the form in Fig. 132



NORRIS & PEUGNET.

MONTHLY RECORD *Lester, W. Va.,............1904.*

CLASS OF WORK

LOCATION

ITEM	AMOUNT	REMARKS
FOREMAN		
LABOR		
MULES		
HIRED TEAMS		
EXPLOSIVES		
....		
....		
Prop. Charges		
Operating Exp's		
Int. & Depre'c.		
Superintendence		
Sundry Expenses		
....		
....		
TOTAL COST		

MONTHLY ESTIMATE	*Engr's Cu. Yds*	*Unit Price*	AMOUNTS RECEIVED	AMOUNTS COST.	*Unit cost*	DIF'ENCE AM'TS	DIF'ENCE UNITS
EARTH							
LOOSE ROCK							
SOLID ROCK							
....							
TOTALS							

LABOR.

TOTAL DAYS	CU. YDS MOVED	CU. YDS. PER MAN PER DAY	

EXPLOSIVES	AM'T IN LBS.	CU. YDS. MOVED. EARTH	CU. YDS. MOVED. LOOSE ROCK	CU. YDS. MOVED. SOLID ROCK	AMOUNT USED PER CU YD	
DYNAMITE						
POWDER						
JUDSON						
....						
TOTALS						

Fig. 131.—Monthly Report, Railroad Grading.

is questionable. It is the engineer's estimate that counts. The foreman's estimate, even if made with sincerity, is more than apt to be influenced by his desire to get a large amount of work done, in order to make a good showing for himself.

These sheets are printed on manila cardboard and Figs 130 and 132 are reproduced natural size, while Figs. 129 and 131 are slightly reduced. The first set was used on the Big Sandy

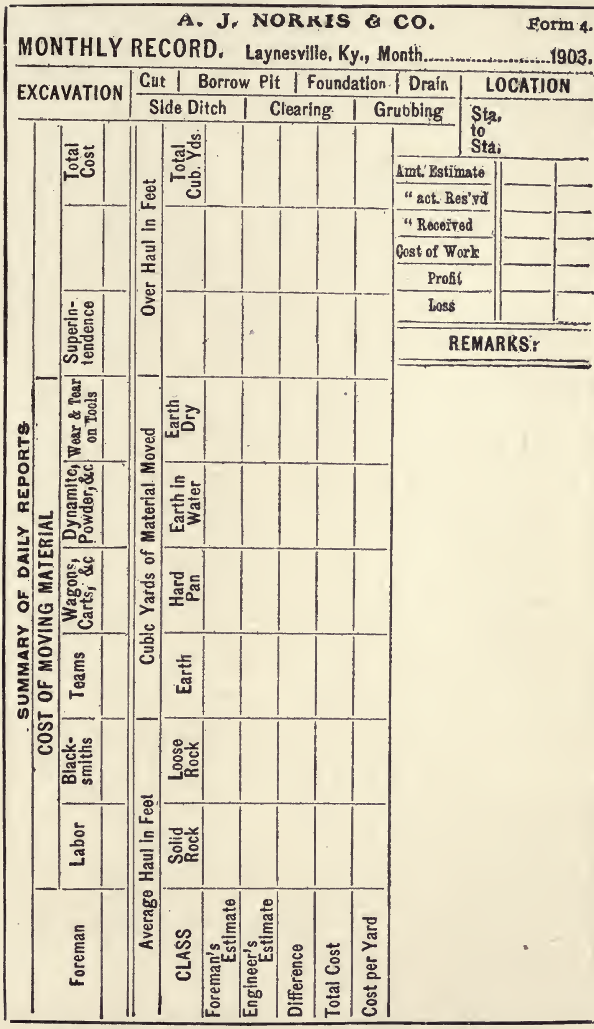


Fig. 132.—Monthly Report, Railroad Construction.

extension of the Chesapeake and Ohio R. R., while the other set was for use on the Deepwater Ry.

Figs. 133 and 134 are records of labor on tunnel construction only. The original sheet was 11 x 21½ ins. The part reproduced shows day shift only, but on the original sheet by the side of the day shift was a reproduction of the same form for a night shift, the only variation being that as the stone quarry was run during

DAILY LABOR REPORT.
NEW GALLITZIN TUNNEL,
PENNA. RAILROAD,
GALLITZIN, PA.

P. F. BRENDLINGER,
CONTRACTOR,
1009 Arcade Building,
PHILA., PA. DATE.................190..

GENERAL FORCE.	$	Cts.
General Superintendent		
Tunnel Superintendent		
Ass't Tunnel Superintendent		
Chief Clerk		
Office		
TOTAL		

EXCAVATION—DAY SHIFT

WEST END. NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.	EAST END. NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.
	HEADING.				HEADING.		
	Foremen				Foremen		
	Drill Runners				Drill Runners		
	Drill Helpers				Drill Helpers		
	Column Jackers				Column Jackers		
	Nippers				Nippers		
	Muck Foremen				Muck Foremen		
	Muckers				Muckers		
	Timber Foremen				Timber Foremen		
	Timbermen				Timber Men		
	Water Boy				Water Boy		
	Driver				Driver		
	Lampman				Lampman		
	BENCH				BENCH		
	Foremen				Foremen		
	Timber Men				Timber Men		
	Pitmen				Pitmen		
	Muckers				Muckers		
	Drivers				Drivers		
	Water Boy				Waterboy		
	Nipper				Nipper		
	Powdermen				Powdermen		
	Shovel Engineer				Shovel Engineer		
	Shovel Cranesman				Shovel Cranseman		
	Dinkey Runners				Dinkey Runners		
	Brakesmen				Brakesmen		
	Blacksmith				Blacksmith		
	Blacksmith Helper				Blacksmith Helper		
	Timekeepers				Timekeepers		
	Watchmen				Watchmen		
	Compressor Engineer				Compressor Engineer		
	Compressor Firemen				Compressor Firemen		
	Machinist				Mechanical Engineer		
	Stable Boss				Stable Boss		
	Drivers				Drivers		
	Hired Teams				Hired Teams		
	Carpenters				Carpenters		
	Carpenter's Helpers				Carpenter's Helpers		
	Dump Foremen				Dump Foremen		
	Dumpmen				Dumpmen		
	Crossing Watchmen				Crossing Watchmen		
	Drill Runners				Drill Runners		
	Drill Helpers				Drill Helpers		
	TOTAL				TOTAL		

MASONRY—DAY SHIFT

WEST END. NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.	EAST END. NO.	OCCUPATION.	RATE PER DAY.	AMOUNT.
	RUBBLE SIDE WALLS.				RUBBLE SIDE WALLS.		
	Foremen				Foremen		
	Masons				Masons		
	Mason's Helpers				Mason's Helpers		
	Laborers				Laborers		
	Mortar Mixers				Mortar Mixers		
	Dinkey Runners				Dinkey Runners		
	Dinkey Brakemen				Dinkey Brakemen		
	TOTAL				TOTAL		
	CONCRETE.				CONCRETE.		
	Foremen				Foremen		
	Skilled Laborers				Skilled Laborers		
	Inside Laborers				Inside Laborers		
	Outside Laborers				Outside Laborers		
	Hoisting Engineers				Hoisting Engineers		
	Dinkey Runners				Dinkey Runners		
	Dinkey Brakemen				Dinkey Brakemen		
	TOTAL				TOTAL		
	PORTAL.				PORTAL.		
	Masonry Foremen				Masonry Foremen		
	Masons				Masons		
	Mason's Helpers				Mason's Helpers		
	Laborers				Laborers		
	Hoisting Engineers				Hoisting Engineers		
	Mortar Mixers				Mortar Mixers		
	TOTAL				TOTAL		
	DAY SHIFT.				DAY SHIFT.		
	Quarrying Stone				Quarrying Stone		
	Foremen				Foremen		
	Quarrymen				Quarrymen		
	Laborers				Laborers		
	Hired Teams				Hired Teams		
	TOTAL				TOTAL		

Fig. 133.—Daily Report, Tunneling.

RECAPITULATION.	$	Cts.
GENERAL FORCE.		
West End Tunnel — Day		
West End Tunnel — Night		
East End Tunnel — Day		
East End Tunnel — Night		
RUBBLE SIDE WALL.		
West End — Day		
West End — Night		
East End — Day		
East End — Night		
Portal Masonry — West End		
Portal Masonry — East End		
CONCRETE MASONRY.		
West End Tunnel — Day		
West End Tunnel — Night		
East End Tunnel — Day		
East End Tunnel — Night		
Quarrying Stone		
Floating Gangs		
Total		
Previous		
Total to Date		
Signed .... CHIEF CLERK.		

Fig. 134.—Daily Report, Tunneling.

the day only, this did not appear in the night shift's report. The form is large and rather cumbersome and does not show details of progress of the work.

All these forms are subject to the criticism that the reports can not be made in duplicate on carbon copies. This is an important feature in cost keeping, for obvious reasons.

Mr J. P. Hallihan, of El Paso, Texas, has described the following system which shows great care and ingenuity in its devising and includes some excellent forms.

While it is not always necessary that the engineer should have a complete cost-analysis, showing subdivision of cost per unit of measurement, it is required that the cost per unit in various locations, as in each cut, should be at his command, as well as the manner of handling, disposition of material and time consumed.

Force reports in use in railroad work are not designed to secure this information, except in a very general way, usually giving a mere statement of force employed each day, without regard to costs.

The accompanying forms were used on some recent work in the Southwest, and were intended to collect all the data required in shape for condensation or further analysis, but the initial form was made as simple as possible, calling for no calculation on the part of foremen.

The field report (shown as Fig. 135) is bound in books of 35 duplicate sheets, colored white and yellow, the white sheet being perforated for removal. In the case of company work, the

FOREMAN'S DAILY TIME REPORT.

Work done on sect.......................................190...
By.......................................Foreman.
Between sta.......................and sta.......................

Name.	Time.	Rate.	Name.	Time.	Rate.
Teams:					
..........4-plow			..........Supply		
..........6-plow			..........Cart		
..........8-plow			..........Stone boat		
..........Slip			..........Wagon		
..........Fresno			..........Car		
..........Wheeler			..........Water		
..........Snatch			..........In corral		

MATERIAL USED.

Pounds of Dynamite.	Kegs Black Powder.	Feet of Fuse.	Number of Caps.	No. and length of Exploders.	Sacks of Cement.	Liters Black Oil.	Liters Cy'l Oil.	

Class of work:
Clearing. Excavation. Earth. Loose rock. Solid rock.
Borrow. Waste. Haul.......................Meters.
Tunnel No.......................Structure No.......................
Cross out words not necessary to express nature of work.

(OVER)

DISTRIBUTION OF LABOR.

No.	Employe.	Time.	Rate.	
	Foreman			
	Sub-Foreman			
	Laborers			
	Drillers			
	Nippers			
	Water boys			
	Blacksmiths			
	Blacksmith Helpers			
	Drivers			
	Corral men			
	Bridgemen			
	Timbermen			
	MISCELLANEOUS:			
	Work done, etc.			

.......................Foreman.

Foreman will fill this blank out daily and forward to timekeeper.

Fig. 135.—Daily Report, Railroad Grading.

FERROCARRIL, RIO GRANDE, SIERRA MADRE Y PACIFICO

....................FORCE REPORT—GRADING.

Contractor..........................Division No...........Section Nos............Station................To Station.................190...

			Clearing & Grubbing.		Excavation and Borrow.								Teams.													Material Used.					Costs.				
																					Plow.												
Date.	Section.	Stations.	Foreman.	Laborers.	Foremen.	Laborers.	Drillers.	Nippers.	Water boys.	Blacksmiths.	Blacksmith Helpers.	Carts.	Stone. Boat.	Slip.	Fresno.	Wheeler.	Snatch.	Supply.	Water.		4	6	8	In Corral.	Total.	Dynamite, Lbs.	Black Powder, Kegs.	Fuse—Feet.	Caps—No.	Exploders No. and Length.	Labor.	Material.	Camp and Miscellaneous.	Total.	Remarks.
To-tals @ Cost																																			

Note.—Under Camp Costs show fixed cost of Camp, which consists of General Foreman, Timekeeper, Corralman, Cook—all fixed employes of camp except Commissary Clerk, who is chargeable to Commissary.

Checked: .... Const. Eng.

Correct: .... Line Rider.

Fig. 136.—Weekly Report, Railroad Construction.

Report of Clearing, Grubbing and Grading During ________________ 190____

Section	Stations	Clearing & Grubbing							Grading												
		Force		Cost					Force				Cost				Total Engineers Estimate To Date	Quanity Moved			
		No. Men	No. Teams	Labor	Material & Misc'l.	Total	Total to Date	Enginr's Estimate to date	No. Men	No. Teams	Graders	Steam Shovels	Labor	Material & Misc'l	Total	Total to date		Earth	Loose Rock	Solid Rock	Haul

Fig. 137.—Monthly Report, Railroad Construction.

form is filled in duplicate, using carbon, then torn out and the information called for on reverse side (distribution of labor and foreman's estimate of material moved or work done) is filled in, carbon impression being taken on reverse side of sheet retained in book. The sheet is then deliverd to the timekeeper, who checks the time given on report against the time which he has personally taken, and forwards report to the division engineer. On isolated jobs, or with small gangs where no timekeeper is employed, the report goes direct to general foreman or division engineer. At the end of the month all books are sent to office of division engineer, who is thus put in possession of the original record of each day's work.

Where work is being done by a contractor, the data are obtained by force reporter using same form, omitting, of course, the names of employes, and noting only the total number of each rate. The other information is obtained from foreman's statement, checked by personal observations.

Fig. 136 is a condensation of daily reports into a weekly report, showing distribution of force on each section and total cost for period covered. Quantities moved may be closely approximated from daily reports and profiles and inserted in weekly report, if desired.

Accurate statement of quantities moved is, however, shown on the monthly sheet (Fig. 137) as derived from engineer's estimates. Fig. 137 also shows total force and cost for month of work done on each section. It can also be arranged to show grand total cost of each section since commencement of work, and, for the use of a general contractor, this would obviously be required.

The daily report form is used for all classes of work, the weekly and monthly reports being printed to conform to nature of work and information required.

Cost Keeping System of Fred T. Ley & Co., Inc., of Springfield, Mass,*—We take up the system of Fred T. Ley & Co., who, as will be seen at the close of this article, have built many miles of electric railways, conduits, etc. The editor visited one line of railway work being done by this company some years ago and found that a very careful system of cost keeping was in

*Engineering-Contracting, April, 1906.

use. Since the visit of the editor, the company has developed and improved its system, and, like all other firms of contractors who have once perfected a cost-keeping system, nothing could induce them to adopt the guesswork plan of cost-keeping.

Before describing the record blanks used by Fred T. Ley & Co., it is well to point out that their work has often been of a kind most difficult to keep track of. Frequently it has been strung out over twenty miles on one contract. Now, it is obvious that a system which is designed for use on work that is concentrated within a limited area, may need decided modifications when applied to scattered work. The features of the Ley system can best be understood from a brief description of the record blanks and their use.

The timekeeper takes the time of each gang on Blank No. 1a (Fig. 138a). He uses a separate sheet for each separate gang of men. He puts down each man's number, the hours worked and the rate per hour. One sheet holds the names of 30 men besides 14 teams. These sheets are bound in a loose-leaf binder, as indicated by the holes. On the reverse side of each sheet is Blank No. 1b (Fig. 138b), which is filled in so as to give the total cost of the day's work of the gang, the amount of work done, the location of the work, and the haul. In this case the work was located between Stations 1 and 8; the haul was 500 ft., and the output was 200 loads of gravel, at a cost of $41.48. Thus we have the cost of the work done March 15, on the cut between Stations 1 and 8.

On every large job there are many general expenses that must be distributed over a number of gangs of men; for example, the salaries of superintendent, timekeeper, etc. These miscellaneous charges are entered on a "miscellaneous sheet" like Fig. 138a, and the total is divided up among the different pieces of work, pro rata. Thus, Fig. 138b shows that $2.48 was charged from the miscellaneous sheet.

On large contracts, the timekeepers make out a daily report, Blank No. 2 (Fig. 139), which gives the total expense each day of the entire contract; and the total of the small detail sheets (Blank No. 1b) must agree with the total of this large sheet.

When the timekeeper takes his time in the morning, he gets from each foreman a supply report filled in on Blank No. 3 (Fig. 140). This gives the amount of material used the day be-

TIME SLIP

W. C. CONTRACT

Mar. 15 1905

NUMBER	HOURS	RATE	NUMBER	HOURS	RATE
700	10	15			
702	"	"			
705	"	"			
709	"	"			
724	"	"			
813	"	"			
825	"	"			
846	"	"			
872	"	"			
925	"	"			
976	"	"			
854	"	"			

TEAMS	HOURS	RATE	TEAMS	HOURS	RATE
Jones	10	45			
"	"	"			
Smith	"	"			
"	"	"			

MISCELLANEOUS

Fig. 138a.—Front of Timekeeper's Sheet.

FRED T. LEY & CO., Contractors.

Mar. 15 1905

Sta. 1 to 8 Haul 500'

FOREMAN Clark

MEN	HOURS	RATE		COST	
				3	
12	120	15		18	
TEAMS	**HOURS**	**RATE**			
4	40	45		18	
MISCELLANEOUS					
			MISC.	2	48
			TOTAL	41	48

MATERIAL Gravel

AMOUNT OF WORK 200 loads

REMARKS

WEATHER

FAIR

Fig. 138b.—Back of Timekeeper's Sheet.

DAILY REPORT.

Contract No.............................. ....Contract.

....190 ....Section.

HELP EMPLOYED.

No.	FOREMEN				No.		LABORERS				
	Foremen @	per hr.	hrs.				Men @	per hr.	hrs.		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				"	"	"		
	"	"	"				Total,				
	Total,						MISCELLANEOUS				
	TEAMS						@	per hr.	hrs.		
	Teams @	per hr.	hrs.				@	"	"		
	"	"	"				@	"	"		
	"	"	"				@	"	"		
	"	"	"				@	"			
	"	"	"				@	"	"		
	"	"	"				@	"	"		
	"	"	"				@	"	"		
							Total,				
							Total Pay Roll,				

.............Time Keeper.

Fig. 130.—Timekeeper's Daily Report.

fore on each particular kind of work. The timekeeper sends in these supply reports with his daily time slips.

When the reports are received in the office, they are first turned over to the pay-roll clerk, who tabulates the time. When he is through with them he turns them over to the record clerk, who records them on the proper sheets. When the pay-roll is made up every two weeks, its totals must agree with the totals on the time slips.

A summary of the time slips (Fig. 138b) is entered on Blanks Nos. 4, 5 and 6 (Figs. 141, 142, 143), a separate blank being used for each cut and for each separate gang of men. Thus, Fig. 141 shows the cost of excavating and filling between Stations 1 to 8, by days beginning with March 15. We see that the total number of loads was 200, and that the cost per load was $0.207. There is room to enter 29 days' work on the front side of each of these blanks, and as many more on the rear side. At a glance it can be seen what each day's work has cost per load, and the contractor is in a position to detect any increase or decrease in the cost, from day to day. This enables him to dis-

STATION. ______________190.

SUPPLY SHEET. GIVE THIS SHEET TO THE TIMEKEEPER EACH DAY.

SUPPLIES	GRADING	ROCK	CONCRETE	RUBBLE	PIPE LAYING	TRACK	BALLAST	CEMENT BAGS RETURNED
DYNAMITE								
EXPLODERS								
POWDER								
CAPS								
FUSE								
CYL. OIL								
BLACK OIL								
WASTE								
CEMENT								
STONE								
LUMBER								

FOREMAN.

Fig. 140.—Daily Supply Report.

cover inefficiencies in men or methods—not weeks after the work is done, but the day after.

Fig. 142 is essentially the same as Fig. 141, excepting that columns are provided in which to enter cost of dynamite and exploders. The number of feet of hole drilled each day is also recorded, and the number of loads of rock hauled.

Fig. 143 is for concrete work, and is self-explanatory.

Blank No. 7 (Fig. 144) is the pay-roll blank, and needs no explanation.

In looking over these blanks we note especially the provision made for recording the work done by each gang of men at each cut, each culvert or bridge, etc., along the line of the work. The blanks are very simple in form, and the system is so flexible that

GRADING Cut from Sta. 1 to 4 Fill from Sta. 4 to 8

DATE	FOREMAN	STATION			MATERIAL	MEN			TEAMS			MISC.	TOTAL	NO.	COST	REMARKS
		CUT	FILL	HAUL		HRS.	RT	COST	HRS.	RT	COST	EXP.	COST	LDS.	LD	
Mar. 15	Clark	2'	7'	500'	Gravel	120	15	1800	40	45	1800	548	4148	200	207	

Fig. 141.—Summary Sheet, Grading Sta. 1 to 8.

ROCK

DATE	FOREMAN	STATION			MEN			TEAMS			MISC.	TOTAL	DYN.	EXP	FEET	NO.	DRILL'G LD.	REMARKS
		C	F	H	HRS	RT	COST	HRS	RT	COST	COST	COST	USED	USED	DRILLED	LDS	COST	

Fig. 142.—Summary Sheet, Grading.

CONCRETE STATION WORK

DATE	LABOR		EXCAVATING		FORMS		MIXING	PLACING	FINISHING	HAULING				C'M'NT	Btch	EMPTY	MISC.	TOTAL	REMARKS
190	MEN	RATE	YDS.	COST	BUILDING	TAKING DOWN	COST	COST	COST	CEMENT	STONE	SAND	LUMBER	USED	Mxd	BAGS RET'D	COST	COST	

Fig. 143.—Summary Sheet, Concrete.

Fred. T. Ley & Co. Pay-Roll. Contract. Two weeks ending 190

NAME OR NUMBER	S	M	T	W	T	F	S	S	M	T	W	T	F	S	Total Hours	Rate per Hour	Amount Due	Amount Paid	Balance Due	REMARKS	

Fig. 144.—Pay-Roll.

it can be extended to cover many classes of work. The recording of earth and rock excavation by wagon loads or car loads is not absolutely accurate, due to the variation in sizes of loads; but when the number of loads is checked by cross-sections of the excavation, it will be found that the loads average a certain tolerably constant yardage under given conditons, and, by a little care, the contractor can be quite sure that the foreman is not sending out light loads so as to make a good record for a day's output.

Fred T. Ley & Co. do a great deal of work on the percentage basis, but they keep just as careful a record of cost on percentage work as on regular contract work, not only because they want to keep the unit cost down as low as possible in behalf of their clients, but because a client is able to visit the work at any time, count the men in any gang and check the accuracy of the time keeping for himself.

Record Card for Railway Section Foremen.*—The diagram, Fig. 145, is a record card to be used by section foremen, and it shows the day's work done by a gang of section men. The vertical lines, or ordinates, show the hours of the day from 7 a. m. to 6 p. m. and the intermediate quarter hours. The horizontal lines, or abscissas, show the number of units of work accomplished. The black circles are holes punched with a conductor's punch. The lines connecting the punch holes can be ruled in after the day's work is done.

This particular card shows that the gang of men arrived at the site of the day's work and started in at 7:30 a. m. At 10 a. m. they had completed 10 units of work, and the key letter S on the straight line between 7:30 and 10 a. m. is found to be the number of rail lengths of track surfaced and lined. At 10 a. m. the gang began putting in ties, as is indicated by the key letter T on the straight line between 10 a. m. and 12 m. Then the curve of work rises vertically from 12 m. to 1 p. m., indicating that no work was done during the noon hour. From 1 to 2 p. m. the work of putting in ties was continued. At 2 p. m. the gang began cutting grass, as is indicated by the key letter G, and quit at 5 p. m., having cut grass for a distance of 55 rail lengths. Then the curve of work rises vertically from 5 to

*Engineering-Contracting, July 17, 1907.

6 p. m., and the key letter D_2 shows that this hour was lost in picking up tools and going home.

It will be noted that a card of this sort gives a perfect log of the day's work, showing all delays, their cause and duration, and number of units of work accomplished. On the back of the card a series of key letters should be printed so that the fore-

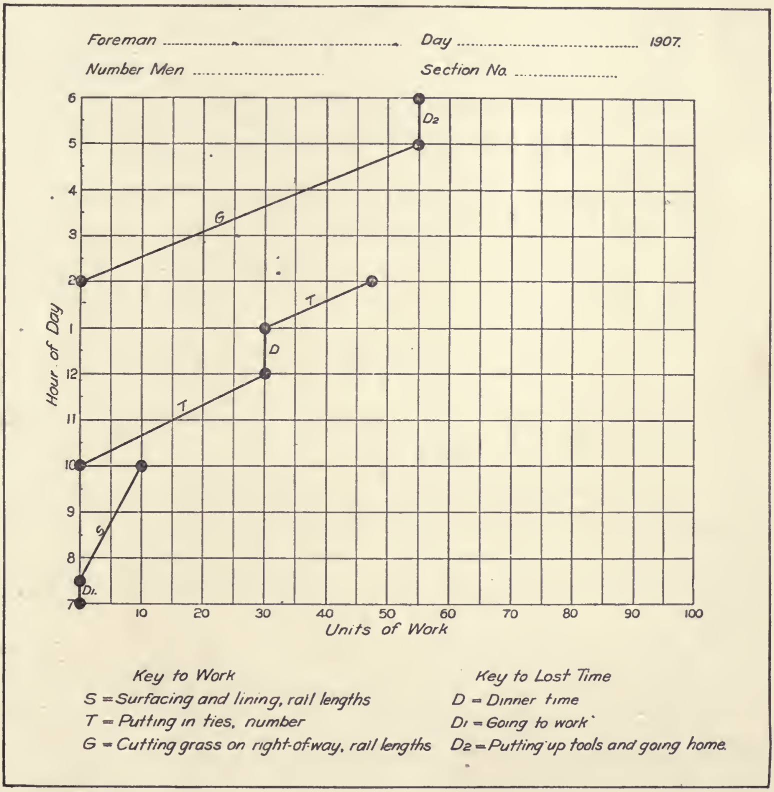


Fig. 145.—Daily Punch Card Record of Railway Section Foreman.

man can indicate on the curve of work any kind of work done, and the units in which it is measured. The rail length is a convenient unit for certain classes of work, the distance between telegraph poles may serve for other classes. Incidentally, all telegraph poles on each section should be numbered consecutively. Then the foreman can be required to report the exact location of the work by putting the number of the pole on the curve of work diagram.

The card shown herewith is obviously applicable to innumerable kinds of construction or manufacturing where men work as individuals or in gangs. It becomes complicated when a gang under a foreman is split up into smaller gangs which are continually shifted from one kind of work to another. But such shifting is usually unnecessary, and can be obviated, as a rule, by the use of better judgment in the management of the work. Indeed, this very objection to the use of such daily card reports points the way to better management by indicating the lack of reason for splitting gangs up into small units that putter away time.

A Cost-Keeping Book-Keeping System for Pipe Line Work.—Mr. W. W. Cummings, M. Am. Soc. C. E., has described in *Engineering News* for October 2, 1902, a system of cost-keeping bookkeeping, which description we herewith reproduce:

It often happens that an engineer is confronted by the problem of doing a certain amount of work with a limited sum of money, and the only way he can keep the cost within the required limits is to so systematize the reports that he can see at any time what the expenses are for the different items and trim them accordingly. In the ordinary methods of bookkeeping, unless a considerable force is kept on the accounts, the knowledge of excessive cost is obtained too late to be of much benefit to the work in hand.

In the construction of the Massachusetts Pipe Line Co.'s mains, the writer had occasion to regret that no previously tried system was available, and after considerable study devised the following methods, which may possibly be used as a base in similar cases.

When the Massachusetts Pipe Line Gas Co. commenced to lay its mains, it was given a limit of cost of $9 per lin. ft., complete, which was to include all repairs and changes to other pipes, conduits, sewers and paving. Much of the route was through districts congested by travel above and obstructed by existing structures below.

The work consisted of laying: 2½ miles of 42-in. pipe, laid in a double line; 3½ of 36-in., double; 1½ of 36 and 30-in., side by side; 7 of 36-in., single; 1 of 24-in. pipe, single. Also three river crossings. Three contractors were employed on the work.

Rates of labor were as follows:

Foreman	$0.45 per hour.
Subforeman	.35 " "
Subforeman	.30 " "
Bracers	.25 " "
Calkers	.25 " "
Pavers	4.00 per day (9 hrs.).
Tenders	2.00 " " "
Laborers: Derrickmen, bottommen, bracers' tenders, pavers' tenders, pipe layers, leadmen	.20 per hour.
Laborers	.18 " "
Laborers	.17½" "
Laborers	.17 " "
Laborers	.16 " "
Laborers	.15 " "
Blacksmith	.20 " "
Blacksmith's helper	.15 " "
Lampman	.15 " "
Toolman	.20 " "
Watchman	.15 " "
Carpenter	.25 " "

The office force consisted of:

1 bookkeeper	$60.00 per month.
1 time-keeper for each contractor	80.00 per month.
1 time-checker for each gang	12.00 per week.
1 engineer for each contractor	75.00 per month.
1 rodman for each contractor	50.00 per month.
1 yardman for each yard	60.00 per month.

The timekeepers and checkers were men selected for their reliability and diligence and were paid good wages. The checkers patroled the line at irregular intervals, at least every two hours, and returned a slip to the timekeeper, showing the men and teams at work each trip with the date and time on each slip. The entire route was mapped and separated into divisions and sections. The different cities constituted the divisions, and were let to different contractors, while the sections were divided according to the anticipated character of the work. That which required piling being one section, that containing rock cut another, where the line crossed private land, passed under the various kinds of street surfacing, was near a railway, etc., each a distinct section. The idea being that the cost of these different classes of work would show in the reports of the sections without further separation.

Five receiving yards were established along the line, where all pipe and material were delivered. Here the pipes were inspected, and a number was marked on the inside of each one with white lead.

A report, Fig. 146, was made in triplicate, containng this data, together with an account of everything shipped from the yard, the division, section and foreman shipped to and the teamster hauling the load. One copy of this report was sent to the office daily, another was forwarded to the auditor and the third remained in the book as a record. The timekeeper was required to return a daily report for each gang, made in duplicate, show-

MASSACHUSETTS PIPE LINE GAS CO.

DAILY PIPE REPORT.

Contractor: .... Received into Parks · St. Yard. Date July 7th. 1899

CARS		PIPE		WEIGHTS AND ~~TEAMSTERS~~ Numbers			Weight ~~DESTINATION~~	REMARKS
Number	Initial	Size	Number					
2769	P. R. R.	36"	2376 6	2590/5245 2591/5327	2592/5183 2593/5164	2594/5225 2595/5237	.12,621;357 31,381	Mc Neal.
2820	Penna Co.	36"	6	2596/5212 2597/5180	2598/5020 2599/5200	2600/5030 2601/5178	30820	Mc Neal.

MASSACHUSETTS PIPE LINE GAS CO.

DAILY PIPE REPORT.

Contractor Mass. P. L. Gas Co. Shipped from Parks St Yard. Date July 7th. 1899

CARS		PIPE		WEIGHTS AND TEAMSTERS			DESTINATION	REMARKS
Number	Initial	Size	Number	Jackson	Fighe.			
		36"	12597	5180			Div 1st Sect. 2. Foreman Gilson	Mc Neal.
		36"	12601	5178				

Fig. 146.—Daily Pipe Report.

ing the number of men of different classes employed, the rates of wages, the daily wages and the total wages to date, on each section on one side, while a list of the tools in use with the daily and the total rentals, if any, were shown on the reverse side. He also noted on this card the numbers of the pipes received and their condition, and the other material received. This report guarded against loss of tools and material in transit to the work.

Of course the total daily payroll of the card checked that of the time books. Figure 147 describes this report.

The division engineer was required to return daily reports for each section (Fig. 148) made in duplicate, showing the excavation, back-fill, paving, repairs made, material used, the numbers of the pipes laid in their order, with remarks covering anything that would affect the cost. This guarded against the loss of material while on the ground. Both the engineer's and timekeeper's reports were cards of convenient size for the coat

FORM 9 1000-11-13-01

MASS. PIPE LINE GAS CO.

Foreman Colman 's Report No. 21
Work .... Date July 7 1899
Location Div. H. Sec p

	No.	Previous	Hrs.	Rates	Amt.	Total
Foremen	1	90 87	.10	.45	4.50	95.34
"	1	35 65	10	.35	3 50	39 15
"	1	36 40	10	.30	3 00	39 40
Laborers	50	3510 90	10	17¼	88 50	
"	27		8	17½	37 50	
"	34		10	15	51 00	
"	6		8	15	7 20	3695 40
Firemen					184.50	
Carpenters		71 42				76 42
Blacksmiths		41 60	9	20	1 80	43 40
Caulkers		36 00				36 00
Pavers		9 25				9 25
" Tenders		6 75				6 70

Front.

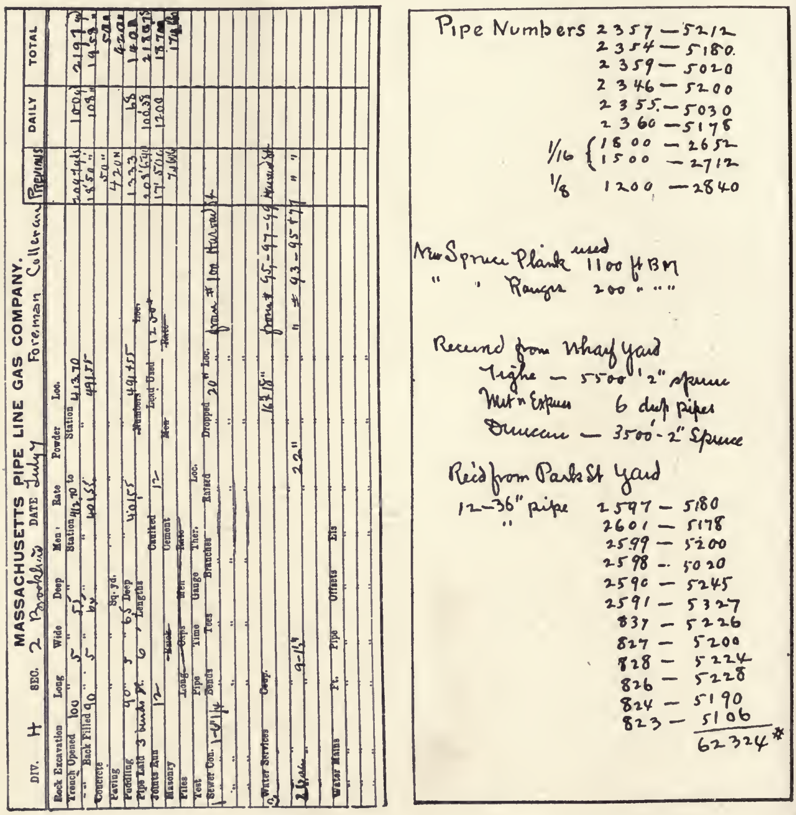
	No.	Previous	Hrs.	Rate	Amt.	Total
Derricks	1	10 00	10	05	50	12 50
Tool boxes		44 00			2 00	46 00
Furnaces	2					
Blacksmiths' kit	1	15 00			75	15 85
Pumps diaphragm	5					
" rotary						
" steam						
Pulsometers						
"						
Lanterns	117					

Reverse Side.

Fig. 147.—Daily Payroll Report, Pipe Laying.

pocket, and stiff enough to avoid crumpling, bound in book form, perforated, and having a thin sheet of parchment for the duplicate.

At the office the bookkeeper entered the pipe as ordered and the data from the cards on a page (Fig. 149), which gives the pipes ordered, received, to come, delivered to each section, laid in each section, on hand, and the length as obtained by average laying length (used as a check).



Front. Reverse.

Fig. 148.—Daily Progress Report, Pipe Laying.

Nearly all the pipe and specials were ordered from the McNeal Pipe & Foundry Co., and the R. D. Wood Co., and the columns headed "McN." and "W." refer to the castings from those dealers.

The bookkeeper also had a ledger account in detail (Fig. 150) which he took from the reports showing the material received, used, and transported from each section. This account

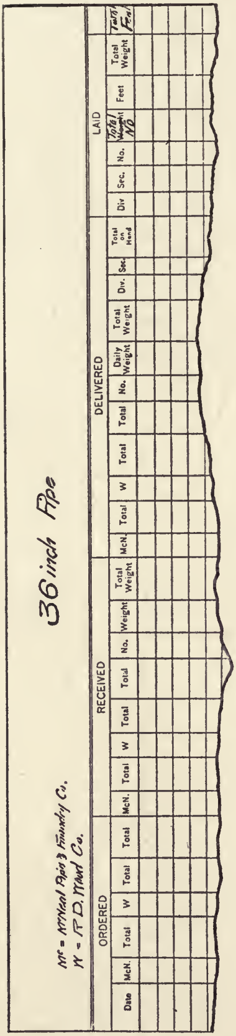


Fig. 149.—Bookkeeper's Pipe Record.

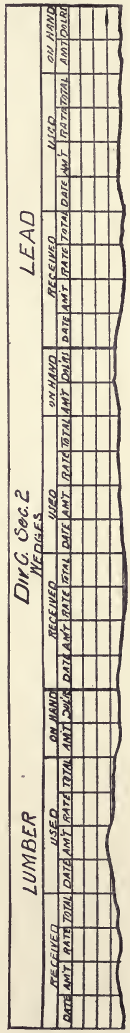


Fig. 150.—Bookkeeper's Material Record.

149

NOTE — * From Wharf Yard.
S " South Boston.

Div. D Sec. 2

DATE	PAVING			in. PIPE					EXCAVATION			LAYING.				BACKFILLING			REPAIRING			HANDLING				SUNDRIES			
190	Sq. Yds.	Rate	Amount	Feet	Weight in Lbs.	Weight in Tons	Rate	Amount	Cu. Yds.	Rate	Amount	Feet	Weight	Rate	Amount	Cu. Yds.	Rate	Amount	Feet	Rate	Amount	Feet	Weight	Rate	Amount	Feet	Rate	Amount	Material
																													30" Pipe
																													36" "
																													30" Drips
																													36" "
																													Wedges
																													Jute
																													Lead
																													Coke
																													Brick
																													Cement
																													Nails
																													Coal
																													Oil
																													Lumber
																													Inspector
																													Pay Roll
																													Insurance
																													Tools (Rentals)
																													Total

Fig. 151.—Bookkeeper's Summary Sheet.

229

Massachusetts Pipe Line Gas Co.—Pipe Record.

	PIPE No.	Wood	McNeal	WEIGHT	DATE TEAMED	Div.	Sec.	TEAMSTER	DATE LAID	FOREMAN	BROKEN PIPE				REMARKS	
											No. OF FEET	WEIGHT	PRICE	AMOUNT		

Fig. 152.—Bookkeeper's Pipe Record.

served to simplify the entries to be made on the page ruled, as in Fig. 151, and further guard against loss.

In practice the daily report cards from the yards, the timekeepers and the engineers, were mailed the evening of the day recorded and reached the office at 8 a. m. The bookkeeper made his entries on the pages, described by Figs. 149 and 150, and transferred his totals to the page, described by Fig. 151, which made the information in detail for the day recorded available by noon of the following day.

The results were combined in a similar manner for each division, as shown by Fig. 151, and again for the entire work. These totals were made up each week unless required oftener by the bad showing.

The bookkeeper also compiled a record of the pipe from the yard keepers' and engineers' reports on a page ruled as shown in Fig. 152, by which any lost pipe could be traced and damage assessed.

A "Division of Labor" sheet, showing the cost of the different items, was sent to the auditor each week. He also received the bills, and kept independent accounts. A daily report, described by Fig. 153, was sent to the president and chief engineer.

The division engineers also kept field books, giving the grade and laying length of each pipe, and the pipe numbers, in the order of their laying. The intersections of cross street lines and important underground structures were noted by station, the locations of each special were tied in to permanent points and the lateral distances from street lines and other pipes, sewers, conduits, etc., were noted.

When repair work was done by city men, a report of the labor, materials and prices was added to the engineer's card, together with the location of the repair. This was credited to the city on a page for that purpose, and when the bill was presented it was "O K'd" from that page.

The highest cost per lineal foot of pipe was $11.61, including all repairs, pipe, etc. This was one 36-in. pipe in rock cut, with a 12-in. gas main on one side and a water pipe and sewer on the other.

The lowest total cost per lineal foot of pipe, for two 36-in. pipes side by side, was $8.16; do., for one 24-in. pipe, $4.29.

The average total cost per lineal foot of pipe was $8.36.

The average total cost of pipe per lineal foot was $4.20, including specials.

The cost of pipe per ton was $17.50 f. o. b. Philadelphia. The cost of specials was 2¼c per lb.

The average cost of excavation (including sheeting) was $1.86 per lin. ft.; for laying (including lead, etc.), 62c; back-filling (including surfacing), 72c; handling (includes unloading cars and piling in yard) was 76c per lin. ft.

MASSACHUSETTS PIPE LINE GAS COMPANY.

July 7th, 1899.

FAIR:

Mr. Cummings in office 8:10. Tunnel, Boston, Roxbury, Brookline, Cambridge, office 5:45. Sullivan in office 8:10, 95 Milk St., office till 5. Tabor in office and works all day. Silsbee and Jeeves in office all day. Murry and assistants in Roxbury, Brookline and Jamaica Plain. Hayden and assistant in Cambridge giving grades.

Div. D. Secs. 1 and 2, Cambridge.

Laborers	233	Engineers	2
Carpenters	3	Pumpmen	20
Blacksmiths	1		
Night watchmen	12	Total	270
Day watchmen	10		
Derricks	1	Supply wagon	1
Furnaces	2	Single carts	1
Blacksmith kits	1	Double carts	40
Pumps	5		

302 lanterns out. Sec. 1, ¾-yd. concrete, 140 sq. yds. paving, 60 ft. edgestones, 114 yds. brick laid, 45 ft. pipe laid, 8 joints calked, 8 pigs lead used, 1 sewer connection made—25 ft. 5-in. pipe, 1 6-in. ¼ bend used.

Sec. 2. 175 ft. trench opened, 75 ft. back filled and puddled, 268.84 ft. pipe laid 17 joints calked, 15 pigs lead used, 15 piles driven, 8 caps used.

Fig. 153.—Daily Report to President.

This does not include engineering other than as above mentioned. The location sheets were as shown by Fig. 154, giving the station of the side streets and specials, with the lateral distance from street lines and other pipes, conduits, etc., wherever obtainable. Each special is tied in from permanent points, so that any joint can be found by locating a special and measuring the distance given in the field books, while keeping on the offset from the street lines.

A further compilation was started, as outlined in Fig. 155, which is modeled on the form used at Halifax, N. S. This gives at a glance all the information connected with the line, but requires a great deal of time. In the case of the Massachusetts Pipe Line Gas Co., it was reserved for winter work.

In case of repairs and leaks, slips (Fig. 156) modeled after those of the Boston Gas Light Company, W. R. Addicks, engi-

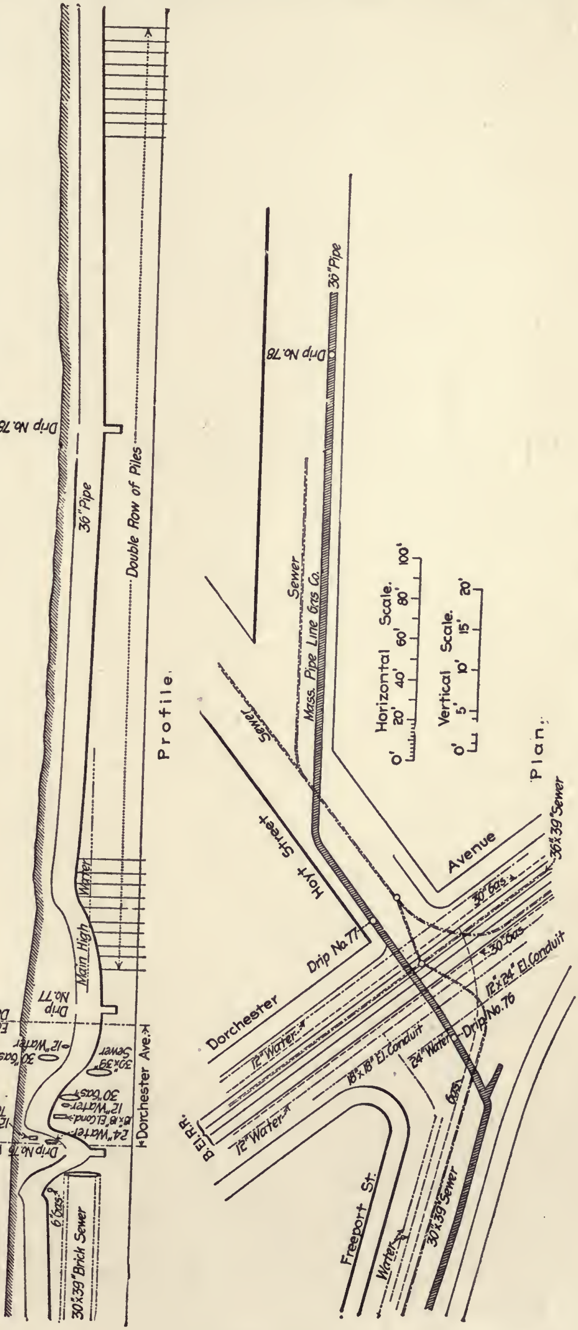


Fig. 154.—Location of Pipe Line.

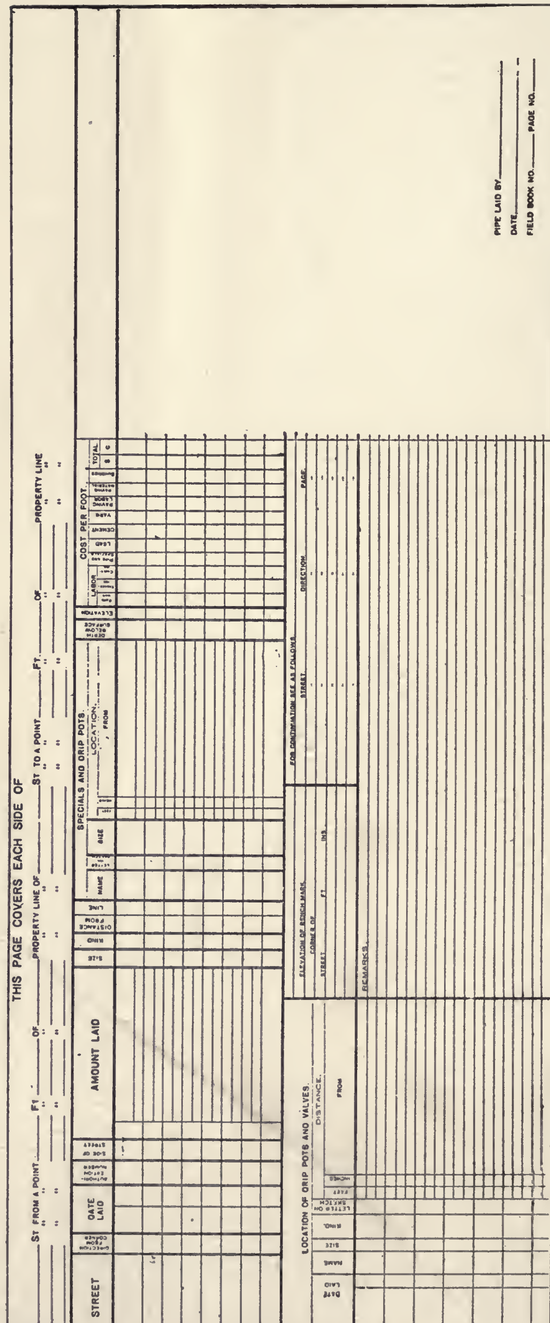


Fig. 155.—Complete Record of Pipe Line.

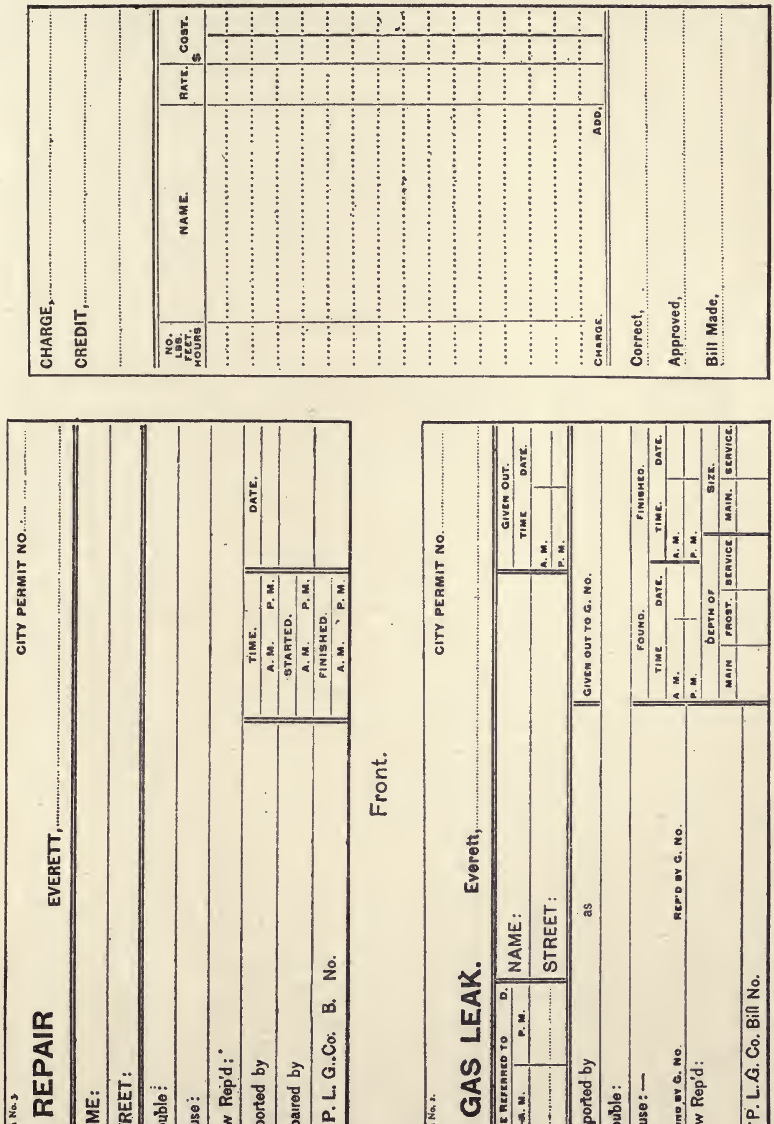


Fig. 156.—Repair and Leak Blanks.

neer, are filled out and filed in a card index under the heading of street names.

Each drip is numbered from the Everett works and a record (Fig. 157) is kept of the depth of drippage and the gallons pumped each visit. The drip wagon contains about 200 gallons, and has a float whose spindle is marked every 25 gallons. By tabulating for each drip the measurements in inches and the number of gallons pumped, it was easily seen about how much drippage there was for each inch, even though the water extended into the pipe (which is often the case in some drips where the pipes have a slight fall), so that a measurement now gives the approximate gallons to be pumped. Each valve is lettered from the works.

MASS. PIPE LINE GAS CO.

	1899								1900							
Drip Number	MONTH	DAY	GALS.	Depth	MONTH	DAY	GALS.	Depth	MONTH	DAY	GALS.	Depth	MONTH	DAY	GALS.	Depth
1	Dec. 18	Mon.		12"	Jan. 19	Fri.		35"	Jan. 30	Tues.		20"	Feb. 7.	Wed.		15"
2	" "	"		10"	" "	"		13"	" "	"		12"	" "	"		0"
3	" "	"		20"	" "	"		22"	" "	"		15"	" "	"		10"
									"	"		10"	" "	"		0"

Fig. 157.—Drip Record.

These drips and valves are located in the usual way by stenciling rectangular co-ordinates on permanent nearby points. All drips are sounded and the valves started once each month.

It would be unfair to close without tribute to the resourcefulness and push of Mr. L. J. Hirt, who was the chief engineer during construction.

Cost Keeping System of the Kosmos Engineering Co., New York City.*—The system about to be described differs materially from any of the systems previously illustrated. It should be stated in advance that the Kosmos Engineering Co. has the contract for building the Brooklyn anchorage for the Manhattan Bridge, the new wire cable suspension bridge across the East River at New York City, and that the blanks shown in this article were especially designed for that work. The system, however, is of general application, as will be noted later on.

*Engineering-Contracting, March 13, 1907.

The first noteworthy feature of the Kosmos system of cost-keeping is the absence of blanks to be filled in by the foremen. The foremen are provided with pads of paper on which they write each day the number of men in the gang and their respective duties and rates of wages. If the work is of a kind that admits of easy measurement, the foreman reports also the amount of work done. On the whole, however, very little is required of the foreman except a statement of the number of men, their occupation and the rates of wages. These he can give on any slip of paper, no printed blanks or rules of procedure being insisted upon.

The foreman's report with the timekeeper's book go each day to the bookkeeper. They, of course, must total up the same amount of daily pay account, and it is the bookkeeper's business to verify this fact. The verified records and time sheet go next directly to the superintendent's assistant, who analyzes them and distributes the costs to the proper accounts. The superintendent's assistant is himself a civil engineer capable of checking all measurements and estimates of quantities. The office is directly on the work so the assistant sees every part of the work himself several times daily. In a word, all analysis of costs is done in the office of a competent man, who is, moreover, in constant touch with the construction work, and so does not require a very elaborate report from the foremen.

Now as to accounts. In this particular contract all costs are charged under six general headings to a number of different items, each of which has its account in the ledger. Of course, the items vary somewhat from time to time, but the accompanying schedule gives a generally fair idea. Keeping to the labor accounts for the present, the superintendent's assistant, in analyzing the foremen's reports and time sheets, records his distribution of costs on blanks 9¾ x 6½ ins. in size and of the form shown in Fig. 158. These blanks are kept in a filing case and are available for inspection at any time and give a complete record of the labor cost of the work at any time.

The pay-roll vouchers are made out every two weeks and are made out from these blanks. The totals from the blanks are recorded on the back of the voucher in properly ruled spaces. Thus each payroll voucher is its own record not only of the total

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

GRANITE

DATE	Unloading and Distributing		DRESSING		TRANSPORTING		Hoisting and Setting					
		COST		COST		COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

EXCAVATION.

DATE	LABOR IN PIT		STONE BREAKERS		TRANSPORTATION		LOADING and TRIMMING SCOWS		BACK FILLING			
		COST		COST		COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

CARPENTERS, ELECTRICIANS.

DATE	CONCRETE FORMS		ARCH CENTERS				ELECTRICIANS		MACHINISTS		WATCHMEN	
		COST		COST		COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

FOUNDATION PILES, SHEET PILES AND BRACES.

DATE	SHEET PILING		BRACING		FOUNDATION PILES		PUMPING					
	LINEAL FEET	COST	FT. B. M.	COST	NO.	COST		COST		COST		COST

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

	CONCRETE						CYCLOPEAN			
DATE	MIXING	Transporting	Hoisting and Depositing	TOTAL	CU YDS.	Cost Cu Yd.	Transportation	Hoisting and Setting	CU. YDS.	Cost Cu. Yd.

KOSMOS ENGINEERING CO.
BROOKLYN, N. Y.

CONTRACT No. 1

LABOR

UNLOADING AND HANDLING CONCRETE MATERIALS.

DATE	CEMENT		CONCRETE STONE		SAND		CYCLOPEAN					
		COST		COST		COST		COST		COST		COST

Fig. 158.—Blanks for Distribution of Costs.

KOSMOS ENGINEERING CO.

DAILY CEMENT REPORT

______________190

NO OF BAGS	Lower Warehouse	Upper Warehouse	Boat	TOTAL
On hand start of day				
Used during day				
On hand close of day				

No. of bags used for Concrete______________

" " " Mortar______________

" " Received______________

Signed______________

Fig. 159.—Daily Cement Report.

payroll, but of the items making up that total. These vouchers go to the bookkeeper and from them he takes the amounts to be charged to the several accounts. The bookkeeper merely transcribes the amounts.

So far reference has been had entirely to the labor cost accounts. The bills for materials, supplies, etc., are also analyzed by the superintendent's assistant, who proportions or distributes the costs to the proper accounts. This distribution is given on the back of the voucher for every bill, and here again the bookkeeper has simply to transcribe the several amounts to the proper accounts.

The foregoing covers the main scheme for keeping costs. Its noteworthy features are that the foremen are called upon to do only the simplest kind of record-keeping and that the analysis of costs and their distribution to the proper accounts are performed by one of the regular engineering staff who is in constant touch with every detail of the work. It is evident that the system as described for one specific job is applicable to general contract work by making obvious modifications in details.

KOSMOS ENGINEERING CO.

EMPTY BAG ACCOUNT

Report for______________190

No. empty bags in stock at start of work______________

No. of empty bags placed in stock during day______________

No of empty bags shipped during day

via______________

No of empty bags on hand at close of day______________

Signed______________

Fig. 160.—Daily Empty Bag Report.

DAILY COST OF ELECTRICAL CURRENT CONSUMED.

________________ 190

Meter No. 1. Anchorage, Present ________ Previous ________ Diff. ________
" " 2. Mixer & Docks " ________ " ________ " ________
" " 3. Railroad " ________ " ________ " ________
" " 4. Arc Lights " ________ " ________ " ________
Total Watts consumed: Anchorage ________ Cost $ ________
" " " Mixer & Docks ________ " ________
" " " Railroad ________ " ________
" " " Arc Lights ________ " ________
Time Previous Readings ________ A. M. ________ P. M. ________
" Present " ________ A. M. ________ P. M. ________
Remarks ________
________ Signed ________

Fig. 161.—Daily Record of Electricity Used.

Besides the labor cost blanks shown in Fig. 158, the Kosmos Engineering Co., on the work referred to above, make use of a variety of other blanks for keeping the daily run of expenses and the condition of the stock of supplies and materials. Figs. 159 and 160 show the blanks for keeping track of the cement stock and the empty bag account. Fig. 161 shows a blank for keeping tab on the daily cost of electric current consumed. This serves the purpose of checking up the bills rendered for current and of detecting waste or other neglect. In a similar way, by means of the blanks shown in Figs. 162 and 163, a daily record is had of the work done by each motor car and hoist. Each hoist, derrick and motor is also inspected at frequent intervals and there are blanks for the inspector's reports. The operators of the several machines also have blanks on which they are required to report needed repairs. In a word, the company strives to know by actual reports the condition every day of its machinery, tools, supplies, etc. These detail records are, of course, not absolute essentials of the cost-keeping system proper, but they combine with that system to make every detail of the work efficient.

MOTOR CAR NO. ________ Date ________ 190 __

Motorman ________
Time Started ________ A. M. ________ P. M. ________
Time Finished ________ A. M. ________ P. M. ________
No. of Hours at ________ c. per hour ________
Cost for Day ________
No. of Cars in Train ________
No. of Trips ________
Kind of Material hauled ________
Amount of Material hauled ________

Remarks ________

Fig. 162.—Daily Record of Motor Car Performance.

HOIST NO.________ Date________190

Operator________
Time Started________A. M.________P. M.________
Time Finished________A. M.________P. M.________
No. of Hours at________c. per hour________
Cost for Day________
No. of Hoists________
Material Handled________

Amount of Oil________
" " Waste________

Remarks________

Fig. 163.—Daily Record of Derrick Performance.

Blanks for Recording Work of Well Drills as Used by the Nevada Consolidated Copper Co.*— Recording the work done in concise and convenient form is a very important item in

DRILL RECORD

Nevada Consolidated Copper Co.

For the Shift ending....................,190..

Previous depth of hole..
Present depth of hole..
Number of feet drilled..
Hours drilled..
Hours Lost..
Barrels of water used..
Cords of wood used..
Formation..
Location of Hole..
Number of hole..
Drill man's wages..
Helper's wages $..
Cost per foot of drilling this shaf $..
REMARKS:..
SIGNED..
FOREMAN..

Fig. 164.—Daily Record of Test Hole Drilling.

prospecting with well drills. Daily time cards should be filled out by each drill man as he comes off the shift. Sample cards are shown by Figs. 164 and 165. The card shown in Fig. 164 is for recording the cost of the work and that shown in Fig. 165 is for keeping a general record of the work. From the daily time cards the superintendent makes up his report to the company at the completion of each hole.

*Engineering-Contracting, July 3, 1907.

Form for Keeping Account of Cars of Materials.*—Mr. George R. Humphrey, member of the firm of Joseph Ross Co., bridge builders and general contractors of Boston, Mass., sends

DAILY DRILLING RECORD

Nevada Consolidated Copper Co.

Ruth, Nevada, ...190..

To..

Mr......................................General Manager

Drill Rig No. 1

Location. Name of Claim ....
Present depth of hole ....
Previous depth of hole ....
Feet of drilling this shaft ....
Hours drilling ....
Hours lost..
Drill man's name..
Helper's name..

Drill Rig No. 2

Location. Name of Claim ....
Present depth of hole ....
Previous depth of hole ....
Feet of drilling this shaft ....
Hours drilling..
Hours lost..
Drill man's name..
Helper's name ....

Above report is for time ending..

Remarks ....

Fig. 165.—Daily Record of Prospect Drilling.

us the form shown in Fig. 166. Mr. Humphrey has used this form for a number of years to keep account of materials received in carload lots.

The form records the number and initial of the car, time of arrival and delivery and also when the car is released. The material man keeps this record and obtains from the railroad agent the time of arrival. This form is ruled up in a small

*Engineering-Contracting, Nov. 20, 1907.

CEMENT.					
NOTE	Car No.	Init.	Arrived	Delivered	Released
	45913	N Y C	9-5 11 am	9-7 2 pm	9-8 9 am
$1 dm	69149	"	" 3 pm	9-8 11 am	9-13 10 am

Fig. 166.—Record of Freight Cars.

UNITED STATES DEPARTMENT OF AGRICULTURE.
OFFICE OF PUBLIC ROADS.

Daily report of work on Object-Lesson road at.................Date:................
Weather:..........Length of working day:.........hours. Signature:..............

Force Employed.

	Total in hours or days.	Pay per hour or day.		Total.	
Foremen..........					
Subforemen on......					
Excavation: Men...					
Teams.					
Shaping: Men.......					
Teams.....					
Quarry: Men.......					
Teams.....					
Crusher: Men......					
Engine and engineer...					
Hauling surfacing material.. To crusher					
To road...					
Loading surfacing material at........					
Spreading surfacing material.......					
Steam or horse roller.					
Sprinkler...........					
..............masonry					
Shoulder drains.....					
...........drains...					
Water boy..........					
Watchman..........					
....					
....					
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....					
....					
Total...........					

Work Done.

Earth excavation........	...cu. yds.	Sta...to Sta..
Subgrade shaped......	...sq. yds.	Sta...to Sta..
First course placed......	...sq. yds.	Sta...to Sta..
Second course placed......	...sq. yds.	Sta...to Sta..
Surface course placed......	...sq. yds.	Sta...to Sta..
Road surface completed...	...sq. yds.	Sta...to Sta..
Material crushed......	....	....
....	....	....

Materials Used, Paid for by Unit Measure.

	Quantity.	Price.	Total.	
Surfacing material......				
Fuel for crusher.....				
Fuel for roller.......				
Oil, waste, repairs.......				
Drain pipe, sizes.......				
Cement.......				
....				
....				
Total.....				

Remarks:..
....

Fig. 167.—Daily Report, Road Construction.
(Engineering-Contracting, Nov. 13, 1907.)

memorandum book, and on the adjoining page is kept a record of the material received in each car and the amount, such as 15 tons stone, or sand, 12 M. ft. of lumber and other materials.

Mr. Humphrey writes that this record shows at a glance what cars are on demurrage or those about to go on demurrage, thus showing the material man the cars to be unloaded first, when there is more than one car waiting to be unloaded. Bills

I. P. H. Form 14

STATE OF NEW YORK

Department of State Engineer and Surveyor—Improvement of Public Highways

Construction Report for the ________ *Road*, *No.* ______, *for week ending* ________

________ *County.* ________ *Contractor*

PROGRESS REPORT

Rough grading completed	Sta.	to Sta.	, Lin. ft.	, Total to date, Sta.	to Sta.
Bottom course laid	"	" "	, " "	, " " "	" "
Top course laid	"	" "	, " "	, " " "	" "
Road completed	"	" "	, " "	, " " "	" "
Concrete			Cu. yds.		

No. of days roller worked ________ No. of days crusher run ________

No. of days sprinkler worked ________ No. of days traction engine used ________

LABOR REPORT

	S.	M.	T.	W.	T.	F	S.	TOTAL	RATE	AMOUNT	DIVISION OF LABOR EXPENSE	
Foremen											ITEM	AMOUNT
Enginemen											Clearing and grubbing	
Drillmen											Excavation (or embankment)	
Masons											Hauling materials for macadam	
Carpenters											Quarrying and crushing stone	
Laborers											Placing and finishing macadam	
Teams											Hauling field stone to crusher	
Carts											Concrete	
											General expenses	
Total labor expense for week											Total	

MATERIALS REPORT

QUANTITY	ITEM	RATE F.O.B.	AMOUNT	LENGTH OF HAUL TO WORK	REMARKS
Cu. yds.	Bottom course stone delivered at				
Cu. yds.	Top course stone delivered at				
Cu. yds.	Screenings delivered at				
Barrels	Cement delivered at				
Ft. b. m.	Lumber delivered at				
Lin. ft.	Vitrified Pipe (Diam. in.) delivered at				
Pounds	Steel at				
Cu. yds.	Sand for concrete at				
Cu. yds.	" " filler at				
Tons	Coal				
Total materials expense for week					

EQUIPMENT REPORT

No.	ITEM	MAKE	REMARKS
	Crushers		
	Steam rollers		
	Traction engines		
	Sprinklers		
	Carts or wagons		
	Steam drills		
	Scrapers		
			SEE DIRECTIONS ON REVERSE SIDE

ENGINEERING FORCE ACCOUNT

NAME	S.	M.	T.	W.	T.	F.	S.
In charge							
Address							

Fig. 168.—Engineer's Weekly Report, Road Construction.

for materials can also be checked up from this record, and freight bills paid only for cars that have been received.

Being in book form, previous day records can be quickly looked up, and the records of cars received for each contract can be kept in one book and readily filed when the job is completed.

We might add that in addition to the information kept by Mr. Humphrey, a few columns might be added to show cost of unloading cars and hauling material. One of the authors used a similar form some years ago. Besides showing the record as

E. P. H. 93— 6-3-07-2000 (6-3807)

County.................... Road No.............. Contractor....................

Cost of........................from..................190 to..................190

LABOR ACCOUNT				MATERIALS ACCOUNT				EQUIPMENT	
Time	Rank	Rate	Amt.	Quan.	Item	Rate	Amt.	Item	Value
								TOTAL	
								SUMMARY	
								Labor expense	
								Materials expense	
								Depreciation of plant	
	TOTAL					TOTAL		Interest on investment	
Description of Work and Conditions								Administrative expense, etc.	
								TOTAL	
								No. of Units	
....................Observer								Cost per Unit	

Fig. 169.—Special Cost Report, Roadwork.

given here, he had a column for foreman, if one was in charge of unloading, a column for the men, one for the teams, and one to show the approximate length of haul.

This record besides giving a cost of the work done, allowed the contractor to know if the work was done with dispatch and prevented the men from idling away their time, as they are likely to do when a few men are sent off by themselves to do such work. In a column for remarks notation was made if any material or goods were received in bad condition.

Cost Keeping Blanks for New York State Road Work.—In the road work done by the state of New York, each engineer in charge of a road contract is provided with a weekly report blank, shown by Fig. 168, which he is required to fill out from careful notes taken throughout the week. These reports are the basis for the progress charts showing the rate of progress on each contract. They also furnish the necessary information for the cost data department. Special cost blanks like the one shown by Fig. 169 are also furnished. These reports are used in cases where exceptional opportunity offers to obtain the cost of any item of work.

The inspectors on the work keep an accurate account of the number of men employed and materials furnished, and report them daily to the engineer in charge. On the last of each month estimates are made out and sent to the division engineer, by the engineer in charge of the work, for the amount of work done during the month. These estimates are checked and signed by the division engineer and forwarded to the state engineer. They are again checked and compared with the original contract on file in the state engineer's office, and if found to be correct, the contractor is paid 90 per cent of the said estimate.

Discussion of Cost Keeping: Smelting Plant, Railroad, and U. S. Reclamation Service—Construction.—We reprint herewith some discussions of a paper on cost keeping by Mr. Myron S. Falk and published in Transactions Am. Soc. C. E. Vol. LXIV, p. 401. We would call particular attention to the last paragraph of Mr. Hammatt's discussion. Note also his distinction between fixed and movable plant. In his work a good deal of plant may be classed as fixed; while in ordinary contract work most of the plant is movable.

W. C. Hammatt, Assoc. M. Am. Soc. C. E. (by letter).—When in charge of various pieces of construction, the writer has always endeavored to keep close and accurate costs, in order to check, not only the unit costs of different classes by previous work of the same class, but also to present to the company, at the end of the work, an accurate and minutely itemized valuation of the work done, for inventory and insurance purposes. He has used practically the same system in his work as Superintendent of Construction for the Mountain Copper Company, at Martinez, the American Smelting and Refining Company, at Chihuahua, Mexico, and the Mammoth Copper Mining Company, at Kennett, Cal.; therefore, only one of these cases, for example, the construction at Chihuahua, will be described.

The first step of the system involved giving a segregation number to each piece of work. This minimized the clerical work, and also gave convenient reference to ledger accounts. In this system of segregation whole numbers are used for the main divisions of work and decimals of various length for the sub-segregations under these divisions. This provided for a combination of all the decimals of a certain degree when segregations of lesser refinement were necessary for certain purposes. For example:

CONSTRUCTION SCHEDULE.

General Expense:
- 01 Superintendence.
- 02 Surveying and drafting.
- 03 Office expenses.
- 04 Proportion, main office.
- 05 Temporary tracks.
- 06 Tools, push cars, concrete mixer.
- 07 Real estate.
- 08 Warehouse stock.
- 09 Warehouse expense.

Blast Furnaces:
- 10 Building.
- 11 Furnace No. 4, bustle pipe, settler, etc.
- 12 Changes in present furnaces.
- 13 Slag and matte equipment.
- 14 Furnace No. 5, bustle pipe, settler, etc.
- 15 ....
- 16 ....
- 17 ....
- 18 Connecting blast pipe.
- 19 Blast pipe in smelter.

(These sub-headings apply to all following headings.)
- 0.1 Grading.
- 0.2 Forms.
- 0.3 Concrete.
- 0.4 Superstructure.
- 0.5 Falsework.
- 0.6 Plumbing.
- 0.7 Wiring.
- 0.8 Painting.

Converter Plant:
- 20 Building (including crane).
- 21 Converter No. 1 (including stand and tilting system).
- 22 Converter No. 2 (including stand and tilting system).
- 23 Downtakes.
- 24 Flue.
- 25 Charge system.
- 26 Copper disposal.
- 27 Slag disposal.
- 28 Blast pipe.
- 29 Hydraulic system.

Relining System:
- 30 Building.
- 31 Relining pit (including tamper and crane).
- 32 Clay mills.
- 33 Clay and quartz bins.
- 34 Track and trestle to same.
- 35 Tunnel.
- 36 Drying stands.
- 37 ....
- 38 ....
- 39 ....

Charging System:

40 Tunnel.
41 Trestle.
42 Trackwork.
43 Equipment, charge cars.
44 ....
45 ....
46 ....
47 ....
48 ....
49 ....

Flue System:

50 Dust chamber, steel work (including hoppers).
51 ....
52 ....
53 ....
54 Tracks.
55 New stack.
56 Equipment, cars, etc.
57 ....
58 ....
59 ....

Power Plant and Blast Mains:

60 North addition (building).
61 South addition (building).
62 Receiver.
63 Changes in present blowers and connections.
64 Blower No. 4 and connections and motor.
65 Blower No. 5 and connections and motor.
66 Blowing engine.
67 Blower No. 6, connection and motor.
68 Blower No. 7, connection and motor.
69 Generating set No. 2.
70 Switch-board.
71 ....
72 ....
73 ....
74 ....
75 ....

Sampling System:

76 Temporary sampling room.
77 ....
78 ....
79 ....

Track System:

80 Standard gauge changes.
81 New standard gauge yard.
82 Slag tracks.
83 Lime track.
84 Track scales.
85 ....
86 ....
87 ....
88 ....
89 ....

0.1 Grading.
0.2 Track-laying.
0.3 Ballasting.
0.4 Switching.

Shops:

90 Machine-shop building and blacksmith shop.
91 Machine-shop plant.
92 Steel shop building.
93 Compressor-motor and building.
94 Boiler-shop and round-house building.
95 Boiler-shop and round-house plant.
96 Carpenter shop building.
97 Carpenter shop plant.
98 Electrical shop building.
99 ....

Bins and Trestles:

100 Main receiving bins.
101 Trestle approach to same.
102 ....
103 ....
104 ....
105 ....
106 ....
107 ....
108 ....
109 ....

Miscellaneous:

110 High-pressure pipe line.
111 Cement sheds.
112 Greek bunk house.
113 Drain tunnel.
114 Smelter stable.
115 ....
116 ....
117 ....
118 ....
119 ....

Standard Gauge Equipment:

120 Oil tank.
121 Locomotives.
122 Wrecking crane.
123 Cars.
124 ....
125 ....
126 ....

In regard to this list, it may be stated that it is faulty in its arrangement, due to the full plans for construction not being complete at the time the work was started. The writer believes in a more complete segregation of fixed and movable plant, for insurance and appraisal purposes, as a machine can be moved to a new site, while its foundation can not, and the superstructure of a building is subject to destruction and damage by fire, while its foundation is not.

In the matter of construction reports: The forms of two reports used for cost keeping from day to day, are given in Figs. 170 and 171. That shown by Fig. 170 was made out daily by the foreman for each kind of work done under his supervision, a separate report being made out for each segregation. At the end of the week the form shown by Fig. 171 was made out by the cost clerk from the data on Fig. 170, and the measurement

AMERICAN SMELTING & REFINING CO.
CHIHUAHUA PLANT

Daily report of labor on ____________
for ____________
Segregation ____________
Date ____________

NO.	EMPLOYEES	NO. HRS.	RATE	AMOUNT
	Foreman			
	Carpenters			
	"			
	Helpers			
	Mechanics			
	"			
	"			
	Helpers			
	Stone Masons			
	Brick "			
	Helpers			
	Engineers			
	Firemen			
	Plumbers			
	Helpers			
	Electricians			
	Laborers			
	"			
	Water boys			

____
FOREMAN

Standard size, 7 by 3¾ in.

Fig. 170.—Foreman's Daily Report.

AMERICAN SMELTING & REFINING CO.
CHIHUAHUA PLANT

Cost report for ____________
____________ on ____________
Segregation ____________
Ending ____________

DATE	ACCOUNT	UNITS	RATE	AMOUNT
	Labor			
	do			
	do			
	do			
	do			
	do			
	do			
	Brick			
	Stone			
	Sand			
	Lime			
	Cement			
	Lumber			
	Cost per unit			

____

Standard size, 7 by 3¾ in.

Fig. 171.—Cost Clerk's Weekly Report.

or estimate of each piece of work performed. The form shown by Fig. 170 was also used by the timekeeper as a check on his time, as the total number of man-hours or man-days should agree in both cases, and also the total in dollars and cents for the pay period.

As there is likely to be inaccuracy in progress measurements which are taken daily, or even weekly, it is well to combine the reports of several weeks. These inaccuracies will then disappear, and a truer calculation of unit cost may be made.

This system had to be varied for the different conditions under which the construction work was conducted, for example, in Mexico, where the foremen were mostly illiterate, special men were employed for the cost keeping, and the forms differed slightly from those used in places and on classes of work where men of better mental capacity were employed.

Bills for materials of construction were distributed by the superintendent or cost clerk at the time of checking to the accounts where they belonged. When bills could not be charged to their regular jobs, on account of the actual quantity of material going to each job being unknown, the total was charged to warehouse, and the different jobs debited and warehouse credited as the material was issued.

It may be added that the engineer generally works under difficulties in keeping accurate cost records, as the general idea among American employers is that such data are useless expense, and they will not allow the necessary clerical force to make them accurate and useful. The sentiment among most of them was expressed in the late Mr. T. S. Austin's remark to the writer that whether the brickwork costs $12 or $30 per 1,000, the work would go on until it was completed or the company "went broke."

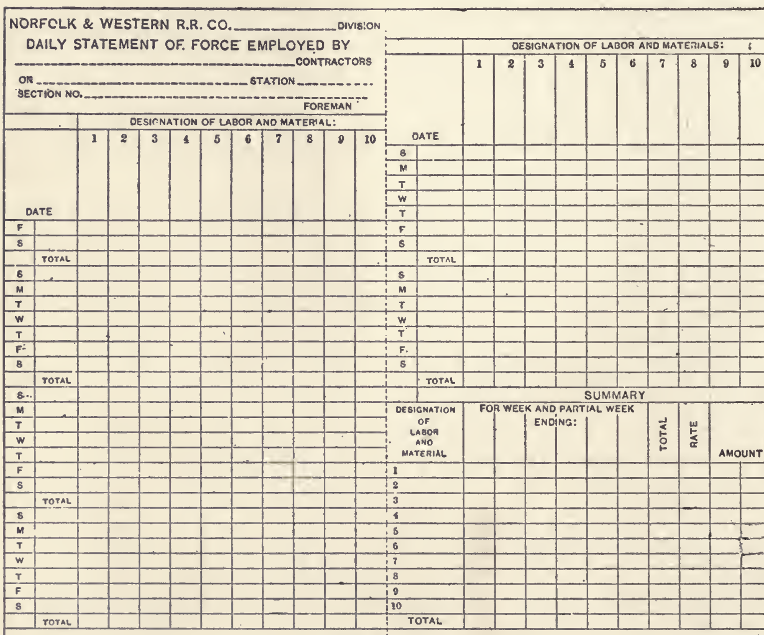
Emile Low, M. Am. Soc. C. E. (by letter).—On construction work it is always interesting for the engineer-in-charge to know, at least approximately, what the work is costing the contractor. For want of absolute knowledge of the cost of some items, it may be difficult to ascertain the total cost, but even a knowledge of the cost of some of the items, as before stated, is of some satisfaction.

It may be stated with some assurance that, during construction, nearly every railroad company keeps some kind of a force account, which is rendered to the chief engineer, generally weekly, by his subordinates.

Some years ago, while the writer was in charge of some heavy railroad construction in Southwestern Virginia, he originated and put into effect a system of cost keeping, which showed monthly the cost to the contractor of various classes of work, the statements of which were submitted with the monthly estimates.

The system was extremeiy simple, and consisted essentially of three blank forms which constituted the basis for keeping the records.

On the railroad in question, each residency consisted of from seven to ten 1-mile sections, thus each residency ranged from 7 to 10 miles in length. The contractor's forces were counted daily by a timekeeper employed by the railroad company, which work comprised his whole duty.


NORFOLK & WESTERN R.R. CO.__________DIVISION
DAILY STATEMENT OF FORCE EMPLOYED BY
__________CONTRACTORS
OR __________STATION__________
SECTION NO.__________
FOREMAN
DESIGNATION OF LABOR AND MATERIAL:
1 2 3 4 5 6 7 8 9 10
DATE
F S TOTAL
S M T W T F S TOTAL
S M T W T F S TOTAL
S M T W T F S TOTAL
DESIGNATION OF LABOR AND MATERIALS:
1 2 3 4 5 6 7 8 9 10
DATE
S M T W T F S TOTAL
S M T W T F S TOTAL
SUMMARY
DESIGNATION OF LABOR AND MATERIAL
FOR WEEK AND PARTIAL WEEK ENDING:
TOTAL
RATE
AMOUNT
1 2 3 4 5 6 7 8 9 10
TOTAL

Standard size, 7 by 8½ in.

Fig. 172.—Record of Labor and Materials, Railroad Construction.

A special timebook was prepared, a double page of which is shown by Fig. 172.

From an inspection of the timebook it will be noted that it is arranged to keep a separate record of each and every piece of work, no matter what it may be. It is also arranged to show the totals for each full week as well as for the partial week. Occasionally, there is a month which includes four full weeks and parts of two weeks, making space for six entries necessary.

The usual practice is to send in the force accounts weekly to headquarters, and the arrangement of the book facilitates this. At the end of the month there is a summary from which the cost of the work is obtained.

________________________RAILROAD CO.,
COMPARATIVE STATEMENT
ESTIMATE vs. EXPENSES

RESIDENCY NO.________ ESTIMATE NO.______
SECTIONS NOS.________ ______________ DIVISION
MONTH OF_____________ ____________CONTRACTOR

	CLASS OF LABOR	RATE	SEC.			SEC.			SEC.			SEC.		
			NO.	AMOUNT		NO.	AMOUNT		NO.	AMOUNT		NO.	AMOUNT	
CLEARING	Foremen													
	Laborers													
	Teams													
	Total Labor													
	Estimate													
	Difference													
GRUBBING	Foremen													
	Laborers													
	Teams													
	Total Labor													
	Estimate													
	Difference													
GRADING	Foremen													
	Laborers													
	Teams													
	Blacksmiths													
	Carpenters													
	Total Labor													
	Superintendence													
	Explosives													
	Total Expense													
	Estimate													
	Difference													
MASONRY	Foremen													
	Stone Cutters													
	Masons													
	Laborers													
	Teams													
	Total Labor													
	Estimate													
	Difference													

Standard size, 8¼ by 10⅝ in.

Fig. 173.—Monthly Summary, Railroad Construction.

Of course, owing to the method used, the cost obtained is not absolute, as the force employed during the morning and afternoon may vary in numbers, the timekeeper passing over the work only once a day. Where absolute accuracy is required, more timekeepers would have to be employed.

As there are no printed headings, the spaces may be filled in as the nature of the work requires. Space is provided for ten

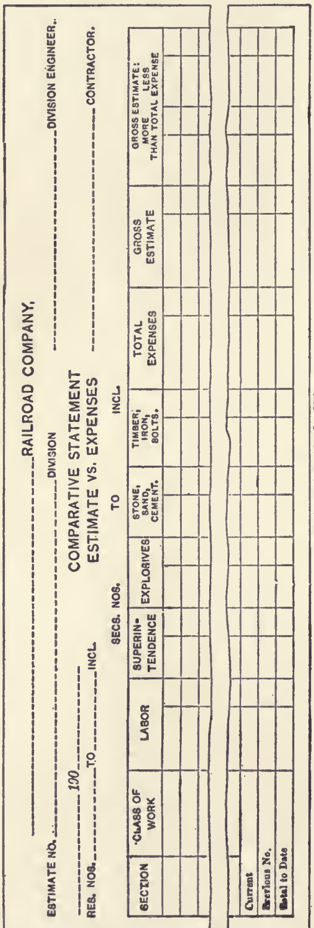


Fig. 174.—Monthly Summary of Actual and Estimated Costs, by Sections.

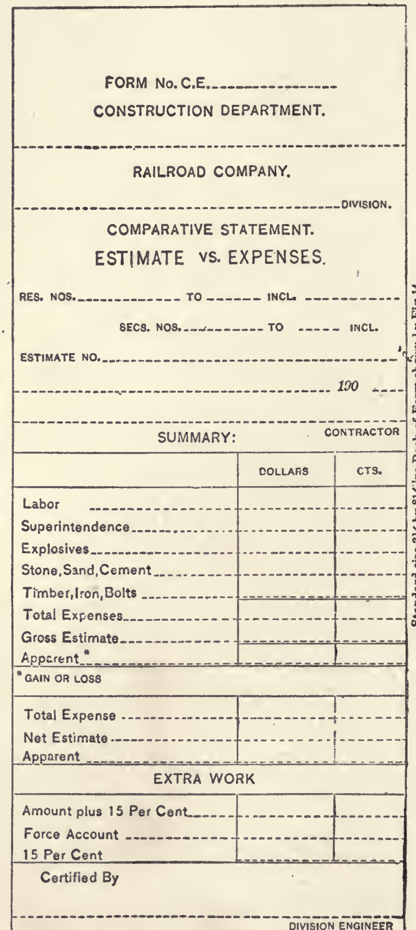


Fig. 175.—Monthly Summary of Actual Cost and Estimated Costs, Entire Contract.

different designations of labor and material, and in cases where there are more items, other pages can be used. It will be seen that the timebook is very flexible, and can be adapted to any contingency.

At the end of the month all work is classified, the form, Fig. 173, being used. The sample sheet shows columns for clearing, grubbing, grading, and masonry. This column is left blank, and the various classes of work are written in, using as many sheets as necessary.

Before the final classification, by sections, the location of each individual piece of work is entered in the column having the printed heading, "Sec." On the grading there may be as many as ten or more forces at work on a mile section; several culverts, bridge abutments, and piers may also be building.

The blank form, Fig. 173, may be used in making a compilation showing the cost for separate localities, or the totals for any one section may be entered, these totals being obtained by the addition of the various separate items.

Fig. 174 is a blank form showing the summary of all the work on a contract.

The main idea underlying the whole scheme is to make a monthly comparison with the engineer's estimate.

Referring to the timebook, Fig. 172, there is on a page the cost to the contractor of a particular piece of work, during the month, say, a bridge abutment. An estimate of quantities and cost has been made by the engineer in charge of this particular work.

The details of the cost to the contractor are transferred to the blank form, Fig. 173, the amounts being shown under the heading marked "Sec.," the "estimate" placed under the total, and the difference obtained, which will be more or less as the case may be. These statements then show in detail the expense and estimate of each particular piece of work.

Then a summary is made of each and every kind of work by sections (1 mile), and also a summary of the various estimates. These summaries then show, mile by mile, the status of the various kinds of work.

The engineer's estimate always shows the total cost of a section, and in order to make a proper comparison of all expense, another blank form is needed, which shows a summary of all the labor, superintendence, explosives, stone, sand, cement, timber, iron, bolts, etc., this being the total cost of all the work in a section.

These totals, shown by Fig. 175, may be readily obtained by using the form shown by Fig. 174, for the purpose of tabulation, as the main items are all placed in separate columns, and can be easily added. In some quarters objection is made to keeping an accurate account of the forces employed by the contractor and the tabulated cost, the main reason assigned being that the engineer's estimate is influenced thereby to some extent. This need not be, as the cost to the contractor is not generally known until some time after the estimate is made out. In most public works nowadays there is no classification of excavation, so there are no grounds whatever for manipulation, although there might be under the classification method of dividing excavation into earth, hardpan, and loose and solid rock.

Again, the contractor's cost may be tabulated wholly in the division engineer's office, or even in the office of the chief engineer, he being furnished with duplicate copies of the timebooks, which, as before stated, form the basis of the whole system described.

The writer is a firm believer in keeping costs of contractor's operations, for the very important reason (and almost the only one), that it affords some tangible evidence of fixing suitable unit prices on future work, instead of using that very undesirable makeshift, guessing at them.

F. H. Newell, M. Am. Soc. C. E. (*by letter*).—The following comments, prepared by Mr. V. C. Croissant, are offered with the hope that they may be of value.

A careful reading of Mr. Falk's paper leads to the conclusion that the system described is for use on work which is highly centralized. The contracts are evidently for compact pieces of work in a city. The opening paragraphs state very clearly the real value of cost-keeping data in the great majority of construction operations, and are especially pertinent to those for which this system is applicable. The method described would result in accurate data covering prime costs of any class of work in which labor was the principal cost element.

It should be noted that there are two sources of error in cost accounting which seem to be almost impossible of complete elimination. With the presence of possible errors due to either or both of these causes, the results are practically valueless to any contractor except (as stated by Mr. Falk) the person actually preparing the data. Even he may be so deceived by his own calculations as to find the bankruptcy courts eventually his only relief. These sources of error are:

1. The substitution of estimates for certainties, in the case of the engineer or proprietor who is so thoroughly impressed with the value of direct and prompt information that he uses assumptions (in many cases purely guesses) for actual mathematical facts. Such a man gathers daily all the data possible, and, because of a lack of system or of a comprehensive plan, fails to consider many items, such as unpaid purchases, unpaid labor, depreciation on plant, interest on investment, the value of his own time, and supplies consumed which are not measureable in the completed units of work, but which, nevertheless, are fundamental and positive cost elements. His main ambition is to "know from day to day how things are going." To do this, he arrives at theoretical results by a series of allowances, the component elements of which are not certainly known. He may guess at them, or he may omit them entirely. His hypothesis may be satisfactory where the work to be done is small, and highly centralized, and when the engineer making the estimates is of large experience and excellent judgment.

2. The delay for accuracy which occurs with the bookkeeper or cost-keeper who is professionally proud of his work, and so short-sighted, as to make absolute accuracy his main concern. Such a man insists on the results being unassailable from any and every angle; the figures must "balance," or "square into" everything that bears on the accounting of the firm. This makes for accuracy—eventually—but the results are largely historical, and, after being neatly typewritten and "tied into" all related statements, are allowed to see the light of day long after the evils which they might have corrected are forgotten by the "man on the job." They are simply the autopsy of a dead transaction, not a diagnosis of the progress of a vital case.

The plan presented by Mr. Falk is one which requires a single book, namely, the cashbook. It would appear that all liabilities must be paid immediately; and that everything purchased in the way of supplies must go into the work immediately. If such is not the case, then future liabilities will not reach the cost accounts until the supplies represented are paid for. If supplies are purchased against a future need, they will be charged in the month paid rather than in the month used.

A cashbook, of course, cannot be used to record estimated depreciation on equipment used from month to month. If the work is done largely by expensive equipment, this important element of cost, depreciation, is overlooked. Interest upon investment would be entered from time to time if money was borrowed and interest paid at the bank. If the capital is actually paid in by the proprietors, and, consequently, no regular interest payment is made, then the cashbook would not record the legitimate earning on this capital to which it would be entitled. The old accounting question of whether bookkeeping should deal with cash receipts and disbursements, or whether it should deal with the question of values received and expended, whether paid for or not, is the one which really comes to the front. It was settled long ago in favor of the latter method.

For a small business, the cashbook may be the only record necessary, but for operations which are extensive, it is, perhaps, the smallest part of the necessary bookkeeping records. The same rule may be laid down to decide whether or not cost-keeping shall become a part of bookkeeping. In small operations, it is quite possible to arrive at very accurate costs by a system of card records entirely independent of bookkeeping, but, for large works, the elements of cost are so numerous that a well-defined automatic system, governed or controlled by analytical accounting methods, must be adopted in order to insure complete records.

In the United States Reclamation Service a system has been adopted in which an attempt has been made to harmonize the views and serve the purpose of both the engineer and the accountant. In all Government work it is necessary, in addition to having the available results for the immediate use of engineers, foremen, etc., to make a permanent record of costs, since that work is subject to investigation by commissions, and by the public; and the expense of construction must be brought within a specific appropriation or allotment of funds, which corresponds to a commercial contractor's bid price for a given undertaking.

The system adopted by the Reclamation Service has been devised in order to place in the hands of the man locally concerned a complete record, which is available for his inspection from day to day, and shows the prime cost of all work. This prime cost takes up the charges for all labor, material, and supplies used; these records are entered daily, and, by the use of the adding machine, totals under any classification of expense, or for all classifications under any feature, can be known in a few hours. After the local cost-keepers have finished this tabulation the results go to the bookkeepers, who add the top extrinsic costs, such as administration, depreciation, and all the other expenses, which are unknown to the timekeepers and storehouse clerks. These are finally assembled in the project offices, and monthly statements for each feature are transmitted to the general office in Washington. When any large, or important feature is finally completed, the project engineer prepares from these local records a cost report showing the cost by units of work done, which is analyzed into all the elements of labor, material, supplies, power, depreciation, superintendence, general expense, etc.

By the method used in the Reclamation Service, the principal machinery for assembling costs is:

1.—An Account Number Book.—Each feature or job of work is assigned a set of numbers, as many being reserved as will be necessary to give each classification of expense a number. The following is an example:

Dam for reservoir.
260 Superintendentence and engineering.
261 Labor, foremen.
262 Labor, masons.
263 Labor, cranemen.
264 Labor, teamsters.
265 Labor, timekeepers and clerical.
266 Labor, laborers.
267 Labor, animals owned and hired.
268 Labor, blacksmiths.
269 Labor, drillermen and machinists.
270 Supplies, cement.
271 Supplies, powder, dynamite, fuse, etc.
272 Supplies, drill steel.
273 Supplies, lumber.
274 Supplies, power.
275 Supplies, miscellaneous supplies.
276 Supplies, labor and repairs.
277 Employers' liability.
278 Depreciation on equipment.
279 General expenses.

2.—Timebooks.—These books are ruled so that the time of each employee may be shown for each class of work performed. When the timekeeper takes time, he makes the proper notation, 7–595

SHEET NO. ---------- TIME BOOK ---------------------------- 19 --
(Month) (Feature) 6–1191

NAME		ACCOUNT NO.	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	
NO.	OCCUPATION																											

Left page. Size 8 by 5¼ in.

Time and rate of pay correct·

(Signed) --
6–1191 (Engineer)

	26	27	28	29	30	31	TOTAL TO -------	TOTAL TIME	CARRIED TO NEXT SHEET RATE Dro't from previous sheet	AMT. EARNED	TOTAL EARNED	MEAL TKTS.	ORDERS ON STORE	RENT AND HOSP.	TOTAL DEDUCTIONS	AMOUNT DUE

Right page, Size 8 by 5¼ in.

Fig. 176.—Timebook. U. S. Reclamation Service.

DEPARTMENT OF THE INTERIOR REQUISITION

U. S. RECLAMATION SERVICE

No.----------

------------------------------*PROJECT*

-----------------19

To STOREHOUSE CLERK:

Please furnish the following on account of the ------------------------------

-----------------------------------feature:

ACCOUNT NO.	QUANTITY		ARTICLES	UNIT PRICE	TOTAL
	WANTED	FURNISHED			
	Original (on white paper) goes to cost keeper				
		for entry in classification book			
	Duplicate (on pink) remains with storehouse				
		clerk for his protection			
	Triplicate (on yellow) is returned to foreman				
	as an	*advice of cost of goods furnished*			

Deliver to --

For forwarding by ----------------------------------

Wagon Bill of Lading No. ------------------------

(Signed)--

Received the articles above listed *as furnished*

(Signed)--

Standard size 5⅜ by 7⅝ in.

Fig. 177.—Requisition Blank, U. S. Reclamation Service.

indicating the hours worked and the class of work. Fig. 176 is an illustration of a timebook adapted for this purpose.

3.—Requisitions.—All supplies, materials, etc., are issued from storehouses at cost plus freight and a percentage addition to cover handling and storehouse expense. For this purpose a requisition blank, Fig. 177, is used. Each foreman is supplied with a list of account numbers which are allotted to the features of work in his immediate charge. When he makes up a requisition, he indicates, opposite each article ordered, the classification to be charged, by inserting the account number assigned to that classification. The storekeeper enters on the requisition the unit price and total value of supplies issued.

4.—General Classification Book.—This book, Fig. 178, is used to assemble the items of expense under each classification. Each folio is ruled with ten columns, and the columns are numbered from 0 to 9. The first folio is not numbered, and the columns 0 to 9 will represent the classification indicated; the second folio is numbered 1. Reading the column numbers as the units with the folio number as the tens, the columns on folio No. 1 will assemble the charges against classifications Nos. 10 to 19. Any number of account numbers can be added by inserting additional folios, as this is a loose-leaf book. There are thirty-one horizontal lines—one for each day of the month—and a few additional for special entries at the end of the month, as depreciation, interest, etc.

The amount of charges appearing on requisition is entered daily in the respective columns, and the earnings of employees, as shown by timebooks, may be thus noted. The foreman or engineer wishing to know the cost of work on any particular feature at any time has only to ask the cost-keeper to add up the columns representing the classifications assigned to that feature, and he will have the total cost for labor and supplies expended to that date.

At the end of the month these sheets are removed from the binder and sent to the bookkeepers, who add the top costs and post the total for the month to the cost ledger which contains all charges for previous months, thus making a final completed record.

With the detailed analysis, as accumulated in this manner, the engineer can make a complete cost statement in minute detail or,

DEPARTMENT OF THE INTERIOR
------FOLIO UNITED STATES RECLAMATION SERVICE 7–530

GENERAL CLASSIFICATION SHEET
MONTH OF------------------190 FOLIO-------

DATE	0	1	2	3	4		DATE	5	6	7	8	9
1							1					
2							2					
3							3					
4							4					
5							5					
6							6					
7							7					
8							8					
9							9					
10							10					
11							11					
12							12					
13							13					
14							14					
15							15					
16							13					
17							17					
18							13					
19							19					
20							20					
21							21					
22							22					
23							23					
24							24					
25							25					
26							26					
27							27					
28							28					
29							29					
30							30					
31							31					
Freight and handling							Freight and handling					
Time book distribution							Time book distribution					
Direct charges							Direct charges					
Journal Vouchers							Journal Vouchers					
TOTALS					6–747		TOTALS					6–747

Standard Size of page, 8 by 10½ in.

Fig. 178.—General Classification Book, U. S. Reclamation Service.

if he prefers, in general terms, by combining several analogous classifications.

There are many other accounting phases which the writer has not mentioned herein, as the purpose is to treat of a method of cost keeping. Any accountant can fit the general plan above described into a well-organized bookkeeping system.

George Hill, M. Am. Soc. C. E. (*by letter*).—Every member of the society who presents a workable solution of a problem, and especially one of such importance, is entitled to the thanks of the members for so doing, and therefore the writer feels that on so important a matter as cost keeping Messrs. Falk, Hammatt, and Low have done well to contribute of their experience.

The attempt has frequently been made to solve the problem in some conventional or semi-conventional manner, usually without success, for the reasons that there existed:

a.—A lack of appreciation of the requirement for simplicity;

b.—A lack of appreciation of the fact that the information required is a combination of figures and the combinations are constantly changing;

c.—The general belief that cost keeping is something different from bookkeeping, instead of being intelligent bookkeeping.

If the accounts of any piece of work can be kept so as to meet, on the one hand, all the requirements of bookkeeping, and, on the other hand, all the requirements of cost keeping, the problem is in the way of being solved.

The real and only purpose of bookkeeping is to show the receipt and disbursal of money in an accurate manner. If this is performed so that, with a minimum of clerical work, clerical and arithmetical errors can be readily detected and eliminated, it is good bookkeeping.

When the next step is taken, and the memoranda of disbursal show for what the disbursal was made, this is beginning cost keeping.

If this is done in sufficient detail and in such a manner that the summations of two or more groups can be readily combined, the problem of cost keeping is solved.

If vouchers, checks, and bills are arranged so that they can be readily examined and compared with the entries, this provides for an accurate and inexpensive audit, and meets completely all the proper requirements of bookkeeping, cost keeping and auditing. The writer would emphasize the word "proper"; there are in use systems which are very complete but are so burdensome that the facts cannot be recorded and transcribed until long after their usefulness has vanished, and they are so full of detail as to blind the mind completely to their true significance. Knowledge of costs should be a weekly matter, and action should follow promptly.

It is a good thing to know that concrete 5 in. thick, placed in forms, cost on a certain job an average of 20 cents per sq. ft., but it is more important to know that Brown's gang laid it for 18 cents, while, with Smith's gang, it cost 22 cents, under the same circumstances.

While it is possible to predetermine the general lines along which costs will be required, two-thirds of the questions asked in regard to costs will call for summations of items other than those originally contemplated, and the same question will rarely be asked twice; consequently, the problem which the writer has attempted to solve is not a simple one. He has been engaged for many years in executing work on a fixed profit basis, and has had experience with the accounting systems of a wide range of clients, and, as a consequence thereof, has been compelled to devise a system of his own. Practical experience with this system has demonstrated its applicability over a wide range of subjects in a satisfactory manner. It is hoped that a description of it will be of interest to the society.

Although the system presents a method of keeping the exact cost of a piece of work, and is therefore in the nature of bookkeeping, it is not bookkeeping in the conventional sense, but an orderly arrangement of memoranda which are kept so that any cost question which may be asked during the progress of the work, either of a detail or of the entire work, can be answered, either immediately or in a few minutes. The memoranda are kept so that, if there are a variety of jobs in the office, each one is separate and distinct in its entirety; finally, they are kept so that, as soon as a piece of work is completed, all memoranda in regard to it are immediately filed away and prevented from interfering with other work in the office.

The writer will describe the system as applied to building operations on a fixed profit basis, as in this way the principles involved will be understood, and concrete examples may be more easily obtained.

1.—Each piece of work is given a designating job number, and the estimate of original cost is entered in a monthly statement in a column headed "Original Allowance." In making up the estimate, the details of work, comprised under each account subdivision or number, are worked out in full, so that the cubic yards of excavation, and the incidental expenses thereof, are clearly stated.

In a column headed "Structural Steel," the number of tons of each of the various classes of steel, cast iron and other work, the price for the fabricated material, and the erection costs are stated, and so on down the list.

The sum of the statements in the column headed "Original Allowance" gives the total cost of the work, and these items are carried along in the monthly statements.

Any changes involving cost alteration are entered in a column headed "Additions." These additions appear in this column only for the month to which they refer, and in the following month are transferred to the "Original Allowance" column, leaving the "Additions" column free for the current month's changes.

The column headed "Payments" contains the summary of the disbursements under the various accounts to the date of the statement, and shows the total cost of the work to date. The sum of the payments plus the balance on hand in the bank (which is stated on blank lines at the bottom of the sheet) must equal the sum of money advanced or set aside for the conduct of the work.

All obligations incurred, either in the nature of sub-contracts, contracts for materials, and the like, are entered under the heading, "Contracts Made;" the column headed "To Complete" is only used occasionally, usually as the work approaches completion, for the guidance of officers or others who are not sufficiently familiar with all the details of the work to be able to supply the figures without assistance. It is rarely used more than three or four times on a job, but by being inserted in the monthly statement makes an additional form unnecessary.

2.—The time is kept in duplicate by using one or more time sheets as may be necessary, and making a carbon copy. The sheets are made up in pads, kept in an enameled leather case, and each week the originals are sent to the office.

The columns, "Total Hours," and "Amount," are usually filled in by the superintendent and checked at the office.

The pay-roll for each account number, as given in the monthly statement, is kept so that one man's name may occur several times on the pay-roll. The only disadvantage connected with this is that sometimes two pay envelopes are made out in the same name, the sum of the two being the correct amount earned.

In the writer's work, weekly pay-rolls amounting to $1,500 require two hours' time to check, draw the money, place it in the envelopes, and prove the accuracy of the distribution.

3.—Materials in general are provided for either in connection with sub-contracts or by agreement with supply houses. If delivery is to be made complete at one time, and the time is determined, one of the orders is issued; but if delivery is to be made piecemeal, or at different times, two or more orders are issued, and these are sub-divided so as to secure each delivery at the time when it will be needed. The order is made out in quadruplicate, the order blanks being made up in pads and in sets of four, so that, by the use of carbons, one writing suffices for the four.

The first or white copy is to be retained by the party receiving the order, and on the back of this the conditions of the order are printed.

The second, or pink copy, is a delivery receipt. It is sent with the order when delivery is made, is signed by the job superintendent, and, when the bill is rendered, is attached to the bill and affords a means of checking it.

The third, or blue copy, is sent to the job superintendent as a notice to him that the order has been placed. As soon as the order is delivered, he signs the blue copy and returns it to the main office, where it is filed temporarily and is an evidence of a debt which should be paid on the first of the following month.

The fourth, or yellow copy, is retained in the office for purposes of comparison with the other copies and as an evidence of an outstanding obligation.

This procedure is followed in all cases except for bricks, sand, broken stone, cement, and loads of rubbish, in which cases slips printed on stiff paper are issued, and are dated with an indelible pencil by the superintendent when issued. These slips are returned with the bill, and, after the bill is checked and audited, are destroyed.

The blue and yellow order slips are kept in the same file, and are usually arranged in groups, so as to be readily reached. When the pink order slip comes with the bill, the blue and the yellow copies which correspond are removed from the file and, after comparison, are crossed off, then the three slips are placed in a file for paid orders.

The order numbers are endorsed on the bill and, if necessary, are grouped under the account numbers so that the bill is separated into its component accounts.

4.—Small sub-contracts are treated the same as orders.

5.—In reference to payments, each job executed is conducted as an independent piece of work, the agreement with the owner providing that, from time to time, he shall furnish the funds necessary to conduct the work. The funds are deposited in the bank to a separate account. This is done because the only effective control that can be exerted on work is the control of the purse strings; that certifying to the owner that payments are due is very far from being the equivalent of a payment, and, finally, that where the builder's own capital is used for the conduct of the work, a charge would necessarily have to be made for such use, which would result in an increase in the cost.

The bank check used for this purpose is twice the width of an ordinary check. It is filled out so that the charge against the proper account number will appear on the face. The checks are carboned when written, so that an exact copy remains in the office. The check when issued is folded longitudinally, is endorsed in the customary way, passes through the bank as an ordinary check, and, although several thousand have been used with different banks, has met with no objection.

The check form is a typical pay-roll check. When a payment is made, the check number is endorsed on the bill or voucher, and the bill or voucher is filed in a Shipman file in numerical order.

6.—In keeping the records, the writer uses a 9 by 13½-in. Shipman Common Sense Binder; heavy manilla sheets, with canvas tags bearing the account numbers, are used to separate the accounts, and regularly ruled ledger sheets are interposed between them for each account, as many sheets being used as are necessary. Additional sub-divisions are provided for recording the checks issued, called the "Cash Account," and for binding in the monthly statements. In small jobs, provision is made for binding in all contracts, sub-contracts, and additional orders received from the owner. On large jobs a separate binder is used.

The cash account sheets are regular ledger sheets, one-quarter of the upper left side of the page being used for the entry of money received. The remainder of the left side of the page is used for entering the checks, with date, number, name of account, and amount. The right side of the page is used for keeping a running balance. This serves two purposes, the balance on hand is always immediately evident, and the sum of the checks to date, obtained at the end of each month, must show a balance equal to that obtained by the partial steps, thereby proving the arithmetical operations. Each check is entered in detail in the detailed accounts, the first page usually being devoted to labor, and the succeeding pages to materials and small contracts. Entries are made in the detailed accounts showing obligations incurred, where contracts are made for specific amounts, and these are entered on the left half of the page. Where checks are drawn to pay bills, the entry on the left half refers to the bill, and the payment is entered by date and check number.

The sum of all the entries on the right side of all the pages must equal the total payments to date. These summations are usually made lightly with a soft pencil at the foot of the page, and are carried ahead for each account, so that the last page of the account shows the total amount paid thereon. The monthly summaries of the larger divisions of each account are made in ink, so that a simple subtraction or the addition of three or four sets of figures will always give the month's business, for that particular item. The bank book is written up each month, and, as no payments are made except by check, the bank balance should correspond with the balance shown in the accounts, which, through the bank, proves the accuracy of the total payments made, and this gives an amount which should be the total of all the detailed accounts. Comparing month by month, as given in the monthly statement, the progress of the work is evident.

The writer has made it a practice always to prepare his own pay-roll checks, and to visit the work at least weekly. Writing out the pay-roll checks serves to fix temporarily the cost of the preceding week's work in the mind, and if a man is experienced in doing work, he can tell at once whether or not for that week's work he has received proper value for the wages disbursed. In the writer's experience, that is the best time to correct a foreman or a superintendent, because there is then likely to be little dispute as to the facts. This prevents the continuance of errors of organization, and shows where the ax should fall.

Generally, order slips and folded checks are of the same size, and all blanks are of conventional file size, so that any one of the filing system cabinets may be used. The cost of the work may be determined within a small fraction of 1 per cent at any time by an examination of the file. Each file is independent for each job, and can be taken away for study, or the entering can be interrupted at any point without difficulty.

All receipts, cancelled checks, and paid bills are filed in a similar Shipman's file, so that on the completion of a job the entire records may be filed. The space required for a $250,000 building operation is about 9 by 14 by 12 in. By the use of the forms in this particular way, duplicates are obtained of orders, checks, pay-rolls, and monthly statements, carbons being an extremely important factor in saving time. On a $250,000 job the average monthly cost for all entering, bookkeeping, checking of pay-rolls, and the preparation of monthly statements was 16 hours at 35 cents, or $5.60.

As described in detail above, the system appears cumbersome; in practical working, it is simplicity itself, as is evident by the time and cost of keeping it up.

Accounting and Cost Methods for Contractors.*—There are two ideas extant regarding the keeping of records by contractors. The one is put forth by a class of accountants who are bookkeepers and nothing else. They regard any work done by men who are not trained in bookkeeping to be an unwarranted infringement on their rights, and claim no one should attempt to make records of a financial transaction except a man of experience in ordinary accounting methods. The other idea regarding the keeping of accounts on contracting jobs is put forth by men of practical experience, who hold that every man on the job who is in a responsible position and can write, should

*Ernest McCullough in Engineering-Contracting, Sept. 1, 8, 15, 22, 1909.

send in a daily record of his work, even if he does not know how to keep books.

One thing exists in common between the warring factions, and that is that forms are required. Of the two, the bookkeeper gets out the most involved. The man without experience in account-keeping gets out forms containing, as a rule, too much detail, but his forms, at any rate, have the merit of being understandable by the average man. Unfortunately, in these days of vertical files and card indexes and business men's magazines and industrial literature generally, a great many amateur form-makers have been working. The preparation of a set of forms to give a man all the information he requires for his business, is not a matter of engaging a form-maker for a few days or hours to turn out a system full fledged. Forms must be tried out on work and changed many times before they finally get down into shape. It is a mistake too often made that each particular business must have forms differing from those used in other lines of work. It is possible to have a practical uniformity about such methods, so that a set of forms used in one place can do in another, and forms prepared for one line of work can be used in another. There may be some difference in some of the details, but it should not go further.

The writer's habit has been to make forms on mimeograph or hektograph and try them out, making changes frequently until by the time a job was completed a form would be worked out, and then when a similar job came up the form for it was ready. Finally, after a number of years of experience in handling work personally, and by means of foremen sent off to distant parts, he worked up a system for small pieces of work that has been very satisfactory in his own case.

In the first place comes the cash book. This is very important. He has had young fellows who took courses in business college, who actually did not know a simple method of keeping track of money spent and money received and how to balance the book. No matter how many forms are devised, the cash book cannot be dispensed with. The size of the page matters little, but for the sake of uniformity and the filing away of books, etc., he prefers a cash book having a page practically 6x9 ins. in size, ruled for single entry. Upon the left-hand page enter all money received, and upon the right-hand page

90

Cash

1899 Jan	15	Cash on hand	270	46
	20	Check #1792 Home office	275	00
			545	46

91

Contra

1899 Jan	15	Smith Hardware Co	3	75
	"	Johnson Yellow P. Lbr Co	10	43
	"	White Mach. Shop	3	34
	16	Gates & Brown (Sand)	24	75
	"	Enslow — Survey	14	50
	18	White Mach. Shop	9	95
	"	Johnson Y. P. Lumber Co	7	45
	"	Unloading S.P. 4071 (Cede)	25	65
	21	Pay roll for week	164	85
			264	67
	22	Cash on hand	280	79
			545	46

Fig. 179.—Pages in Single Entry Cash Book.

enter all money expended. Figure 179 shows the appearance of a cash book used on one job, with the names changed. These pages illustrated give the account for one week. It is presumed that a report will be made out each pay day evening to the home office, and the report for the week shown on the cash book pages is given in Figure 180. The report is made on a sheet of paper purchasable at any stationery store.

One book will do on almost any job of the ordinary size that one man will be sent away to take care of. The habit of the writer is to buy a book containing about 180 pages. The job has to be completed within a certain number of weeks. For instance, some job we are now considering will take 30 weeks. Reserve all the pages up to page 70 for cash accounts. The cash received will occupy one page and the cash paid out will occupy the facing page. Therefore, for each week there will

Cash Report.

Brownson Power Plant, Week ending Jan. 21-99

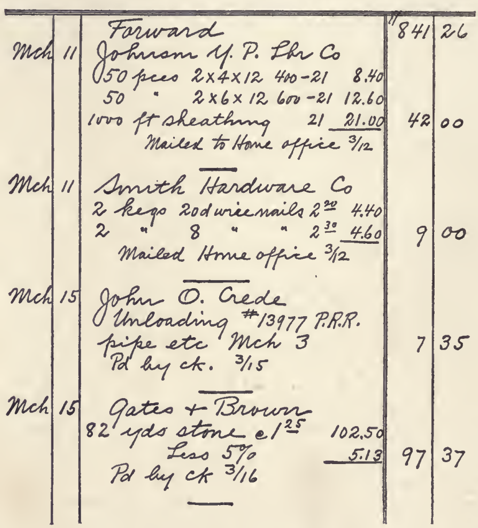
		Cash.				
Jan	15	On hand			$ 270	46
	20	Check #1792 Home office			275	00
		Disbursements.				
Jan	15	Smith Hardware Co	$ 3	75		
	"	Johnson Yellow Pine Lbr Co.	10	43		
	"	White Mach Shop	3	34		
	16	Gates & Brown, sand	24	75		
	"	Enslow - Survey	14	50		
	18	White Mach shop	9	95		
	"	Johnson Y.P. Lbr Co	7	45		
	"	Unloading S.P. 4071 (Crede)	25	65		
	21	Payroll for week	164	85		
			264	67		
		Cash on hand	280	79		
			545	46	545	46

E. & O.E.
Bert Johnson
Foreman

Fig. 180.—Weekly Cash Report from Cash Book.

be two pages reserved, and a few can be added in case the job overruns the time. Even if the cash items only take a few lines, it is well to give the whole page to the week's items, as it looks neater and allows of the making of entries afterwards in case the books are gone over to get unit costs, etc. On the job shown here there was supposed to be a cash balance in the bank at all times of not less than $200, and a check for the weekly payroll was sent on from headquarters in time to take care of pay day, which was Saturday.

Having reserved for the cash account a little over double the number of pages it is estimated the job will last weeks, the remaining pages are used for keeping track of bills received. Each bill is copied in full the day it is received. Figure 181 shows how a page looks. These bills should be copied in full daily and mailed to the home office with the daily work report. There should be no delay in doing this work. The experience of the writer, and of every employer of men, has been that if things like this are not attended to daily they will be neglected and at the final moment there will be a rush. A man who will



		Forward	841	26
Mch	11	Johnson Y. P. Lbr Co 50 pces 2x4x12 400-21 8.40 50 " 2x6x12 600-21 12.60 1000 ft sheathing 21 21.00 Mailed to Home office 3/12	42	00
Mch	11	Smith Hardware Co 2 kegs 20d wire nails 2^{20} 4.40 2 " 8 " " 2^{30} 4.60 Mailed Home office 3/12	9	00
Mch	15	John O. Crede Unloading #13977 P.R.R. pipe etc Mch 3 Pd by ck. 3/15	7	35
Mch	15	Gates + Brown 82 yds stone @ 1^{25} 102.50 Less 5% 5.13 Pd by ck 3/16	97	37

Fig. 181.—Page from Book Containing Copies of Bills.

not do this work daily should be discharged. There is no excuse. A few minutes' work each day saves a great deal of worry and bad work before the job is completed. The home office always wants the original bills. Very many times a home office does not see why the man on the job needs any copies of bills at all. Invariably when a dispute arises the home office appeals to the man on the job, and it is a fine thing for him to have a record.

Instead of going to the trouble of copying these bills, it is required by some firms that duplicate bills be obtained for all purchases. There are some objections to this. Many times purchases are made for cash, and to delay while the slow-moving bookkeeper makes out a duplicate bill, might cost more dollars in lost time than it is worth. Take the cash slip and go. A great many firms, especially in the smaller towns, never make a habit of giving duplicate bills, and to ask for them causes bother and delay. Very often they are not given and then some part of the account is lost. Duplicate bills are a source of great annoyance nine times out of ten, and very often a first-class foreman becomes poor in looking after his regular work because of the time consumed in looking after the accounts. The duplicate bill idea is good if it were the habit of every business house to make them out. In one town a small contractor was told by one house that his business amounted to so little that they did not care to keep it if they had to remember every time to make out duplicate bills for every little purchase he made.

Duplicate bills are pasted in invoice books or put in letter files, and when the inevitable inquiry comes from the bookkeeper in the home office, the particular bill wanted is often missing. It does happen sometimes that mail is lost or destroyed, and the importance of having copies of all papers should not be overlooked. The writer is very firmly impressed with the value of a hand-made copy of every bill received. These bills should be sent to the home office every night in order that there will be no accumulation.

In the back of the book there should be a record of carload freight received. It is usually easy to tell in advance about how many carloads of material will be received. Counting one line for each car record, count off twice as many lines (for sometimes things turn out differently from what was expected), and rule up the pages covered by these lines as shown in Fig. 182. These pages can be the very last pages in the book. The book will then hold a complete record of cash received and expended on the job; a complete record of all bills received and the disposition made of the bills; a complete record of freight receipts in carloads. This makes a complete and satisfactory log of the job, and the average contractor will find such a record a good thing to have.

It usually happens that a number of blank pages are left in the book when the job is completed. The writer, therefore, completes his books by writing in them, after everything is cleaned up, a concise history of the job. The first page is used as an index and here he indexes the items so that they can be referred to. In this history he records how the job was secured, pasting in clippings, if they will help, gives some idea of conditions encountered, the weather, the satisfaction given by the foreman, etc., and whether a profit was made or a loss sustained. If a profit, then the places on the work where it was made; if a loss, then some ideas are given as to why the loss was incurred and the lessons learned. This looks like a great deal to place in the one little book, but it is simplicity itself when started, and a book for each job gives a man a splendid record of a life's work. It very seldom happens that the head office ever considers that a man has such records, therefore the general run of

Shipped	Consignor	Material	Car	Received	Unloaded	Freight		Demurrage		Switching		Remarks
						Amt.	Billed	Amt.	Billed	Amt.	Billed	

Fig. 182.—Double Page Ruling for Carload Freight Shipments.

foremen are at perfect liberty to keep them, and in this way reduce their experience to writing for guidance in future work.

The daily record is an important subject. The writer has used the form here given (Fig. 183) for a number of years. He has been employed by firms that asked him not to bother sending in a daily report, but he always replied that if he did not make it out every day he would soon try every possible means to avoid making out a weekly or monthly detailed report. As some daily idea is wanted of how the work is progressing, this report should be made out daily. It takes only a few minutes and when done is a great convenience to have to refer to; besides, a record like this is very valuable in case of lawsuit. Lawsuits cannot be always avoided. The sheet of paper is 8½x12 ins. The lines ruled for records are ¼ of an inch apart. There are nine lines for the payroll division, six lines for the material subdivision, five lines for the record of bills received and material ordered, and four lines at the bottom for the daily progress statement, which is continued on the back by reversing the sheet. The back is unruled.

The report is made out generally in lead pencil and a carbon copy made. The original is sent to the home office and the carbon kept on the job. Such a report, it may be readily seen, lends itself to any job or class of work. If the job is large and

DAILY REPORT FROM .... (City) .... 19....

On Job........ For........

Approved........ Supt. Const.

Weather........ Wind........

Temperature

8 A. M........ Noon........ 5 P. M........

Weather Indications Next 24 Hours

Daily Report must be mailed each evening, including Sundays and Holidays, using this form. If no work is done the fact, with reasons, must be reported. Give all information necessary to enable Home Office to keep in close touch with the work.

Accidents must be mentioned in this report and full particulars on separate sheet mailed in same envelope.

Troubles, Disputes or Disagreements must be mentioned in this report and full particulars on separate sheet mailed in same envelope.

PAY ROLL						LABOR DISTRIBUTION and WORK DONE						
Number of Men	Hours	Rate	Amount	Occupation	Remarks	Number of Men	Hours	Rate	Amount	Class of Work	Am't	Units

MATERIAL USED			MATERIAL RECEIVED					
						Car Numbers		
Amount	Units	Class	From	Kind	When	Unloaded	Not Unloaded	Remarks

STATEMENT OF BILLS RECEIVED

This statement refers to bills enclosed with Daily Report. All bills must be checked and forwarded the day received. Send copy if the original cannot be forwarded. Get all bills in duplicate.

MATERIAL ORDERED

(Enclose carbon copy of order)

Date	Name	For	Amount	From	Kind	Estimated Cost	Date Expected

DAILY PROGRESS. State here fully the progress made this day, with amount of work done and give causes of delays, if any. Use sketches when necessary. References must be made to drawings, maps, profiles, sections, etc., in order that progress may be noted on office copies.

Be brief but omit nothing essential. Use back of this sheet in preference to using two or more sheets of paper, turning over so ends will be reversed.

.... 19....
(Put Date on this line also)

Fig. 183.—Daily Report.

divided into a number of classes or sections, then such a blank can be filled for each. It does not necessarily mean that all the details of a large job shall be crowded on to one small sheet if more space is really required. The main thing is to have a record of all that is done each day, and have on the record enough information so that cost statements can be worked up from it and unit costs derived when wanted.

The time to distribute the cost accounts is each day as the work is done. Records are made of delays and why they occurred. If high costs are encountered, the daily report shows why and how.

The writer, and every man engaged in this kind of work, knows that very few firms work up their cost records as they would have us believe they do when they read papers before societies on the subject. Much data is collected that is never made use of in the future. Elaborate blanks are often prepared that fall into disuse a short time after adoption. Therefore the importance of having a plain, common-sense record of daily operations can be appreciated. Some firms do not want daily reports. Others go to the other extreme and want more than the one lone man on the job has any right to be expected to give, and instead of having a first-class foreman on the work, they make the bookkeeping part take so much of his time that they have a high-priced and incompetent accountant on the job, which is allowed pretty much to run itself. More complaints are received by the foreman about the poor way in which he sends in his reports than about the loss of money on the job through neglect of his work.

The payroll deserves a section to itself, and another article will take up this important subject. For the average job on which a man will be sent away from home to manage, the common payroll books to be found in every stationery store will be sufficient. After all, it simply requires that the time of every man be kept properly. To avoid taking too much time in copying names, it is well to use on a weekly payroll the one-week books; on a bi-weekly pay roll the two-week books, and on a monthly payroll the monthly books. They cost five or ten cents each and fit nicely in the pocket. Such instruction seems elementary, but the writer has run across men whose books were so marked up because of the wrong blank having been started with, that a little elementary caution about payroll books seems necessary. When a job requires fewer than 100 men, the ordinary stock payroll book will be all right. It is only when a larger number of men are employed that something better is required.

The keeping of accounts on an ordinary contracting job is very simple. It is, however, absolutely necessary that the work required be performed every day. Five to ten minutes per day will do it, whereas letting it go to the end of the week or to any more convenient season means, very often, almost invariably, a quarrel with headquarters. Five minutes each day is a short time and can be spent after quitting time to advantage. The feeling of satisfaction coming with completed work is fine. Five minutes per day accumulates until it means half an hour on Saturday and many times means more than this, for the spirit that leads a man to put off the five minutes makes him careless about placing his papers where he can lay his hands on them. Many times the disinclination to do the five minutes' daily work has cost a man an afternoon and night of worry on Saturday or Sunday. In fact, if the work is let go until the end of the week, it is generally neglected until Sunday night, and then the Monday begins with headache and clouded mind.

The cash report has been dealt with as one of the items comprising the weekly report. Accompanying it should be all the vouchers, in the shape of receipted bills, cash slips, receipts for money paid, the payroll and cancelled checks returned from the bank.

Bills paid by check from the home office are sent there daily, after copying in the bill record book. They are also noted on the daily report as shown. It is important that the bills be sent in daily so the home office can take advantage of cash discounts and bills paid locally should be met promptly for the same reason. This cash discount is an important item as affecting credits and profits, so some explanation may be of benefit to young men just embarking in business or on their first independent job.

The following explanation from Ryerson's Monthly can hardly be improved upon:

"A Cash Discount is a premium or inducement offered by a merchant to his customer to pay a bill before it is due.

Cash Discounts vary in the several lines of trade and their importance may be judged when it is stated that in some large concerns, the total profits at the close of a year's business are represented by the savings through taking advantage of all discounts.

Some houses have the terms and discounts fully and plainly stated on each invoice; others mark it, for example, "30—1-10," which means the bill matures thirty days from date, but if paid in ten days a discount of 1 per cent from the face of the bill may be deducted.

All progressive business houses take advantage of every cash discount that equals or exceeds the prevailing rate of interest. The values of various discounts are:

60 days, less 2 per cent.—10 days = Interest at 14 10-25 per cent.
60 days, less 1 per cent.—10 days = Interest at 7 1-5 per cent.
30 days, less 2 per cent.—10 days = Interest at 36 per cent.
30 days, less 1 per cent.—10 days = Interest at 18 per cent.
30 days, less ½ per cent.—10 days = Interest at 9 per cent.
30 days, less ½ per cent.—for cash. = Interest at 6 per cent.

To present it in another way. If you have purchased a bill amounting to $300 on terms of 30 days—less 1 per cent, if paid in ten days and the prevailing bank rate of interest is 6 per cent, you could make a saving of 12 per cent, by borrowing the necessary amount from your banker and discounting the bill.

1 per cent on $300 = $3; 6 per cent on $300 for 20 days = $1; amount saved, $2. Which equals 12 per cent on $300 for 20 days."

We thus see that in the course of a year considerable saving may be made and profits enhanced by discounting bills.

If discounts are taken, common honesty requires that payment be promptly made according to stated terms. If the discount time is ten days, do not let it run over that time and then deduct it. The merchant feels, and justly, too, that he has been defrauded out of a portion of his profit. The consequent damage to the credit of the tricky purchaser is of greater moment than the small amount he may have gained by taking an extra five or ten days to which he is not entitled.

The bills paid locally and shown in the cash report should be folded so they will be 3½ ins. wide and be less than 9 ins. long. On one end should be a memorandum giving date of bill, amount and name of firm. Receipts and cash slips on small pieces of paper should be pasted separately on sheets of regular letter size and folded and marked in the same manner. These vouchers should then be arranged in order to correspond with the items in the cash report so the clerk at headquarters may readily check the items. Put a band of paper about four inches wide around the bundle, leaving the written memoranda clear, and on the band write:

Cash Vouchers.

Week ending .... 19....

.... Job

.... Foreman

This should be written on both sides, but is really not required except upon the side showing the memoranda on the ends of the folded vouchers.

The payroll report should not be enclosed with the cash report vouchers, as it is a separate matter, like bills paid from the home office. If the company has no special form for payroll report that shown by accompanying blank,, Fig. 184, is a good one.

This form is used when men are paid by check or in some way not requiring the payroll to be receipted. If the payroll

PAY ROLL, Week Ending......................................19..

....Job at...

....Contractor ....Owner

No.	Name	Occupation	Rate		Time		Amount	
			Day	Hour	Days	Hrs.		

Fig. 184.—Payroll Report.

has to be receipted two more columns must be added: one to contain the name of the workman, the other that of the person in whose presence he was paid. This person should be some one besides the foreman, who signs the roll at the bottom as "Correct," so there will be two witnesses.

In arranging the payroll report put at the head the head man, letting each line hold the name of a man lower in position or authority than the preceding line, until the ordinary laborers are reached, when they will be placed according to number. In the columns giving rate of pay such an arrangement groups men by pay and makes the report easy to check. In these columns use "ditto" marks instead of repeating the rate on each line. Never use "ditto" marks in the columns headed "Days" and "Hours" no matter how many men have the same time, and never use "ditto" marks in the columns headed "Amount." The payroll report should be in duplicate, the original sent to the home office and the copy kept on the job. It is well to make the report in lead pencil, using an indelible pencil, and have a carbon copy. Placing a damp blotter over the original will bring out the marks clearly and "set" them.

A regular order blank should be used for all material and as these blanks are stock forms carried by all stationery stores no particular form need be given here. No matter how unimportant the purchase, always make out a written order. If goods are ordered by telephone the written order should be mailed and marked "Confirming telephone order." Two carbons should be made of every order. The original should go to the dealer, the duplicate be mailed to the home office with the daily report, and the triplicate be filed on the job to check the bills when received. It is understood, of course, that there is a letter file on the job in which to keep correspondence and carry papers. When bills are received they should be checked with the copies of orders and each order marked "Billed...... .... 19....," to guard against a second billing for the same material. All orders should be numbered consecutively and in checking bills the order number should be marked against each item. If an order is spoiled mark it "Spoiled" and send the original to the home office to preserve the sequence, and file the spoiled carbon.

Never pay money without a receipt. Carry a receipt book always and have the receipts numbered. The stub is the job record and the receipt is sent in with the weekly cash report as a voucher.

Have the bank book balanced weekly. Check all cancelled returned checks on the stubs of the check book. With the weekly cash report send all returned checks to the home office. Arrange them according to number and date. Place around them a band of paper endorsed thus:

Checks Returned.

Week ending .... 19....
.... Job
.... Foreman
.... Checks amount $........
Outstanding numbers ....
amounting to $........................

One or two pages should be ruled in the cash book giving the number of each check, the date and amount. A final column should give date check is returned canceled to home office. The foreman can thus keep track of checks issued and go after men who are disposed to keep them. No check should be out for more than a week. Payments the last week or two should be made in cash so matters can be closed up at the bank properly.

If the workmen are paid by check there should be a separate check book with another series of numbers. For example, the regular check book may begin with 1 and the labor account check book may begin with 1001. A rubber hand stamp should be made for pay checks reading about as follows:

> This check is accepted as payment in full for labor and all services rendered to and including the date hereon, by the undersigned payee for ....
> on the ....job in the city of.......

the blank spaces, of course, in the above form, containing the proper names, as they could not be filled in with pen within any reasonable expense. That is, there should be a rubber stamp for each job. If the cost will not be too great the above could be printed on the back of each check. The place for this receipt is across the upper end on the back so the first endorsement by the payee comes under it. With such a receipt it is unnecessary to have the men sign the payroll.

When making the weekly cash report put the returned pay checks in bundles, having a wrapper endorsed:

PAY CHECKS.

Week ending ....19....
.... Job
.... Foreman
Amount of payroll $..............................
Checks herewith $..............................
Numbers out ....

The payroll is, of course, the voucher for labor cost each week, but the following week nearly all the checks will come in and can be sent on, thus completely vouchering this item. The pay checks for each week should be kept separate even when there may be only one. When received at the home office the clerks there will collect them and by cleaning up every paper each week on the job the foreman is relieved of the worry of having several items to keep track of until each account is complete. At the home office there are men employed to keep accounts. The foreman on the job has merely to send everything they require in the way of information and send it in such a way that it will be clear to all concerned. He has no business keeping payroll checks until they are all in. He has no business keeping any papers relating to unfinished business. His desk must be kept clean no matter how the clerks at home growl. They have the facilities for caring for the information and in proportion as the business grows the more thankful they are to have a conscientious, careful foreman on the out-of-town job.

The accident report is something that must be attended to very promptly. All contractors carry some accident insurance and the companies are strict in regard to having reports made promptly. No time should be lost in making out the report and mailing it to the proper address.

In this particular considerable trouble arises. When a man is injured common humanity demands that such relief be given him as he requires. There must be no delay, for delays are sometimes fatal. Therefore, the foreman should have some bandages and appliances and supplies on hand for first aid work and should know how to use them. The aid should be given promptly and the injured man and his friends should be made to feel immediately that the boss sympathizes and is anxious to get him fixed right.

Owing to the insurance matters, however, we generally see a rather scared, and sometimes a badly injured, man sitting helplessly holding to the injured place while a lot of helpless looking men hang around waiting for the surgeon, and the foreman who should be competent to give some help, is worrying everyone with questions and showing about as much sympathy as Jack Frost shows for the tender bud in the early spring. So far as the men see, the boss cares nothing for the injured man but is merely intent on getting the information required by the insurance company. The men also know that there is nothing humane in the business at all but that the insurance company intends fighting the case at once. In the picture can be seen the seeds sown for a fight between the injured employe and the unknown corporation that has insured his boss against claims from him. Such things breed antagonism.

The things the insurance company wants to know about the man are simply his name, age, address, occupation, whether married or not and his nationality. When he is injured and scared, for all these strong fellows get terribly scared when hurt, it is heartless, to say the least, to annoy him and his friends with such questions, especially when they all know it is for the purpose of giving information to an indemnity company. The time to collect such facts is when the man is hired. There may be one hundred men constantly at work. Owing to the shifting constantly going on there may be a total of several hundred men engaged upon the work during its progress and it is a bare possibility that none will be injured. Nevertheless it pays to keep all the statistical information ready for use when wanted. A man may be killed and his companions may not be able to give information when questioned. The class of lawyers known as "ambulance chasers" is annoying, and it often happens when a man is carried home that a representative of one of these harpies has been there already and the mouths of the family are closed tight.

The writer has on each job a small plain book with a couple of hundred pages. Each man has a number and it happens always that in the progress of the work several men will have the same number. Each page of this book has a number and he puts on each page the name of the man who has the number on that page. As each page has between 20 and 30 lines it is possible to keep a complete record of the names of men who have had the number. Following each name is put down the date the man started to work. The day he stopped may, of course, be put down, but it is not necessary and is often neglected. This book is merely an index to keep track of the names attached to the numbers.

For keeping track of the men he has small cards, 3x5 ins., in a small pasteboard box with an alphabetical index. Such an outfit costs about 50 cts. The cards may be purchased with printing on, providing lines for the name, address, nationality, etc. These are stock cards. On the other lines may be put down whether a man is married, his age, number of children, etc. When a man is hired a card should be filled out with this information and the number he is given should be placed on the card. The date he begins is there also and these cards are very convenient to have to keep a record of the man throughout, if he is a man who may be good enough to attract the attention of the boss while he is on the job. Having filled this card it is filed alphabetically and on the book containing a record of numbers, the name is put down. When a man is injured it is just possible he can say nothing so he will be identified by the number attached to his clothing. By referring to the number record book, or to the time book, his name can be found and on reference to the card index his residence and accident insurance information will be found. These preliminaries being out of the way it is possible to show the proper sympathy and give the man first aid. Promptness and efficiency in these two very important particulars have a wonderful effect on the men. After the injured man has gone the witnesses may be brought in one at a time, and their evidence obtained. The accident report may be filled out, the record completed on the card and the foreman is ready then for the next accident. In such cases it is highly important that there be due regard for common decency and everything possible should be done to avoid giving offense. Common laborers at such time feel particularly helpless.

Each foreman will have, of course, a book containing the names and numbers of the men under him. This book he is supposed to check with the timekeeper daily. It very often happens that the job is so arranged that the work can be attended to by the timekeeper alone and the foreman will not be required to keep track of the men. In the majority of cases when this can be done it is a decided advantage. If the foreman has nothing to think of but his men and getting the most possible out of them, he will do his work satisfactorily. When he has to keep a book, however, and make entries in it, he loses much time.

The timekeeper should go over the job twice each day. In the morning between eleven and twelve and in the afternoon after four o'clock. His time book should be arranged with a page for each foreman and his men. The names of the men should be arranged consecutively by number. This will insure the least possible loss of time in getting the time.

On some work employing a certain class of men, and especially in large cities, the men shift frequently. In a city like Chicago, in certain sections, the common laborers seldom stay more than two or three days. They may work on the job several times a month but only for very short periods. The law requires that a man be paid in full when discharged, and these fellows generally manage to be discharged, for if they left voluntarily they would have to wait until pay day for their money. The obvious thing to do is to learn to know these men and after awhile decline to employ them. It often is the case, however, that men are not too plentiful and some of these fellows are really good workers when they do work, so it is well to ignore their peculiarity of wanting to draw their pay too often and merely arrange the time keeping system so they can be kept track of. Here is where the number system is awkward and sometimes to oblige the timekeeper and to simplify his work, good men are refused employment after they have quit several times. It is not always possible to save numbers for such fellows. The writer makes it a rule to avoid duplication during each pay day interval. That is, if pay day comes each Saturday, a number will be given only once during the week. If pay day comes twice a month, then the number is given out only once in the two weeks. Such systems cannot be always followed if one has a small supply of numbers. On a job requiring 100 men there should be about 300 numbers to carry out such a system. The writer generally figures on having about twice as many numbers as he has men on a job constantly employed and then giving out a particular number only once between pay days. It has happened in seasons of the year when the weather conditions were very bad and there were frequent lay off periods, that such a supply of numbers was not sufficient. This occurs in large cities, as a rule where work is being done in the vicinity of large industrial establishments where indoor work may be had. The common laborers will do their best to secure an indoor job as soon as bad weather comes on and will hang around the big establishment until their money is gone before applying for an outdoor job on construction. So it often means that after a couple of days' lay off almost an entirely new gang has to be hired. The matter is complicated often by some of the older men turning up some morning and getting their number in the first seven o'clock rush, and thereby causing lots of trouble when the new man who has that number comes in two minutes later and demands it. Such little problems the time keeper must wrestle with and get up schemes to make his work as easy as possible.

The writer used for years on his work a silicate slate book. These books may be obtained at almost any stationery store and have four, six or eight pages, ruled in lines for names. On the right hand edge rule a line and put down the numbers in ink. An acid ink is best. On the line opposite the numbers put the names of the men in lead pencil. By dampening the finger the name may be readily erased and when the man goes off the job his record will be completed in the time book and his name erased from the silicate slate. On the line opposite the number put down the date on which that number may be again allotted. When the number is given erase the date and put down the new name. On the left hand edge of the page is to be ruled a column in which may be entered the time daily.

The advantage of such a book is that the time may be obtained on a job very rapidly and with the least number of mistakes. Every man is supposed to have conspicuously displayed a numbered badge. When the timekeeper goes out for the time he can stop each man he comes to, regardless of where he finds him, and turning to the number in his book ask the man his name. If it agrees with the name there he checks the time and goes on. After a while he, of course, learns the names of most of the men. It is an easy matter to check all the men after going over the job. If some have been missed the fact is discovered before returning to the office and the particular numbers can be hunted for. This is very much better than taking the time from a foreman's book. It eliminates favoritism and occasionally a foreman will put a man down as working merely to save time for himself, when the man may really be soldiering in the brush.

Upon returning to the office the time is transferred to the time book. On going out in the morning the men entitled to full time are checked off with a vertical mark. If only part time the number of hours will be set down. In the afternoon a cross mark will indicate full time. The transfers are made to the time book after the afternoon round. As each transfer is made the timekeeper must cross out on the slate, the time record for that day. After all the entries are made he should go over the slate very carefully indeed to see that everything has been entered properly, and thus avoid troubles on pay day. The only objection to this system is that the record taken on the job is erased and if an entry has been forgotten the workman will have a right to complain. Care, however, will prevent this. The writer in handling thousands of names in nearly twenty years of work has had so very few cases of trouble that he believes this system very good. Trouble will always come up about time, no matter what system is used.

An improvement on this system would require a slip for every man every day and the making of these slips would take too much time. The timekeeping must be done with a minimum of work. If ordinary time books are used the constant changing of the men makes it annoying and very often a timekeeper gets mixed on his numbers. By having the silicate slate book the vacant lines always show at a glance the numbers available for new men and the dates on which they may be given out. Duplicate numbers on the pay roll can then be avoided and the pay roll easily made up on pay day for the report to headquarters.

Every man should have a number. Foreman and timekeepers complain that the men do not like to wear the numbers where they may be readily seen, and if not in plain sight much of the object of having numbers is defeated. A small, round brass tag with a hole to which is attached a strap is often given to the men, who hang it to a button hole like a watch fob. This is too low down on the person to be readily seen by the timekeeper and is in a place where the lifting of materials may tear it off. A number attached by a safety pin and worn on the breast is often knocked off when men have to lift heavy loads or climb to some position where they can work. The fact that the missing check is charged to them makes many men carry the numbers in their pockets and time is lost whenever they have to produce them for the inspection of the timekeeper. The writer believes it a good idea to have brass checks about the size of a silver dollar attached by a catch pin to the hat. Here it is out of the way and is readily seen. So far he has had few men object to wearing it there. The check should have not only the number on it but the name of the company.

The men, of course, must pay for lost checks in order to teach them to be careful.

These systems here described are intended for the small contractor and the man who is sent from home and who for the time being is practically a small contractor. Large concerns will have their own methods and blanks and a book of instructions to guide foremen. Gilbreth's "Field System" is an excellent book for every man to own who is in charge of work. The way to obtain costs from the papers and books here shown will be given in the following article.

On the subject of paying men, a few words will not be amiss. If there ever was a fiendish invention devised to keep contractors and their men apart it was the invention of the payment of common laborers by check instead of in currency and coin. It saves very little work for the timekeeping department and is a most inhumane proceeding. The writer never does it if permitted to do otherwise. The men feel awkward in going to a bank. No matter how considerate the bank officials may try to be, offense is easily given and very often a supercilious young fellow irritates the poor, ignorant men who go in. The question of identification is something that must be attended to and the bank officials, working on salary, cannot take too many chances. All this is very bewildering to the men.

Banks close earlier in the day than the workmen get off, so they must go at noon to cash their checks, and oftentimes they stay longer than they should. If they cannot get off to cash the check they have to go to a saloon. The saloon is the place to which they go naturally, because there is no bother about identification. The saloonkeeper is glad to see them and the check is cashed cheerfully. Several saloonkeepers in different cities told the writer that they figured on getting 75 per cent of the money back into their cash registers within five or six hours after cashing the checks.

In paying money to the men it is well to know that nearly all of them owe a little money to the stores at which they trade. If they are paid in bills of large denomination they will go to a saloon to have the bills broken, for if they sent the large bill to the storekeeper he would keep his debt out of it. If they owe nothing at the stores it is almost impossible to get any bill larger than five dollars changed, and frequently the small storekeepers with whom such men trade cannot change a five-dollar bill. They do a small cash business in which the amounts seldom run higher than 50 cts. and they have very little money on hand. In fact, in many sections it would not do for the storekeeper to let his customers know that he keeps more than a few dollars on hand.

In paying men, therefore, a rule should be adopted to the effect that no man will receive a bill larger than $5 and that no one bill shall amount to more than half the total pay, and that not more than half of a man's pay shall be in one bill. If a man, therefore, earns $11, he will receive one five-dollar bill and the rest of the money will be in small change, and small bills. If he earns $9 he will not receive a five-dollar bill, but all his pay will be in small currency and change. By adopting such a rule the writer on several occasions has kept his gangs filled when other firms who were careless of the men's feelings had difficulty in keeping a full force at work. It was surprising to see how the men slighted the saloons when they were paid in small change. Most of the workmen went to the saloons as banks and money-changers' establishments and not because they really wanted to go there before going home. The day has gone by when the workmen on a job are to be considered merely as so much machinery. So far as the personal relations go, they are machinery, and to recognize the human element too much lowers efficiency. By treating them humanely, however, they respond very quickly. In no way can sympathy be more quickly established between the workmen and their foreman and employers than by treating them on pay day as if they were getting something they were entitled to. They feel they have earned their money and resent any lack of feeling on the part of the timekeeper and the paymaster. The writer on pay day has the watchmen and foremen keep the men in line and accompanies the paying off with badinage and jokes as the men file by. It is easy to do and they stand around cheerfully. Too often on pay day the men are yelled at and treated disgracefully. It is as easy to grin as it is to scowl, and grins are always reflected. So are scowls. The writer has never yet witnessed a pay day when loud yelling and brutality on the part of the men who keep the men in line was justified, yet he has witnessed it many a time. Not that it is common on the majority of jobs, but it is unfortunately too common simply because of the attitude of some men being like that of the policeman who apologized when he hit a man by saying, "No offinse, sur. I don't bate ye because I hate ye, but ye see I have de autority."

The methods taken up in the preceding articles are accounting methods pure and simple. They show merely how the man in charge on the job reports to headquarters all his doings day by day so the accounting department can attend to its business properly.

On the daily report is a section devoted to the distribution of labor cost. This cost is obtained by making trips over the work and ascertaining as closely as possible what each man is doing, and such data are obtained readily when the timekeeper makes his rounds. It is not necessary to split cents on this matter. Each foreman can give a pretty good account of what he has been doing with his men. These costs will be distributed after the collector gets back to the office.

Bearing in mind always that large concerns will have their own methods and that blank forms will be supplied on which to collect and report this information, the methods to be adopted by the foreman in charge of work for small concerns can be his own methods, changed, perhaps, for each piece of work.

A blank book ruled in squares, six, eight or ten to the inch, as may be desired, is a handy thing to carry round. It becomes a regular diary and entries are made in it irregularly day after day. That is, when going over the work and a certain piece of work is going on, a stop can be made and the movements of the men studied and their work timed. The notes can be made in the book, and as it grows it becomes very valuable.

The writer has found a small case holding about 15 or 20 3x5-in. cards a handy thing to carry around on work. The cards are ruled and at the top of one will be written a heading and a date. For example, one card has on it, "Erecting gin pole on Sumach Creek Power Plant, Aug. 15th, 1891." On the lines underneath are data telling the size of the pole, the size and length of the ropes used as guys; the number of men employed, the tackle, and what the pole was erected for. Some account was given of performance. Under the Gin Pole index in the file will be found a number of cards relating to gin poles on different jobs.

A series of cards relating to Derricks, Engine Setting, etc., will be found also in the card index file carried by a man who has been busy in such work for a term of years. This is the sort of data wanted by the foreman. To be sure, a pretty good knowledge grows on such matters and that is why experienced men are more valuable as a rule than inexperienced men. Under the modern system of ticketing information the new man gains over the old very rapidly.

Labor is the hardest thing to estimate on any work. It is the largest item on work generally. Because of the uncertainty of the labor item many contractors go to extremes in the purchase and use of machinery. A contractor may become "machinery poor," just as a farmer may become "land poor." The reasons are the same in both cases. The ignorant farmer, unable to make a decent living on a small farm, buys more land until he can hardly earn enough to pay taxes. The more intelligent farmer concentrates his efforts on a small place and gets along well. A contractor who does not know how to handle men properly, or who does not keep up to date on methods and whose knowledge of costs is not allowable of analysis, sees himself falling behind and blaming it on the labor, buys machinery until he is too heavily loaded.

Old contractors are fond of telling of the times when a sewer contract, for example, having been obtained, the contractor hired a gang of men and they needed no foreman. Each man knew his place and the work proceeded finely, the contractor visiting it only occasionally. Nowadays the labor is always ignorant and the best of supervision is required. Wages have gone up and prices have come down. The remedy is obviously machinery. This is the remedy in some cases, but not in all, and the incompetent contractor cannot differentiate.

Here is where the man with accurate cost and method data comes in as a useful member of society. The writer has seen a great many notebooks of contractors of the old school, and he found very little matter of value from their own experience. Their notebooks were full of clippings. They sneered at books and book men and yet cut clippings freely from papers and saved them for reference. They talked glibly of letting prices, but knew little about "doing" prices. They knew vaguely that certain prices could be bid for work and there would be a "fair profit." The words "fair profit" were overworked and the legal profession still likes the term. Within a very few years the man with well filled notebooks containing records of work he has been in charge of and work with which he has been connected, is in demand. The writer last year was talking with the president of a contracting company who was bitter in his denunciation of the publication of "method and cost" data, yet who kept for several months an advertisement standing in a number of papers for a man with records of work covering not less than ten years. His company wanted a chief engineer and manager with written records of not less than ten years' work in a variety of employments, and he would employ no other. Yet he was angry because of the fact that methods and costs are things taught in engineering schools, and talked feelingly of the good old times when foremen and contractors were born and not made. Personally the writer prefers the manufactured article.

The previous articles tell the young man how to do the clerical work that goes with every job, so he will make a good impression at headquarters. This article attempts to show him how to secure the data he requires for himself so every particle of experience will be of value to him always. It is not so easy to do it. How can he do it? Each job is an experimental laboratory. Professors and investigators make experiments on materials and the designer works from very meager data very often, but relies implicitly upon it. The contractor must do the same. Costs are of value in proportion as the conditions are stated. It has been said they are of value only to the men who collect the data, but if they are of value to the collector alone, something has been gained by the collection and compilation. He is a better man for his observations and deductions. His methods will improve with his knowledge of costs, for the two are interwoven. Good methods mean lowest possible costs, and low costs can be secured only by following good methods.

Take the gin pole, for instance. Records of a dozen jobs on which gin poles were used showed that the last three or four gin poles were erected in less than half the time of the first. On the first job the young observer saw his first gin pole raised. The foreman of the gang and his men had raised gin poles before. On the next job the foreman was also an old hand, and the young observer had nothing to do with it. On the third job he noticed a little wrinkle and put it down approvingly. Finally we come to jobs where he is a foreman instead of a timekeeper, and one job shows how he put up a gin pole with some experienced workmen and some ignorant laborers. The last three jobs he erected gin poles himself as foreman with laborers from the south of Europe who did not know English and who were green at the work, yet the time was ridiculously short as compared with the first job observed, and, of course, the cost was low. He had learned. It had covered a period of fifteen years and during that time only a few occasions had arisen for this particular kind of work. If it had been left to the treacherous memory to record, no record would have been broken. As the facts were recorded, however, with sketches, it was an easy matter to refresh the mind when such a piece of work came up and the experience of others summed up in his experience produced results with which his employer was well satisfied. Now, as he went at the work in a proper and methodical manner, who can doubt that his men did not have something added to their stock in trade of methods and costs. Suppose he published the facts and showed how he did it. We can believe that every man who reads it will know better how to erect a gin pole and even if he does not have one to erect today he can file the information in something more durable than the brain tissues and have it ready against the time he needs it.

In this manner the young man will collect his cost data, remembering always that good methods and low costs are so intertwined that they cannot be separated. This is why published cost data are valuable. If the costs are very low, there must be a reason. If due to good methods, then there has been a distinct advance in knowledge for the men who work. If the costs given are low because a mistake was made in omitting some items, these costs are subjected at once to a rigid analysis by men who know and there results another gain.

Some years ago, and it was not so very many years either, a man was employed because he knew how to handle men. That was always the sort of man wanted. Today the average employer wants a man who knows something about costs and is well versed in methods. It is the same kind of man after all, but the employers have learned. The man they employ has become methodical and therefore is a better and stronger man. He knows how to handle men because he knows so well what a certain piece of work should cost and knows so well the best methods to save time and motion, that the men respect him. Formerly the foreman had worked his way up from the gang and was obeyed because of the success he had made, yet his men were free to criticize many times where their experience had been perhaps slightly better than his. The trained foreman of today commands their respect because of the unhesitating manner in which he goes at things and because he knows just when to come back to view the finished job.

Like timekeeping and bookkeeping and the making of daily reports, the young man in a responsible position and the older man in charge cannot spend so much time hunting for method and cost data that they neglect their work, which is to keep the men moving and the job going at fever heat. They are there to obtain for the boss the most work at the lowest cost. He does not care whether they collect cost data or not. If he wants it he is willing to pay a man to collect it. He wants them to get the work out of the men and machinery and to obtain for him the largest possible profit on the job. Every minute spent on the collection of cost data that can be employed in looking after the job is a minute of his time lost.

Everything is useful. If a tab is kept of the time of men going to the storeroom for tool supplies and it can be shown that economy can be effected by putting in a couple of messenger boys or even installing an intercommunicating telephone system, then the time spent in observing this detail has been well spent. If a few minutes spent in watching the moving of a derrick results in the saving of a half hour on the next change, then the time has been well spent. What the eager seeker after knowledge must guard against is the habit of collecting data to such an extent that a man degenerates into a collector of data and nothing else. The writer knows men who can reel off costs by the yard and by the hour and who know all about the best methods of doing work, yet they are peculiarly helpless in directing men in the doing of these things. Such men are spoiled in trying to manufacture a foreman. Yet such a man on a job to help out a born foreman is an experiment worth trying. It was done on one piece of work where a good hustler was sent to help out such a man. The hustler knew how to keep men moving without false motions and the other man knew the motions. It was an ideal combination, for which the hustler, however, got no credit finally. He is still working as a foreman and the other fellow is president of a contracting company.

The collection of data is important and the study of methods is important. The good man will learn to strike a balance and not neglect his work, while getting data from it that will be of service on succeeding jobs.

However, it must be said that just as it is necessary for the accountant to know every item of expense entering into a contract in order to strike a balance between expenses and income, so is it necessary for the man in charge to know unit costs and how to obtain them. Too much nicety in getting them is as bad as too much carelessness. The segregation of unit labor costs and unit material costs may really be made very broadly on the general run of work. A close study of all the operations connected with the conduct of the work and especially things that take gangs temporarily from straight work, will well repay the student.

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