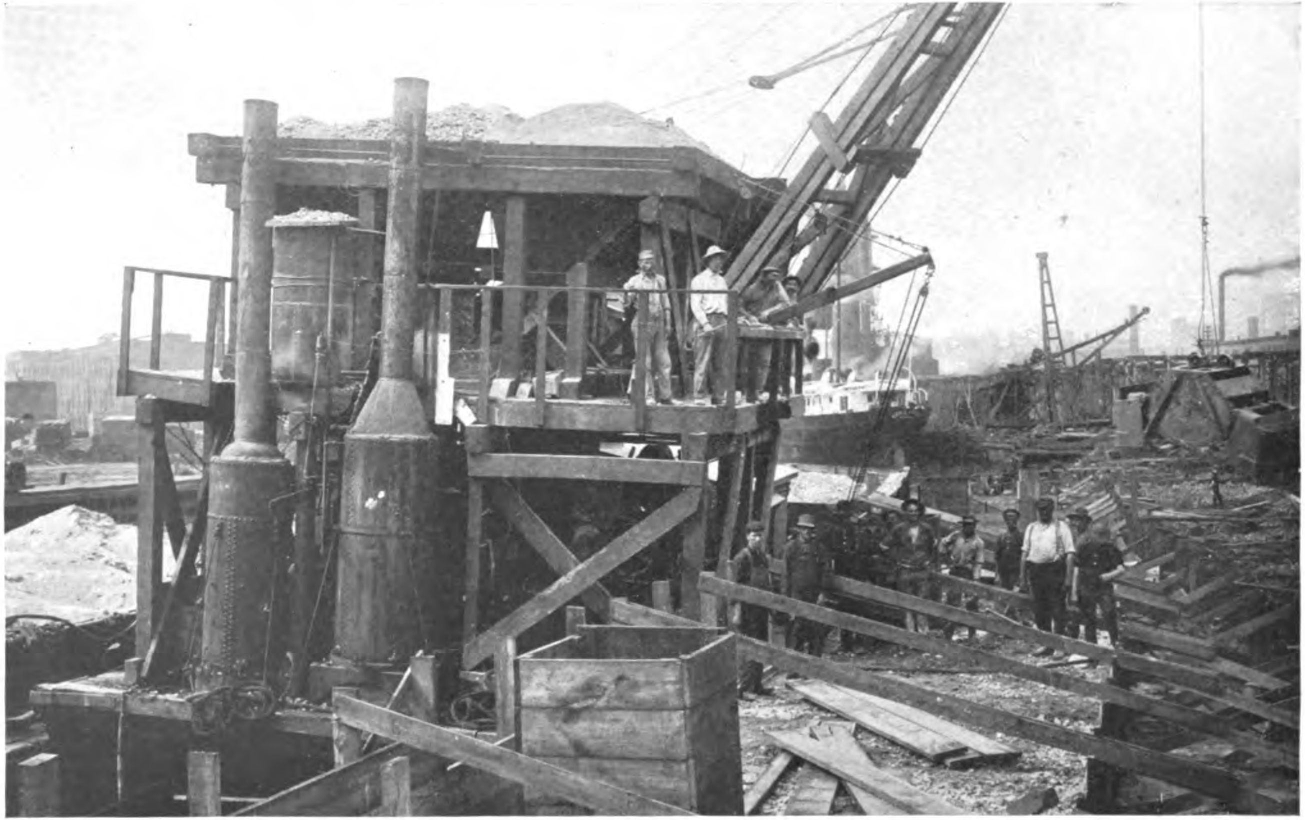

CONCRETING PLANT AT WORK IN CONSTRUCTION OF LARGE DOCK AT CLEVELAND, OHIO.

Radford's Cyclopedia of Construction

Carpentry, Building *and* Architecture

A General Reference Work on

MODERN BUILDING MATERIALS AND METHODS AND THEIR PRACTICAL APPLICATION TO ALL FORMS OF CONSTRUCTION IN WOOD, STONE, BRICK, STEEL, AND CONCRETE; INCLUDING ALSO SUCH ALLIED BRANCHES OF THE STRUCTURAL FIELD AS HEATING AND VENTILATING, PLUMBING, ELECTRIC WIRING, PAINTING, CONTRACTS, SPECIFICATIONS, ESTIMATING, STRUCTURAL DRAFTING, ETC.

Based on the Practical Experience of a
LARGE STAFF OF EXPERTS IN ACTUAL CONSTRUCTION WORK

Illustrated

TWELVE VOLUMES

THE RADFORD ARCHITECTURAL COMPANY
CHICAGO, ILL.

Radford's Cyclopedia of Construction

Prepared under the Supervision of

WILLIAM A. RADFORD

Editor-in-Chief

President of the Radford Architectural Company, Chicago, Ill.
Editor-in-Chief of the "American Carpenter and Builder" and the "Cement World"

ALFRED SIDNEY JOHNSON, A. M., PH. D.

Editor in Charge

Author of "The Materials and Manufacture of Concrete," etc.
Formerly Editor of "Current History." Associate Editor of Numerous Standard Works of Reference

Partial List of Authors and Collaborators

JOHN P. BROOKS, M. S.

Associate Professor of Civil Engineering, and Acting Head of Department of Civil Engineering, University of Illinois

FRANK O. DUFOUR, C. E.

Assistant Professor of Structural Engineering, University of Illinois
Author of "Bridge Engineering," "Roof Trusses," etc.

DAVID P. MORETON, B. S.

Associate Professor of Electrical Engineering, Armour Institute of Technology

ALFRED G. KING

Consulting Engineer on Heating and Ventilating
Author of "Practical Steam and Hot-Water Heating and Ventilation," "Steam and Hot-Water Heating Charts," "Practical Heating Illustrated," etc.

ERVIN KENISON, S. B.

Assistant Professor of Mechanical Drawing and Descriptive Geometry, Massachusetts Institute of Technology
Author of a Practical Textbook of Mechanical Drawing

AUTHORS AND COLLABORATORS—(Continued)

LORING H. PROVINE, B. S.

Instructor in Architectural Engineering, Department of Architecture, University of Illinois

THOMAS TAIT, C. E.

Consulting Heating, Ventilating, and Sanitary Engineer
Member American Society of Inspectors of Plumbing and Sanitary Engineers
Member American Society of Heating and Ventilating Engineers

RICHARD T. DANA

Consulting Engineer
Chief Engineer, Construction Service Company, New York, N. Y.
Joint Author with Halbert P. Gillette of "Cost-Analysis Engineering"
Member American Society of Civil Engineers
Member American Institute of Mechanical Engineers

WILLIAM A. RADFORD

President, The Radford Architectural Company, Chicago, Ill.
Editor-in-Chief, "American Carpenter and Builder" and "Cement World"
Author of "Practical Carpentry," "The Steel Square," etc.

GEORGE W. ASHBY

Architect
Vice-President, The Radford Architectural Company, Chicago, Ill.

CHARLES W. RADFORD

Treasurer, The Radford Architectural Company, Chicago, Ill.

CHARLES D. WARNER

Editor "Cement World" and "Dealers Record."

BERNARD L. JOHNSON, B. S.

Editor "American Carpenter and Builder" and "Woodworkers Review"
Formerly Mechanical Engineer, Fitz-Hugh Luther Locomotive & Car Company, Chicago, Ill.

E. L. HATFIELD

General Manager, Cement World Company, Chicago, Ill.

IRA S. GRIFFITH, A. B.

Supervisor of Manual Training, Oak Park, Ill.
Member Editorial Board, Western Drawing and Manual Training Association
Formerly Professor of Mathematics, Eureka College
Author of "Essentials of Woodworking"

AUTHORS AND COLLABORATORS—(Concluded)

CHARLES EDWARD PAUL, S. B.

Associate Professor of Mechanics, Armour Institute of Technology
Member American Society of Mechanical Engineers
Member American Society for Testing Materials

EDWIN O. GREIFENHAGEN, B. S., C. E.

Office Engineer, Bridge and Building Department, Chicago, Milwaukee & St. Paul Railway

ALFRED W. WOODS

Architect
Inventor of "Wood's Key to the Steel Square"
Joint Author of "The Steel Square and Its Uses"

WILLIAM REUTHER

Expert on Modern Building Methods

T. B. KIDNER

Director of Manual Training and Household Science, Department of Education, Province of New Brunswick
Fellow of the British Institute of Carpentry

P. W. RATHBUN, B. S.

Consulting Engineer
Member American Society of Heating and Ventilating Engineers

EDWARD HURST BROWN

Editor "Painters' Magazine"

CHARLES P. RAWSON

Chief Draftsman, The Radford Architectural Company, Chicago, Ill.

I. P. HICKS

Architect and Contractor

Bibliography of Construction

BEING A SELECTED LIST OF STANDARD WORKS COVERING VARIOUS PORTIONS OF THE GENERAL FIELD OF CONSTRUCTION

In addition to the vast store of up-to-date practical information never before published, the editors have embodied in the Cyclopedia of Construction the cream of the world's best literature in this field, giving in condensed form the substance of everything essential in the experience of the past to enable the worker of the present to meet every problem likely to be met with under the conditions of ordinary practice.

For the sake, however, of those who may be interested in pursuing further study along various special lines, we furnish a list of important works that have appeared covering different portions of the field.

In this connection, the editors wish to express their thanks to American manufacturers and dealers in the machinery and materials of construction, as well as to proprietors and patentees of various special mechanical devices and processes, for valuable data, illustrations and suggestions.

Authorities on Construction

MANSFIELD MERRIMAN, C. E., Ph. D.

Professor of Civil Engineering, Lehigh University
Author of "Mechanics of Materials;" "Retaining Walls and Masonry Dams;" "Elements of Sanitary Engineering;" "A Textbook on Roofs and Bridges," etc.

HALBERT P. GILLETTE

Late Chief Engineer, Washington State Railroad Commission
Author of "Handbook of Cost Data for Contractors and Engineers"

JOHN C. TRAUTWINE

Author of "The Civil Engineer's Pocketbook"

FREDERICK W. TAYLOR, M. E., and SANFORD E. THOMPSON, S. B., C. E.

Authors of "A Treatise on Concrete, Plain and Reinforced"

FREDERICK E. TURNEAURE, C. E., Dr. Eng.

Dean of College of Engineering, University of Wisconsin
Joint Author of "Principles of Reinforced Concrete Construction;" "Theory and Practice of Modern Framed Structures," etc.

EDWARD GODFREY

Structural Engineer for Robert W. Hunt & Co.
Author of "Structural Engineering" (Book I—"Tables;" Book II—"Concrete."

A. PRESCOTT FOLWELL

Editor, "Municipal Journal and Engineer"
Author of "Sewerage;" "Water-Supply Engineering," etc.

AUTHORITIES ON CONSTRUCTION

IRA O. BAKER, C. E.

Professor of Civil Engineering, University of Illinois
Author of "A Treatise on Masonry Construction;" "Roads and Pavements," etc.

FRANK E. KIDDER, C. E., Ph. D.

Author of "Architect's and Builder's Pocketbook;" "Building Construction and Superintendence," etc.

CHARLES EVAN FOWLER, C. E.

President, Pacific Northwestern Society of Engineers
Author of "Ordinary Foundations"

FRED T. HODGSON, ARCHITECT

Author of "Modern Carpentry;" "Builder and Contractor's Guide, etc.

HENRY R. TOWNE

Author of "Locks and Builders' Hardware"

HENRY N. OGDEN, C. E.

Assistant Professor of Civil Engineering, Cornell University
Author of "Sewer Construction"

CHARLES E. GREENE, A. M., C. E.

Late Professor of Civil Engineering, University of Michigan
Author of "Trusses and Arches," "Structural Mechanics," etc.

WILLIAM H. BIRKMIRE, C. E.

Author of "Planning and Construction of High Office Buildings;" "Architectural Iron and Steel, and Its Application in the Construction of Buildings;" "Compound Riveted Girders;" "Skeleton Construction in Buildings," etc.

FRANK W. SKINNER

Lecturer on Field Engineering, Cornell University
Author of "Types and Details of Bridge Construction"

JAMES J. LAWLER

Author of "Modern Plumbing, Steam and Hot-Water Heating"

WILLIAM H. BURR, C. E.

Professor of Civil Engineering, Columbia University, New York
Author of "Elasticity and Resistance of the Materials of Engineering;" Joint Author of "The Design and Construction of Metallic Bridges"

HOMER A. REID

Assistant Engineer, Bureau of Buildings, New York City
Author of "Concrete and Reinforced Concrete Construction"

J. B. JOHNSON, C. E.

Author of "Materials of Construction;" "Engineering Contracts and Specifications;" Joint Author of "Theory and Practice in the Designing of Modern Framed Structures"

AUTHORITIES ON CONSTRUCTION

W. R. WARE

Formerly Professor of Architecture, Columbia University, New York
Author of "Shades and Shadows;" "Modern Perspective," etc.

JOHN CASSAN WAIT, M. C. E., LL. B.

Formerly Assistant Professor of Engineering, Harvard University
Author of "Engineering and Architectural Jurisprudence;" "The Law of Contracts," etc.

T. M. CLARK

Author of "Building Superintendence;" "Architect, Builder, and Owner before the Law," etc.

CLARENCE A. MARTIN

Director of College of Architecture, Cornell University
Author of "Details of Building Construction"

CHARLES H. SNOW

Dean of School of Applied Science, New York University
Author of "The Principal Species of Wood, Their Characteristic Properties"

GAETANO LANZA, S. B., C. E.

Head of Department of Mechanical Engineering and Applied Mechanics, Massachusetts Institute of Technology
Author of "Applied Mechanics"

A. W. BUEL AND C. S. HILL

Authors of "Reinforced Concrete"

NEWTON HARRISON, E. E.

Author of "Electric Wiring, Diagrams and Switchboards"

EVERETT U. CROSBY and HENRY A. FISKE

Authors of "Handbook of Fire Protection for Improved Risk"

GEORGE E. THACKRAY, C. E.

Structural Engineer, Cambria Steel Co.
Author of "Handbook of Information Relating to Structural Steel"

ALPHA PIERCE JAMISON, M. E.

Assistant Professor of Mechanical Drawing, Purdue University
Author of "Elements of Mechanical Drawing;" "Advanced Mechanical Drawing," etc.

RUSSELL STURGIS

Author of "A Dictionary of Architecture and Building;" "How to Judge Architecture," etc.

A. D. F. HAMLIN, A. M.

Professor of the History of Architecture, Columbia University, New York
Author of "A Textbook of the History of Architecture"

ROLLA C. CARPENTER, M. S., C. E., M. M. E.

Professor of Experimental Engineering, Cornell University
Author of "Heating and Ventilating Buildings"

AUTHORITIES ON CONSTRUCTION

I. J. COSGROVE

Author of "Principles and Practice of Plumbing"

WILLIAM PAUL GERHARD, C. E.

Author of "A Guide to Sanitary House-Inspection;" "Sanitation of Public Buildings," etc.

FRANK O. DUFOUR, C. E.

Assistant Professor of Structural Engineering, University of Illinois
Author of "Bridge Engineering—Roof Trusses"

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Author of "Manufacture and Properties of Structural Steel"

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Author of "Essentials of Woodworking."

WILLIAM J. BALDWIN

Author of "Steam Heating for Buildings"

CLIFFORD DYER HOLLEY, M. S., Ph. D., and E. F. LADD, B. S.

Authors of "Analysis of Mixed Paints, Color Pigments, and Varnishes"

JAMES H. MONCKTON

Author of "Stair-Building"

HARMON HOWARD RICE

Author of "Concrete-Block Manufacture: Processes and Machines"

H. G. RICHEY

Superintendent of Construction, U. S. Public Buildings
Author of "A Handbook for Superintendents of Construction, Architects, Builders, and Building Inspectors;" "The Building Mechanic's Ready Reference"

J. A. L. WADDELL, C. E., D. Sc., LL. D.

Author of "De Pontibus;" "Specifications and Contracts," etc.

R. M. STARBUCK

Author of "Modern Plumbing Illustrated"

SYDNEY F. WALKER, M. I. E. E.

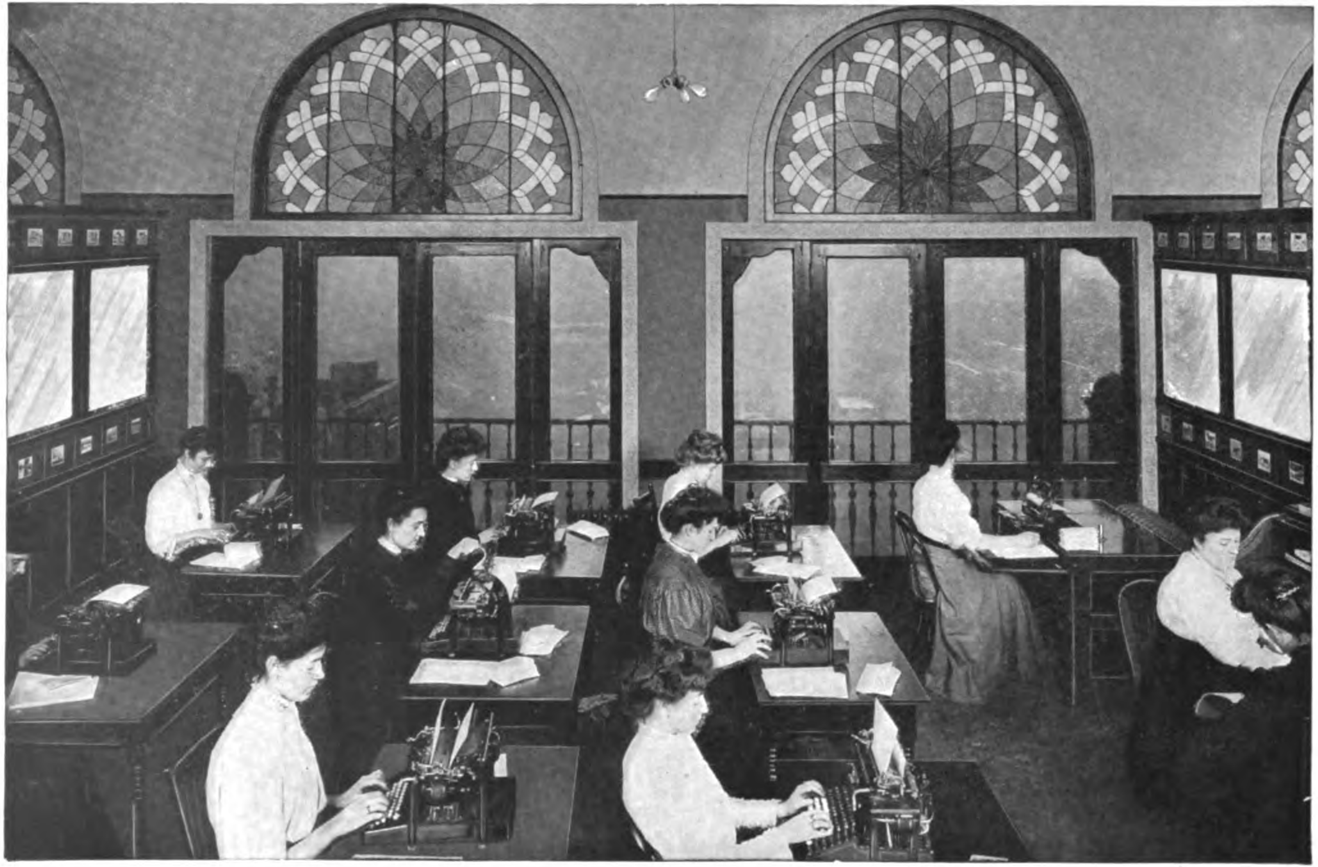
Author of "Electric Lighting and Heating"

ERNEST McCULLOUGH, C. E.

Author of "The Business of Contracting;" "Reinforced Concrete," etc.

GEORGE D. ARMSTRONG

Author of "Cyclopedia of Painting"



STENOGRAPHIC DEPARTMENT, THE RADFORD ARCHITECTURAL COMPANY, CHICAGO, ILL.

Preface

THE Building Industry, in its various branches, is more closely identified than any other with the marvelous engineering progress of the present day and the untold possibilities of the future. To put all classes of workers in familiar touch with modern methods of construction and the latest advances in this great field, and to bring to them in a form easily available for practical use the best fruits of the highest technical training and achievement, is the service which the CYCLOPEDIA OF CONSTRUCTION aims to render.

The work is pre-eminently a product of practical experience, designed for practical workers. It is based on the idea that even in the larger problems of engineering construction, it is not now necessary for the ordinary worker in concrete, or steel, or any other form of material, to attempt the impracticable task of exploring all the highways and byways where the trained engineer or technical expert finds himself at home. The theories have been worked out; the tests and calculations have been made; observations have been recorded in thousands of instances of actual construction; and the results thus accumulated form a vast treasure of labor-saving information which is now available in the shape of practical working rules, tables, instructions, etc., covering every phase of every construction problem likely to be met with in ordinary experience. This is perhaps most apparent in the sections on *Cement and Concrete Construction, Plain and Reinforced.* To this subject, on account of its supreme importance as a structural factor of the present day, three entire volumes are devoted, embodying the cream of all the valuable information which engineers have gathered up to date. Much of this practical information now presented in this Cyclopedia, has never before been published in any form. By its use, anyone is enabled to take advantage of the vast labors of others, and to bring to bear on any problem confronting him the results of the widest experience and the highest skill.

The keynote of the Cyclopedia is found in the emphasis constantly laid on the *practical* as distinguished from the *theoretical* form of treatment, in its total avoidance of the complicated formulas of higher mathematics, and in its reduction of all technical subjects to terms of the simplest and clearest English. Throughout the pages devoted to Steel Construction, for example, the mathematics of the subject have been eliminated to such an extent that *the reader will not find a single instance where even a square root sign has been used.*

In addition to the larger problems of engineering and building construction, one entire volume, as well as many chapters scattered through the work, is devoted to those smaller constructions that are of special interest to the teacher or student of manual training or the home shop worker of a mechanical turn of mind.

Inasmuch as a wider knowledge and a more intelligent grasp of the fundamental principles of construction and design will tend to greater efficiency on the part of workingmen, and to greater economy in production, the purpose of the CYCLOPEDIA OF CONSTRUCTION is one which will appeal strongly, not only to the men themselves, but also to the architectural and engineering fraternity as a whole.

The authors of the various sections are all men of wide experience whose recognized standing is a guarantee of reliability and practical thoroughness.

Table of Contents

HOUSE AT BABYLON, LONG ISLAND, NEW YORK.

Detailed working plans, specifications, and revised estimate based on actual cost to builder, are given in this volume.

Construction Contracts

INTRODUCTION

As the result of a great many centuries of experience, it has been found of advantage to do a very large percentage of the total business of the world by the **contract** method. In its essentials this method consists of an agreement embodying the amount of the compensation to be paid, on the one hand, and the amount and quality of the performance, on the other. In the simplest forms of business, where there is a cash transaction to be carried out, a man can buy a horse or a suit of clothes, the transaction taking place by delivery, without what we are here considering as a formal contract; but, even in its simplest cases, there must be an understanding before the parties actually do business, and this understanding constitutes a contract.

When a man employs a carpenter to work for $3.00 a day, the arrangement—whether verbal or written—under which the carpenter goes to work, usually means that he is to comply with the instructions of his employer as to what work he is to do and how he is to do it, in consideration of which he receives $3.00 per day; and the employer is under obligation to pay the

$3.00, and to confine the nature of his instructions and requirements to the limits of the usual practice in his neighborhood and in the particular trade to which the man belongs. This is a contract in which the $3.00 per day is a **stipulated feature.** The **implied features** are one of the great troubles—and necessary troubles—in the economic administration of business of this kind, because, as a general thing, the parties in interest never have exactly the same idea of what the implied features are; and, moreover, it is frequently the case that the clauses in a written contract, as well as the intentions of the parties, are subject to differences in the interpretations that may be given them by different people.

There are two principal ways of looking upon a contract; it may be considered as a **legal instrument** pure and simple; or it may be considered as a **business arrangement,** entered into for the purpose of making money, by two or more parties, for their mutual financial benefit, but never for the exclusive benefit of either party, since the fundamental basis of the administration of business law is that a man shall not be obliged to enter into an agreement unless he considers it to his interest to do so. A contract cannot be properly considered under either of these points of view without taking into consideration the manner in which it must necessarily be affected by the other. In this discussion, the consideration of the contract as a business arrangement is made the fundamental one, and its legal status has been discussed only so far as it affects the practice in an economic sense.

Contract Defined. A construction contract is an agreement between parties to pay a certain compensation for certain valuable possessions or services, and may be for labor, material, money, or any valuable consideration. It may be in writing or simply a verbal understanding; but so long as it is an arrangement between the parties interested, and is understood by both or all of them to be such, it is a contract, and they are both or all equally bound by it.

Often it happens, in the case of written as well as verbal contracts, that, after unforeseen conditions have developed, the understanding of the parties may differ as to the meaning of certain clauses—their scope and the original intent when the contract was made. Furthermore, when a dispute arises, it may appear that when the contract was originally prepared the contractor had an entirely different idea from that held by the owner, as to what he (the contractor) was expected to do. In such case, unless it can be clearly shown that one of the parties was guilty of fraud—a criminal matter—the contract is sound and binding, and the meaning of the disputed clause is taken to be what its language would imply to an intelligent and unprejudiced third person. This third person may be a witness to a verbal agreement, or he may be one to whom a written contract is afterward submitted. Therefore, although the parties must both or all understand that they have an agreement in order that the contract shall be valid, yet one of the parties cannot abrogate it with impunity by claiming or proving that he has misunderstood the meaning of a part of it.

Classification of Contracts. There are three main classes of contracts for building construction in general use to-day. They are as follows:

(1) The **lump sum contract,** where the contractor receives a certain amount of money for completing the work delivered in place.

(2) The **unit-price contract,** where the contractor receives so much money per thousand brick, per cubic yard of concrete, per pound of steel, etc.

(3) The **cost plus compensation contract,** which means that the owner advances the money, and the contractor supplies the managerial skill and organization.

These different kinds of contract, and all their complications, may be subject to a large number of various modifying clauses and restrictions on both sides; but in general almost any contract in use to-day for building construction in the United States may be classified under one or other of the above headings.

Essentials to the Contractor. Before taking up the classes and general structure of the contract in detail, it is important to consider the general features of the contract in their economic bearing. For this purpose we shall consider that there are two principal parties in interest, one of whom does the work—whom we shall call the **contractor**, and ordinarily designate as the **party of the first part**; and the other party, the **owner**, who advances the money and is to obtain possession of the completed work, and who is frequently designated the **party of the second part.**

From an economic standpoint, the essentials that the contractor requires, in order that the matter may be a satisfactory business venture for him, are as follows:

(a) Pay, regular and sufficient.

(b) Freedom from interference with the economic conduct of the work.

(c) Special privileges.

These we shall here discuss in this order.

(a) **Pay.** A contractor in all forms of contracts except the third class indicated above (cost plus compensation), requires capital in order to pay his men, to pay for materials and supplies, and to support himself while the work is in progress and before he receives his money from the owner; but the amount of capital that he actually needs is by no means as great as the total cost of the work when completed. If the amount of work that a contractor has on hand, when ultimately completed, will cost $100,000, the amount of money that the contractor himself must have in the business may often be as low as $5,000, and is seldom higher than $15,000 or $20,000.

To understand this, let us see how the work actually proceeds. Upon completing the agreement, the contractor engages men to work for him, and he wants materials. The materials are ordered from the manufacturer or jobber upon an understanding whereby the contractor is to pay for them, let us say, 30 days after delivery upon the work; and the workmen are to receive their pay at the end of each week or month. Thus the contractor will not have to pay out anything in actual cash, except what might be called "petty cash items," until the first pay-day. On the first pay-day he will have to pay for the labor to date. At the end of the month the materials and supplies that were delivered when he first commenced operations will have to be paid for, but not material that has been delivered during the first month; therefore the actual work done to date, by the end of the month will represent a considerably larger amount of money than the contractor has had occasion to pay out for labor and materials, although the contractor is obliged ultimately to pay for these materials and labor from time to time as the payments become due.

Now, in the majority of contracts it is stipulated that the owner shall place with the contractor from time to time—usually from month to month—certain installments of the contract price, which installments will be as nearly as possible proportionate to the value of the work that the contractor has done, less a percentage (usually figured at 10 per cent or so) which is held up in order that the contractor may not be financially at liberty to stop the work and seek other employment to the detriment of the particular work covered by the contract in question.

It is evident that if the installments of the contractor's pay are not forthcoming when they are due, the contractor will not receive enough money to meet the payments that he has obligated himself to make for labor and materials; and conversely, it is clear that if the payments are made by the owner with proper regularity and are sufficient in amount to cover the contractor's expenses and obligations as they become due, he (the contractor) will not be obliged to furnish money to "carry on the job." When work has been badly laid out in the beginning, so that through a mistake or otherwise the contractor is obligated for amounts in large excess of what he is obliged to pay out, the carrying charges may be very large; and if he is swinging a million dollars' worth of business on $100,000 capital, he may find himself at a comparatively early stage of the proceedings with most or all of his capital "tied up," and may be obliged to borrow more money at high rates of interest. He will therefore not only be losing interest on the money that he has himself invested in the business, but also be paying an additional interest on the money borrowed. When it is appreciated that this interest may easily be 6 or more per cent on the loan, and that his profits, which are his compensation for his own services, may not be more than 10 or 15 per cent on the contract price, it seems clear that insufficient and irregular payments are to be very carefully avoided.

Attention is here called to the hardships—often unnecessary hardships—that can be brought upon the contractor through the holding up of his regular payments by the architect or engineer. Sometimes, when a contractor has not complied with the terms of the contract, and is seeking to do other work and make other money to the financial prejudice of the owner of the job on which he is employed, an architect has no right to authorize the regular payments until the contractor has lived up to his obligations; but, on the other hand, it is an injustice to the contractor to hold up a certificate because the architect happens to be too busy to check the figures, or on a technical or finely drawn point which is not entirely justified by the cold facts. This injustice is not always a matter of consequence, but may result in serious complications if pushed too far.

The owner can have no objection to making payments regularly if the contractor carries out his part of the contract, for the reason that the owner knows beforehand when each payment ought to come due, and he is in a position to prepare himself against such time well in advance of its occurrence. Inasmuch as the partially completed structure belongs to the owner, he at all times has got value received for his money.

(b) **Freedom from Interference.** The contractor undertakes to perform a certain specified act, or series of acts, or groups of acts, for a certain consideration, and it is of the highest economic importance to the contractor that he be not obliged to do things which he did not originally obligate himself to do or which he did not expect to do when he entered into the contract. If a contractor enters upon a piece of work with the idea of meeting the ordinary regular conditions that he can foresee, and if suddenly unforeseen difficulties develop which prevent him from executing the work as economically as he had originally planned, he is immediately in trouble, and he is in a position similar to that of a man who pays a good price for a cantaloupe and, after cutting it open, discovers it to be spoiled. As a matter of law, with the usual form of contract, if the contractor meets with difficulties which are not the fault of the owner in any way, and which the contractor ought to have foreseen himself, it is the contractor's fault, and he must bear the burden of it. On the other hand, if he is subjected to interference with the economic conduct of the work because of the actions of the owner, such privileges not having been granted to the owner in the contract, the owner is at fault, and in this case it is he who must bear the burden. There are, however, a great number of cases which do not come within either of these assumptions. For example, if the contractor meets with difficulties which are forced upon him by outside parties, or by what the lawyers term "the acts of God," the financial responsibility is often a very difficult one to determine.

In brief, the contractor is supposed to be able to foresee the ordinary conditions that will govern his work, and to make provisions for them in the terms of the contract which he signs; and to meet these conditions he is responsible. For unreasonable interference with him on his work, due to the owner, a contractor is not responsible. For outside conditions which are not foreseen in the contract and not of such ordinary occurrence that they should have been foreseen in the contract or by an intelligent estimator, and which, at the same time, are not imposed by the owner or anyone employed by him, there is usually room for question as to who must bear the responsibility.

(c) **Special Privileges.** No two contracts can be exactly alike, because no two engineering or architectural purposes are exactly alike. Every piece of work has its own particular and peculiar features which require to be dealt with in a way particular and peculiar to that work; and therefore nearly every contract has clauses which are intended to guard against misunderstandings arising from special conditions. If these special conditions are expected to interfere with the right or the interest of the owner, the attempt is generally made to guard the owner's interest by introducing the special privileges that he may need; while, if the peculiar conditions are expected to affect the contractor detrimentally, he may insist upon certain special privileges for his protection.

The contractor may be allowed to use equipment belonging to the owner; he may be allowed to use the owner's property to store materials and supplies upon; he may be allowed special rates on materials sold to him by the owner; and he may be allowed special leeway as to when certain parts of the work ought to be completed —all of which special privileges are worth something to the contractor and are certain inducements to him to take the contract at a low figure; or they may be inducements to him to waive payments at certain times.

Essentials to the Owner. The owner, on his part, is under the economic necessity of obtaining most or all of the following valuable things as a result of his contract:

(a) Quantity of work.
(b) Quality of work.
(c) Time of completion.
(d) Special privileges.

(a) **Quantity of Work.** In a construction contract, when the work has been completed, the owner is to have something that he did not have before; and the amount of what he is to have, secured for him by the contract, should be most carefully understood before the work is commenced. If the structure is to be built of concrete, the owner must receive enough cement, enough sand, enough stone, enough steel, and enough of all the various materials that are going into the structure, to justify him in his expenditure, or it will not be a financial success. Moreover, he must have the quantity that his original understanding with the contractor guarantees. His architect, for this purpose, lays out elaborate **plans** showing in detail a very large portion of the finished work; and the **specifications**, which accompany the plans, and which are regularly made a part of the contract, are intended to insure, among other things, that there shall be no skimping in work below the understood and agreed-upon standard. In actual fact, as the practice runs to-day, it is not at all easy to guard against errors in and violations of the original arrangement in this regard. Take the simple case of cement, for example. The architect may specify that the concrete shall be made of a 1:3:5 mixture, meaning one part of cement, three of sand, five of stone. If the materials are specified as of these parts by weight, it will be difficult to enforce the rule with exactness, because of the ordinary difficulty of weighing upon the ground, and also because of the fact that these materials, except stone, weigh considerably more when they are wet than when they are dry. When, on the other hand—as is usually the case—the materials are specified by measure, there is room for misunderstanding, because the space which a given amount of sand or cement will take up depends to a considerable extent upon the degree to which it is packed. A packed barrel of Portland cement contains about 3.8 cubic feet, more or less, of cement; but, if sifted, the dry cement in one barrel may easily amount to considerably over 4 cubic feet; and, depending upon the way in which such a term of the specification is interpreted, will the owner get more or less material for his money.

Sometimes the contract may provide that the mixture is at the discretion of the contractor, and that the owner is satisfied if the finished concrete will pass certain tests, in which case there is less room for misunderstanding. Such practice, however, has not yet become general in the United States.

A contract for structural steel work may be for a lump sum or for so many cents per pound. If on the lump sum basis, the owner is interested in receiving the number of pounds of material as covered by the plans. Now, it happens that the steel mills cannot roll the sections with absolute uniformity, and there is sometimes a difference of several per cent between the estimated standard handbook weight per foot of steel shapes and the actual weight of those steel shapes when shipped. The difference is caused by the variations in the adjustment of the rolls in which the material is made. In a case of this kind, it is generally conceded that variations in the estimated weight amounting to 2½ per cent are permissible, except in the case of such material as sheared plates more than 100 inches wide, in which case 5 per cent variation from the theoretical weight is ordinarily allowed. In a large piece of steel work, some of the material will be over-weight and some under-weight, so that in the long run the errors will tend in some degree to balance each other.

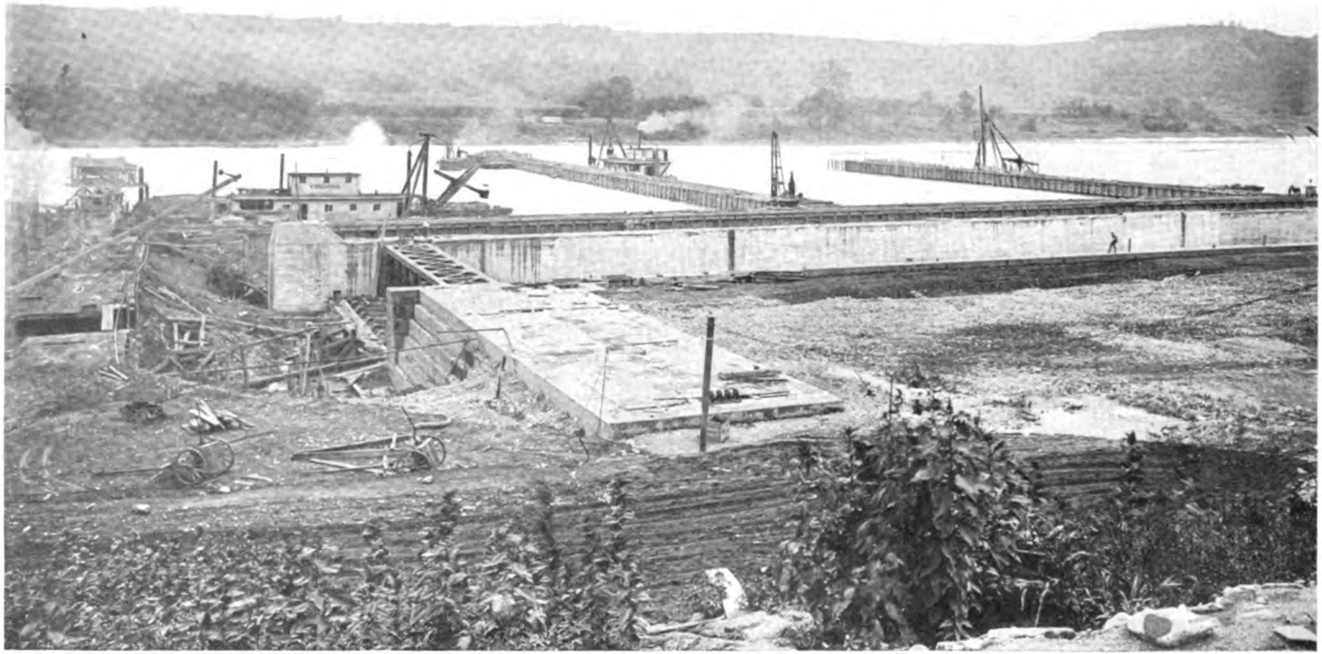
In the case of a brick building where the contract is upon the unit-price basis, there is likely to be some discussion as to what allowance must be made for the spaces of doors, windows, and other openings; and it is essential, in a contract of this kind, to specify carefully how the number of units of performance in the work shall be estimated or determined.

The owner is interested in the quantity of material and of labor entering into his structure, in so far as it affects the quality of the finished work, its durability, and serviceability. The distinction between quantity of labor as an asset to the owner, and quality of workmanship, is a fine one; but there is no question that the owner is entitled to the proper amount of material and the proper amount of labor necessary to make the structure what the two parties agreed upon when the contract was signed.

(b) **Quality of the Work.** In addition to the amount, the owner is entitled to a certain **quality of material** and **quality of labor**; and here is one of the difficult problems that arise in all contract framing, and one which is worthy of careful study. As a general thing, what the parties have in mind when they sign the contract is that the material shall be of **standard quality**—the sort of quality that enters into a first-class job, the sort of quality that is readily obtainable at fair prices in the open market; but this understanding is so general and is subject to so many different interpretations, and the variation in interpretation is so great with different kinds of material, that it is exceedingly difficult to decide properly and equitably.

Take the common example of the ordinary red hard-burned brick. In the first place, the bricks made by different makers are of different sizes and of different shapes; and a big brick is worth more money than a small brick, other conditions being equal. A standard brick specification would require that a brick should show, when broken, a comparatively uniform structure, hard and somewhat glassy, and free from pebbles, cracks, cavities, and lumps; and yet, as a matter of fact, many a brick gets on the market which contains one or more pebbles the size of a hickory nut. An over-burned brick will be of a different size from an under-burned brick, and will have very different characteristics. Moreover, the art of brick-burning is such as not to admit at present of the most exact uniformity in the product. The bricks which are on the outside of the kiln will not receive as thorough a burning as the bricks toward the center of the fire; and therefore the finished product will necessarily show irregularity, and the justifiable range of irregularities is not easy to specify in terms of units. The owner is entitled to require upon inspection a quality which was standard when the contract was signed; and it is essential to the proper success of his part of the business that the standard quality be assured to him; but if the owner requires a quality which is higher than the standard and more difficult to obtain, the increase of usefulness thereby secured is usually not so great as the increase of cost involved.

It frequently happens that the owner changes his mind after the contract has been entered upon, as to what quality he wants in certain materials; and then, by an agreement with the contractor, he pays a certain amount for the privilege of changing the quality of the material. As a general thing, when so inserted, the cost of these **extras** to the contractor and also to the owner is greater than it would have been if they had been properly foreseen in the draft of the original contract. Sometimes a contractor takes advantage of the fact that the owner wants to change his mind, and exacts an exorbitant compensation for the extras, in which case the contractor makes money out of it. Making these extra charges on a large number



GENERAL VIEW OF CONSTRUCTION WORK OF MILLION-DOLLAR CONCRETE DAM AT FERNBANK, NEAR CINCINNATI, OHIO.

One of a series of dams erected under federal government supervision, which, with a system of locks, will make the Ohio river permanently navigable, with 9-foot stage of water the year round.

of items is one method of turning an unprofitable contract into a profitable one. It is nearly always strongly objected to by the owner, and is likely to lead to lawsuits.

The illustration of the red brick has been used above because it is such a common article for construction purposes. Another type of article to which attention should be called in this connection, comes within the class of special fittings, hardware, etc. The standard quality of door-knob, for example, is a very difficult thing to decide on beforehand, or to agree upon afterward. There are so many different types of door-knobs, and so many different makers furnishing them, that sometimes the only way to solve this problem is to specify by catalogues and numbers. Then, if this particular manufacturer happens to have a surplus of orders and cannot deliver on time, the contractor has the excuse for delaying the work, that he could not get the special object specified by the owner, and the owner is in a quandary as to how to get what he wants without delay to his work in general.

The quality of the labor is still more difficult to contract for with accuracy than the quality of the material. When the contractor starts in on the contract, he may not have in his employ more than two or three of the men who are to work upon the job, but he undertakes to see that the work shall be performed in a "thoroughly workmanlike manner." The workmanlike manner of the human laborer in times of great business prosperity, when there is a job for every man, is a different matter from the workmanlike manner of the same man after he has resigned from the union or before he has joined it, when there are two men for every job. The owner is entitled unquestionably to receive the grade of work that the contract calls for; but how to specify in words that grade of work without room for a great deal of misunderstanding and subsequent trouble, is a problem that has not yet been generally solved except upon the understanding that the grade of work shall be in accordance with the established practice in the locality and at the time when the contract was signed or when the work is carried out.

The quality of the finished work, its appearance, its dimensions, its density, and its general resistance to outside forces, can often be pretty well defined, and this implies a certain quality of workmanship. On a piece of riveting work, for example, the owner on an ordinary contract should be reasonably entitled to have the riveting done by men of experience in this class of labor; and it might perhaps be a violation of his rights to have the contractor place upon the riveting work green men, training them as the work progresses. The contractor may claim that so long as the rivets fill the holes, are properly finished, are not burned, and cannot be found fault with on inspection, he is doing his part; and probably this is true, so long as the green gang does not take so much time upon the work as to interfere with the owner's rights.

(c) **Time of Completion.** As a business proposition, the owner in the contract makes a stipulation that he is to receive his completed structure or certain parts of the completed structure at certain times. The contract for the structure is of more value to the owner if the structure is completed at a certain time than if it be delayed, for the reason that he makes his ordinary business plans and arranges his various business matters so that he can make use of the structure at the time specified. He does not expect to receive it sooner; and if he did receive it sooner, his other arrangements might not admit of its being any more valuable to him than if delivered later; while, if there is considerable delay, he may be put to a large monetary loss. Therefore he is entitled to receive the structure at the time agreed upon, provided that an extension of time is not agreed upon, or provided that the delay is not caused through the fault of the owner, or through an "act of God," so called, or through some other cause which is beyond the power of the contractor to prevent.

One of the causes most likely to produce a delay of this kind is a **strike.** Now, a strike may be caused by ignorance on the part of the contractor of proper methods of management. Men will sometimes strike while working for an ignorant contractor, whereas if working for a successful manager, they would not strike under the same conditions. A contract such as we are now considering frequently includes a clause to the effect that a strike shall involve an extension of the contract time corresponding to the amount of the delay from the strike. It will be noticed that such a clause, while protecting the contractor in absolving him from the assumption of such risk, is a distinct disadvantage to the owner, who has no redress on that account if the strike takes place; and if a contractor finds that he is going to be delayed in the work, he can with very little trouble produce a strike. The time or duration of a strike may not be the same as the time of delay caused by such strike, and it is sometimes difficult to establish just what this time allowance ought to be.

(d) **Special Privileges.** A railroad building a bridge on a contract will often require that the contractor shall so conduct his work as not to interfere "in any manner" with the regular passage of the trains that are operated by the railroad. This gives the railroad, or the "owner," the privilege of very considerably interfering with the work of the contractor at times in order to maintain its traffic in an uninterrupted way. Such a clause, when worded as above, is often ridiculous in its importance, because a contractor cannot build a bridge under traffic without requiring at least that the trains shall be slowed down. The owner may sometimes wish to have certain articles that he possesses, and for which he has special fondness, incorporated in the work

—for instance, such as an ancestral mantel-piece or a particular grade of stone or a particular colored stone. Special features such as these are very frequently inserted by architects in order to obtain special artistic effects, and they unquestionably have a certain monetary value, which is very difficult to estimate in dollars and cents from the owner's point of view, but which may cost a very definite amount from the point of view of the contractor.

The owner will frequently decide upon asking certain privileges of this kind after the contract is well under way, and at a time when compliance with his wishes will involve a much greater hardship upon the contractor than would have been imposed had the privilege been settled upon originally. This forms an excellent reason —and too often an excellent excuse—for the contractor to demand a large extra compensation.

OBLIGATIONS OF A CONTRACT

Lump Sum Contracts

Under the usual lump sum form of contract, the contractor agrees to furnish the following:

1. Money.
2. Plans and specifications.
3. General instructions, stakes, and layout.

The contractor furnishes:

1. Labor.
2. Materials.

3. Plant.
4. Supplies.
5. Organization.
6. Superintendence.
7. Experience.
8. Insurance, as to time.
9. Insurance, as to cost.

It will be noted that the owner furnishes something which is usually definite, and the proof of the furnishing of which is usually easy. By the dates on the checks or on the receipts, it is entirely feasible to establish just when the owner made the advance payments, and there is rarely much trouble as to whether or not the owner furnished a sufficiency of plans and specifications, stakes, and general instructions for the work, although at least one instance is on record of a lawsuit arising in which one of the principal grounds of contention was that the owner did not furnish a sufficiency of plans to enable the contractor to proceed.

While it is easy to establish the dates at which the owner has made payments, and their amounts, trouble may arise on a contract because the owner refuses to make payments, claiming that he is justified in withholding money, on the ground of something that the contractor has done. Now, the contractor, in furnishing each of the above nine items of value, supplies something which is not a definite medium of exchange, which cannot be specified with absolute precision, and the cost of which to the contractor may not be the same when he is ready to use it as it was when he signed the contract. Therefore the chances for misunderstanding as to the contractor's performance are very much greater than the chances as to the owner's performance; and this fact ought to be borne in mind by all owners, contractors, and architects, not only in preparing the contract, but in using ordinary common sense in its interpretation afterward.

Plant. The items of **labor** and **materials** have already been discussed. **Plant** is a factor in which there is a wide range of variation in efficiency and cost and in general adaptability to different kinds of work. A contractor who has a small business of considerable variety must have a plant which is as adaptable as possible to different classes of work, so that when he finishes one piece of work of a certain type he can put the same plant on another piece of work of a different type without any large loss of efficiency. Such a plant will not operate as efficiently as one which is adapted to but one kind of work and which is made especially for that work. It therefore behooves the owner, before entering into a contract, to consider in general what sort of plant the contractor owns, which he intends to use on the particular work in hand.

Supplies, such as coal, oil, dynamite, etc., which are consumed in carrying on the work and which do not remain as part of the finished structure, do not particularly concern the owner as to their quality or amount; but they will have a considerable effect upon the contractor's efficiency. If they are not of proper quality, delays are likely to result, which the contractor may claim are not his fault. This is a danger that the owner has got to run, because it is not advisable for the owner, before signing a contract, to stipulate much as to the grade of supplies which the contractor is to use. Although there is no theoretical reason why it cannot be done, it would be unusual.

Organization. It is the contractor's duty to furnish the organization on the work—by which is meant the assembling of men of proper training to get the work carried on successfully. Some of this organization—namely, the Superintendent and Foremen—may be regularly carried upon the contractor's pay-rolls, and he may know exactly what they are capable of doing; and the owner may be able to get references as to the contractor's past performances, which will give him to understand just what he can expect from the contractor's employees of these grades. The great bulk of the organization, however, is likely to be engaged at the beginning of each job, and to some extent the owner must take a chance as to the results of this selection.

Men vary, and they vary greatly, in their individual efficiency. Under the ordinary system of handling outside work in use to-day, in taking on a number of men, there will be perhaps some very good workers, some fairly good workers, and some altogether bad workers. The general average of the workmen's performance is what the contractor figures on in making his estimate; and if he gets a certain man or gang of men better than the average, he is that much better off; if they are worse than the average, he is just that much the worse off. His chance of getting a combination that is pretty close to the average is greater on large jobs and in large communities where there are many men looking for work, than on small jobs or in small communities where there is not so much doing. Therefore, the gambling chance as to the quality of workmen is greater in small communities on small jobs of work than vice versa, and this feature usually involves a larger contract price.

Superintendence. Superintendence of the work, to see that it goes smoothly and economically, is the special service which is expected of the contractor, and the one which the nature of his business makes him particularly fitted to render. He is supposed to know how to get the best foremen, and to see that they get the most out of their men; and his office is supposed to buy materials at the lowest prices. He may be seriously limited in his opportunity to get the best foremen for any particular piece of work, because in dull times, in order to reduce expenses, he discharges his idle men, and when business becomes lively again it is difficult to get good men at short notice. Many large contractors, therefore, keep a few of their good men over dull times; but this is done under the penalty of increasing the "overhead" charges, thus making it difficult to compete with small contractors on anything but large operations.

Some contractors are particularly skilful in handling certain kinds of labor, and have indifferent success with others. A manager accustomed to the type of bricklayers to be found in the New England States might have difficulty in getting satisfactory work out of negro labor in the South.

Some contractors can purchase materials and supplies more economically than others, because their credit is better, since the dealer will always quote better prices when he is sure of his money than when he is not; and some men have a natural gift as buyers which is not always possessed by other men equally clever as regards the handling of men.

It is clear that in furnishing superintendence or managerial skill, the contractor is delivering something which cannot be measured or estimated with much accuracy before commencing work, and not always afterward. If the contractor has a record as an efficient manager, and has in his employ some good men who are available for the work to be undertaken, he may be expected to manage or superintend the work efficiently, provided that his financial inducement to do so is sufficiently strong. This is supposed to be insured in the unit-price or lump-sum forms of contract, by having him guarantee the cost.

Experience. A contractor may be a good manager and may have an excellent organization, and he may have a very good plant and be able to obtain satisfactory labor—all of these without being able to do efficient work. Unless his experience has been of the right kind to fit him for the particular work to be done, he is likely to have a good deal of trouble. For the best results, he requires to have had experience on the type of work in question. There are, for example, a great many "tricks of the trade" which are peculiar to a piece of **brickwork,** for the knowledge of which some experience seems to be necessary. In bricklaying the contractor employs a very high-priced class of labor for the actual laying of bricks; and he employs an entirely different class to act as helpers to keep the bricklayer supplied with material, to raise and move scaffolding, and, in general, to facilitate the brick problem. The management of the work so that the bricklayer can handle his bricks with a minimum of labor on his own part, can always find a brick at the right place when he reaches his hand for it, and not only find the brick there but find it in its proper position with the right side up so that the bricklayer standing upon his scaffolding is always at the proper position with regard to the growing wall—this kind of management is an art by itself. It is, moreover, a highly intricate art—one involving not only the ability to manage men well, but the ability to plan and foresee conditions that are likely to arise during the day's work. While this art can be studied scientifically, and a great deal can be learned about it that pertains to the economics of the subject, its efficient carrying-out requires practice.

In **concrete construction** the amount of material on the work is pretty rigidly limited by the plans and specifications, and the most variable feature is that of labor. This labor consists not only in the placing of the concrete itself, but in the making and setting of the forms; and it is likely to be the case in most work of this kind that the keynote of successful performance is experience and ability in handling these forms. Forms are generally made of wood that can be used again and again, and if properly treated, can be used much oftener than when improperly handled. The life of the forms is also very much governed by the manner in which they are designed and put together. To handle them properly upon the work and manage the general work so that they can be used to the best advantage, is an art entirely distinct from bricklaying, and one which seems to require a considerable amount of training and experience before it can be mastered. One reason for this is that heretofore no very thorough economic study of this subject has been made.

Another class of construction on which a contractor should have had special experience in order to insure his efficiency is that of **steel buildings.** Here the units to be handled are often very large and heavy. The handling of heavy weights economically by a small force of men and with the aid of derricks and other plant, is a peculiar art which comes only from practice. Sailors are generally good at this sort of work, and men who have not had experience in it are practically helpless when confronted by its problems. The iron worker as a laborer is in a class by himself. He is courageous and determined, strong and active, and under some circumstances requires considerable tact, as well as firmness, on the part of his manager. After the metal has been set up and bolted, it is necessary to rivet it together—which is a large item of cost; and here special experience will generally teach a manager how he can apply devices for pushing the work.

The contractor should have some experience of the locality in which he expects to work, since local ordinances are likely to vary a good deal, and the manner in which the laws are administered is also likely to vary a great deal in different localities. The local conditions of labor, besides, are likely to vary. One town may be pretty well unionized, and another not far away may contain a rather different class of labor and require different methods for pushing work. The prices of labor and material are not very different in New York City and in Brooklyn, just across the East River; yet prices obtained by contractors for doing work on Manhattan Island are considerably higher than those in the other Borough. This is due partly to these local conditions as above mentioned, and partly to the density of traffic on Manhattan Island and the difficulty of getting through the streets. A strange contractor cannot easily tell beforehand how much trouble he is going to have in unloading his wagons in the streets until he has been at least once "up against" the local ordinances.

Size of the Job. A man who is accustomed to handle small pieces of work is generally in the habit of doing a good deal of the field managing himself, and is not necessarily very strong in the organization line. He may be able to manage very efficiently a piece of work which requires a small number of workmen, but not be so good where the individual counts for less and the general business organization counts for more. If the bulk of his experience has been on works of small magnitude, he is not likely to be particularly good at the large ones; and on the other hand, if his work has been in the line of heavy construction, employing a good many men, he will usually not bid as low on a small piece of work as will a man who has had most of his experience in small jobs.

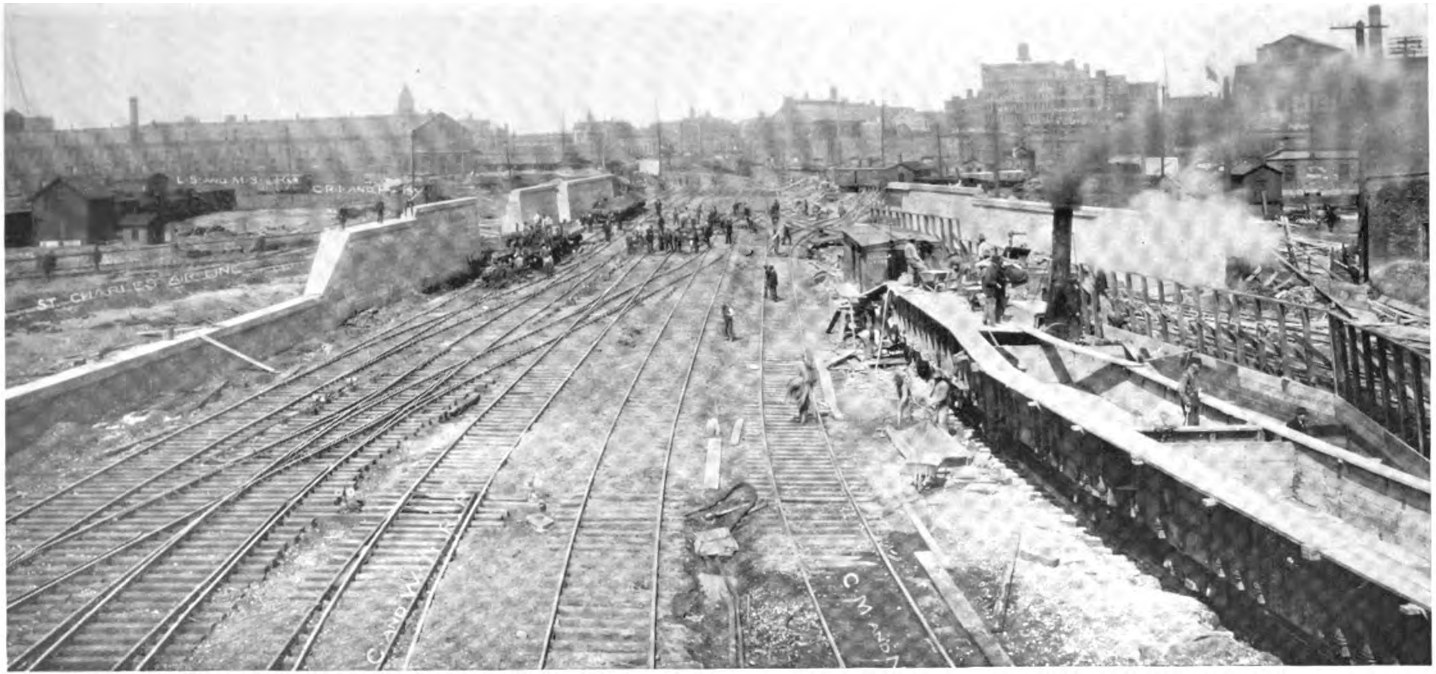
Insurance. In the old-fashioned form of contract, the contractor guarantees that he will do the work for so much money. This particular part of his contract is nothing else than a sort of insurance by which he undertakes to assume the risk of the work being more expensive than he originally figured. If it costs more, he loses; and if it costs less, he gains just that much—which, as has been indicated above, is an inducement to him to operate with economy. In practice, this works out in the following way: The contractor always either makes or loses, and frequently his bookkeeping methods are such that he does not know whether he has made a profit on the contract or whether he has actually lost unless the profit and loss should happen to run into a considerable amount. If he is generally successful in making substantial profits his business grows and he waxes prosperous; or if he makes a good many small losses, or one or two very large ones, the amount of capital at his disposal is not sufficient to enable him to stand the losses, and he fails. If he fails while the contract is at a critical stage, the owner is likely to lose money unless he is protected by a bond, and he is sure to lose in the matter of time for the completion of the work. The large contractor with a large capital is less likely, of course, to fail on a comparatively small contract than a small contractor, and the additional security in the way of insurance which this larger capital gives the owner is one reason why the owner is sometimes willing to accept a higher bid from a large contractor than he can obtain from a small one.

The insurance feature has a decided economic value from the standpoint of the owner, and is a tremendous risk from the standpoint of the small contractor. It will be noted that this insurance which the contractor provides is insurance **as to cost** and **as to time**, the former being by far the more dangerous to the contractor, and the latter sometimes of greater importance to the owner. These features will be considered more fully under the Cost plus Compensation Contract.

Unit-Price Contracts

The general bearing of the obligations of the parties to each other is very similar to that in the case of the lump sum contract, except that here the totals of the quantities are often not determined until the finish of the work. Any effect that this uncertainty may have upon the interests of the parties will properly influence the contract prices on the one hand, or the contractor's profit or loss on the other.

The case of structural steel work affords an excellent example of the workings of this feature upon the obligations and attitude of the parties. A great many steel structures are let upon the lump sum basis, and a very large number on that of the pound price. In either case the owner furnishes to the various bidders on the work **plans and specifications** in more or less detail, indicating the type, size, general strength, and character of construction. The bidders submit with their figures **stress sheets**, indicating how they propose to treat the various structural



WORK OF TRACK ELEVATION IN CHICAGO, ILL.

View of C. & W. I. tracks before elevating from Sixteenth street looking northeast. Walls and abutments of concrete masonry on the left, concrete mixer on the right. When the work of elevating the more than 1,600 miles of steam railroad track within the city limits is completed, all grade crossings will be forever abolished. This work is being carried out at the expense of the railroads.

TRACK ELEVATION WORK IN CHICAGO, ILL.

View at Sixteenth and Clark streets; tracks of C. & W. I., Santa Fé, C. M. & N., and St. Chairles Air Line Railways elevated temporarily on sand filling.

problems. On the basis of the quoted prices and the stress sheets submitted, a contractor is selected for the work, and a form of contract entered into with him. Before the work can be proceeded with, however, it is necessary that more elaborate detailed plans be prepared, and this is generally done by the contractor. He then proceeds along the lines indicated by the stress sheet. The details have to be approved by the owner's representative before actual construction commences. Now, it is clear that the more pounds of metal in the structure under the form of contract that we are now discussing, the greater will be the contractor's profit; whereas, the fewer the pounds of metal, the weaker the structure, and the less his profit. Since there are various ways of calculating the amount of metal necessary—column formulas, impact formulas, and various assumptions as to the performance of metal under stress made by different authorities, each of which assumptions will have to do with the amount of metal for a given amount of supporting power—there will be room for a variegated interpretation not only of the specifications but of the stress sheet; and it is the business of the owner's representative, the architect or engineer, to see to it that the detailed drawings do not call for an unnecessary amount of material at the owner's expense, while at the same time not imposing restrictions which will make the finished structure too weak. If the architect or engineer cut down the metal too much for agreement with the stress sheet, the contractor can very properly claim that he is entitled to sell the owner more material, on account of the provisions of the stress sheet, which then is a part of the contract.

In any steel structure, even with quite rigid specifications, there is room for the exercise of considerable judgment in designing the "connections" whereby the stress is transmitted from one main number to another or others. Where it is to the contractor's interest to supply an excess of material, he will generally show a desire to adhere to the best and safest and most conservative engineering practice. There is, then, the further complication that the weights of the material as actually shipped are likely to vary several per cent from the theoretical weights of the members called for in the stress sheet. The contractor is usually paid on the basis of the actual shipping weight of the steel. This feature has been more fully discussed above, under the caption "Quantity of Work."

The main distinction in the actual working results between the unit-price contract and the lump sum contract, is that in the former case the contractor demands the best engineering practice, whereas under the lump sum contract the owner is doing the fighting for good practice.

Cost plus Compensation Contract

Much has been heard of late years about this kind of contract, and a good deal of work has been done under it. So much uncertainty seems to obtain in the minds of most people concerning its true inwardness, and there is such a considerable diversity of opinion in the minds of different people as to what this form of contract really means to the owner as well as to the contractor, that it would be well to go into its analysis with some care. Under its provisions the owner pays the entire cost of the work, plus something to the contractor for his profit. In some forms of this contract, the contractor furnishes the money as he goes along, and the owner reimburses him from time to time for what he has paid out until the end of the job, when a final settlement is made; while in other forms the contractor O K's all bills which are sent to the owner for payment, and the contractor does not handle any money at all. Even the pay-roll is settled by the owner sending his representative to the job on every pay-day and paying the men off on vouchers approved by the contractor or his representative.

It will be seen at once that this contract presents some particular advantages in certain localities and on certain classes of work, from the standpoint of all parties. On the other hand, it has certain peculiarities that do not immediately appear. Taking the same basis of analysis that we did in the consideration of the lump sum contract, we find that under the cost plus compensation form the owner furnishes the following items:

1. **Money.**
2. **Insurance.**

3. Plans and specifications.
4. Sketches and instructions.
5. Plant.
6. Labor.
7. Materials.
8. Supplies.

And the contractor furnishes:

1. Organization.
2. Superintendence.
3. Experience.

1. **Money.** The way in which the owner is going to make his payments is a point that has a great deal to do with the economical results of the work so far as the contractor is concerned. If the owner furnishes all the money from the beginning, the contractor does not have to tie up any capital in the work at all. The method followed by one well-known contractor of large experience has much to recommend it. In this case, when the work is started, the owner turns over to the contractor a sum of money which is intended to cover the cost for the first month or six weeks. This money is then deposited in a bank in a special account, against which the contractor is authorized to draw checks. Each check drawn, besides being in the usual form of banking check, contains the job number, the account number, and a complete list of all the items which are being paid for by that check. When the check comes back from the bank, it is filed with the papers for that particular job;

and the owner can immediately, by going over the returned checks, see exactly how all the money was spent—for what accounts, in what manner, and at what times. Checks covering the payroll can be drawn either to the individual workmen or to a foreman or time-keeper, who accounts for his distribution of the men's pay.

2. **Insurance.** In contrast with nearly every other form of contract, under the cost plus compensation system the owner furnishes the insurance. Note that the contractor guarantees absolutely nothing. In the standard form of the "cost plus" contract, the contractor is not responsible for the time of completion; he is not responsible for the cost exceeding a certain amount; he gets no extra money if the cost is excessive or if he saves money; and, in short, the contractor has practically the minimum of interest in how he really does his work. The only real incentive that he has for making the work go expeditiously and economically, is his personal ambition and a desire to make or keep a good reputation for efficient work. He is on what might be called a peculiarily professional basis; and if the men strike on the work, if the men whom he has selected for directing the work mismanage it, if lightning strikes it, or if the work is held up by injunctions or lawsuits, either through his own negligence or through the negligence of his employees, he is not responsible, being simply the agent of the owner. The owner, on the other hand, guarantees that he will pay

the bills when the contractor sends them in; that he will be responsible for all the errors and mistakes of the contractor so far as economic performance goes; and he further stands the damages when accidents which are not the fault of anybody in particular occur and cause considerable delay. He practically stands in the position of guaranteeing to himself that the contractor will do his work properly, and that no external agency will put the work back. If the contractor is slow, he is in the owner's employ, and the owner has no redress except to cancel the contract and let the contractor sue him for profits.

In order to mitigate some of this insurance that the owner has to stand, he is frequently accorded the right in the contract to require that the contractor shall take away from the job any foreman whom the owner considers to be incompetent. The trouble with this arrangement is that if the owner does order an incompetent foreman off the work, the contractor can be dilatory about providing another good foreman; and if the owner wishes to name a foreman, a contractor can say—and perhaps with logic—that he will not be responsible for any errors that the foreman selected by the owner makes. As he is not responsible anyway, it does not seem as if this would make much difference.

3 and 4. **Plans and Specifications; Sketches and Instructions.** These are furnished by the owner as in the lump sum contract.

5. **Plant.** The contractors who do work on a "cost plus a fixed sum" basis, do not, as a general thing, own much plant themselves, and the owner is in the position of either purchasing or renting plant. If the contractor happens to own plant which he can turn over for this kind of work, he usually does so on a rental basis—so much per day or per month. This rental clause is really a separate contract by itself, since, after the renting has taken place, the plant is under the direct control of the owner through his agent, the contractor, and if accidents happen to it, the owner is responsible. Some contractors, particularly where the amount of plant involved is small, will agree in their contracts to furnish the necessary plant out of their own stock, the rental for plant, or compensation for its use, being waived. This feature is not so satisfactory from the owner's point of view as might at first appear, because the contractor is tempted to use a minimum amount of plant and one which may not be the most suitable for the work; and therefore, if the owner furnished or rented his own plant, it might be more suited to the particular class of work to be done and thus ultimately result to the economic advantage of the job.

6. **Labor.** Generally the contractor knows where he can find men to employ on the class of work to be done, and he engages the men as the representative or agent of the owner. When he pays them out of his own bank account from funds supplied by the owner in the first place,

the contractor usually acts as paymaster; but in the case where the contractor is not to handle any money, the paymaster is outside of the contractor's organization entirely. Under this arrangement, the men learn immediately what kind of contract is being carried, and they are likely to get the idea that efficiency does not count much in the results of the work, and therefore are disposed to "soldier;" whereas, if they thought that they were working for the contractor, and the contractor's vital financial interest was at stake, they would be more inclined to expect to lose their places if they did not work well and rapidly.

7 and 8. **Materials and Supplies.** We have outlined above how the contractor buys the materials, and have called attention to the fact that the owner is usually given the privilege of furnishing materials himself if he thinks he can do so to advantage. At first sight it would appear that this protects the owner against graft; but it is not difficult to see how it would be possible for a dishonest contractor, after getting bids for materials, to accept upon delivery an inferior grade of materials and receive from the dealer furnishing them a rake-off for himself. Unless the owner put someone on the site to supervise the work with great care and inspect all materials as they came in, it would be difficult for him to prevent this. To be sure, this inspecting is the duty of the architect; but to inspect sufficiently well to provide against such contingencies would

mean that specifications as to materials would have to be very accurately drawn in the first place, and, in the second place, that the architect would have to spend a great deal more time in inspecting than he is likely to spend. Where the contractor orders for the owner, he is practically in the position of a purchasing agent for materials, with all the advantages and disadvantages that ordinarily pertain to purchasing agents in general—with this difference, that, if the owner does not like the way he does his work, instead of discharging him as he does a purchasing agent, the owner has got to spend time and extra money and do the purchasing himself.

As against these things that the owner furnishes, we have the items that are supplied by the contractor:

1. **Organization.** This has been discussed above, and is not essentially different here, in its economic features, from the case of the lump sum and unit-price contracts. The contractor is seldom in a position to throw upon any particular piece of work an organization of his own, because, when this organization is good, it is occupied on other work and cannot come to a new position except with some injustice to the work already on hand. As a general thing, when the contractor is not busy, he cuts down his force to the very smallest possible minimum, in order to save himself from carrying expensive men without financial return; and then he has no one in his employ to throw upon new work. However,

it is his business to keep in touch with men all over the country whom he can get for his work when he has work to do, and therefore, if he has had much experience, it is not difficult for him to get together in a comparatively short time an organization of men whom he knows something about personally, and in whom he feels that he and the men can have confidence.

2 and 3. **Superintendence and Experience.** A contractor under a "cost plus a fixed sum" contract may have had a good deal of experience in the particular line of work to be done, and yet this experience may have nothing to do with the work unless he have more incentive to economic performance than ordinarily obtains under such a form of contract. His own experience in the particular line involved may be of very little value to the owner. If his superintendent is inefficient, as sometimes happens, apparently the only redress that the owner has is to cancel the contract and allow the contractor to sue him for profits, which is a remedy that is sometimes worse than the disease. When the contractor has a great deal of work to do, he cannot put much of his time in supervising any one piece of it; and when he has not much to do, he generally spends most of his time looking for new propositions.

Other Forms of "Cost Plus" Contract. Sometimes, instead of the cost plus a **fixed sum** contract, there is the cost plus **percentage** contract, in which the contractor receives 10 or 15 per cent of the actual cost of the work for his compensation and profit. Here, the more the work costs, the more the contractor gets as profit, and there is a positive premium upon inefficient work. The percentage basis—where the amount of work to be done was indefinite, and when, because of uncertainty in regard to the facts connected with the work, it was not desired to make up elaborate specifications—was used to a considerable extent ten or fifteen years ago. To-day it is giving place to the cost-plus-a-fixed-sum form.

It has been said that the lump sum contract is a license to support lawyers, and that when the owner changes his mind, and the architect changes his plans, "extra work" comes into play to the advantage of the contractor and to the detriment of the owner; and it has been argued that the only disadvantage that has been discovered in the "cost plus a fixed sum" contract is that the owner cannot possibly get his work completed for less than cost as he might do under the lump sum contract if the contractor made a mistake in his estimate and did not get the benefit of the assistance of "extra work."

Some few years ago, a list was made of the stock arguments in favor of the cost plus a fixed sum contract from the standpoint of the owner and the contractor. These we give below:

1. **Owner's and contractor's interest are made identical.**—This is not so.

2. **Owner knows in advance amount of con-**

tractor's profit.—This is true when the owner can be assured of the contractor's honesty; but it is questionable whether the fact of the owner knowing in advance how much the contractor is going to make is of any economic value to the owner. It is interesting information, but not much else.

3. **Owner's interests demand:**

(a) **Shortest time for completion.**
(b) **Lowest possible cost.**
(c) **Best possible workmanship.**

It is true that the owner's interests demand results **a, b,** and **c**; but, as has been pointed out above, while the contractor's interests may be forwarded by these things, all of them except the first affect principally his reputation and his professional pride. He is not supposed to have professional pride; and his reputation will not suffer, even if the cost is considerably more than the lowest possible, since it is almost impossible for the owner to find out what the lowest possible cost is going to be, or what the cost would have been if he had had the work done by some other contractor, unless he has obtained bids for it from other contractors and has had the "cost plus" contractor do the work without any alterations in the plans or specifications.

4. **Owner relieved of menace of extra work.**—This is a thoroughly good argument in favor of the cost plus contract. It is true that esti-

mates as to the cost of extra work generally appear unreasonable to the owner; but it is also true that extra work done in a hurry and without having been properly incorporated in the original plans is generally a good deal more costly than the same amount of work when properly planned in the beginning. While some contractors demand exorbitant pay for doing extra work on a contract, many of them ask amounts which seem exorbitant to the owner, because in reality the extra work disturbs the contractor's general layout and co-ordination of his work, and adds more than his proportion to the cost of the entire job.

5. **Owner has benefit of all cash discounts for materials.**—The claim that the owner has the benefit of all cash discounts for materials is rather fictitious, because under a low bid from a responsible contractor the owner really gets this profit anyway.

6. **Owner knows what all materials will cost before they are purchased.**—The proposition that the owner knows what all materials will cost before they are purchased is somewhat similar to claim No. 2 (above); it is interesting information, but not of any particular value to the owner financially. All the owner ought to care for is that the materials shall be purchased for the lowest possible price consistent with quality, and he is assured of this under the old-fashioned contract, so that this hardly seems to be a distinct advantage.

7. **Owner can purchase materials if he so desires.**—The reservation to the owner to purchase materials if he so desires has been discussed above.

8. **Owner can have excavations and foundations completed while plans for superstructure are being drawn.**—Because it is not necessary to have all plans carefully laid out before the contract is ready, it is true that the owner can have excavations and foundations completed while the finished plans for the rest of the work are being drawn; and where a building is burned down, and has to be replaced at the earliest possible moment without waiting for preliminary drawings and specifications, which generally take time, this feature is a tremendous blessing to the owner.

9. **Owner, engineer, or architect can make changes or alterations at any time without delaying the work.**—This proposition is not true, since, after a contract has been signed on the old-fashioned basis, practically any changes that would delay the work would produce delays under the cost plus a fixed sum contract, although often it would not be possible to know just how much these delays amounted to. Changes in plans after work has been well started, almost invariably result in delays and interruptions.

10. **Owner can have any number of skilled and carefully trained mechanics on this contract at a moment's notice.**—This is rather obscure.

If the owner can have any number of skilfully trained mechanics at a moment's notice under this form of contract, the method by which it is accomplished is not known to the writer.

11. **As contractor's profit is the same regardless of the cost of work, there is no incentive for contractor to produce anything but substantial and economical work.**—This is perfectly true, and is of great value to the owner.

12. **Owner has his building completed as rapidly as is consistent with good workmanship.**—It is difficult to see how this proposition differs under a "cost plus a fixed sum" contract from under a "lump sum" contract. On the lump sum basis the contractor is just as anxious to finish his work and get his profit as on any other basis.

13. **Owner or his authorized representative has access at all times to all matters pertaining to the work.**—The owner, or his authorized representative, as a general proposition, has access at all times to all matters pertaining to the work under any form of contract.

14. **Owner can pay bonuses for speedy delivery of materials.**—This advantage is usually true under any form of contract, and is not peculiar to the form at present under discussion.

The arguments for this form of contract from the contractor's point of view, outlined by the same authority, are substantially as follows:

1. **Contractor has opportunity to earn upon his own merit an enviable position in the business world's confidence.**—Under this form of

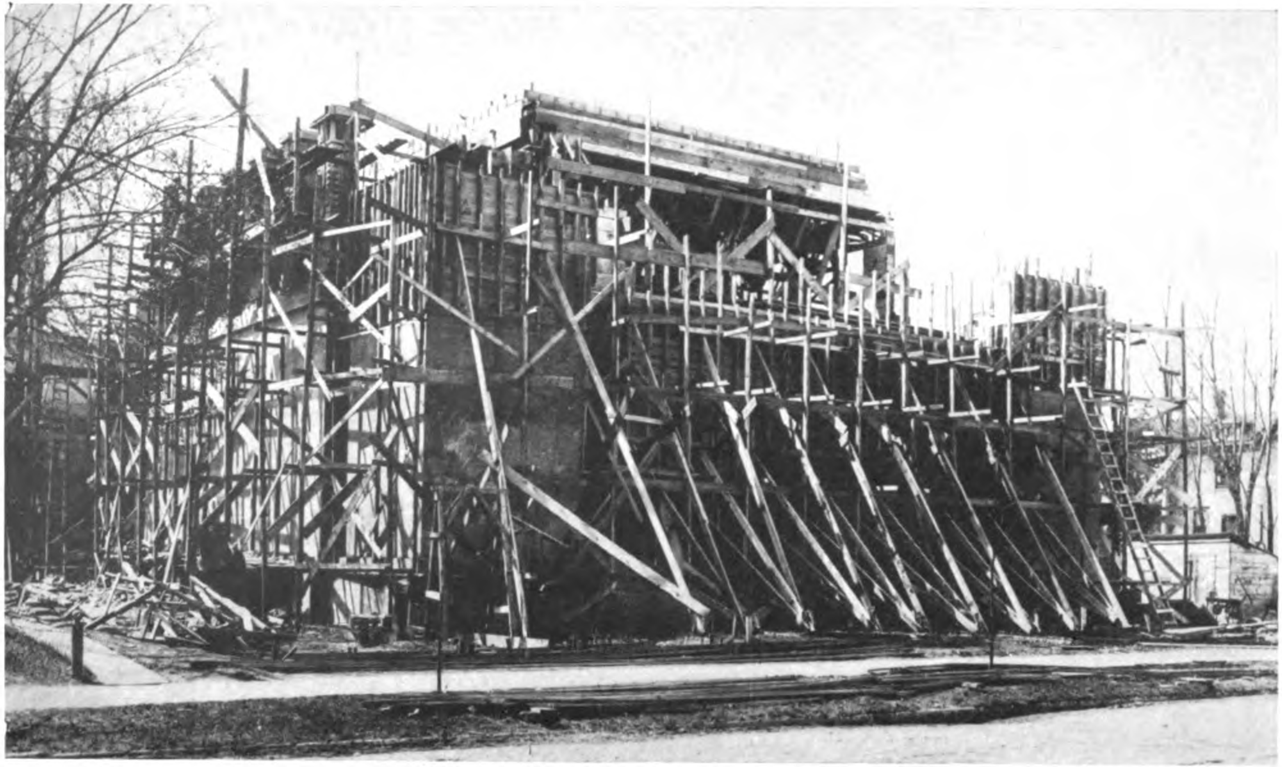
contract the contractor is in a sort of quasi-professional position; and in so far as he makes good and obtains a reputation for efficiency and reliability, does he advance.

2. **Profit assured.**—There is no question on the part of the contractor as to how much money he is going to make; he takes no risk, and is not under any mental worry or strain of any kind so far as finances go, and he therefore is in a position to spend as much time as he desires to further the interest of the owner and further his own reputation. Not being worried about his profit and the cost of the work, it stands to reason that he is not going to be as strenuous as he otherwise might be.

3. **Contractor free from relations with owners who have not the courage to take legitimate risks attendant upon their own enterprises, and who wish to saddle them upon a contractor upon a lump sum basis and leave him to gamble his way out as best he can.**—The contractor under this form of contract is not likely to get into a poker game with a dishonest owner, wherein the owner may succeed in obtaining more than his money's worth at the contractor's expense.

4. **Contractor has satisfaction of dealing with an owner who has no reason to suspect him of over-reaching, who is not in constant dread of extortionate charges for "extra work," and who has a contract offering complete insight into the financial affairs of the job.**—We might add a fifth advantage—which is, that under the pecu-

FOUNDATION WALL CONSTRUCTION FOR LARGE REINFORCED CONCRETE WAREHOUSE IN TOLEDO, OHIO.



FALSEWORK USED IN THE ERECTION OF UNITY CHURCH, OAK PARK, ILLINOIS.

Building is a monolithic reinforced concrete structure.

liar features pretty thoroughly discussed above, the contractor is in a position to keep his own overhead charges down to the very minimum. All the contractor's fixed expenses which he cannot charge to his owner, are the expense of advertising, and his traveling expenses while hunting for new work, so that the fixed sum or percentage that he gets is always all clear profit, without risks of any kind.

Attention should be called in this connection to the fact that when a contractor has lump sum work and cost-plus-a-fixed-sum work at the same time, he is likely to put his best men upon the lump-sum work and let the cost plus work take care of itself so far as efficiency is concerned.

Finally, it appears that, in the last analysis, taking all the facts into consideration, the cost-plus-a-fixed-sum contract is simply a contract for superintendence with the burden and the responsibility upon the owner. However, if the owner can have some method of insuring that he can properly supervise the contractor's work and keep him up to the mark in efficiency, this form of contract (cost plus a fixed sum), when the work is to be done in a hurry or under conditions which cannot easily be laid down in his specifications, will accomplish results which are utterly impossible under the lump sum system.

UNIFORM CONTRACT

We now come to the consideration of a specific form of contract which is here given for more definite illustration. The form selected is that adopted and recommended for general use by the American Institute of Architects and the National Association of Builders, as revised in 1907. It reads as follows:

"**This Agreement,** made the.........day of ....in the year one thousand nine hundred and ..., by and between.........., party of the first part (hereinafter designated the Contractor), and.........., party of the second part (hereinafter designated the Owner),

"**Witnesseth,** that the Contractor , in consideration of the agreements herein made by the Owner , agrees with the said Owner as follows:

"Article I. The Contractor shall and will provide all the materials and perform all the work for the.........., as shown on the drawings and described in the specifications prepared by.........., Architect, which drawings and specifications are identified by the signatures of the parties hereto, and become hereby a part of this contract."

It will be noted that this first article calls for the identification of drawings and specifications by the signatures of the parties. This article does not always work well in practice, for the reason that the drawings are usually made on tracing cloth, and the tracings are filed in the architect's office. Frequently the principal parties do not take the trouble to sign the plans and specifications; and when they do sign them, it is not feasible for them to sign all the alterations and additions that are likely to be made during the progress of the work. If the architect wants a change made on the drawings, he generally makes a change, and it does not usually appear whether the change was made before or after the signature. Thus the value, as a legal instrument, of a signature on the drawings, is likely to become nil.

"Article II. It is understood and agreed by and between the parties hereto, that the work included in this contract is to be done under the direction of the said Architect, and that his decision as to the true construction and meaning of the drawings and specifications shall be final. It is also understood and agreed by and between the parties hereto, that such additional drawings and explanations as may be necessary to detail and illustrate the work to be done are to be furnished by said Architect, and they agree to conform to and abide by the same so far as they may be consistent with the purpose and intent of the original drawings and specifications referred to in Article I.

"It is further understood and agreed by the parties hereto, that any and all drawings and specifications prepared for the purpose of this contract by the said Architect are and remain his property, and that all charges for the use of the same, and for the services of said Architect, are to be paid by the said Owner."

The provision that the architect's decision as to the true construction and meaning of the drawings and specifications shall be final, is liable to result in a great deal of trouble unless all parties understand the same thing when the contract is prepared. The architect is supposed to know what is meant when he made his drawings and prepared his specifications; but the true intent and meaning of the drawings and specifications as a business proposition between the contractor and the owner, depend upon what was standard practice at the time the contract was signed; upon what the contractor understood that he was bidding on; and upon what an ordinary third person, skilled in the business, would take the plans and specifications to mean. If the architect did not mean what he said, or did not say what he meant, it seems unfair to make the contractor financially responsible for the architect's errors; and to appoint the architect the arbitrator as to what his own instrument means is to appoint a more or less biased judge. Notwithstanding these objections, it has heretofore been impossible to find a more satisfactory way of settling differences as to what plans and specifications mean, than by the above clause. If the matter should be left to a board of arbitrators or to an unprejudiced third person, it would involve explanations and probably a good deal of delay—which is the reason why the first clause of Article II remains to-day in standard practice.

The second paragraph of Article II, providing that the owner shall pay for all services of the architect, is generally inserted to protect the architect in case the owner shall have imagined that the contractor is responsible for, or from any other reason shall have become liable for, the architect's fees, thus involving a controversy among the mazes of which the architect might lose part of his fees.

"Article III. No alterations shall be made in the work, except upon written order of the Architect, the amount to be paid by the Owner or allowed by the Contractor by virtue of such alterations to be stated in said order. Should the Owner and Contractor not agree as to amount to be paid or allowed, the work shall go on under the order required above; and, in case of failure to agree, the determination of said amount shall be referred to arbitration, as provided for in Article XII of this contract."

This is an excellent provision, and more or less constant effort is made to live up to it on most building contracts to-day. However, every practical man realizes that a great many questions involving alterations or minor points come up from day to day under inspection on the work, and are settled verbally by the architect without further red tape. If the architect has had much experience, and has prepared his plans and specifications with great care, these verbal settlements are comparatively unimportant, and no trouble is liable to arise from them; but if, on the other hand, the architect is young, and if his mind is possessed with his artistic conceptions to the exclusion of ordinary practical construction, the number of these alterations may be very large, and they may be very important—so important, in fact, as to affect to a considerable extent the economic results to the contractor. Under these circumstances trouble usually follows. Article III is an attempt to eliminate this source of trouble as much as possible.

"Article IV. The Contractor shall provide sufficient, safe, and proper facilities at all times for the inspection of the work by the Architect or his authorized representatives; shall, within twenty-four hours after receiving written notice from the Architect to that effect, proceed to remove from the grounds or buildings all materials condemned by him, whether worked or unworked, and to take down all portions of the work which the Architect shall by like written notice condemn as unsound or improper, or as in any way failing to conform to the drawings and specifications, and shall make good all work damaged or destroyed thereby."

This article is intended to insure, under direction of the architect, proper execution of the work. It will be noted that it makes the architect the arbitrator as to the quality of the work, and puts the contractor in the position of being obliged to take down any portion of the work condemned by the architect, whether or not the condemnation is just.

"Article V. Should the Contractor at any time refuse or neglect to supply a sufficiency of properly skilled workmen, or of materials of the proper quality, or fail in any respect to prosecute the work with promptness and diligence, or fail in the performance of any of the agreements herein contained, such refusal, neglect, or failure being certified by the Architect, the Owner shall be at liberty, after three days' written notice to the Contractor, to provide any such labor or materials, and to deduct the cost thereof from any money then due or thereafter to become due to the Contractor under this contract; and if the Architect shall certify that such refusal, neglect, or failure is sufficient ground for such action, the Owner shall also be at liberty to terminate the employment of the Contractor for the said work, and to enter upon the premises and take possession, for the purpose of completing the work included under this contract, of all materials, tools, and appliances thereon, and to employ any other person or persons to finish the work, and to provide the materials therefor; and in case of such discontinuance of the employment of the Contractor ,............shall not be entitled to receive any further payment under this contract until the said work shall be wholly finished, at which time, if the unpaid balance of the amount to be paid under this contract shall exceed the expense incurred by the Owner in finishing the work, such excess shall be paid by the Owner to the Contractor ; but if such expense shall exceed such unpaid balance, the Contractor shall pay the difference to the Owner . The expense incurred by the Owner as herein provided, either for furnishing materials or for finishing the work, and any damage incurred through such default, shall be audited and certified by the Architect, whose certificate thereof shall be conclusive upon the parties."

This article is intended to protect the owner in case the contractor should abandon the work for any reason. It sometimes appears that the contractor finds a certain portion of work unprofitable, and for various reasons is unable or unwilling to push it as he should; and if some such article as this were not inserted for the protection of the owner, it would be impossible for him in such a case to avoid very large losses. As a general thing, architects are very slow to enforce this clause, except under the greatest provocation, because it involves a lot of extra work on the part of the architect for which he does not get paid, and it is very difficult to carry it out without involving complications which may result in lawsuits.

"Article VI. The Contractor shall complete the several portions, and the whole of the work comprehended in this Agreement, by and at the time or times hereinafter stated, to wit:

....

...."

In prosecuting the work, the real value of this article is often interfered with. Any important alterations or additions made on plans or specifications that require various changes to be made, will involve differences in the time of completing the several parts of the work; and, unless corresponding changes are made with the consent of both parties to the provisions of this article, its effect is liable to be greatly lessened. This subject has been discussed above.

"Article VII. Should the Contractor be delayed in the prosecution or completion of the work by the act, neglect, or default of the Owner , of the Architect , or of any other contractor employed by the Owner upon the work, or by any damage caused by fire or other casualty for which the Contractor ....not responsible, or by combined action of workmen in no wise caused by or resulting from default or collusion on the part of the Contractor , then the time herein fixed for the completion of the work shall be extended for a period equivalent to the time lost by reason of any or all the causes aforesaid, which extended period shall be determined and fixed by the Architect ; but no such allowance shall be made unless a claim therefor is presented in writing to the Architect within forty-eight hours of the occurrence of such delay."

Here we have the contractor released from the time insurance feature of this contract, if he is delayed in the prosecution of the work by the act, neglect, or default of the owner or of anyone employed by him or by any outside agency the responsibility for which is not traceable to the contractor. In order to avoid disputes as to what delays have been caused by outside agencies, the burden is placed upon the contractor of notifying the owner through the architect in writing within forty-eight hours of such delays. Therefore, unless the architect does not receive such written notice, the burden of completing the work within the time limit still rests with the contractor.

"Article VIII. The Owner agrees to provide all labor and materials essential to the conduct of this work not included in this contract, in such manner as not to delay its progress, and in the event of failure so to do, thereby causing loss to the Contractor, agrees that.........will reimburse the Contractor for such loss; and the Contractor agrees that if...........shall delay the progress of the work so as to cause loss for which the Owner shall become liable, then ....shall reimburse Owner for such loss. Should the Owner and Contractor fail to agree as to the amount of loss comprehended in this Article, the determination of the amount shall be referred to arbitration as provided in Article XII of this contract."

This means that if there are other contractors upon the work, the owner must see that they do not interfere with the performance of this contract. Where upon one building a plumbing contractor, a carpenter contractor, a mason contractor, and various others are working at the same time, it is not at all difficult for one of the contractors, in case he fall behind in his work, to point to acts of one or more of the other contractors which afford him a plausible excuse; and for this reason many architects prefer to have the whole work conducted under one general contractor to whom the other contractors will be subsidiary. As a general thing, one contractor can manage other contractors, and get them to do their work for him more satisfactorily and efficiently than the architect can get several contractors of equal standing to work together. In New York City a great deal of work is done in this way, the general contractor employing the others, and the architect simply having one organization to direct. A great deal of work in this way is done on a cost plus 10 per cent basis, the general contractor guaranteeing the total cost not to exceed a certain figure. Many contractors have worked up a large business in this way, the owner finding upon the day of settlement that he is paying 10 per cent to the general contractor on all sub-contracts, and that the general contractor does practically no work himself, but simply runs an office which is a clearing house for the other contractors, enabling him to charge practically all of his expenses, except those of one bookkeeper and his office force, to the various owners for whom he is working. Under such circumstances, 10 per cent is a very nice profit. The owner should be entitled to have the architect direct all of the contractors and run the work in this way without sub-letting. Many contracts contain a clause to the effect that no sub-letting shall be allowed except upon written consent of the owner or of the architect.

"Article IX. It is hereby mutually agreed between the parties hereto, that the sum to be paid by the Owner to the Contractor for said work and materials shall be ...., subject to additions and deductions as hereinbefore provided, and that such sum shall be paid by the Owner to the Contractor , in current funds, and only upon certificates of the Architect, as follows:

"The final payment shall be made within .... days after the completion of the work included in this contract, and all payments shall be due when certificates for the same are issued.

"If at any time there shall be evidence of any lien or claim for which, if established, the Owner of the said premises might become liable, and which is chargeable to the Contractor , the Owner shall have the right to retain out of any payment then due or thereafter to become due an amount sufficient to completely indemnify .... against such lien or claim. Should there prove to be any such claim after all payments are made, the Contractor shall refund to the Owner all moneys that the latter may be compelled to pay in discharging any lien on said premises made obligatory in consequence of the Contractor's default."

This article is self-explanatory. It should, like Article VI, be considered subject to any changes or alterations in plans or specifications. The last paragraph is intended to protect the owner against liens placed by subcontractors or by people furnishing material, in case a contractor should have attempted to over-finance the work, so to speak. ¶It often happens that the contractor does not pay his bills until after he has received his monthly installments from the owner; and sometimes, with too many irons in the fire, the contractor is likely to be so much involved as not to settle his accounts. This paragraph is very useful in such cases, and provides the owner a much needed protection.

"Article X. It is further mutually agreed between the parties hereto, that no certificate given or payment made under this contract, except the final certificate or final payment, shall be conclusive evidence of the performance of this contract, either wholly or in part, and that no payment shall be construed to be an acceptance of defective work or improper materials."

This is in the nature of a legal protection to the owner. Under some circumstances, if an owner makes payment for certain work performed, the courts would consider it as evidence that the work performed had been satisfactory;

and this article is inserted in order to guard against the owner being placed at an unfair disadvantage upon paying any certificate except the final one.

"Article XI. The Owner shall, during the progress of the work, maintain insurance on the same against loss or damage by fire, ...
....,
the policies to cover all work incorporated in the building, and all materials for the same in or about the premises, and to be made payable to the parties hereto, as their interest may appear."

While the building is going up, the owner makes partial payments which are supposed to be aproximately equal in value to the actual work done; and by virtue of these, he becomes the owner of the completed portion of the work. It is therefore his business to insure for the further protection of all parties. It is sometimes wise to provide that the policy shall be in the custody of the architect until the final payment has been made. The architect will then see to it that the insurance is actually taken out, and that the policies are in the proper form.

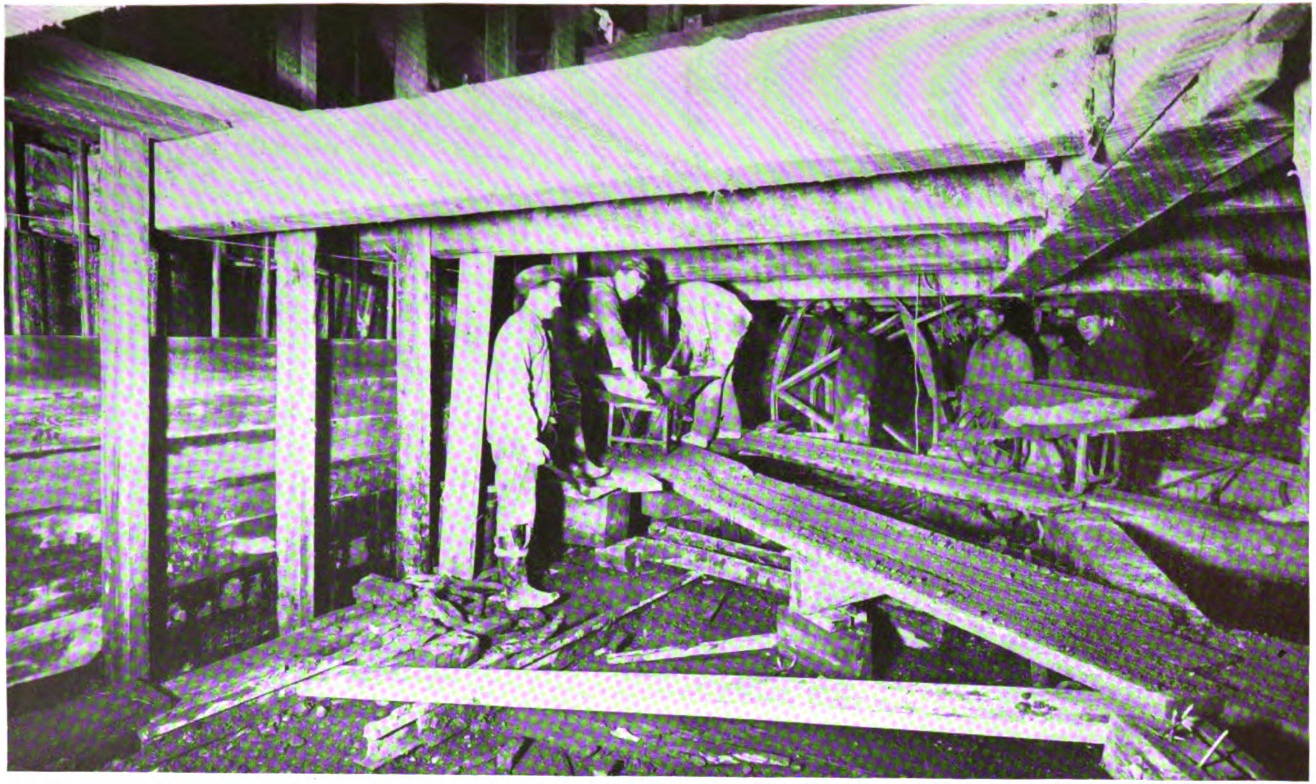
"Article XII. In case the Owner and Contractor fail to agree in relation to matters of payment, allowance, or loss referred to in Articles

III or VIII of this contract, or should either of them dissent from the decision of the Architect referred to in Article VII of this contract, which dissent shall have been filed in writing with the Architect within ten days of the announcement of such decision, then the matter shall be referred to a Board of Arbitration to consist of one person selected by the Owner , and one person selected by the Contractor , these two to select a third. The decision of any two of this Board shall be final and binding on both parties thereto. Each party hereto shall pay one-half of the expense of such reference."

This is the standard arbitration agreement. It often happens that in an arbitration of this kind each party will select a representative, and these two representatives will hear the evidence and attempt to come to an understanding without the selection of the third arbitrator. If they disagree, the whole controversy then boils down to a discussion in which each of the two representatives is an advocate for the side which has enlisted him; and the deciding vote is cast by the third representative, who is thus made a sort of referee. This should be avoided by the selection of the third man in the first stages of the proceeding—thus, in the long run, avoiding expense and rendering probable the obtaining of a more equitable adjustment of the differences.

FOUNDATION WORK FOR LARGE CONCRETE ARCH BRIDGE OVER ROCKY RIVER, NEAR CLEVELAND, OHIO.

Steel structure to be replaced is shown at right.



PLACING CONCRETE IN FORMS FOR WALLS OF REINFORCED CONCRETE WAREHOUSE FOR STEELE-WEDELES CO., CHICAGO, ILL.

Forms here shown are 46 feet below street level; entrance to tunnel system of Illinois Tunnel Co. shown in background.

Specifications

A properly drawn set of specifications, with accompanying plans, is a part of the contract as a legal instrument, and performs the function of elaborating just what specific things the contractor has to do and just how he has to do them. The specifications should contain a reference to the contract, and the contract should mention the specifications, in order that they shall be taken together as forming the parts of one entire agreement. So far as referred to, the specifications become constructively a part of the contract. While in ordinary practice the specifications are made a part of the contract, and are with it signed and sealed, they are not in the legal form of a contract, because the burden of performance falls entirely upon one party. In the contract the owner agrees to pay certain sums for the performance of certain work by the contractor; but, under the specifications, the owner is a passive party, and for that reason practically all clauses of the specifications are directed to the contractor and are statements of his duties. There are practically no clauses in the specifications that require anything of the owner.

General Faults. The man who draws up specifications finds himself between two difficulties. On the one hand, there is the probability of making a specification too verbose, too cumbersome, and too unwieldy; and on the other, in the attempt to eliminate this fault, there is the probability of leaving out something which might be desirable and which is necessary to make the instrument intelligible.

A common fault in the writing of these documents is caused by the desire of the writer to show those who are going to work under them his vast knowledge of the subject covered by the specifications. He puts in many things that are not necessary to the proper guidance of the contractor, and in many cases things that handicap the contractor in his work and bring about no compensating good. When this is the case, the contractor is liable to think that the specifications are antagonistic to his advantage, and he will act accordingly and be disposed upon the slightest pretext to attempt to "even up."

Another grave fault is the placing of too many restrictions upon those who are going to do the work. The contractor should be restricted as little as possible, the only requirements being that he must confine himself to good practice, and must, in the end, show proper and acceptable results.

The owner wants to get just as much for his money as possible—wants the best workmanship and materials because he is paying his good money for them—while the contractor, on the other hand, even though he may have no idea of skimping and no desire to skimp in any way, is working for his livelihood and wants to do the work as cheaply as may be consistent with acceptable performance, and so make as great a profit as possible.

If the specifications are clearly drawn when submitted to the contractor, he can make his bid accordingly; and no matter how severe the requirements may be, his bid will make allowances for the difficulties imposed by them. If, on the other hand, a specification is capable of several interpretations, or if it is stated in such a way that there are "holes in it," the contractor will be led to take chances in his bid. This is especially true if the contractor has done much work under the architect, and thus knows how closely or how loosely he will be held to the letter of the specifications. Bidding under such specifications works a hardship on the contractor who is unfamiliar with the architect. No matter how strict the specifications may be, and how well known to the contractor the architect's peculiarities are, the personal equation should have to be taken into consideration as little as possible. Remember that a well-defined specification is essential to a fair contract.

In the following pages, before giving a complete specification for a building, some examples are given which have been chosen from specifications used on many different contracts. They include examples of good as well as of bad practice. Here, for instance, is a specification for concrete which is very commonly seen:

"All mixing must be **thoroughly done,** and must be **to the satisfaction of the architect.**"

One might say at the start that the two parts of this specification are redundant; but to the contractor it does not appear so. He will mix the mortar in what is from his point of view a most thorough manner, by turning it two or three times, and, after adding the stone, will turn the mortar, say, two times before loading it or shoveling it into place; and he counts this last shoveling as helping in the mixing. This manner of mixing is what he figured on in making up his bid. But the inspector may say that the sand and cement must be turned six times, and, after the ballast or coarse aggregate is added, the concrete must be turned four times before leaving the board. He thereby adds to the cost as estimated by the contractor 200 to 300 per cent for the board work on the mortar, and 200 per cent to the mixing in of the ballast, and thus makes the actual mixing cost perhaps twice as much as the contractor figured on. The inspector may or may not be wrong in his interpretation of what "thoroughly done" means; but in either case controversy arises, and suspicions and hard feelings are created.

Suppose the specification had read in this way:

"The dry sand and cement shall be mixed and turned by shovels not less than six times, a spreading motion being given in turning before the water is added; and, upon addition of the water, the mix shall be turned until every particle of the mass is thoroughly wet. The stone, after having been wetted, shall be added to the mixed mortar, and the whole mass turned with shovels until every particle of stone is completely enveloped with mortar—or not less than four times."

There would then be no chance for misunderstanding and subsequent heartburnings.

The second part of the specification is also one which leads to a gamble on the part of the contractor—"to the satisfaction of the architect." Unless he wants to take chances, the contractor should make up his mind that the architect is bent on the strictest interpretation of the specification, and should be governed accordingly in his bid. He will then be on the safe side, and any easement of the specification by the architect will be in his favor. This prudent course, unfortunately, is more than likely to result in some more venturesome bidder "landing the job."

The Architect's Power. The powers of the architect are often far-reaching, and it is entirely right that they should be so, for he has no such interest in the work as the owner and the contractor have, with the result that in most cases he will be found very fair, his sympathy generally being with the contractor so long as he thinks that the contractor is making consciencious efforts to do right; but he will still insist—and rightly—that the best service be given his client, the owner, whose interest he is especially employed to look after.

Here is a clause, however, which seems to carry to extremes the power of the architect, and there are but few who would use it. Of those who do use it, but few would care to take full advantage of it:

"To prevent all suits and litigations, it is further agreed by and between the parties to this contract, that the Architect shall in all cases determine the amounts of work done which are to be paid for under this contract; that he shall have the sole charge of the manner of construction, of the quantities of materials, and of the interpretation of the specifications; that he shall decide all questions which may arise relative to the carrying out of the contract; and that his estimates, figures, measurements, directions. and decisions shall be final and conclusive, neither party to this contract having recourse to the opinion of other experts."

The first part of this specification is what is commonly found in these instruments—the simple statement that the architect is judge of the quality of the work, the fitness of the materials, and the amount of work done. There is no question as to his position in these matters. Making the architect the sole and final judge of the amount of work done, is in a way entirely proper; but if carried to extremes, such as the latter part of the clause would permit, it would be very improper.

For the architect to set up the contention that his opinion and decision are of such a nature that they must not be disputed by outsiders or by experts, is of very rare occurrence. In fact, hardly any architect would care to establish the reputation of having taken advantage of such a clause as this; and, in case of controversy, if no amicable arrangement could be made by the parties to the contract, most men would be only too glad to appeal to expert opinion in the form of arbitration, not only to keep their own reputations, but to keep the good opinion of their clients and of the contractors who may at some future time again do work for them.

The Inspector's Power. When the inspector is given too much power by the specification, or where he is inclined to consider himself an authority as the representative of the architect, trouble may result. If he be given full authority by the architect, and is at the same time a capable man—perhaps an engineer of some ability—he will give a fair interpretation of difficult clauses. It often happens, however, that the inspector is young and comparatively inexperienced. He will make a ruling which seems in keeping with the letter of the specification, but which is not quite what it should be in the light of ordinary practice. The ruling having been made, the architect, upon being appealed to by the contractor, will sustain his inspector for "moral effect," unless the ruling is extremely unfair. The suspicion at once enters the contractor's mind, that he is not getting a "square deal." This suspicion having once been aroused, it will take but little to cause an outburst upon the contractor's part—perhaps upon some really trivial matter—and trouble ensues that is against the best interest of all parties on the work. If the contractor thinks that he is getting the worst of the deal, he will likely start a line of action that he thinks will "even up," and some portion of the work is bound to suffer.

Inspector's Authority Defined. The following are clauses that are rarely found, but which have much to recommend them. The contractor is always glad to work under such a specification; and it really works to the architect's advantage since it puts all question of change of plans and subsequent claims for extra work upon the party who has the matter fully in mind and who is best able to deal with it as it should be dealt with:

"It is hereby distinctly understood and mutually agreed between the parties to this contract, that the Inspector of the work is not in any sense considered a deputy in charge. His duties are simply to act as a representative to protect the interest of the party (or parties) of the second part; to measure up the work done under the direction and supervision of the engineer in charge, if so requested; to report to the engineer in charge any deviation he may notice from the specification; and to order work stopped until the engineer can be communicated with, if, in his opinion, such action becomes necessary. All disputes regarding the manner of doing the work and interpretations of the specification and contract shall be referred to the engineer in charge; and no change or deviations or allowances of any kind ordered by the inspector without written instructions to that effect from the engineer in charge will be recognized by the party (or parties) of the second part.

"It is furthermore agreed and expressly understood by both parties to this contract, that if the engineer in charge shall at any time be compelled to be absent, and cannot be communicated with in a reasonable time, he shall appoint in writing a deputy who shall perform his duties until he is again in touch with the work; and at that time the authority of the deputy shall cease without notice until further appointment is made."

Layout of the Work. It is manifestly unfair to make the contractor responsible for the proper layout of the work by the architect. The careful contractor will check over the layout before he begins his work; but there are certain phases of this work for which he ought to be able to depend upon those who furnish the specifications.

The Architect's Errors. The following is a specification which often puts the contractor in a rather unfair position:

"The Contractor must satisfy himself, before commencing work, as to the meaning and correctness of all stakes and marks; and no claims will be entertained by the Owner for or on account of any alleged inaccuracies, or for alterations subsequently rendered necessary on account of such inaccuracies, unless the Contractor notifies the Architect thereof in writing before commencing the work thereon."

Here we have the statement that a contractor not only must be responsible for the proper management of the work and of the men, but also must attend to the checking of the architect and be held to account not only for his own carelessness and mistakes but for those of the architect as well. This is to a certain extent a good thing, but it is hard to say to just what extent it is good. If errors are due to the carelessness of the contractor, and are not discovered in time, all marks may have been removed which would lead to the placing of the responsibility for the error; and the contractor will blame them on the architect, and the architect will blame them on the contractor. Without such a clause, the contractor may say that he did the work as shown by the architect, whether he did or not, and thus shift upon the architect's shoulders all blame. The architect or his representative is on the work especially to prevent mistakes, and can have nothing to fall back on except such a specification. It would seem, then, that it is perhaps necessary for his protection, although it may work a hardship on the contractor.

In keeping with the tendency to make the contractor responsible for the errors of the architect, the following clause is often found:

"Correction of errors or omissions in drawings or specifications may be made by the Architect when such correction is necessary for the proper fulfilment of the intentions of such drawings or specifications, the effect of such correction to date from the time that the Architect gave notice thereof to said Contractor."

In making corrections and supplying omissions, the architect might do almost anything he wished, and say that it was only "in fulfilment of the intentions." Perhaps a contractor did not realize these intentions when he made his bid, and, in consequence, will have to do work that he has made no provision for in his estimate.

The plans and specifications are supposed to work in harmony with one another, and it is generally so stated as follows:

"The drawings and specifications are intended to co-operate; and work shown on the drawings and not particularly described in the specifications, or any work evidently necessary to the complete finish of the work included in this specification, as specified or shown, is to be done by the Contractor without extra charge, the same as if it were both shown and specified."

This is a fair specification, for it simply says that anything omitted in this specification that shows in the drawings, or any essential that is omitted from the drawings and is covered by the specification, shall be executed as if it were shown in both; and since the contractor has both the drawings and specifications, he has had due notice of the requirements, and can act accordingly in making up his bid. But where the omission occurs in both drawings and specifications, it is unfair to hold him as if he were expected to know what the architect intended and wanted. He should have an allowance for extra work in case of additions to both specifications and drawings required by the architect's carelessness and omissions.

Extra Work. Perhaps the most prolific cause of trouble and argument on contract work is "extra work," and the payment for same. As an example of the ordinary specifications on this subject, we have the following:

"No extra work will be allowed unless ordered by the Architect in writing. No bill for extra work so ordered will be approved by the Architect unless it is rendered immediately upon completion of the work."

In this specification there is not a single assurance to the contractor that he will come out on the right side financially on extra work. The contractor will probably not attempt to do any extra work unless he is sure of being compensated for it; but even when he has proper authority for performance, the compensation under this clause may not be what he asks for. That a great deal of extra work is done on the architect's verbal authority is a fact, and that the bills for the greater part of it are allowed is also true; but, as in the case of the approval of samples by the architect, he may withhold his approval of payment when the result obtained by work done under verbal orders is not up to expectation. If the contractor were always able to obtain from the architect the written order, there would be no fault to find with the first sentence of this paragraph.

Now, as to the second part—suppose the contractor had done the extra work on the written order of the architect and had presented his bill "immediately upon completion of the work." Some particular piece of extra work may be found to extend over the greater part of the job, and may not be completed until the entire job is nearly finished. If such were the case, the architect might hold up payment for the work several months, and the contractor would have no allowable claim until, perhaps, the completion of the entire job.

And what, under this clause, is the contractor to be paid for his extra work? Suppose in his bill he includes all items of his expense—material, labor, plant, superintendence, overhead charges—while the architect's inspector has kept account only of labor and material. There will be a great difference in the amount of the bills. The architect will probably be willing to concede something to the contractor for other charges; but the percentage may not be what the contractor has figured on, and he is thus left short. Under this clause he has no redress.

Another specification covering the same matter, and showing the contractor a little more clearly where he stands in figuring extra work, is as follows:

"In estimating the cost of such work, no allowance shall be made to the Contractor for the use of tools or for general superintendence."

This specification precludes all possibility of such trouble as mentioned above, but does not give the contractor just what he should get. Moreover, it introduces a feature that brings about a gamble on the contractor's part. In making the bid, he must spread over the various items such a charge as will care for the plant cost that will accrue while his plant is engaged in extra work which, according to specification, he will receive no direct compensation for. He cannot tell how much of that work there will be, and so how much plant time will be unprofitable; and as a result he is working on an uncertainty. It is then evident that full cost should be allowed so that the contractor will not have to inflate ordinary figures to take care of demands that might be made later.

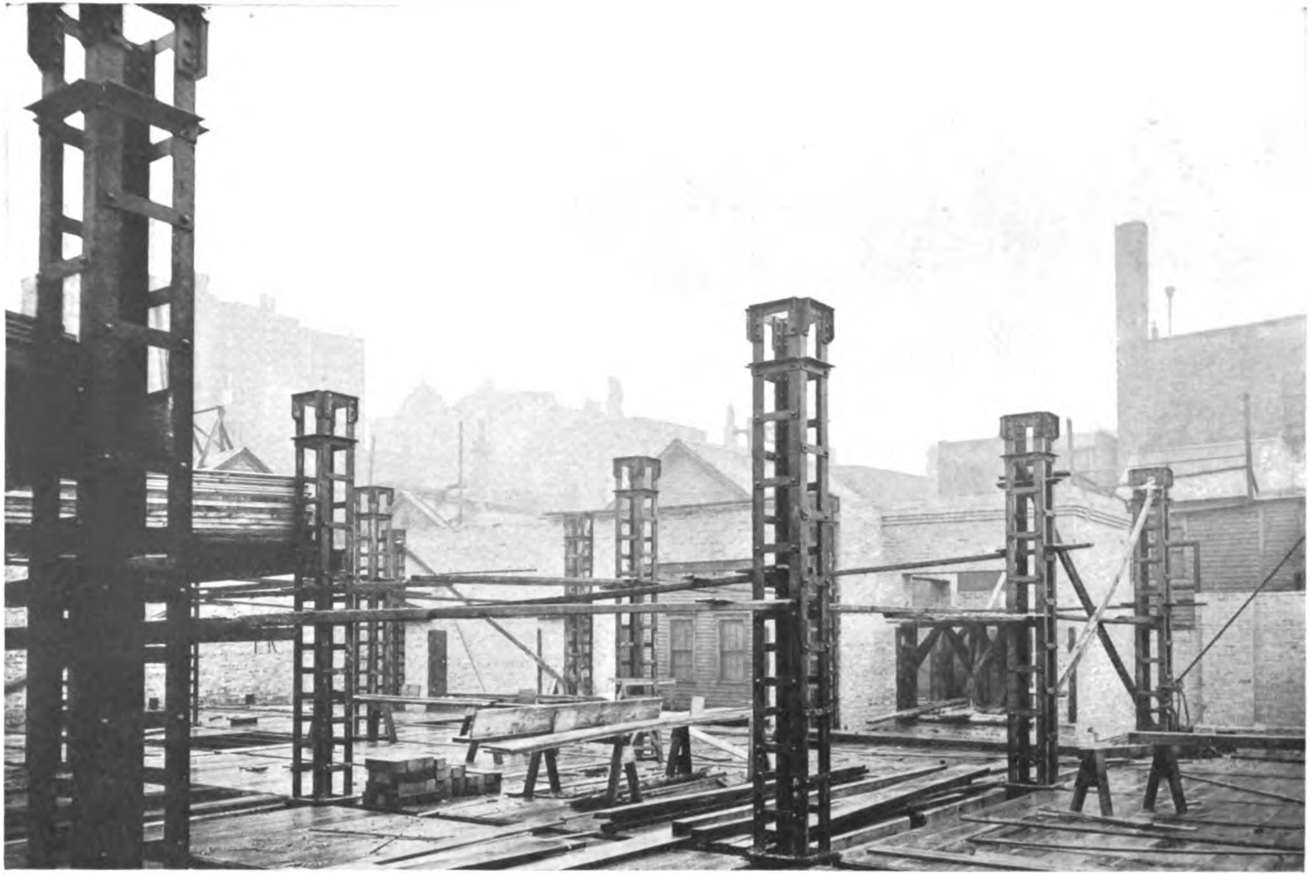
A fairer specification would cover plant charges by allowing a fair percentage for the same. Here is such a specification:

"The Contractor must be prepared to do any extra work that may be ordered in writing by the Architect; and for this he will be paid the actual reasonable cost as determined by the Architect, plus 15 per cent of said cost."

This, however, has a particular weakness, in that 15 per cent is generally too low. The 15 per cent may be said to cover all costs outside of those that can be definitely charged to the extra work. The charge for labor and material can, of course, be accurately determined; but when it comes to plant charges and maintenance, superintendence and overhead charges, and the profit which the contractor is entitled to receive, 15 per cent may fall woefully short. In fact, the 15 per cent might be said to be sufficient to cover only the contractor's profit, and other charges would be left uncared for. It is perhaps meant that the architect will include plant and overhead charges in the "actual reasonable cost," but the specification does not definitely state this. The architect might add a percentage to the labor and material cost, and say that it is to cover plant and superintendence. If he does, and if the percentage is fair, the clause is all right.

The use of "actual" and "reasonable" may be rather paradoxical. Conditions might arise which make the actual cost seem unreasonable, and the contractor might suffer the consequence if the architect laid stress upon the "reasonable" part of the clause. Suppose, on the other hand, the contractor, by taking advantage of conditions, produced the work at a much lower figure than the estimate of the architect allowed—a figure which might seem unreasonably low. The architect would be sure to be governed by the "actual" part of the specification, and the contractor would gain nothing for himself by his effort to economize. In fact, he would suffer by the decrease in return under the 15 per cent item. The contractor would be entirely at the mercy of the architect, not only in the interpretation of the clause, but in the payment for the work, according to how the architect wished to interpret "actual cost," the "reasonable cost," or the "actual reasonable cost."

Another specification covering extra work may well be given as an excellent example of how justice to the contractor may be secured:



STEEL REINFORCEMENT FOR COLUMNS IN REINFORCED CONCRETE WAREHOUSE.

REINFORCED CONCRETE STORE BUILDING UNDER CONSTRUCTION IN LOS ANGELES, CALIFORNIA.

Building 100 by 150 ft., with 5 floors and basement. First, second, third, and fourth floors carried by 63 columns each; columns poured first, floors and beams poured together; reinforcement of twisted steel up to 1¾ inch.

"The Contractor shall do any and all extra work that may be ordered by the Architect; and, as full compensation for such extra work, the Contractor shall receive an amount equal to the actual cost of the extra work, plus 15 per cent profit, superintendence, and general expenses, plus 1 per cent per month on the cost of the plant and plant rental. The said actual cost of the extra work shall include all fuel, materials, and labor furnished by the Contractor; but it shall not include office expenses, general superintendence, salaries, or other general expenses."

Time Limit. The clause covering the time of the completion of the work is generally embodied in the contract proper, but it is often found under "Specifications" as well. When the owner expects to be able to occupy his property—say a building—at a certain time, and makes his plans accordingly, it often means a severe loss to him if he is disappointed; and to compensate this he should be able to collect damages because of the failure of the contractor to live up to his agreement. It is often remarked that if the damage to the owner for delay is, say, $100 a day, he ought to be willing to pay as much for the saving of time if the work is completed before the expiration of the time limit. This is not necessarily the case, as it may be that a penalty of $100 a day is not too high to compensate him adequately for the loss from delay; while, on the other hand, the completion of the work before the prescribed time would be of little advantage to him. For this reason, and to make it as binding as possible, the penalty for non-completion on time is usually stated in the contract.

In all cases the damage is hard to determine if the work runs over the time limit; and it is impossible to predetermine it at the time when the specifications are drawn. In many cases it happens that the only expense that the owner is put to is that of the employing of some extra force to look after his interest, which expense would stop with the completion of the work. To take care of a case of this kind, the following clause, taken from specifications for some municipal work, is quoted:

"No charge shall be made for any delay; but if the completion of the work is delayed beyond the time stipulated in the contract through any act, neglect, or inability of the contractor, and at the same time through no fault of the Village or Engineer, the Contractor shall bear the expense of the Engineer for all the time that may elapse until the work is completed, at the rate of $5.00 per day, which amount shall be deducted by the Village from the settlement bill with the Contractor, and shall be paid to the Engineer. Should delays be occasioned through any fault, neglect, or act on the part of the Village, then the time of the contract shall be extended proportionately."

On some classes of work, it might be desirable to rush work as much as possible; and as extra inducement, it would be well to offer the $5.00 for each day saved. This would not be much expense on the owner's part, nor much gain on the contractor's; but the contractor would strive for it, if only to gain the reputation of having received a bonus under such a specification.

The Department of the Interior has a clause in its irrigation contract that covers this matter even more fully:

"In case the Contractor shall fail to complete his work in the time agreed upon in this contract, or in such extra time as may have been allowed for reasonable delay incidental to the work, the Engineer shall compute and apply the direct damage for the loss sustained by the Secretary of the Interior on account of further employment of engineers, inspectors, and other employees, including all disbursement on the engineering account properly chargeable to the work. The amount so applied and computed shall be deducted from any money due the Contractor under this contract. The decision of the Chief Engineer as to the appraisal of such damage shall be final and binding upon both parties."

Specifications should recognize the fact that delays on the work by the architect, engineer, or owner entitle the contractor to some consideration. He must be at least granted an addition to the time of completion. One of the most unfair specifications imaginable is the following:

"In the event of any delay in completing the work employed in this contract, the party of the first part shall be entitled to no extra compensation on account of such delay, as it is hereby assumed that in submitting its tenders it took chances for the occurrence of such delays."

Under this clause, if the owner runs short of money or wishes for any reason to shut down the work, he can do so with no cost to himself; but the contractor loses because of idle plant and the percentage of estimate that is held up. He waits in uncertainty until the owner is ready to go ahead; and he gets nothing for waiting. It is extremely doubtful if such a specification would be upheld by the courts if a contractor took the matter that far. Absolutely no good is accomplished by such a clause; and it lends an element of uncertainty to the work which will be reflected in a contractor's bid in a manner that is bound to be disadvantageous to the owner in the long run.

The architect, apparently governed by a desire to have things go well, but perhaps with the idea of having work done to suit his own fancy, will sometimes put in a clause like this:

"The Architect will indicate the points at which the work shall be begun. He will have the power to concentrate the work in particular places or to scatter it over different parts at will."

This specification may work no end of hardship on the contractor. Under it, he might be compelled to begin upon a portion of the work on which he has figured no profit, thinking that he could leave it until enough profit had accrued from the other portions of the work to allow of the whole being carried without loss. Thus the unprofitable work would be done entirely at the expense of the contractor's capital. This might be used as a method of preventing "unbalanced" bids, if this prevention were thought desirable; but if such were the object, a clause to that effect and nothing more could be used, and this club-like specification be omitted.

Another disadvantage under which such a specification places the contractor is that, after concentrating his entire force and plant and efforts upon one portion of the work, he may at any time have to change his plans and divert part of his outfit for a short time to some other part of the work, upon the whim of the architect. This disorganizes the work and means much additional expense to him. Even if the architect should not want to take advantage of the clause, he could use it as a club to "influence" the contractor into doing many things that were not exactly specified.

In the following pages an example of specifications for a building has been given, and in many cases comment upon specific clauses has been made. In the drawing of specifications for a special case, those that have been used before, and which have been evolved through many years of experience, must be depended upon to a large extent. Exact copying of the clauses of an old specification should, however, be done with great caution. No matter how well they may have worked in other cases, some slight change of conditions in the next case might make them entirely inapplicable. Where years of practice have reduced some particular line of work to such exactness that there is almost no deviation from the fixed methods, it would seem that the specifications for such work might be the same, job after job. Such, however, is not always the case; and no matter how well established the rules of practice may be, each clause should be carefully thought out, and its probable effect upon the work carefully gone over. Never copy a specification simply because it has been used before and has worked well.

TYPICAL EXAMPLE OF SPECIFICATIONS

For the sake of illustration of the principles that should govern the writing of specifications for construction work, we shall now reproduce

a typical set of building specifications, inserting critical comment on many of the clauses:

SPECIFICATIONS

To accompany contract dated . . . between . . . Owner and . . . Contractor, to accompany and be a part of drawings prepared by . . . Architect

"**Conditions**—The drawings and specifications are intended to co-operate; any work shown on the drawings and not particularly described in this specification, and any work evidently necessary to the complete finish of the work included in this specification, as specified or shown, is to be done by the Contractor without extra charge, the same as if it were both shown and specified."

An element of uncertainty is introduced in this, the very first paragraph. If the contractor has done work under the architect, and knows the completeness with which his plans are prepared and his general method of interpreting the specifications, he will be able to take chances under this clause that would not be warranted if he were working under an unknown architect. The statement that the drawings and specifications are intended to co-operate is true, and fair enough; but that the contractor must do the work which the carelessness of the architect may have caused to be omitted from the plans, simply because such work would in the mind of the architect make the construction complete, might work a hardship on the contractor. Such conditions should be provided for more carefully, or else specified under extra work.

"The Contractor must comply with the Building Code, the corporation ordinances, the State and other laws; the Contractor shall be liable for any and all penalties imposed by reason of violations of the Building Code, the corporation ordinances, the State and other laws, in connection with the work herein specified; and he shall also be liable for all expenses incurred by the Owner and by the Architect for penalties imposed and for defending actions at law that may be brought by reason of said violations."

Of course the contractor must comply with such laws and ordinances as deal directly with construction; but that he should be responsible for the fulfilment of rules and laws of any Building Department which may govern design is entirely out of reason. This clause is in keeping with one elsewhere mentioned, concerning the staking out of work and the responsibility and correctness of lines and boundaries, and might in effect make it necessary for the contractor to do practically all the engineering work, which he is not supposed to be qualified to do.

"The Contractor shall be liable for all damage to life and limb that may occur owing to his negligence or that of his employees or his subcontractors or parties doing work for or furnishing materials to him during the time that work is being performed at the building, at any time before the completion and final acceptance of the work included in this specification.

"Within twenty days after the award of the contract, the Contractor is to submit in writing the names of all the sub-contractors to the Architect, for approval; in no case will any work be accepted furnished by sub-contractors whose names have not been approved or whose names have not been submitted for approval. The approval or disapproval of names of sub-contractors does not relieve the Contractor from any obligations under his contract.

"**Extra Work**—No extra work will be allowed unless ordered by the Architect in writing. No bill for extra work so ordered will be approved by the Architect unless it is rendered immediately upon completion of the work."

This last paragraph is, of course, a very common one in specifications; but it is seldom explicit enough, and generally leaves the matter and amount of payment for extra work one-sided and apparently entirely to the discretion of the architect. Examples of a better form of paragraph covering this requirement have been given above.

"The work is to be executed strictly in accordance with the drawings and specifications, and any work made without or not in strict conformity with the drawings, or differing from the requirements of the specifications, will be rejected, and must be removed and replaced by work in conformity with the requirements of the drawings and the specifications; and all work of all kinds injured or destroyed thereby must be made good at the Contractor's expense."

This paragraph is superfluous, as the contract is the statement of exactly the same thing.

"The Contractor must, at all times, properly protect his work from injury, and he will be responsible for its condition until the final completion and acceptance of the same.

"Any damage done to work of other contractors by the Contractor, his sub-contractors and employees, will be made good at the Contractor's expense."

The contractor is in turn protected against damage done by his sub-contractors, by the contract he has made with these sub-contractors, protecting his own work and the work of other contractors.

"The Contractor must give his personal attention to the work included in this specification, and he must supervise the work of his subcontractors; he must have at the building a skilled Foreman, who must carry out the directions given by the Architect. The Contractor must keep at the building, in charge of his Foreman, a complete set of drawings and detail drawings and a complete copy of this specification, to which the Architect is to have access at any time.

"The true meaning and intent of the drawings and the specification, or any part thereof, shall be interpreted and determined by the Architect, and his decision thereon shall be final.

"**Materials and Workmanship**—All materials, of every kind and description, are to be of the very best quality; and all work necessary to the complete finish of the work included in this specification, as shown on the drawings and as specified, is to be executed in the most thorough, substantial, neat, and workmanlike manner, to the entire satisfaction of the Owner and the Architect, to whom every facility is to be afforded by the Contractor for inspecting the work as it progresses."

"Very best quality," "the most thorough, substantial, neat, and workmanlike manner," and "to the entire satisfaction"—these are in themselves very ambiguous expressions. In most branches of the building trades, common practice has defined these terms more or less; but, as practice varies very widely among contractors, and as "entire satisfaction" varies quite as widely among architects, and is liable to be even more erratic among owners who are inexperienced in building operations, the contractor is liable to find trouble with them. This is, of course, a very general clause, too general to safely hold water.

"The Contractor is to furnish all necessary materials and labor, and he is to provide all tools, scaffolding, planks, and all necessary appliances, mechanical and otherwise, for the proper prosecution of the work. All necessary freights, cartages, transportation, and all handling of materials, must be paid for by the Contractor.

"The Contractor must erect and construct his work in a proper and orderly manner, and must not in any way obstruct or interfere with the progress of the work of other contractors.

"In all cases where the terms 'proper,' 'suitable,' and 'equally good' are used, the nature, quality, and character of the materials to be furnished, and the work to be done to which these terms are applied, shall be determined by the Architect; and his decision shall be final. In each case, the approval of the Architect must be in writing; and no material or work will be accepted unless the same has been submitted and the Architect's approval has been obtained before the work is commenced."

Here is a clause which admits, in effect, that certain terms used above are ambiguous; but, instead of removing the ambiguity by limitation, it says that the architect will decide what these terms mean when any question in which they are involved shall arise. If the difficulty be due to a previous error of the architect in the plans or specifications he becomes an interested party, and his decision cannot be impartial. A specification should, as far as possible, describe by quantities or by comparison with some well-established standard, just what quality or what style of practice is to be enforced.

"The Contractor will procure and pay for all necessary permits in connection with his work. The Contractor must procure the vault permit, and pay for same. The certificate for the vaults and receipt must be delivered to the Architect.

"**Surveys**—The Contractor must employ at his expense a City Surveyor to prepare the vault certificate, and to give, at the site, necessary lines, levels, and other data and such information as the Architect may require.

"The Contractor must furnish to the Architect, before the final acceptance of the work included in this specification, a City Surveyor's certificate, showing the location of the building in reference to the street lines and lot lines, both near the sidewalk and at the top, showing irregularities, if any, in all walls as to whether they are plumb or otherwise, and such other information as the Architect may desire.

"**Handling of Materials**—All materials are to be handled at the site and at the building so as not to obstruct or interfere with the work of other contractors.

"The Contractor will have charge of the sidewalk and roadway in front of the building; and it shall be his duty to keep the same free and unobstructed at all times, in compliance with the law, and to remove all rubbish, snow, and accumulations of all kinds.

"Mortar and concrete are not to be deposited, mixed, or tempered on any of the floors of the building. Specially constructed waterproof boxes are to be provided for this purpose. Water barrels in any part of the building must be placed in waterproof boxes. This applies also to the basement. Leaky hose or pipes for conveying water will not be permitted. All damage to the building or any part thereof on account of soakage by water, will be made good at the Contractor's expense."

This is in keeping with the general protection which the contractor must give to the building, and works no hardship upon him.

"**Watchmen**—The Contractor is to provide and keep a watchman on the premises at all times of the day and night, until the building is completed and until the Owner takes charge of the same.

"It shall be the duty of the watchman to guard the building and premises at all times, and to protect the work of all contractors.

"The watchman is to perform no work or labor at the building, except what is necessary for the performance of his duties.

"In case, at any time, it is found that there is no watchman at the building, the Owner, through the Architect, may provide a watchman, without notice to the Contractor, and may deduct the expense incurred from the amount of the contract.

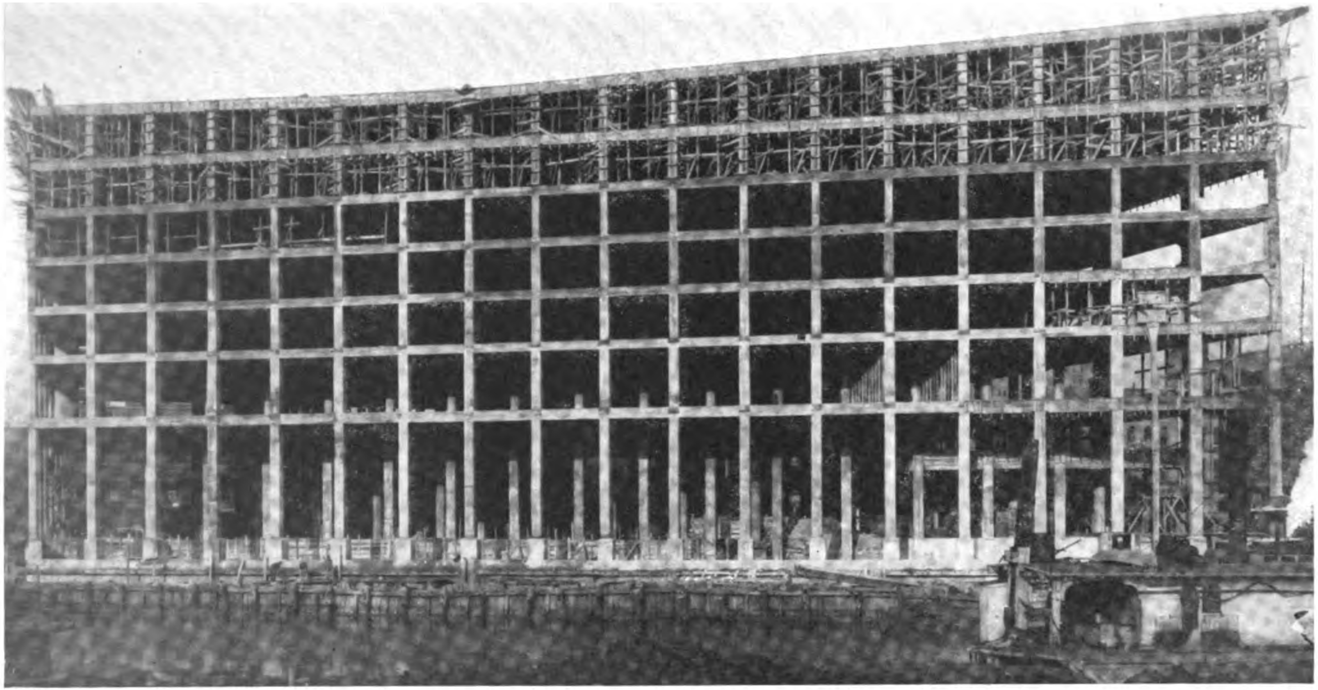
"**Excavations**—The Contractor is to do all necessary excavations (including all rock-blasting) for the basement, the vaults under the sidewalks; for elevator pits, machine pits, and boiler pit; for walls, piers, footings, and other parts, to such depths as shown on the drawings; also all excavations for cisterns, cesspools, underground pipes, ducts, etc. (in the building and vaults), as may be directed; also all excavations for shoring, sheath-piling, and underpinning.

"The rock excavations for the floor of the sub-basement and basement must be carried 12 inches below the finish floor lines to allow for asphalting, concreting, etc.

"Sinks, cesspools, wells, and cisterns, or portions of 'made ground,' soft ground, or bog, that may be on the premises, are to be cleaned out to the bottom, and filled in solid with concrete, made as hereinafter specified for the footing courses. This is in addition to the footing courses shown on the drawings."

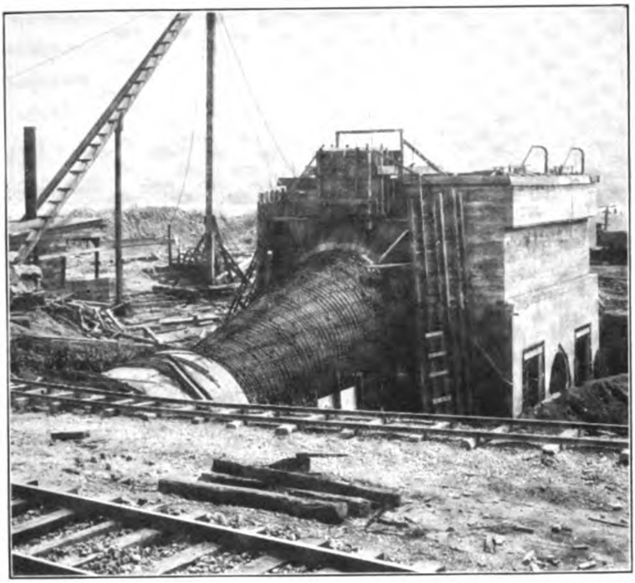
The architect should know the condition existing at the bottom of the property, and should be able so to state it in his specification or in the bidding sheet that the contractor will not be bidding blindly and trusting to luck that he will not run into adverse conditions upon excavating. This paragraph might readily cause trouble if certain conditions were encountered, where the contractor might make a claim for extra work, which in many cases would be justified. If, on the other hand, the exact conditions were stated, and the contractor knew more exactly just what to expect, he could so arrange his bid as to cover the conditions, and the specification would so read as to preclude the possibility of any extra claim on his part.

"The trenches for foundations and footings are to be excavated down to solid rock; the top of the rock is to be trimmed off to present an

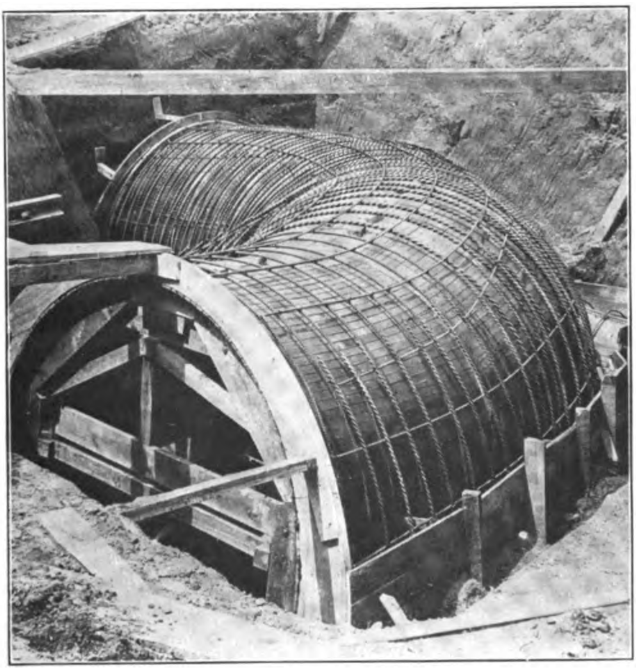


REINFORCED CONCRETE WAREHOUSE UNDER CONSTRUCTION IN TOLEDO, OHIO.

Floors designed to carry 500 lbs. per square foot. Turner "Mushroom" System.



Reinforcement at Inlet Gate.



Method of Conduit Reinforcement.

REINFORCED CONCRETE CONDUIT FOR FILTRATION PLANT OF PITTSBURG, PA.

even, level, and uniform surface for the foundations and footings.

"All excavated matter, including earth, sand, rock, bowlders, old building materials, and other debris, must be promptly removed from the premises.

"The borings which the Architect has caused to be made show the character of the ground, but the Architect does not guarantee these borings to be correct. Additional borings that may be required are to be made by the Contractor at his own expense."

> This clause allows doubt in the mind of the contractor as to conditions, and causes him to bid higher than otherwise. If the architect does not know that the borings are correct, and will not guarantee them, the contractor certainly can place no faith in them. If additional borings are required, it is no fault of the contractor, and he should not be made to stand their cost. All conditions previous to the entering of the contractor upon the ground should be known to the architect, as only in this way can comprehensive specifications be made.

"**Pumping**—The Contractor is to provide all necessary pumps and all apparatus in connection therewith, and is to do all pumping that may be required to keep the trenches and other excavated parts free from water when the footings are being laid and the column bases and pit pans are being set and other necessary work is being done, and to keep the entire basement and sub-basement free from water until the waterproofing is completed. No water is to be allowed to accumulate in the basement or sub-basement after the waterproofing is done; the Contractor is to remove all surface water promptly."

While this may entail some expense, it is quite as much to the contractor's advantage to keep things dry as to the owner's, if not more so. The clause is unnecessarily verbose; that is, its substance could be put in fewer words.

"**Cesspool**—A cesspool is to be built in the boiler vault, to have 12-inch brick walls, laid in Portland cement mortar in the very best manner, as may be directed, to be 3 feet diameter inside, and 4 feet deep, with brick necking and bottom. Perforated cast-iron plate is to be provided to be set into the stone top.

"**Shoring and Underpinning**—The old walls are to be thoroughly braced and made secure.

"The adjoining and contiguous walls and structures are to be preserved from injury, and underpinned wherever necessary, by the Contractor, in accordance with the requirements of the Building Code.

"The Contractor is to provide all materials of all kinds, to the satisfaction of the Architect, including shores, braces, needles, blocking, screw pumps, wedges, sheath-piling, wedge blocks, steel wedges, concrete footings, brick underpinning laid in Portland cement mortar, stone posts, etc.

"**Protecting Adjoining Property**—All adjoining property must be protected in the very best manner.

"The Contractor must procure permission from the adjoining property holders to enter the premises for the purpose of shoring, underpinning, and protecting the contiguous walls in accordance with the Building Code.

"All damage and injury to the adjoining property, including the buildings, walls, streets, and sidewalks, stoops, vaults, vault lights, copings, railings, fences, lamp posts, etc., must be repaired and made good in the very best manner, by the Contractor, at his expense.

"The Contractor must hold the Owner harmless against any and all claims for damages on account of injury to the adjoining property, and must defend any actions at law that may be brought by reason thereof.

"**Sheath-Piling**—The Contractor is to do all necessary sheath-piling, in the very best manner, for retaining the streets and sidewalks and the adjoining property, yards, etc., to the satisfaction of the Architect and the Department of Highways.

"All necessary plank curbing for the

trenches, properly braced, must be furnished and set by the Contractor.

"The sheath-piling, where directed by the authorities or by the Architect, is not to be removed.

"**Sewers, water mains**, and all other pipes in the streets, including the electrical subways, are to be protected in the very best manner. All to be done in accordance with the requirements of the rules and regulations of the President, Borough of . . . ; Offices, Commissioner of Public Works, the Department of Water, Gas, and Electricity, and the Consolidated Telegraph and Electrical Subway Company, the Contractor obtaining the necessary permits and paying all expenses in connection therewith.

"**Bridge, Staging, Scaffolding, etc.**—Sidewalk bridges are to be built of proper materials, for the three fronts; steps are to be provided at each end of the bridges and wherever required, and necessary railings are to be put up. Shed roofs are to be built, extending the full width of the sidewalk and the full front of the building, covered with roofing felt, constructed of proper materials, to have cant-boards, posts, braces, etc.

"The Contractor is to provide, put up, and maintain all necessary electric lights, wiring, connections, etc., to supply electric lighting for the space under the shed roof, as required by law.

"**Cement**—All cements are to be of the very best quality, approved by the Architect; all are to be properly stored, housed, and protected.

"The following kinds of cement are to be used: La Farge Cement, . . . Portland Cement, and Rosendale Cement."

> Since the cements are to be tested and must be up to a certain standard, to specify the brand in addition, when there is a large cement market, seems unnecessary. A common clause is: "of . . . brand, or quality equal thereto."

"The cements, when tested, must give a minimum tensile strength per square inch as follows: Portland Cement 24 hours after mixing, 120 lbs.; 6 days, 300 lbs. Rosendale Cement 24 hours after mixing, 60 lbs.; 6 days, 120 lbs."

> The tensile strengths required by this specification are very low. For a 24-hour test, at least 150 pounds should be required. The ordinary time test is 7 days, and should show a strength of 350-400 lbs. Just why 6 days is specified in this case, and the strength of only 300 pounds required, does not seem clear.

"The cements will be tested by the Architect from time to time; and if the same prove to be of inferior quality, the cement of such brands will be rejected, and all work built of such cement will have to be removed and rebuilt.

"**Sand**—The sand is to be of the very best quality, clean, sharp, grit sand, entirely free from loam, to be properly screened."

> "The very best quality" of sand is well standardized; but a better specification of sand, which is more comprehensive, especially in regard to loam, would be as follows:
>
> "All sand shall be clean, sharp, grit, or fresh-water sand of uniform texture and free from all impurities. It shall show no loam and not more than 5 per cent by volume of silt, after being shaken in water and allowed to settle."
>
> A sand specification can easily be so strict as to add a great deal to the cost of the work, without corresponding advantage.

"**Cement Mortar**—Cement mortar is to be made in the following manner: The parts of cement and sand are to be mixed dry, carefully and thoroughly; to this a sufficient quantity of water only to make it of good working consistency is to be added. Mortar is to be made in no greater quantity than is required for the work on hand; and no excess that may have been left over night, or that has been mixed more than two hours, is to be retempered or used in any way.

"Cement mortars are to be mixed as follows:

"Rosendale cement mortar—one barrel of cement and two barrels of sand.

"Portland cement mortar—one barrel of cement and three barrels of sand."

Literally, under this, no lots requiring less than one barrel of cement can be mixed.

In the last two clauses, no statement is made as to the size of barrel, whether the cement is to be measured packed or loose, or how to be measured. It is a common specification at the present day to state that a barrel of Portland cement shall be considered as 380 pounds net.

"In all cases the sand used for cement mortar is to be measured in barrels; this must be strictly carried out, and no deviation will be allowed.

"Any work built with cement mortar not properly mixed, or in whole or in part retempered, will be rejected.

"La Farge cement mortar is to be made of one part of La Farge cement, and three parts of clean sharp white sand, to which one part of lime putty, properly slaked and run, is to be added.

"**Concrete**—The concrete is to be made of one part of cement and three parts of sand, mixed as before specified for cement mortar, to which add four parts of clear broken stone, broken so as to pass in any way through a 2-inch ring. Concrete is to be mixed in no greater quantity than can be used immediately; and no excess that has been left over night, or that may have been mixed more than two hours, is to be retempered or used in any way."

With all the wealth of literature upon the mixing of concrete, and with all the excellent examples of specifications for such work that are in existence, it is indeed surprising to find such a clause as this in supposedly up-to-date specifications. In the first place, the mortar specification is in itself incomplete, but is referred to in the concrete specification; and no specification is made as to how or when the stone shall be added, or how it shall be mixed. According to the letter of this specification, as the mortar is mixed the required quantity of stone might be dumped in the midst of it and immediately shoveled into place or into some vehicle for transportation, without becoming in any sense of the term a true mixture of concrete. Perhaps the architect intends the very word "concrete" to imply what the mixture shall be like; but here again there is such a variety of interpretations that a crafty contractor might want to make almost anything go.

"After the concrete has been dumped in place, it is to be slightly rammed, enough only to flush the water to the surface; then it is to be leveled off and allowed to set without being disturbed."

The old-fashioned way of mixing concrete was to add so little water that a great deal of ramming was necessary in order to get the water to come to the surface. Of late years the practice has been to mix concrete "very wet," in which case no ramming at all can be done. In walls, in order to obtain a smooth finish, it is often customary to force a spade along the inner surface of the forms so as to bring the mortar and smaller stones to the face, and keep the larger stones away from the face and well within the body of the concrete mass.

"In all cases the concrete is to be mixed, and the parts are to be accurately measured, in the same manner as above described for cement mortar."

No method of accurately measuring the parts was given under the specification for cement mortar; hence this specification for concrete is senseless. This is evidently a case of copying from some other specifications without even taking the trouble to study them.

"Concrete not properly mixed will be rejected.

"**Concrete Footings**—The footings under all walls, columns, piers, and vault walls are to be made of concrete, of such widths and depths as shown on the drawings.

"All concrete footings are to be laid between plank curbs or sheath-piling, as before specified.

"In all cases the bottoms of the trenches must be approved by the Architect before the footings are laid.

"**Concrete Flooring, etc.**—The concrete flooring is to be put down three inches thick, graded and leveled off as may be directed, covering the entire sub-basement floor, including the boiler room, engine rooms, etc., prepared to receive the waterproofing; after the waterproofing has been laid, all is to be concreted 6 inches thick, including the top finish of Portland cement.

"All the above concrete to be of gravel composed of pebbles varying from ½ inch to 1 inch, four parts; sand, two parts; and Portland cement, one part; and top finish of Portland cement 1 inch thick."

As this reads, the top finish is to be a layer of pure Portland cement 1 inch thick. This is rather an unusual finish, and the chances that the contractor will put it down as per this specification are very slim indeed. Moreover, it is neither necessary nor advisable to have the finish coat so thick.

"Drain tiles 3 inches diameter laid in broken stone, are to be provided as directed, to drain the space under the sub-basement floor to the cesspool as directed.

"**Asphalting and Waterproofing**—The materials used for waterproofing must be of the very best quality, tarred roofing felt, laid in courses, five-ply; each course is to be cemented with asphalt, applied hot, well mopped; the entire surface is to be covered with asphalt before the felt is applied, and after the felt has been applied."

A very good specification for meeting ordinary conditions.

"Natural asphalt—Trindad, Seyssel, Sicilian, or other equally good—approved by the Architect, entirely free from adulterations, is to be used; to be applied hot in all cases.

"In all cases where asphalt work is jointed, the lap is to be not less than 12 inches. Particular care must be taken so that all the work will be perfectly water-tight; necessary precautions are to be taken to prevent lifting and opening of joints, and all the work must be warranted for five years after the completion of the building."

A five-year guarantee on this sort of work is likely to prove ineffective, as so many unforeseen things may happen in five years.

"**Damp-Proofing**—All the walls and piers are to have damp-proof courses connected with the wall and floor waterproofing.

"The parapet walls are to have damp-proof courses as hereinafter specified under the head of 'Slag Roof.'

"The Contractor is to build a 4-inch brick wall, laid in Portland cement mortar, on the outside of the stone vault wall of the basement; and the inside of this 4-inch wall is to be asphalted before the stone wall is built. In all cases the waterproofing of the vault walls is to be connected with the damp-proof course of floor and sidewalk.

"All damage to the building and machinery on account of leaks, will be made good at the Contractor's expense."

This is in form of guarantee that all waterproofing is properly done.

"**Stone Masonry**—The exterior vault walls and other walls of the basement and sub-basement, as indicated on the plans, are to be built of good, sound, selected stone from the excavation; to be laid in Rosendale cement mortar, except that part below the basement floor, which is to be built with Portland cement mortar; with solid beds and joints between stones of mortar. All to be properly bonded and to be faced on the inside with brick where shown and specified. The inside face is to be built as directed, with recesses; and necessary iron anchors, provided by the Contractor, are to be built in."

This is a rather unusual specification, since the excavation was made in solid rock and required blasting. In heavy masonry work, it is commonly specified that no rock shall be used which has been blasted by high explosives, as, after being thrown out by such explosives, there is always a possibility of the rock being injured in the blast. In this case, however, perhaps a very rough rubble wall is intended, in which small pieces of rock may be used, and in which a few shattered pieces would not make any very great difference. As a general thing, however, a specification allowing the use of such material should be avoided.

"**Brickwork**—The brickwork throughout indicated on plans is to be built of the very best quality hard-burnt bricks, laid in Rosendale cement mortar, except that below the basement floor, which is to be laid in Portland cement mortar. All to be laid solid with the joints well filled; to be laid perfectly plumb and to a line; soft and pale bricks are not to be used. Every sixth course is to be a heading course; face bricks are to be clipped, and the headers built in diagonally.

"All bricks are to be thoroughly wet when being laid.

"All the present brickwork of the adjoining buildings, where cut or disturbed, is to be repaired and rebuilt in the very best manner; old chases, beam holes, flues, and channels are to be bricked up. The flues in the adjoining party walls must not be disturbed, and must be repaired, cleaned out, and delivered in good condition.

"The joints of all exposed brickwork not specified to be plastered, are to be neatly struck.

"At all the floors, the channels and chases must be filled in solid at the floors, as required by the Building Code.

"The vault arches of the sidewalks are to be built 8 inches thick, the Contractor furnishing the necessary centers.

"Window-frames must be built in solid and pointed up, before the plastering is started; if not properly built in or pointed, they will be calked with oakum at the Contractor's expense.

"All wooden beams, steel beams, and girders are to be well bedded, and are to be built in solid.

"Offsets on walls are to be made on top of the beams.

"The metal cornice of the front is to be backed up as shown; the brickwork is to be carried up to the top of the cornice.

"Build in all anchors, bolts, tie-bars, eyes, clamps, etc., and all pipes, ducts, etc., furnished under other contracts.

"All furred walls are to have on each story corbeled offsets, as required by the Building Code.

"Dwarf walls, pit walls, retaining walls, basement walls at boiler, elevators, manholes for underground traps and valves, and all other brickwork not specially mentioned, are to be built as directed by the Architect."

The plans should show distinctly, and specifications should mention, all walls coming under this specification. As it now stands, it leaves entirely too much that should come under the head of "extra work" which the architect may order the contractor to do.

"All other brickwork not specially mentioned is to be built as directed."

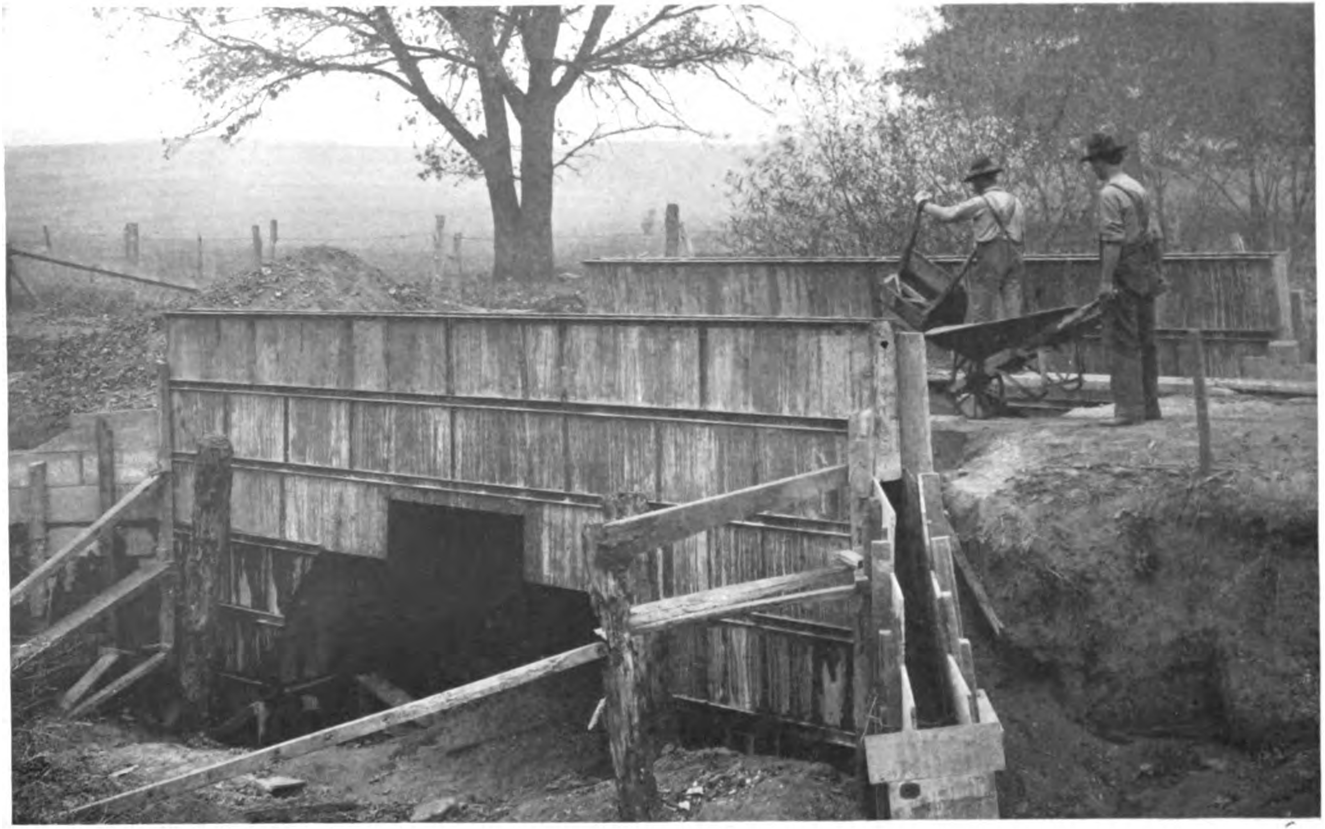
Here, again, more specific information should be given in plans and specifications.

"**Fire Bricks**—The boiler flue chimney is to be lined with first-quality fire bricks, all laid in fire clay from the bottom to 25 feet above the boiler flue connection.

"**Face Brickwork**—The fronts above the sidewalk as indicated on the plans, and the returns on the gable walls at A2½ and H2½, are to be faced with light grey 'Powhatan' bricks or other best-quality pressed bricks, selected by the Architect, samples to be submitted for approval. The returns on the gable walls are to be 3 feet wide."

This is a specification that may work considerable hardship to the contractor. The different kinds of pressed brick vary a good deal in their color and the consequent architectural effect; and it may easily be that, in order to get the exact color satisfactory to the architect, the contractor will have to buy a more expensive brick than the one which he has figured on in making up his bid. On the other hand, an unscrupulous contractor could submit for approval a brick that he knows is not satisfactory, and then claim an extra price for furnishing a satisfactory one. It is best, whenever possible, for the architect to have on exhibition a sample of what will be satisfactory. As the specification reads, a Powhatan brick will pass, and any other brick of exactly the same color and other physical characteristics will pass; but it is evident that numbers of other bricks will also pass; and just how much variation from the Powhatan size, quality, or color will be permitted, does not appear. If the architect has in his office numbered samples of, say, six bricks, all of which or any of which he will pass, and refers to them, allowing the contractor to see them before closing the contract, all uncertainty and ambiguity will vanish.

"The back of pier H2½, and the wall of the entrance back of this pier to the vestibule door, are to be faced with same bricks; see drawing No. 10. . . .



USE OF STEEL FORMS IN CONCRETE CULVERT CONSTRUCTION.

CONCRETE ARCH CULVERT BUILT BY USE OF INTERCHANGEABLE STEEL FORMS.

"All pressed bricks are to be of the very best quality; the Contractor must guarantee their not changing color."

To guarantee that a brick will not change color is a hard matter. In cities where soft coal is burned, the bricks of a building apparently change color, those near the sidewalk generally more than those in the upper stories. Moreover, a few years after erection, unless very careful and special scientific records were kept, it would be exceedingly difficult to prove whether certain bricks had changed color or not.

"All face bricks must be of uniform color throughout, and must be properly gauged, laid in La Farge cement mortar tinted as directed, with joints struck and trimmed to the satisfaction of the Architect.

"All face brickwork must be delivered clean and in perfect condition.

"**Terra-Cotta Work**—All the terra-cotta work throughout is to be of the very best quality, hard-burnt; the color is to match the limestone, uniform throughout, without imperfections or discolorations, and must correspond with the samples approved by the Architect, furnished by the Contractor."

The observations above recorded on

"Face Brickwork" apply also to this paragraph.

"Pieces resting on iron lintels or beams are to be properly rabbeted and fitted.

"Each piece of terra-cotta is to be properly marked; and the Contractor must prepare, at his expense, and furnish to the setter at the building, plans and diagrams drawn to a uniform scale, showing the location of each piece; and must also furnish full-size sections, showing the projections of the various parts, in accordance with the Architect's detail drawings.

"All the terra-cotta work must be free from accidental injury, spalls, cracks, discolorations, or other defects. Pieces that are repaired, patched, or painted will not be accepted.

"All parts of the elevations, not fully drawn in all details, showing the parts blocked out, are to be executed in the same manner as the corresponding parts fully drawn and tinted.

"All models and moulds are to be made by the Contractor at his expense. Models must be submitted to the Architect for approval before the work is executed.

"The terra-cotta work is to be set in the very best manner with La Farge cement mortar; necessary fitting and trimming are to be done by the Contractor.

"Each piece of terra-cotta is to be filled solid with bricks and La Farge cement mortar from back to the face of wall; particular care is to be taken to fill solid all parts under compression.

"The Contractor will be liable for all damage to the terra-cotta work on account of improper filling and setting; and all terra-cotta work which is cracked or broken within six months after the completion of the building is to be cut out and replaced at the Contractor's expense.

"**Cleaning**—On completion, all defective face brickwork and terra-cotta work must be cut out and replaced by good work; and all the brickwork and terra-cotta work must be properly cleaned and delivered in a perfect condition.

"**Slag Roof**—The roof is to be covered with five (5) thicknesses of the very best quality of tarred roofing felt; each layer is to be thoroughly asphalted with the very best quality natural asphalt, applied hot, without adulterations. All to be covered on top with a good coat of the same kind of asphalt, and with W..... E..... or other equally good slag roofing, approved by the Architect."

As has been elsewhere observed, "very best" is a general term which is a poor substitute for specific standards.

"**Metal Work**—All the flashings on the roof, at the brick walls, deck houses, skylights, ventilators, cornice back, flagpoles, and other parts are to be of 16-ounce copper, in no case to be less than 10 inches high in any place above the finished roof line; the scuttle curb is to be covered the full height, turned over on top 3 inches; at the roof, all flashings are to be 4 inches wide on the flat, imbedded in the roof covering; to set in all cases 3 inches into the brickwork; all to be set after the parapet walls are leveled off and asphalted, and all to be securely fastened. The roof over the basement, under the fire escape, is to be of 20-ounce copper, including all necessary flashings. Roofers' cement or paint skins are to be used for the brickwork.

"All tin work is to be of N. & G. T.....O... S... or M...O...M..., or other equally good I. C. tin, 14 inches by 20 inches, all to be well soldered, nailed, and fastened, in the very best manner.

"All tin is to be painted both sides with .... metallic paint (double label) and pure linseed oil, and allowed to dry before it is laid; and after it is laid, an additional coat of the same kind of paint is to be applied.

"The boxes for receiving the top of the rain-water leaders are to be made of copper 12 inches square and 3 inches deep, properly flashed, folded over 1/8-inch by 1½-inch iron frames, to be tinned on the inside; to have extra heavy galvanized wire netting protectors, covering the boxes; to be convex and properly hinged.

"All galvanized iron work is to be made of the very best quality B. B. No. 26 galvanized iron, except where otherwise specified, all to be formed, bent, and folded in the very best manner, well soldered and riveted, and to have all necessary iron braces and stays that may be required. All the ornamental work is to be of heavy stamped zinc, models to be submitted to the Architect for approval; to be accurately fitted, well fastened and soldered; to be made perfectly water-tight.

"The Contractor for the carpenter work will supply necessary brackets for the cornices of the first story; and the brackets for the roof cornice will be put up by the Contractor for the iron and steel work. The metal work is to be particularly well made, all parts are to be free from buckles and dents; all arrises and mouldings are to be true and sharp, well fitted and jointed. All parts must be perfectly water-tight.

"Braces made of ½-inch by 1½-inch iron, spaced every four feet, and accurately formed to fit the shape of the cornice, are to be securely bolted to the same. All necessary iron straps and reinforcements of all kinds, except as above specified, are to be supplied by the Contractor. All the iron work is to be painted two good coats of ..... metallic paint. All the galvanized-iron and metal work of the front is to be painted two good coats of best ...... white lead and pure linseed oil, tinted limestone color; the paint is to be allowed to dry before the work is sent to the building.

"Galvanized-iron ventilating flues are to be provided for the engineer's toilet-room and the toilet-room of the first story, as shown on plans and directed; to be provided with 12-inch by 16-inch white japanned iron registers, with louvers and chains, etc., as directed.

"The skylights on the roof over the pipe shaft, over the offices, and over the stairs and hall, and the skylights over the elevator bulkhead, and the skylight at the foot of the fourth fire-escape, are to be made of first-quality No. 24 B. B. galvanized iron of ..... or other equally good make, approved by the Architect. The sash bars and rafters of the skylight over the elevator shaft are to be strengthened by steel core pieces; and all are to have condensation gutters, cappings, leaders, etc., complete, and are to be made perfectly water-tight.

"All skylights to be glazed with 1/4-inch thick first-quality solid cast wire glass, bedded in white putty; all to be provided with ventilators and dampers as directed.

"**Blue Stone Work**—The blue stone work is to be of the very best quality Hudson River blue stone, except for the pier bases, and all to be rubbed unless otherwise specified; all faces to be full and true; all to be set in the very best manner, and, on completion, to be pointed up and cleaned."

"Very best quality Hudson River blue stone" is rather an indefinite specification. In the case of stone, there is even greater chance than in many other materials, for variance of opinion as to what the best quality may be. This is an excellent example of the case where the Architect should have samples on file for the Contractor's reference, and should require quality of material to be equal to quality of samples.

The following items are apparently supposed to come under the heading of "Blue Stone Work;" but the specification would be much clearer if statement of this were made:

"**Sills**—Window-sills of the court and gable walls are to be 5 inches by 8 inches, without lugs and washers. Sills 4 inches thick and width of wall are to be provided for rear doors on all stories to the fire-escape.

"**Lintels**—Window and door lintels of the court and gable walls are to be 4 inches by 10½ inches. Soffits 3 inches thick are to be placed back of the door lintels.

"**Copings**—Parapet wall copings, including the coping at foot of fire-escape, are to be 3 inches by 14 inches, to be in five-foot lengths, properly jointed, and to have leaded clamps.

"**Chimney Cap**—The chimney cap is to be in four pieces, rabbeted at the ends, to be 4 inches thick, and properly clamped.

"**Curbing**—The curbing on the avenues and street is to be 6 inches by 18 inches, in five-foot lengths, outside upper edge rounded, and inside cut down square 4 inches from the top, to receive sidewalk. The curbing at the corners is to be carefully cut, and no more than three stones are to be used for one full corner curve. All to be set and jointed in Portland cement mortar."

> The kind and quality of stone to be used in curbing should certainly be stated more carefully than is indicated by putting curbing under the general heading of "blue stone." The quality of curbing on tangents and on the curves at corners is probably in accordance with rules and laws of the City; but if a contractor at a distance were attempting to bid on work, it might be highly inconvenient for him to gain access to all city regulations.

"**Bases**—The pier bases, with the mouldings on top of the same, all of one piece for each pier, are to be supplied; the bases are to extend 6 inches below the grade line for each pier, and all the work is to be carefully cut and rubbed.

"These bases are to be of .... blue stone.

"**Artificial Stone Pavement**—The sidewalks on the avenues and the streets are to be of artificial stone, Portland cement composition, granolithic, flintolithic, or other equally good, approved by the Architect. After the arches have been concreted and asphalted as before specified, they are to be covered with a layer of Portland cement concrete, not less than 5 inches thick, made as before specified. Before the concrete has set, all is to be covered with a layer of composition as above, to be not less than one inch thick, put down in sections, and finished with indented pattern, flush with the curb and the vault lights."

The architect here has evidently worked on the supposition that ordinary practice will govern the laying of sidewalks and pavements. This is rather a long chance to take, as practice in this work varies greatly. Specifications applicable to this work are easily obtained if the architect wishes to use standard specifications, and should be inserted rather than to leave the contractor the leeway implied in the expression "approved by the architect."

"**Hollow-Tile Arches**—The floor of the basement near A1½ and A2½, the engine room, and also the floor and part of the roof of the elevator deck-house, are to have built in between the steel beams, hollow-tile hard-burnt terra-cotta flat arches, to be 10 inches deep, all laid in the very best manner in Portland cement mortar, on centers which the Contractor is to provide and set."

Here again the specification is incomplete, the architect probably having intentionally left it so, counting upon well-defined practice in this line of work. The kind of tile to be used, and more definite information as to the sizes, should be given.

"**Fireproof Partitions, etc.**—The partitions shown on plans for the elevator shaft, the pipe shaft, and the vent shaft, are to be built of first-quality hard-burnt, porous, hollow terra-cotta blocks 4 inches thick, laid in Portland cement mortar, plumb, true, and to a line, properly bonded and fitted to the iron framework.

"The roof of the deck-house to be lined with the same kind of fireproof blocks, properly fitted to the iron framework and set in Portland cement mortar.

"The furring shown on basement plan No. 2, against the vault walls, is to be of 4-inch terra-cotta blocks laid in Portland cement mortar.

"The columns in the basement are to be enclosed with the same kind of terra-cotta blocks, 2 inches thick, made to proper radii, and fitted and built up in the very best manner, properly bonded."

> As in the case of the floor blocks, the specification for column fireproofing should be more carefully drawn. The architect has no doubt depended upon the rules of common practice.

"**Metal Ceilings**—All the ceilings throughout, on all stories, including the basement and sub-basement (but not in the vault under the side-walk), and all other parts necessary, including skylights, bulkheads, curbs, etc., are to be covered with flat embossed No. 29 stamped mild steel sheets. The show-windows are included.

"The ceiling sheets are to be 2 feet by 8 feet, and the other parts are to be of proper sizes, all to be of the very best quality, uniform in pattern, straight and true, to have concealed lap joints."

> The choice of this ceiling, while apparently left to the contractor, was no doubt made by the architect. It certainly should have been so, and such should have been specified.

"Coves and mouldings, 10 inches deep, are to be provided for all first-story walls and partitions. Coves and mouldings, 6 inches deep, are to be provided for the walls and partitions on all the other stories. In all cases, a neat finish must be made at the walls; wood cover mouldings $1\frac{1}{2}$ inches wide are to be provided. The ceiling pattern is to be properly arranged for the gas and electric light outlets; the Contractor is to give the exact location of the pattern before the work is put up.

"Furring strips are to be 1 inch by $1\frac{1}{2}$ inches, and 1 inch by 2 inches, placed 12 inches on centers, securely nailed, properly leveled and blocked so as to allow sufficient space for the electric wire conduits; where necessary, the strips are to be doubled, and strips are to be provided for all cross-joints; walls and back of stairs and other parts are to be properly furred by the Contractor.

"The hung ceilings under the roofs will be furred down and prepared to receive the furring strips by the Contractor; the first-story toilet-room ceiling is to be furred down.

"The Contractor is to provide and put up on all walls and partitions 1-inch by 1½-inch plaster grounds near the ceilings, to which the plastering is to be finished, and for affording a nailing surface for the wood mouldings, before specified.

"All the sheet-metal work is to be painted on both sides, uniformly and evenly, one coat of best ...... white lead and pure linseed oil, and allowed to dry before it is delivered at the building. If in the opinion of the Architect, the coat of paint is not 'a good coat,' the Contractor must paint the sheet-metal work another coat as above specified, after the metal work is in place.

"All metal ceiling work is to be put up after the plastering is finished, and before the finished floors are laid; walls, etc., are to be protected."

"All the work is to be delivered complete and in a clean condition."

This is a clause that is invariably inserted in specifications, and the latter part almost as surely ignored by the Contractor.

"Samples must be submitted to the Architect for approval."

This clause is evidently inserted for the protection of both the architect and the contractor; but, as a matter of fact, it generally works out in favor of the architect alone. The contractor may submit samples for the architect's approval. The architect, however, seldom approves them in writing; but, upon his verbal approval, the contractor goes ahead and installs the work. If it is not what the architect anticipated, he is at liberty to, and very often does, cause the work to be changed, without allowing the contractor extra compensation for the extra work. If the form of samples were made imperative, and the approval properly made, much trouble would be avoided.

"**Lathing and Plastering**—The stud partitions and furrings on all stores, including those in the basement, are to be lathed with well-seasoned, dry spruce laths, securely nailed, joints broken every sixth lath, all laid horizontally.

"All the ceilings, except the vaults which are to be plastered, will be of metal as above specified.

"All the plastering throughout is to be of the very best quality; all brick walls and fireproof blocks are to be plastered two-coat work; all lathing is to be plastered three-coat work, with hair in the scratch coat.

"The parts hereinbefore specified under the head of 'Metal Ceilings,' will not be plastered.

"All the plastering is to be of either ...... cement, ..., or other equally good plaster, approved by the Architect, mixed and applied in accordance with the rules of the manufacturer. The Contractor may use machine-made mortar, provided it is free from loam or rubbish; machine-made mortar so used is to be mixed immediately before applying with one-half barrel of Portland cement to every cubic yard of mortar; but no sand, earth, loam, or other material is to be mixed with the machine-made mortar. Hard finish is to be of the very best quality—best lime putty and beach sand—highly gauged with plaster of Paris, troweled down to a smooth surface to the satisfaction of the Architect.

"All angles and corners must be true and straight; and finished corner beads, 1-inch radius, are to be run with a mould.

"Recesses for pipes, conduits, and pipes on the face of walls, jambs of windows (see detail No.), and other parts where required, are to be covered with metal lathing, securely fastened.

"All walls back of wainscoting and bases are to be plastered.

"All the columns of the basement, including those of iron, are to have moulded plaster caps; and the show-window columns are to have moulded caps.

"The window-jambs and heads of all exterior windows and of all interior partition windows, including the sills of the latter, are to be plastered, and are to have quarter-rounds—all as shown on detail drawing No. . The metal lathing at the bullnoses must be carefully done so as to avoid shrinkage cracks.

"The plastering must be delivered clean and perfect in every respect, upon completion of the building. All parts not clean will be cleaned and calcimined at the Contractor's expense."

This is a hard specification to fulfil, because of the carelessness in sub-contractors gouging holes and tearing out sections in walls. The result is about the same as that obtained when the specification requires work to be left neat and clean. The lack of consideration shown by various contractors for their fellow-contractors is not more plainly marked than in such a case as this.

"All plastering must be properly protected.

"All defects must be made good; and all necessary repairs and patching are to be done to finish up after other mechanics."

The same thing may be said of this specification as of the second preceding clause.

"**Marble Work**—The main entrance, the vestibule, and the entrance hall, the elevator enclosure, including walls, the staircase in back of the elevator, as shown on drawing No. , are to have wainscotings of white Italian Carrara heavy English veined marble. The borders forming the paneling and the capping are to be of imported fancy marble as selected by the Architect.

"All the work is to be as shown on drawings Nos. and . Samples of marble are to be submitted to the Architect for approval, within ...... days after the award of the contract.

"The trims of the main outside entrance, vestibule, store, and rear doors, are to be of wood; but base-blocks are to be supplied for same, of marble.

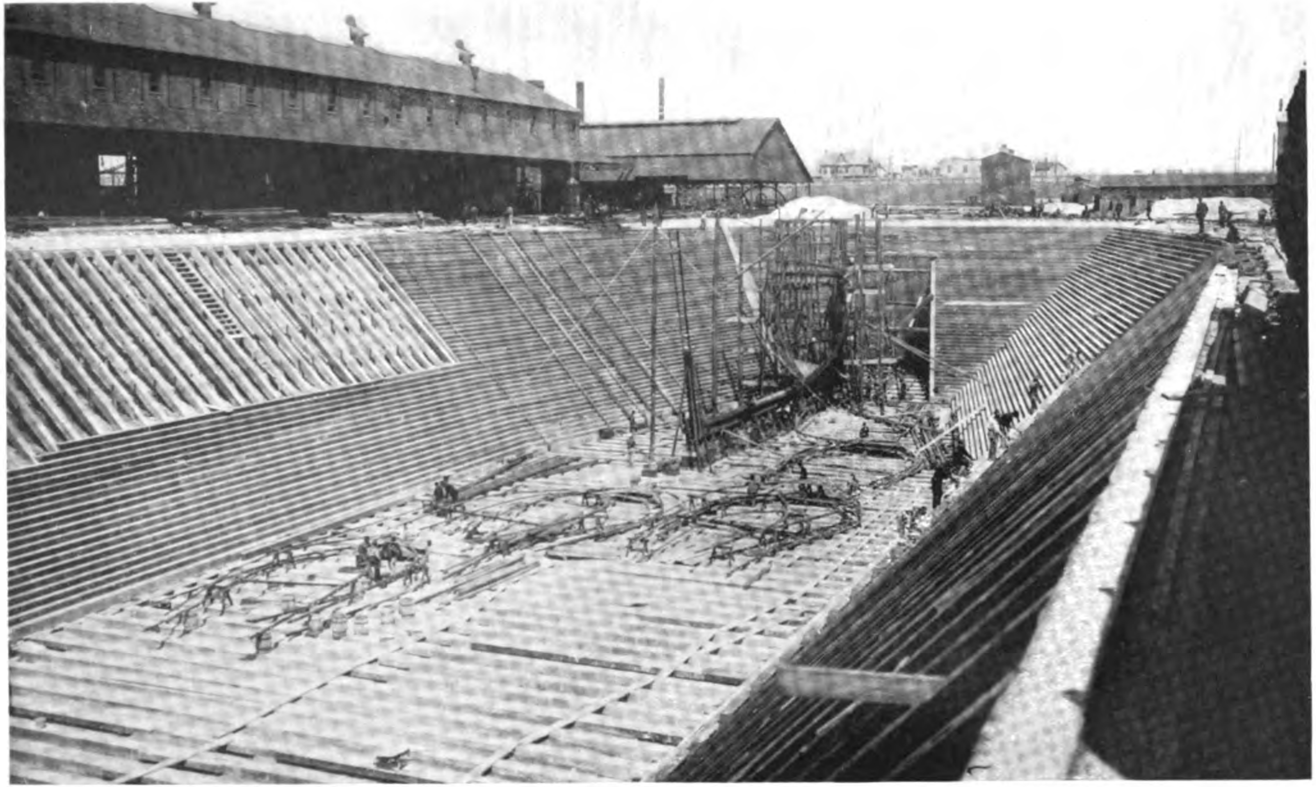
"All the marble is to be of the very best selected stock, all to be highly polished, properly jointed and fitted, of proper thickness, and in no case less than 7/8 inch thick, backed where necessary.

"The treads, risers, and platform of the stairs back of the elevators, on the first story to the door on the platform, are to be made of ...... marble. The treads and platforms are to be two inches thick, with polished half-round nosings. The risers are to be 7/8 inch thick, polished.

"All the toilet-rooms and lavatories on all stories are to have 16 inches high bases of polished marble, with the top edges polished; all the water-closets are to have rubbed platforms 1½ inches thick, countersunk the full width of the compartments.

CONSTRUCTION OF FOUNDATION FOR LARGE CONCRETE DOCK AT CLEVELAND, OHIO.

Four rows of oak piles.



CONSTRUCTION OF CONCRETE DRY DOCK AT PUGET SOUND NAVY YARD, WASHINGTON.

Concrete walls of dock lined with concrete blocks; concrete pavement.

"All urinal stalls are to have 1½ inches thick countersunk rubbed platforms, with stalls of ⅞ inch thick backs, 1½ inches thick partitions, ⅞ inch thick sides, and 1½ inches thick caps. All to be polished and to have exposed edges rounded.

"All the toilet-room marble is to be Carrara, English vein.

"The treads and platforms of all staircases will be of slate, as hereinafter specified under 'Iron and Steel Work,' except the treads and platforms at the start of the stairs on the first story, which are to be as before specified.

"**Terrazzo Floor Tiling**—All the terrazzo flooring is to be of the very best quality, 1½ inches thick, laid in the very best manner in panels, rubbed down, finished smooth and uniform, and to be finished with pure raw linseed oil, well rubbed down. The marble must be evenly distributed, so as to present a uniform finish and a true and even surface. White and colored marble chips, half and half, are to be used, in proper quantities so that there will be a minimum of cement exposed.

"Border strips and stiles of 3 rows of black marble mosaic, ¾-inch cubes, are to be laid, forming panels of no more than 35 square feet for the terrazzo flooring; and the terrazzo is to be cut through at the panels to allow for shrinkage.

"The following parts of the building are to have terrazzo flooring: In all the toilet-rooms throughout the building, except engineer's toilet-room, and in the first-story entrance, the vestibule, and the hall. The terrazzo is to be laid on top of the under-flooring, on tar paper supplied by the Contractor, and on top of metal lath also supplied by the Contractor.

"**Miscellaneous**—The Contractor must repair the street pavement in accordance with the rules and regulations of the Office of the Commissioner of Public Works.

"All the brickwork and masonry, etc., of the sub-basement and basement, where not plastered, is to receive two good coats of ...., ..., or other equally good cold water paint, applied with brush by hand in the very best manner, warranted not to rub off, and must be delivered clean.

"All the staircase walls and halls, and all other parts of the building where directed by the Architect, are to have the plastering calcimined one or two coats as directed; all must be delivered clean upon completion of the building.

"Do all cutting of work that may be required by and for other mechanics, and finish up after them."

This is one of the universal specifications, and is nearly always slighted.

"All rubbish and refuse materials of all kinds are to be removed as fast as they accumulate, and the premises must be left clean.

"In order to avoid the usual controversy as to the removal of rubbish, it shall be the duty of the Contractor to remove all debris, rubbish, refuse materials of all kinds whatsoever, whenever directed by the Architect.

"All the work must be delivered clean and perfect in every respect."

The last four clauses are intended to say the same thing in different ways.

"**Guarantees and Surveys**—The following guarantees and surveys are to be delivered to the Architect:

"1. Guarantee for all the asphalt work for one year after completion of the building."

More careful specification should be made of the guarantee required, as there are so many ways in which asphalt may become defective.

"2. Guarantee for the slag roof and all the metal work to remain tight for two years after the completion of the building.

"3. Guarantee for the artificial stone sidewalk for two years after the completion of the building."

By this guarantee, the architect probably intends to protect himself from the result of the careless specification made for this work.

"4. Guarantee for the plastering, to repair all blisters, cracks, and other defects, six months after completion of the building.

"5. The City Surveyor's certificate for the vault is to be delivered to the Architect.

"6. A survey of the property, after completion of the work, showing the location of all outside walls both at the sidewalk level and at the top of the building."

Brickwork guarantee, that the brickwork shall not change color, was made earlier in this document. It is well to place the guarantees together in one place, under their proper heading.

Iron and Steel Work

"**Shop Drawings**—The Contractor is to submit copies of all shop drawings to the Architect for approval, and no work is to be started unless such drawings are submitted to and approved by the Architect in writing.

"**Setting**—All the iron and steel work is to be set in the very best manner; all bearings are to be full and true, the Contractor providing all necessary scaffolding, trestling, shores, and braces that may be required. In all cases the work must be bolted and riveted together as it progresses. All channels, beams, and girders are to be set level; and all columns must be set perfectly plumb and in alignment.

"The Contractor must do all necessary cutting and drilling that may be required for other mechanics, and is to finish after them.

"**Painting**—All iron and steel work must be properly cleaned from rust and cinders, before paint is applied.

"All iron and steel work is to be painted on all sides, with two good coats of best red lead paint. One coat is to be applied and allowed to dry before the work is delivered at the building; and the second coat is to be applied after the work has been erected, except the cast-iron columns, which are to receive both coats at the building.

"**Steel Beams and Girders**—All steel beams and girders are to be of the sizes and weights for supporting floors, sidewalks, walls, etc., shown on the drawings.

"All steel is to be in accordance with the requirements of the standard specification governing the physical properties of structural steel adopted by the Association of American Steel Manufacturers."

If the work were large and important, and required any amount of special shapes or special work, a more careful specification would have to be made for the steel. Mentioning the standard specification as adopted by the Association of American Steel Manufacturers, is, however, sufficient in this case.

"All framing is to be done in the very best manner, and standard connection and ¾-inch diameter bolts are to be used.

"All the girders carrying the floor beams are to rest on the columns and piers; to be bolted to the columns by means of ¾-inch bolts. See details on drawing No. ."

The drawings should show this, thereby making this clause superfluous.

"All beams and girders resting on walls are to be provided with anchors as directed.

"**Cast Iron**—All cast iron is to be of the very best quality grey iron; and all castings are to be sound and perfect, free from blow-holes, honeycombs, cinders, cold chutes, seam marks, and other imperfections. All castings which are not first-class in every respect will be rejected.

"**Cast-Iron Columns**—All columns are to be of cast iron, to be true and straight, and must have a uniform thickness of metal. The ends are to be faced off at right angles with their axes. All to have lugs, brackets, and seats for beams and girders, and must be true and without a flaw. Brackets, lugs, etc., are to be cast on the columns to support the girders and wooden beams as shown on drawing No. .

"The ends of the columns are to have flanges of the same thickness as the shell of the columns through which they are to be bolted together by means of four ¾-inch bolts; all flanges are to be circular.

"All bolt-holes are to be drilled.

"All the columns must be put up plumb, and no shimming or wedging will be allowed.

"All the columns are to be drilled, two holes in opposite sides of the column, four feet from the bottom, to ascertain the thickness of the shell.

"**Cast-Iron Column Bases**—All the basement and sub-basement columns are to rest on cast-iron bases, to be cast with flanges, ribs, webs, and rings, as shown. The thickness of shells is to correspond with that of the columns. The top flanges are to be not less than 1¼ inches thick; to have bottom plates and ribs; and all to be of such sizes as shown on schedule drawing No. .

"The flanges on which the columns rest are to be faced off in a lathe.

"All column bases are to be firmly bedded on the foundations with Portland Cement mortar, without wedging. The mortar to be supplied by the iron Contractor.

"**Lintels**—Angle and channel lintels are to be provided for all the openings in interior brick and stone walls of the sub-basement and basement as directed.

"**Staircases**—All the staircases throughout are to be built of iron, with slate treads and platforms.

"All strings are to be of channels, with proper corner mouldings at the walls; and all risers are to be of cast iron.

"Fasciæ are to be provided to cover the staircase framing beams of crimped wrought iron No. 16, with angle-iron top to receive the railing, and angle at bottom to finish the ceiling, etc.

"The railings to be plain square bars ⅝-inch iron, spaced 5 inches on centers, with cast-iron newels, and handrail bar 1½ inches by ½ inch, ready to receive the wooden handrail. All necessary railings are to be provided, including the horizontal railings with cast-iron newels.

"The lower partition of the staircase to the second story in back of the elevator, to the door on the landing, is to be made with concealed strings and risers ready for marble (see plan No.). The upper part of the stairs to the second story is to be constructed with string to carry partition enclosing the same.

"The treads and platforms of all the staircases except part on first story at back of elevator, are to be of slate to be 1½ inches thick, with rounded edges on the nosings. Landing steps are to be provided for all staircases, and are to be 6 inches wide. All slate to be clear black, and to be rubbed and finished, except the under side; and all must be securely fastened, and must be warranted not to come loose within one year after the completion of the building."

Another guarantee out of its proper place.

"Wrought-iron plates not less than ⅛ inch thick are to be provided for all treads and landings under the slate, as required by the Building Code.

"On completion of the building, when directed, all slate work is to be well cleaned and oiled with raw linseed oil; and after the building is occupied, and at such time as directed by the Architect, a second coat of oil is to be applied.

"**Ladders**—Provide and set the following ladders: One from the sixth story to the roof; one for the tank on the roof; one from the roof to the deck-house roof; and one from boiler room to the sidewalk; all to have strings made of 2½-inch by ½-inch iron, with double rungs; the ladder on the roof to have 6-inch by ⅜-inch foot-plate; and all to have handrails as directed.

"**Elevator Fronts and Doors**—The door-frames of all the elevator enclosures for the first story and above, are to be as shown on plan No.   of cast iron moulded. A similar frame is to be provided on the front east side of the first story only, facing the street, and is to be glazed with wire glass, and to be similar to the doors shown on plan No. .

"All the doors to the elevator shafts, except the basement and sub-basement, are to be of wrought-iron tubing, with wrought-iron mouldings, etc., glazed with rough plate wire glass. The doors to the easterly elevator are to be arranged for one to slide and the other to be stationary; and the doors to the westerly elevator to be arranged for one to slide, and for both to swing out into the hall on pivots to allow full opening for freight. The overhead tracks to be ball-bearing; and approved latches are to be provided, to open on outside with key only. Angle-iron frames 6 inches by 4 inches, extending to the ceilings, are to be provided for all the iron frames above specified; these angle frames to have one leg in the shaft to form trim, and the leg on outside to be cut out over the door so that same does not project beyond the fireproof blocks, and plastering can extend over the same as directed. Heads of wrought-iron angles or of cast iron are to be provided as directed, and are to be arranged to allow room for overhead tracks. All to be properly arranged, and fastened to the floor and ceiling beams as directed.

"Angle frames are also to be provided for the elevator door openings of the basement and sub-basement, cut for plastering, etc., same as the upper stories.

"Wood metal-covered fireproof doors are to be provided for the basement openings of the shaft, to be arranged to slide the same as other doors above and to be glazed with wire glass."

More careful specification should be made of details of these fireproof doors. The types of fireproof doors on the market, and those made by contractors, vary widely.

"**Fence**—The Contractor is to supply the fence shown on plan at the foot of the court at first story, which is to have ¾-inch diameter steel bars with pointed tops spaced 5 inches on centers, and to have cross-bars of flat iron, the cross-bars to be built into the wall, and uprights leaded to blue stone coping. Fence to be 8 feet high.

"**Iron Doors**—Iron doors are to be made of $3/8$-inch by $1\frac{1}{2}$-inch iron frames, covered with No. 16 crimped iron, securely and properly riveted, hung on wrought-iron hinges, and provided with heavy bolts and locks.

"All the doors in the sub-basement are to be of iron, and the door to the sidewalk elevator in the basement is to be of iron.

"The coal vault door is to be made with a flap at the bottom, and is to be provided with bars extending across the same, with proper sockets on the door frame, as directed."

The number of bars required should be mentioned.

"The door to the deck-house on the roof is to be of iron.

"All iron doors at walls are to have cast-iron eyes properly built into the masonry.

"**Shaft Framing**—The vent shaft at the boiler flue, and the pipe shaft at the toilet-rooms, are to have $3\frac{1}{2}$-inch by $3\frac{1}{2}$-inch by $3/8$-inch angle posts at the corners, extending from the bottom of the shafts to and above the roof, as shown on plans. In the height of each story, there are to be two sets of cross-pieces made of 3-inch by 3-inch by $3/8$-inch angles extending from the posts to the walls, securely bolted with countersunk head bolts, and securely fastened to the brickwork.

"All the above framing is to be put up perfectly plumb, and is to be riveted together with ½-inch rivets, prepared to receive the fireproof blocks, and fastened to the wooden beams by means of lag screws and proper packing pieces.

"The deck-house, including the roof of the same, is to be framed with good and sufficient angles and tees, prepared to receive the fireproof blocks and the skylights.

"**Light Cast-Iron Work**—All cast-iron work is to be particularly well made and finished and of uniform thickness; and all castings must be clean and sharp."

> This specification is perhaps as clear as it is possible to make a specification for cast iron. Nevertheless, there is room for trouble to arise from difference in opinion as to what the terms "particularly well made and finished" and "clean and sharp" may mean.

"The front column at the rear entrance, first story, is to be made of cast iron as directed, with panels.

"The sills for the elevator door openings are to be special, and to have groove for sliding doors, to have nosing and beveled apron; and all are to be properly fastened.

"Door-sills with nosings and risers, all with 4-inch bottom flanges to receive the vault lights and sidewalks, are to be provided for all the entrances. The tops of the sills are to be checkered as directed; all to be made perfectly water-tight.

"**Vault Lights**—The vault light work comprises all the work shown on the first-story plan, including the trap doors, ventilators, and all the circular vault covers. Steps and risers are to be made as before specified under the heading of 'Light Cast-Iron Work.'

"The vault light work is to be that manufactured by ......, or by ......, or others approved by the Architect in writing; to be made of concrete construction reinforced with steel and iron, glazed with approved lights; to be laid in sections, with allowance for expansion and contraction; joints are to be calked with spun oakum, and pitched; all to be perfectly water-tight and guaranteed. The vault light work must be made of sufficient strength to sustain a uniformly distributed safe load of 400 pounds to the square foot.

"Ventilators are to be provided as shown on plan No. , made as directed, with top and sides and register faces with movable slate louvers, all as directed, and to be made perfectly weather-tight, to be operated by worm gear and pole. Two poles are to be supplied.

"The trap-doors at the sidewalk elevator are to be made as may be directed, of heavy angle and bar frames and No. 10 sheet iron, galvanized, hung on extra heavy brass butts, with proper fastenings, to have necessary hasps, staples, brass padlocks, rings, stays, guard bars, and holdfasts.

"Railings of galvanized iron pipe 2 inches diameter with malleable ball and flange fittings, are to be supplied and set for the opening of the sidewalk elevator, to be securely fastened and to have extra heavy chain on front.

"**Flagpoles**—Provide and set two first-quality spruce flagpoles, 50 feet long, 12 inches diameter at the butt and 5 inches diameter at the top; to be dressed and painted four good coats best white lead; to be stepped into proper cast-iron foot-blocks, placed on the roof beams properly bolted, and to be braced to the roof beams; to have 14 inches diameter gilt copper ball, lignum vitae truck, and two pulleys, and to have two best cotton halyards and galvanized-iron cleats. On completion of the contract, an additional coat of paint is to be applied.

"**Miscellaneous**—Polished cast brass saddles are to be provided for the entrance and hall store doors and all entrance doors, and for the vestibule doors; to be fastened with counter-sunk brass screws and expansion bolts.

"All necessary cutting, drilling, and tapping of iron and steel work that may be required by other contractors, is to be done by the Contractor, as the Architect may direct."

This may cause the contractor no little extra work. Some better specification than this should be made of it. If the architect in his design could not foresee the necessary cutting when comparing the plans for all contractors, the steel contractor certainly would not be able to foresee how much he would be called upon to do, especially if he were working on the structural plans alone. This is another way of making the contractor responsible for errors and omissions, and is to him unfair.

"**Guarantees**—The following guarantees are to be delivered to the Architect:

"1. Guarantee for all the skylight work for two years after the completion of the building.

"2. Guarantee for all the vault light work for two years after the completion of the building.

"3. Guarantee that the slate treads will not come loose for one year after completion."

All of these guarantees are superfluous as given here.

Carpenter Work

"**Centers and Lintels**—The Contractor is to provide and set on proper supports, strongly built centers for all arches in the walls. Timber lintels of proper sizes are to be provided and set over window-frames and door openings in brick walls, except those in the basement, which will be of iron, and for others in front wall where iron lintels are shown.

"**Timbering**—All the timbering throughout is to be of long-leaf Georgia yellow pine, to be properly framed, mortised-and-tenoned in the very best manner.

"The ends of all beams resting on walls are to be cut on a bevel of three inches, and must have a full level bearing of four inches.

"The Contractor is to provide wooden blocking, beveled to fit the bottom flange of the floor girders, and bolted to the same as shown on plan No. ; bolts will be provided by the Iron Contractor.

"Double beams are to be placed under all partitions running parallel to the same, whether shown on the plan or not.

"All the beams are to be of the sizes marked on the drawings, placed and framed as shown. All trimmers and headers are to be made of two or more beams, bolted together at the ends and at intervals not over two feet apart with ¾-inch bolts, with nuts and washers, to be furnished by the Contractor for double beams.

"Each tier of beams is to have double-bearing bone cross-bridging, spaced about 5 feet apart; to be made of 2-inch by 3-inch spruce, accurately cut and fitted, and nailed at each end with two 12-penny nails.

"**Lumber**—All lumber throughout is to be of the very best quality, for joiner work; to be kiln-dried, clear stock of the several kinds specified, to be selected and of uniform color.

"Finish of the first story to be of straight-grain white oak; and other finish throughout,

A ROW OF MODERN HOMES FOR WORKINGMEN AT GARY, INDIANA.

Brick, cement plaster, timber, and tile enter into the exterior construction of the houses.

unless otherwise specified, to be of straight-grain dark oak; this includes doors, windows, interior partition, sash, etc.

"**Partitions**—All partitions throughout, except those around the elevator, vent- and pipe-shafts, are to be built of 3-inch by 4-inch spruce joists, 16 inches on centers, with plates and sills, to be properly bridged and well nailed. At door openings, double joists are to be set. All joists are to be straight, and must be plumb and true.

"**Furring**—All the ceilings will be covered with metal, and the furring for the same will be done by the Contractor for the metal ceiling work as above specified; but the Contractor is to provide and put up all necessary blocking and timbering, to receive this furring. All the toilet-room ceilings are to be furred down to a uniform level, to cover the plumbing pipes and vent flues.

"All necessary furring of all kinds is to be done with proper materials, securely nailed, for affording nailing surfaces for lathing and metal ceilings and for finished woodwork, and wherever required.

"The roof is to be furred up by means of 3-inch by 4-inch joists, not over 18 inches on centers, for the roof planking, as shown and as directed; valleys, hips, and breaks are to be formed.

"Furring for metal lath is to be provided around exterior and interior windows (see details on plan No.).

"**Plaster Grounds**—Plaster grounds are to be set to all openings, and where necessary for nailing surfaces for the trims, wainscots, bases, etc. All are to be perfectly true, and must be securely nailed.

"**Roof Boarding**—The roof is to be boarded with first-quality tongued-and-grooved, matched hemlock $1\frac{1}{8}$ inches thick, not over 6 inches wide, well surface-nailed. Proper hips and valleys are to be formed; and the top of the roof cornice, and the roof at bottom of fire escape, the tops of the show-window cornices, and other parts, are to be covered with the same kind of boarding, the Contractor providing all necessary sleepers, blockings, and furring that may be required for the same.

"**Underflooring**—All the floors throughout, except the sub-basement, are to have an underflooring of square-edged, matched, first-quality hemlock, $1\frac{1}{8}$ inches thick, not over 6 inches wide, well surface-nailed to each beam; all to be laid diagonally.

"The underflooring is to be laid as the building is erected, as required by the Building Code.

"**Flooring**—All the flooring throughout is to be of No. 1 maple, tongued-and-grooved, $\frac{7}{8}$ inch thick and not over $3\frac{1}{2}$ inches wide, to be well blind-nailed at each beam, laid in courses, true and straight, planed off at the butts and joints. The staircase platforms, toilet-rooms, and halls are to be of the same kind of flooring.

"There will be no wood flooring in the boiler and engine rooms in the basement, or in the entire sub-basement.

"Trap doors are to be provided in the flooring over the house traps.

"On completion of the building, the floors must be delivered clean and in perfect condition."

This is a specification for cleaning up that can easily be enforced.

"**Thresholds**—All doors, except the outside entrance doors, store entrance doors, and elevator doors, are to have finished cherry or oak thresholds, moulded, properly fitted and nailed.

"**Windows**—All windows of the fronts on the third story and above, and all rear windows, are to have box frames and double-hung sash, to be as shown on detail drawing No. .

"Rear windows to be 'fireproof' as hereinafter specified.

"Transom sashes over doors to be made the same thickness as doors, to be rabbeted, to have rabbeted bronze centers and transom lifts and locks.

"The transom sashes on the show-windows to be 2 inches thick, and to be pivoted and provided with catches, etc., as directed.

"The transom sashes over the hall entrance doors are to be stationary; and over the store entrance doors and vestibule doors, to be pivoted.

"The windows in the wall of the elevator shaft and the court and gable walls will be fireproof as hereinafter specified.

"**Show-Windows**—The show-windows are to be built as shown. The base of show-windows must be substantially built; and the exterior of the base, transoms, etc., will be of white pine, the interior of the same to be finished in straight-grain white oak. The cornice will be of metal under another contract; but the Contractor is to do all necessary blocking, furring, etc., for the same.

"The glass is to be set up without sash or corner-posts; but all necessary mouldings, framework, etc., that may be required are to be supplied to make a proper finish as shown. Inside is to be cased and trimmed in oak, to be furred for metal ceiling and plastered jambs.

"The cornices of the projecting show-windows are to be furred, and are to have 4-inch steel angles and tees supplied by the Contractor, and fastened to the steel beams above and to extend out (cantilever); and the transom frames are to be supported on and braced to the same, and must be perfectly rigid. The transom bars of the show-windows along the bottom of the transoms of the projecting show-windows are to be reinforced with 2-inch steel angles.

"**Metal Fireproof Windows**—All fireproof windows are to be made as before specified for other windows, and hung and fastened in the same manner, except as otherwise directed.

"All the sills, pulley stiles, outside casings, hanging stiles, parting strips, and the sashes, etc., are to be of No. 24 galvanized iron; are to be hollow, to be properly finished, free from buckles, indentations, or other defects, all to be made in accordance with the requirements of the Building Code and the Rules and Regulations of the Board of Fire Underwriters. Hardware same as specified for other windows.

"Samples of windows must be submitted to the Architect before the frames are delivered.

"**Doors**—All doors are to be paneled and moulded both sides.

"The main entrance doors, and the store entrance and hall doors, are to be 2½-inches thick; the two vestibule doors are to be 2 inches thick; all doors from halls to lofts and offices, and the door on the first-story staircase, and all other doors throughout, are to be 1¾ inches thick; fanlights are to be the same thickness as the doors.

"The entrance doors, store entrance and hall doors, the vestibule doors, the door on first-story stairs, the doors at the stairs in basement and sub-basement, doors from halls to lofts and offices, and toilet-room doors, are to have the upper panels glazed.

"All doors are to have stiles and rails made of best pine stock glued up, covered with ¼ inch thick straight-grain dark oak veneers, mouldings and panels solid, except doors on first story, which are to be of white oak.

"All doors are to be warranted not to warp or twist, and must be well fitted.

"All the toilet-room doors are to have glazed panels above five feet above the floor; and the lower panel of store toilet-room door is to have stationary slat louvers mortised into the stiles, as directed.

"All other doors not mentioned are to be made as directed. The doors to fire escape, and doors to the pipe shaft, will be fireproof, as hereinafter specified; and trims for the same are included in this specification.

"**Metal-Covered Fireproof Doors**—All the fire-escape doors and pipe-shaft doors on all stories, including the first story, are to be made of kiln-dried, first-quality, clear white pine, properly framed and paneled, all covered with calcimined iron in manner approved by the Architect and in accordance with the requirements of the Building Code, and acceptable to the Department of Buildings.

"Metal-covered jambs and heads are to be provided.

"**Hardware** throughout is to be of the very best quality, of either .... Mfg. Co., ... Mfg. Co., or other equally good make, approved by the Architect.

"Samples of all kinds of hardware are to be submitted to the Architect for his approval.

"All knobs, escutcheons, butts, hinges, flaps, sash-lifts, and sash-fasts, facework of locks, bolts, latches, catches, strikes, nosings, door checks, and all other work exposed to view, are to be of real cast bronze, extra heavy, polished, of such designs, patterns, and finish as the Architect may select.

"Stamped work, pressed work, or imitation bronze will not be accepted.

"The front windows of the second and third stories are to be pivoted vertically on heavy .... pivots, and are to be fastened with two mortise bolts with lever handles and large adjustable stays.

"Transom sashes and fanlights are to have extra heavy bronze sash centers, friction centers, ... or other equally good lifts and locks, and all necessary fixtures complete.

"All locks are to be mortise locks, not less than 5-inch, of approved pattern; bolts, knobs, escutcheons, etc., are to be of cast bronze, polished, of such pattern as may be selected. Double doors are in all cases to be provided with proper size bronze-face flush bolts, set into the edge of the door. The outside entrance doors and the store entrance and hall doors are to have extra large ornamental escutcheon plates, handles and thumb latches combined, as the Architect may select, with Yale store door locks.

"All the hall doors to the offices and lofts are to have .... or other mortise cylinder locks, with corrugated keys, as the Architect may select.

"The hardware for the fireproof windows and doors is to be the same as that specified for the other windows and doors, and lock to door to be with bolt on the inside, and no knob on the outside except for the first story.

"All small doors, and the door for each electrical distribution box in the building, and the pipe-shaft doors, are to be supplied with butts and locks with keys; keys to pass as directed.

"All hardware throughout must be furnished in sufficient quantities and of proper sizes, whether the same is especially mentioned or not; all to be provided complete in every respect, and must be in perfect working order.

"All other hardware necessary for the complete finish of the work, not particularly described, is to be furnished, of such sizes as may be directed.

"In case any of the hardware is not of the very best kind, and not in accordance with the samples furnished, the same will be removed and replaced at the Contractor's expense, and the Contractor will be liable for all work injured thereby.

"**Glazing**—All glazing is to be done in the very best manner, all to be well sprigged and back-puttied

"**Polished plate glass** of the very best quality, not less than 1/4 inch thick, large sheets 3/8 inch thick, is to be used for glazing the show-windows, the main entrance doors, the store entrance doors, the vestibule doors, and transom sashes over the same, and all the front windows on the second and third stories.

"The show-window glass is to be put up without mullion or corner posts; special nickel-plated clips satisfactory to the plate glass insurance companies are to be used.

"The edges of the glass are to be cut, and glass pieces are to be set back of joints to reinforce the same. All to be made water-tight.

"**Wire glass** of the very best quality, $\frac{1}{4}$ inch thick, solid cast (without selvedge) figured pattern, is to be used for glazing, all the doors and transoms from the halls to the lofts and offices, all toilet-room doors, fire-escape doors, and shaft windows, and all windows in the court and gable walls on all stories, except where polished as below specified, and for the doors at the first-story staircase and doors for basement and sub-basement stairs, and for the windows.

"**American sheet glass**, double-thick, of the very best quality, is to be used for glazing the front windows of the fourth story and above, and all other windows throughout not otherwise specified.

"**Bases**—All walls, partitions, boxed columns, etc., on all stories, are to have moulded and subbed bases, 8 inches high on the first story, and 6 inches high on the upper stories and in the basement (see detail drawing No.). All to be of dark straight-grain oak, except for the first story, where they are to be white oak.

"**Wainscot**—The wainscot in the first story will be of marble as hereinbefore specified.

"**Painting and Finishing**—All the woodwork throughout is to be putty-stopped in the very best manner, and all iron work and metal work is to be putty-stopped.

"All hardwood, except flooring, is to be stained, filled, and varnished two good coats, and rubbed down, before it is delivered at the building; and an additional coat is to be applied and rubbed down after all the work is in place; all must be finished in an even and uniform color throughout.

"All the other woodwork, all the iron work, both inside and outside of the building, including iron stairs, elevator doors, iron doors, fire escapes, iron frontwork, interior iron columns, gas meter brackets, galvanized-iron work, trapdoors, gratings, fireproof doors and windows, etc., and other work shown and specified, also all roof houses, bulkheads, tank on roof, skylights, ventilators, and vent flues in basement, plumbing and gas pipes, exposed electric conduits, and all other work as the Architect may direct, are to be painted three good coats of the very best .... white lead and pure linseed oil, tinted as the Architect directs.

"All the metal ceilings throughout, including the basement and sub-basement, are to be painted three good coats of the same kind of paint, in addition to the prime coat applied under another contract; and if three coats will not make a satisfactory job, another coat is to be applied.

"All the hardwood work throughout is to be stained and filled with .... filler or such filler as the Architect may direct; and three coats of ...., ... or equally good rubbing varnish of the very best quality are to be applied, to be well rubbed down to a smooth surface.

"Samples of graining and of colors are to be provided for approval.

"Any work not specially enumerated is to be painted, grained, and finished as the Architect may direct.

"On the glass of the transom sash over all the entrance doors, gilt numbers 10 inches high are to be provided, to be done in the very best manner. Gilt numbers two inches high are to be provided on the glass of all hall office doors, as directed.

"On all the elevator doors on each story above the first story, numbers in black, 6 inches high, are to be painted as directed.

"All the work throughout must be delivered clean and perfect in every respect.

"**Miscellaneous**—The plumbing work is to be fitted up as directed; runs and backs for pipes are to be put up where directed; pipes are to be covered with finished casings, fastened with round-head brass screws.

"The Contractor is to do all necessary cutting of work included in this specification for other mechanics, and must finish up after them.

"The Contractor will be responsible for the condition of his work until the completion and acceptance of the building."

Sub-contractors are, of course, responsible to the contractor for the condition of their work; and if he makes them live up to specifications as he may expect that he himself will have to do, trouble will be avoided under this specification.

"On completion, all the work is to be left clean. All rubbish and refuse materials must be removed promptly from the premises as fast as they accumulate; and all floors are to be scrubbed twice, and all the glass in the windows and doors must be washed.

"The Contractor must protect his work properly, and must deliver the same complete, clean, and in a perfect condition."

The last two clauses have been specified half a dozen times before.

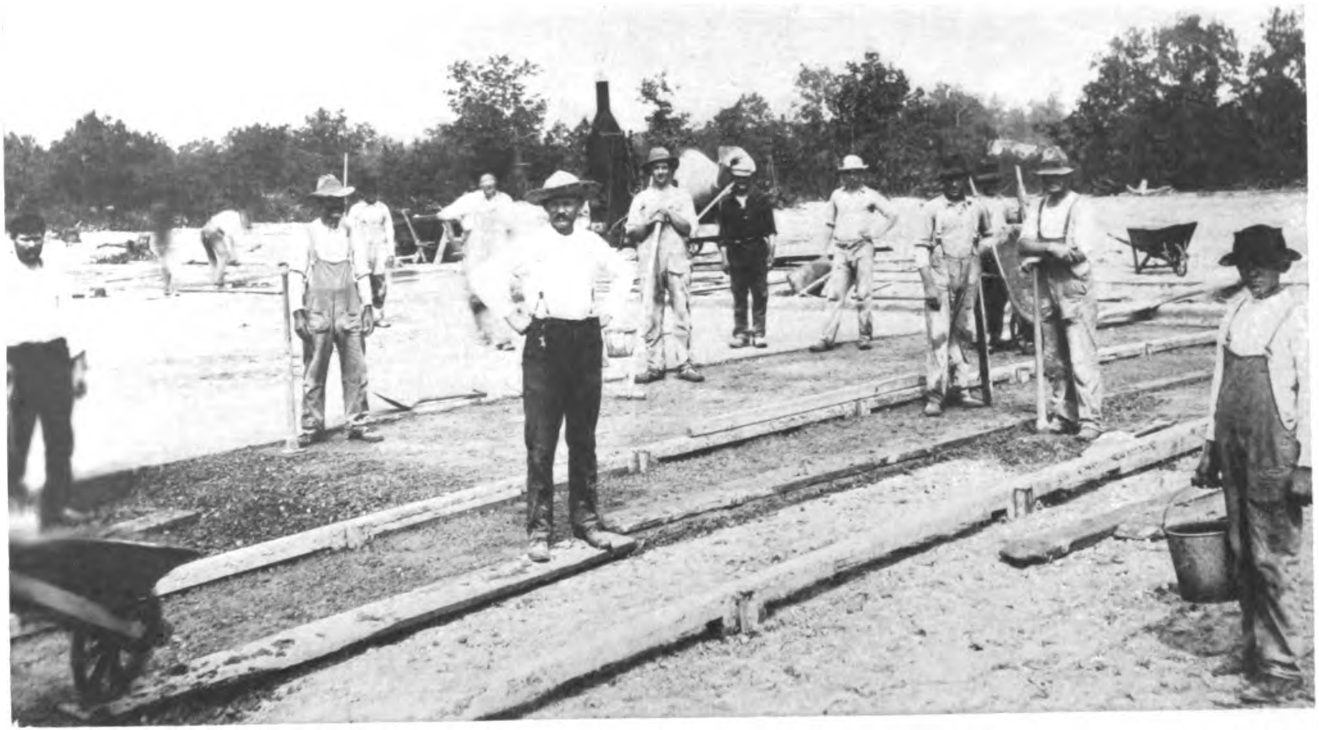
Accepted.

____
Owner

____
Contractor]

. . . .

. . . ., 19. .
(Date)



GANG OF CONSTRUCTION MEN LAYING PAVEMENT FOUNDATION.

Estimating

To predict with accuracy what it will cost in time or money, or both, to accomplish work, is at best an exceedingly difficult task. To begin with, in out-of-door work the conditions are—many of them—speculative. We do not know the personalities of most of the men who are to be employed; we do not know how much rain or frost we shall have to contend with; and we are required to work under a contract many of the terms of which are vague, and some of them prohibitory. What wonder that estimates for the same work differ—and differ widely? There is a certain cost at which projected work is going to be done; but no two men will guess alike before the fact; and, after having guessed, no two men would come out with the same figures of performance on identically similar jobs, if it were possible to get together two identically similar jobs. In this volume we have given a number of conditions which affect costs, without by any means exhausting the possibilities of the field. An ideal estimator should take into consideration all the conditions which affect costs, and should allow each condition to have just the correct influence upon his figures.

Conditions Affecting Cost. The conditions affecting the cost of construction work will naturally group themselves into three classes:

1. Those whose **quantitative** effect upon cost can be reasonably predicted.
2. Those of which the **qualitative** effect can be determined only in advance.
3. Those conditions the influence of which may be to increase or perhaps to decrease the cost above or below an assumed normal.

By way of example, (1) we can say in advance about how much more it will cost to haul bricks two miles along a known highway than to haul the same bricks only one mile along the same road; (2) we know that when we have to blast out a medium-hard shale, the work will cost more if the rock is full of seams and faults, with dikes of hard material, than if ordinarily regular in structure; but just how much more, or even nearly how much more, we cannot predict. Again, (3), the coming of a new superintendent upon the work will surely have an effect upon it, good or bad; but until he has been tried out, there is no telling which it will be. This last-mentioned fact accounts in large measure for the reluctance with which contractors let their old men go after they have run out of contracts.

In addition to the above, there are emergency and unforeseen conditions that from time to time unexpectedly arise and make a carefully prepared estimate seem like a poor affair.

Obviously it is impossible to eliminate the element of uncertainty in estimates. The problem for us is how to make the **closest estimate possible from the known facts.** The most careful rules and the most elaborate system, if followed, would not reduce the art of estimating to an exact science. Much must depend upon the intelligence, the information, the aptitude, and—above all—the experience of the estimator; lastly, he must have the elusive and intangible but nevertheless positive and essential quality of judgment, without which all theory is helpless.

It is possible, however, by the use of cumulative evidence, to reinforce a man's experience with the facts contributed by other men; and it is possible, by the presentation of correct theory, to show a man how to make his own experience of the most value with the least effort and fatigue. As a step in this direction, the present article has been prepared.

Men Who Make Estimates. Estimates in general are made by three classes of men:

1. The **Engineer** or **Architect**, who makes them as the basis for designs, preliminary to obtaining contracts.
2. The **Contractor**, who undertakes to carry out the work.
3. The **man in the field**, who is carrying on the work.

1. **The Engineer or Architect.** The engineer or architect who makes his estimates as a guide to his client in deciding what work shall be planned, is usually in the position of the man who estimates without having to carry out the work himself; and he is always in great danger

of making his estimates too low. The reasons for this are not generally appreciated. Some of them are as follows:

(a) His client is seldom willing to pay for a thorough investigation of the conditions that are to be met, it being assumed that since a contractor is willing to spend his own money in making an estimate on the chance of obtaining a profitable contract, the cost of estimating is so low that the engineer or architect can do it himself out of what he receives as his fee, and that it should therefore be a part of his office expenses. He cannot afford to make an extended investigation at his own expense, and thus fails to take into consideration many conditions which are more likely to increase the cost than to decrease it.

(b) As the business of the engineer or architect is to make designs, and as he is not particularly concerned with their execution except as an overseer, he seldom has actual experience of what it costs to do work, and is obliged to depend upon his records of contractors' bids on work of the class that he is contemplating. Since his figures on these bids are not in sufficient detail to make them applicable to his work except in a general way, he is at a serious disadvantage as compared with a contractor; and his disadvantage consists specifically in not having at hand a large number of facts which go to make up the contractor's cost. The engineer or architect seldom considers—because it has not been

PART OF MORE THAN 1,600 MILES OF STEAM RAILROAD TRACK IN COURSE OF ELEVATION IN CHICAGO, ILLINOIS.

With the completion of this work—which is being carried out at the expense of the railroads themselves—all grade crossings in the city will be permanently abolished.

brought to his attention—the fact that the contractor must pay from 1 to 10 per cent of his payroll for liability insurance, and, after he has paid for liability insurance, he has such items as bad bills, lawsuits (outside of his liability insurance), discounts, and the like, all of which have to be taken care of by his average receipts. The estimating architect is therefore prone to make use of published data of costs, without adding anything for these special contingencies, thus frequently getting into serious trouble.

(c) The owner, or his representative, usually draws a contract which the contractor is expected to sign; and this contract contains clauses intended for the reasonable protection of the owner, but which are too often liable to result in an unreasonable hardship upon the contractor. The owner's engineer—be it said to the credit of the profession—is, in the large majority of cases, both fair-minded and unprejudiced; and it has long been a maxim of the engineering profession to give a contractor the benefit of any doubt as to the interpretation of any specific clauses. Often the man who draws a contract by way of insurance puts in clauses which are intended for protection against certain contingencies, but which may become operative in a number of other ways; and the contractor is obliged to put on a high price, rather than run the risk of large financial loss in the event of such clauses becoming operative. The following is a clause taken from the standard steel specifications of a large railroad:

"The Contractor shall so conduct his work as not to interfere in any way with the operations of the road or with the work of other contractors, or close any thoroughfare, by land or water, except by the special permission of the Chief Engineer. The erection shall be carried on with despatch, and in such manner as may be designated by the Chief Engineer."

This sort of clause, if enforceable, is one that makes the Chief Engineer the absolute arbiter or controller of the financial success or failure of the contractor on the work. To build a bridge on a railroad that is in full operation, in such manner as not to interfere in any way with the operations of the road, is one of those amusing inconsistencies that cost money. The author has had to do with many railroad bridges, and yet has to meet with a single instance in which a railroad bridge was built under traffic without in some measure interfering with the operations of the road. Such a clause as this means, of course, that the contractor must do his work with the minimum reasonabe interference with the railroad; but it does not say so, and a contractor signing a contract with such a clause puts his head in the lion's mouth, and bids accordingly—often to the engineer's surprise and humiliation. Ambiguous specifications will force a careful contractor to bid high, and, by offering a reckless contractor an inducement to bid low, will result in almost surely placing the contract where it will be inefficiently performed. The reckless contractor is not generally a good manager; and the careful contractor, if he gets the contract, will require more money than he would have been willing to work for had the specifications been precise.

(d) When work is done under national, state, or municipal authority, the law usually provides that the contract shall be let to the lowest responsible bidder; and everyone has an opportunity to bid. On private or railroad work, on the other hand, usually a selected number of contractors are invited to bid. In the former case, the architect or engineer has to guard against a contractor taking advantage of loose clauses, and must fortify himself—which he usually does—by making the terms as much one-sided as he can. The contractor who knows him personally, who knows the object for which the strict clauses were drawn and the extent to which they are to be enforced on the work, is thus enabled to make much lower prices than the man to whom the individual in charge is an entire stranger. This accounts for part of the large diversity of bids on any public work, and is a further reason why such bids, when published, are a very poor basis on which to make estimates.

2. **The Contractor.** In making estimates, the contractor is generally more expert than the owner's engineer or architect, because he is con-

tinually being confronted with the financial problem, and naturally makes more of a study of it; nevertheless his estimates are very difficult to make properly, for reasons among which are the following:

(a) The contractor rarely, if ever, receives compensation for his labor in preparing an estimate, and that labor is frequently very considerable; therefore he makes the estimate with as small a cost to himself as possible.

(b) The time within which the contractor must prepare his estimate is limited, and generally too much limited, so that he seldom has opportunity properly to investigate the conditions under which he is to bid.

(c) When ten men are to bid on one piece of work, it is manifestly unfortunate that each of the ten men should pay for an investigation which can as well be made by one; and yet it is seldom practicable for the bidders on a piece of work to combine and obtain all the information. For instance, in a job involving earth and rock work for foundations, unless the job is very large the owner rarely makes sufficient test borings to thoroughly determine the existing field conditions; and yet the total cost of one investigation made by the owner would be very much less than the cost of all the investigations made by each contractor individually. The owner's point is that the successful contractor will make enough money to pay for the investigation; but it is almost never appreciated that when a contractor obtains a contract, he must make enough profit to pay for the investigation not only on that contract but for all those on which he has been unsuccessful as well; and the average of his bids must therefore be correspondingly higher than if it were the general practice among owners to furnish complete statistics when asking for bids.

The writer had occasion to bid on a large bridge for a municipality in West Virginia, on which almost no information from the municipality was forthcoming. Each contractor made an investigation more or less thorough, and was obliged to furnish his own design. The result was that over fifty bids, fifty investigations, and fifty designs were submitted, ranging from a minimum of about $40,000 to a maximum of about $140,000. All bids were rejected; and the municipality, reinforced and greatly benefited by the discussion that arose, re-advertised for bids. It is needless to add that the author did not bid again; but the question is, who paid for all those estimates?

(d) After bidding upon work under a certain architect whom he knows, and whose attitude on certain clauses in his specifications he considers himself reasonably able to predict, the contractor may be confronted by a change of architects, and the new man may be more strict than the old. This is a danger more to be feared in long contracts than in short ones. In the former case, it is likely to be a very serious matter, and frequently offsets the advantage of having time thoroughly to organize and systematize the work.

Remedy. It will be noted that all of the causes for inaccurate estimates which have been pointed out above could be very largely remedied if two rules were rigidly adhered to by parties who ask for bids—namely:

First—Make specifications as specific as the limitations of language will permit.

Second—Obtain all available information before asking for bids, and furnish it to the contractors.

3. **The Man in the Field.** In order to reduce costs in the field, it is necessary to make estimates so as to know how the work is progressing. The field chief or superintendent frequently has to make estimates of the cost of work in progress.

Purposes of Estimates. The purposes of an estimate are to enable a contractor to know what it is going to cost in money or in time, or both, to carry out work. There is usually in contemplation a contract of one of the following forms:

1. Lump Sum;
2. Unit-Price;
3. Cost plus a Fixed Sum;
4. Cost plus Percentage.

1. The first and oldest form involves the describing, by means of plans and specifications, what is to be done, and a guarantee by the con-

tractor to perform all the work for a fixed consideration. After the contract is signed, it is up to the contractor to get the work done, and the owner is supposed to have no responsibility beyond making the specified payments. The contractor assumes all risk, and meets all difficulties whether foreseen or unforeseen.

2. In the second form of contract mentioned above—the Unit-Price—the contractor receives an established price per yard, per pound, per ton, etc., and the owner assumes responsibility for the quantity. Since changes in plan involving increase or decrease of the amount of work are usually an accompaniment of most contracts after the contracts have been signed, this type admits of more elasticity than the first for meeting this condition.

3. Of late years, in order to permit of freedom in making changes without interfering with the liability of the parties, to save time, and for other reasons, the cost-plus-a-fixed-sum type of contract has come into vogue. Its advantage, among others, is that the contractor is under no risk, and therefore cannot be put out of business; and where the quantity and conditions cannot be determined beforehand, it has much merit. One argument against it, from the standpoint of the owner, is that the contractor, not having anything to lose, will not be likely to strive as hard for economy as he would if he guaranteed the price.

4. The fourth form of contract enumerated

above—Cost plus Percentage—has long been used on railroad work, and usually provides that the contractor is to receive as his compensation and for his overhead charges a certain percentage of his pay-roll, with plant rental added. On this basis the contractor has nothing to lose; and the owner is at the disadvantage that the less the contractor's economy of operation, the greater is the contractor's financial gain, so that the contractor apparently has an incentive to wastefulness. Many contracts, especially on road work, require the contractor to maintain the finished work for a certain number of years. This places a peculiar hardship upon the contractor who is not expecting to remain long in that locality, thus eliminating the journeyman contractor. It requires, however, that he shall keep a considerable amount of money invested in plant at the call of that particular job, and therefore tends to impel a conservative man to bid high.

Warning. The man who is entrusted with the making of important estimates has resting upon him a large responsibility. His blunders may beggar him or his employer; yet too often cheap men of limited experience are employed on this work, and rules are accepted as substitutes for judgment. Effort has been made in this article to make the methods of estimating simple and the theory clear; and to the younger men of the profession, it may seem that estimating is easy. Nothing could be farther from the truth. All that we can hope to have done is to boil down some of the gambling features of estimating, and place it upon a rational plane. To claim more would be dishonest and misleading. When a man says that he can safely estimate the cost of outside work within two per cent of performance, he may at once be written down as a fool or a liar. The difference in cost between a job that is run with ordinary methods and ordinary management, and the same job with proper cost analysis and thoroughly up-to-date management, handled with push and snap, may easily be 30 per cent; and the claim of ability to guess within two or three per cent, without knowing a large number of the uncertain elements, is absurd. Therefore, in making use of this article, the reader must bear in mind that it is not attempted to predict what he or his organization will be able to do. A schedule is presented, covering most of the items on the main classes of work discussed in this treatise, the use of which should prevent many blunders of omission; but the reader must not understand that we claim to have given him a substitute for brains. He must use his own good judgment in every case.

With this preliminary consideration of general principles and conditions, we now pass to the specific discussion of estimates.

GENERAL RULES FOR ESTIMATING

An estimator should rigidly adhere to the following general rules:

1. Make all estimates in the fullest possible detail.

2. Get together and classify all the available data before commencing to figure.

3. Use a carefully prepared standard schedule of items for the classification.

4. Go over the ground with great care—visiting the site of the work, if possible—to guard against the omission of items not provided for in the standard schedule.

5. Put down all the unit-quantities first; then all the unit-prices; and finally, make the arithmetical computations in such manner that you will not know even approximately the final results until all the figures have been thoroughly gone over and tabulated.

6. Check over the final results by every available means, such as contract prices on similar work, which are unsatisfactory as preliminary data, but may be very useful as a check.

The reasons for these rules are as follows:

1. At first sight it would seem that it requires more labor and time on the part of the estimator to make estimates in elaborate detail than to make them in general. This, however, is not the case according to experience, since a much larger part of the detailed estimate can be done mechanically than when many of the items are lumped, and because the more elaborate the detail, the more confidence a man has in his own figures, and the faster he is able to work.

When an estimate is made in careful detail, gaps in the available information become apparent; and in this way it is easy for an estimator to know just what information he lacks, and where the dangerous parts of his estimate are likely to be. Then, again, an estimate made in detail is much more easily checked by the subordinate or by the estimator's superior officers; and, when filed for reference, such an estimate is a document of great utility in future work. When the field costs are properly prepared, they can be used to check up the estimate for the work, in a way that is not possible if the estimate is not made in full detail.

2. It is a psychological fact—one based on the natural tendencies of the human mind—that if an estimate is made as the figures come in, it is impossible to obtain as good a grasp of the general problem as when the data are first collated, and the estimate then prepared on the data. While the estimates should be made in full detail, this does not mean that they should be made for different items of the work independently, since all parts of a piece of construction work are to a large extent dependent upon one another; and thus, if the estimated cost of one item is set down before the other items are known, their interdependence or mutual relations will not be appreciated and will not be allowed for in the estimate.

3. Rolling off a log is a difficult and elaborate feat compared with forgetting items in an

estimate; and it has been found, from wide experience, that **the best way to avoid omitting items is to start with a standard schedule.** To write a zero after an item that is not going to come into the estimate, takes practically no time; and the use of such a schedule in all cases is excellent insurance against blunders. A good plan is to have such schedules in stock, printed on sheets of coarse-ruled paper.

4. It is a sad fact that a great many estimates are made without the estimator ever seeing the work. This is utterly wrong; and it should be an invariable rule that the estimator must go over the ground, and go over it thoroughly; else it will be impossible for him to use the essential quality of judgment. Moreover, there is nothing like a physical view of the field for enabling a man to grasp all the details of the work. For this purpose, plans are of great assistance in the detailed analysis; but they are no substitute for a good look at the ground.

5. An estimate, to be accurate, should be **absolutely unbiased**; and where a question of judgment is involved, it is essential that the estimator make his figures without regard to what they will amount to in the grand total.

6. After the grand total has been computed, it should be checked; and the checks may throw some light upon erroneous items, which can then be corrected. The estimator's judgment will be a great deal more accurate if he works the problem out in detail first, than if he tries—perhaps

sub-consciously, or without fully realizing the fact—to work to a desired or hoped-for result.

The practice of taking somebody else's contract price as a base for figuring, is very deceptive if you do not know what specifications he had, how he intended to do his work, what layout he anticipated, and what his financial arrangements were. All of these items are of the utmost importance in figuring the economics, or the financial features, of any particular piece of work. Conditions vary in places short distances apart; rates of wages vary in different parts of the country; specifications, and the interpretations of identical specifications by different engineers, vary greatly; the bid prices are frequently too low or much too high; the bid prices may be purposely "unbalanced"—that is, made abnormally high on certain items, and abnormally low on others, but always so as to offset one another and "even up" in the grand total; a unit-price for a large job is usually too low for a small job, on account of the falling percentages, or relatively lower rates, of overhead charges and superintendence on the larger jobs; a contractor well equipped with plant can usually bid lower than contractors not so equipped.

STANDARD SCHEDULE

The following is a good standard schedule for the work covered in this volume:

Job Number— **Page Number—**
Estimate Number— **Date—**

VI. Type of Work

Field Conditions

ABBREVIATIONS

C A.......Amount of work.
C Ek......Kind of equipment available.
C Ec......Condition of equipment.
C F.......Character of superintendence available.
C G.......General layout.
C H.......Time of year when work will probably be done.
C Lk......Character of labor available.
C Lq......Condition of labor market.
C Lr......Rate of wages.
C Mq.....Kind of material to be handled, and its quality.
C O.......Management.
C P.......Kind of power to be used on the majority of the work.
C S.......Kind of supplies to be handled, and probable means to be em-employed in getting them on the work.
C Tk......Kind of tools to be used.
C V.......Amount of haste to be expected, whether the work is to be night-shifted, etc.
C W.......Probable weather to be anticipated.
C X.......Miscellaneous.

V. Specific Quantities

Number of units (cubic yards, tons, barrels, bags, square feet of forms, thousand feet, B. M. (board measure), thousand brick, etc.).

IV. Amount of Capital

ABBREVIATIONS

C E.......Amount of capital necessary for equipment.
C T.......Amount of capital necessary for tools.
C B.......Amount of capital necessary for buildings.
C C.......Amount of capital necessary for cash.
C X.......Amount of capital necessary for miscellaneous purposes.

III. Estimated Total Cost for Completing Entire Job under Items as Below

ABBREVIATIONS

A.........Storage.
B.........Bonus or discounts.
C.........Charity or accidents.
D.........Depreciation.
F.........Fire insurance.
G.........Bond to guarantee contractor.
H.........Rent.
I.........Interest.
O.........Preparatory costs.
P.........Advertising.
R.........Repairs.

S..........Burglary insurance.
T..........Freight, express, and traveling expenses.
Q..........Accident insurance.

II. Estimated Unit-Cost under Items as Below

ABBREVIATIONS

Lh.........Hourly direct labor.
L m & w...Weekly and monthly labor.
Li.........Incidental labor.
F..........Superintendence.
M..........Materials.
S..........Supplies.
X.........Miscellaneous.

These can then be grouped together under the following heads:

I. Estimated Total Unit-Cost

ABBREVIATIONS

F..........Field.
U..........Sub-contract.
O..........Overhead, office.
X..........Overhead, miscellaneous.

Grand Total of Cost........
Profit.....................

VI. TYPE OF WORK

The estimator will find no difficulty in determining the type of work and the processes involved.

UNDERGRADE RAILWAY CROSSING IN LOUISVILLE, KENTUCKY.

Driveway in center, street-car lines at right, and sidewalk at left, all completely separated.

SUBSTANTIALLY BUILT—HIGH AND DRY—CONTAINS SEVEN ROOMS AND BASEMENT.

Field Conditions

C A. The estimator will generally have trouble when it comes to the **amount of work** to be done, this usually being roughly approximated, with the right to increase or decrease it later. A good method is to write down the maximum and minimum amounts that are likely to be involved. Clauses in the contract which enable the owner to change the contractor's quantities without changing unit-prices, should add something to the contractor's estimate, for the reason that there is one best plant, one best arrangement, one best organization, and one best outfit for every particular work. It has been shown that many of the conditions which affect the economy of the work are themselves affected by the quantities of work to be done; and any change on the part of the owner's mind affecting the quantity of work to be done, should—but rarely does—tend to increase or decrease the contractor's unit-price. In order to guard against such a contingency, the contractor should add something to his price by way of insurance. After an estimate has been made, it is a practice of many contractors to "unbalance" their bids. A great danger from this is that the work may have to be completed with quantities different from what were originally figured.

C Ek and **C Ec.** The kind and condition of **the equipment** available should be at hand, but is not often turned over to the estimator, unless he asks for it.

C F. Frequently the name of the man who is going to **superintend** the work is not known in advance, and it should be established if possible.

C G. The **general layout** of the work can be determined only by a personal inspection of the ground; and on this the estimator should make copious notes, having special reference to the distance of railroad connections, the distance of the railroad connection from shipping points of materials and supplies, the character of the country, the kind of water, and as many of the local conditions as can be reasonably and quickly noted.

C H. He will find that the **time for completing** the contract will be usually determined by the business conditions. This ought to be ascertained with considerable care, because upon it depends the scale of the work.

C L—State of the Labor Market. It is difficult to predict this two or three years in advance. In unfamiliar territory, if the Padrone system is in use in the neighborhood, it is not difficult to obtain from the nearest Padrone an estimate of how many men he can furnish, and then, by cutting the estimate in two, get somewhere near the probabilities. If it is necessary to board or transport the men, a provision for this should be made in the estimate.

C M—Kind of Material. This is perhaps the most important item, and is the hardest to establish, because of the expense attendant upon the digging of test borings, making borings, etc. Personal inspection, where a man has had considerable experience, will go a long way toward helping out; but in earth and rock work a certain amount of boring is absolutely necessary for proper results.

C O—Management. The method of managing should be understood before the estimate is to be made. If upon the work a bonus system and cost analysis are to be used, prices can be materially lower than when the ordinary day labor method is to be employed. Just how much lower, is a matter of judgment; but from past experience it may be safely said to be some 10 to 40 per cent—with 20 per cent as a safe average on general work.

C P. If electric **power** is available, the fact should be carefully noted.

C S. The **kind of supplies** readily available, and their cost on the work, should be estimated, not neglecting the water problem. The cost of coal of good quality will vary a great deal; and if a poor quality has got to be used, a very much larger amount should be allowed for than if the quality were good.

C T. It is well to put this item **(tools)** in the estimate, as the estimator is more likely to know the proper kind and size of tools than the purchasing agent, and it serves as a useful reminder. Shovels of the proper size may not be locally purchasable on short notice.

C V. Whether or not to work **night shift,** can be determined by estimating the necessary daily output to complete the work in time; and if this daily output cannot be safely reached with the labor available by day, night shift must be figured on. If one night shift is to be employed, from 7 to 10 per cent should be added to the labor cost; while, if two night shifts are to be put on, 10 to 12 per cent of the unit labor cost should be added, since the output per man working night shift is likely to be from 15 to 20 per cent less than by day. Of course, judgment must be used here, depending upon the kind of work, conditions, etc. Night shifting in summer is a much simpler matter than in winter.

C W. The **weather** is the greatest controlling factor, excepting in tunneling and on the interior parts of building to be done after the roof is on; and the probable number of working days on a short job cannot be estimated, except at considerable risk. Therefore, when the job is small, the unit-prices have to be assumed higher on this account than when the work is of long duration and the average weather counted on. When the work is to be done in an unfamiliar climate in the United States, the records of the Weather Bureau can be consulted, either by personal inspection or by writing to the Observer; and from these records the probable number of rainy days and days of excessive frost can be quite closely estimated if the work is to be of long duration. This should always be done as carefully as possible, since the weather is economically one of the most important field conditions to be considered.

A **working day** is a day, not a holiday, suitable for work. If the day is not a holiday, and is suitable for a working day, whether work is done or not, that day is a working day.

IV. AMOUNT OF CAPITAL INVOLVED

C E—Equipment. It is usually not difficult to estimate with reasonable accuracy how much plant will be necessary, provided that the working conditions are well established. Where drilling is to be done, the maximum and minimum average performance per drill must be determined from an inspection of the local conditions. It should be borne in mind that under ordinary working conditions from 10 to 20 per cent of the drilling equipment will be in the shop for repairs, and that a surplus of at least 15 per cent should be provided. Extra drills can easily be procured at comparatively short notice; but extra steam or air service cannot, and therefore a more liberal margin should be provided for the boilers and compressors than the actual number of drills to be taken on. Liberal allowance should be provided for pipe lines and for connections, whenever the work is to be done in cold weather.

For the process of loading, the grab bucket, steam shovel, derrick and skips are the logical types of equipment, with the advantages lying in the order named; and given the conditions and class of work, a fairly close approximation of the cost of equipment can be very rapidly made. It is necessary to be very careful to make a proper allowance for lost time. It has been aptly observed that a steam shovel can put material on cars about as fast as you can take the cars away from it; and in earth work, this is generally true. Therefore the performance per unit of equipment, and consequently the size and amount of equipment necessary for the work, will depend largely upon the proper layout of the transportation facilities. From one-third to two-thirds the theoretical capacity of a steam shovel is about the range of what it may be expected to do in average practice. It is proper here to remark parenthetically, that, in estimating, it is not safe to assume that the practice will be extraordinarily good.

T. Before deciding upon cost of transportation, it is necessary to have some approximate idea of the grades to be worked over; and in wagon work the assumed net load which can be safely handled upon the roads in their probable condition will determine this factor. On large jobs, 10 per cent should be allowed for equipment undergoing repairs. In estimating, it is wise to figure on standard ordinary equipment wherever possible. Bear in mind that an engine cannot operate for many months without thorough overhauling.

C T. One pick to every two shovels. The cost of tools per cubic yard handled is trifling.

C B. A close estimate of the cost of temporary buildings can be made by roughly figuring the cubical contents necessary, then the amount of square feet of wall surface and partitions. The cost of a building should never be guessed at in a lump, as it depends upon the available material.

C C—Cash Capital. On a good-sized piece of work, $200.00 for petty cash on a job is ordinarily ample to take care of express charges, etc. The amount of the pay-roll per month will depend upon the number of men employed; and when monthly settlements are made about two weeks after the end of the month, this amount will have to be "carried," so that about half or two-thirds of the average pay-roll for the entire job will have to be considered as continually losing interest.

C X. This amount of capital to be considered available is in the nature of an insurance fund against emergencies; and the more risky the nature of the work, the larger it should be. Ordinarily the interest upon this is comparatively insignificant.

III. ESTIMATED TOTAL COST

Having established the foregoing facts, the estimator is now prepared to decide upon the total amounts for completing the work under the items of classification III, enumerated above,

A—Storage. He must make a list of the approximate amount of material to be kept continually on hand, which will vary with different classes of work and the facilities that must be provided for storage. Where a stock pile is to be used, the preliminary work of getting ready the ground, erecting a handling plant, etc., is a part of this item, which also includes the salary of the storekeeper who looks after not only the storage of the material but also that of plant and supplies. The cost of rehandling material may be classified either as **storage** or as **preparatory charges.** The storekeeper, supplies, stationery, coal to warm the storehouse, as well as necessary materials for labor, should not be forgotten. For the total cost of storage, 5 per cent of the actual value of small tools and material, ignoring storage of large plant on average construction work, is liberal.

B—Bonus or Discounts. This item depends largely upon the particular business followed. If the contractor is figuring to earn a bonus on the contract price by getting through before the time limit, such being provided in the contract, it should appear in the estimate; and, as offsetting this, what he can lose by delay should also appear in the estimate. Not many months ago, one of the largest cities in the United States paid for a considerable amount of work in bonds at par, which several contractors, needing the money, sold at a discount of not far from 3 or 4 per cent, as it was not convenient for the city to raise the money on short notice. It is safe to say that this had not been figured on in their estimates.

C—Charity or Accidents. This is an item about which it is practically impossible to give advice in advance. The first part of it covers a good many sins and other things in contract work; while accidents are generally provided against, as far as possible, by insurance. Where the insurance companies refuse to insure, the contractor has got to provide against this item in the estimate somehow; and it is well to estimate the rate that the insurance companies would be likely to insure for if their rules did not prevent them from doing so, and to multiply this rate by about two.

A contractor is supposed to assume certain risks; but, as pointed out by Colonel Raban, of the Institution of Civil Engineers of Great Britain, it is another question whether all of the risks should be put upon the contractor. Risks from weather, the problems of handling men, and the general vagaries that go with all construction work, are probably the contractor's risk; but, when held up by strikes, or by eventualities that are not peculiar to his line of business, it seems unreasonable to shift these risks to the contractor's shoulders, and thus needlessly raise his estimate.

D—Depreciation. No other part of the estimator's task will call for the exercise of more careful judgment than the determination of the percentages of depreciation.

F—Fire Insurance. For brick buildings and for dwellings and their contents, the present rate, 1909, in the eastern part of the United States ranges from 1/4 per cent to 1/2 per cent for three years. For a plant such as is in use in the Hudson River Trap Rock Quarries, the present rate is from 2 to 2 1/2 per cent per year. The rates vary widely with different localities and with different kinds of buildings or equipment insured; and where a general approximation is not sufficiently definite, the estimator will have to go to the nearest fire insurance agent, who, with the idea of getting business, will be so keen to furnish him with information as to make it a pleasure to ask for it.

H—Rent. This depends entirely upon the local conditions, and can be obtained by the writing of a postal card to some representative agent in the vicinity.

I—Interest. This may be ordinarily assumed as a fair average at 6 per cent per annum, or 1/2 per cent per month. In times of financial stress, or in certain parts of the United States where money is scarce, the rates will be higher than this. For a year or two after a panic, and on good collateral, money can often be borrowed for as low as 4 per cent.

O—Preparatory Costs. The best way to get a good estimate on the preparatory costs is to interview the man who is going to take charge of the job on the ground, and go over with him in detail how many men he is willing to undertake to get into full operation with, and how long it will take him to organize.

P—Advertising. This is an overhead charge depending upon the policy of the manager.

R—Repairs. The estimator must use his best judgment on this difficult and perplexing item.

S—Burglary Insurance. This, like fire insurance, will depend upon local conditions and the state of mind of the insurance companies. For private dwellings, 1909, the rates in some companies are $12.50 per thousand dollars per year, or 1¼ per cent per year. Where it is not thought advisable to purchase burglary insurance, the estimator should nevertheless realize that theft is possible if not likely, and it is wise to allow about 2½ per cent of the value of the constant stock of small tools and supplies on the work for this item.

T—Freight, Express, etc. This must depend upon the class of material handled, the distance to be hauled along the railroad, and the amount of competition between roads. It will be more in sparsely settled country than where there is much competition.

Q—Accident Insurance. Insurance against accident to both employees and outsiders, on work of normal risk, will cost about as follows:

Masonry	3	per cent of the pay-roll,
Ornamental Iron Work	3	" " " " " "
Excavating (no blasting)	3	" " " " " "
Carpentry	2.25	" " " " " "
Private dwellings	1.85	" " " " " "
Plumbing	1.25	" " " " " "
Painting	1.25	" " " " " "

When the risk is great, these items may run as high as 8 or 10 per cent. Insurance on building wrecking runs as high as 13 per cent.

On some reservoir pipe line in New Jersey, the insurance was 2¾ per cent; and insurance of this kind has been obtained as low as 1 per cent or even sometimes less, on such work as road construction where there was practically nothing that could happen. On aqueduct work with a rock tunnel, a rate less than 4 per cent has been obtained. In deep trench work, accidents to the men are likely to be frequent; and accident insurance companies, when the work is to be done in certain kinds of soil, will usually refuse to insure the men on this sort of contract.

G—Bond. From a well-known indemnity company, in 1909, when a bond is in favor of New York City and is for 50 per cent or more of the contract price, ½ of 1 per cent of the bond is charged. When it is less than 50 per cent, ¼ of 1 per cent is charged. The minimum charge is $10.00. All other bonds cost ½ of 1 per cent of contract price. Bonds on contracts for furnishing supplies only (no labor) cost ¼ of 1 per cent of contract price.

II. ESTIMATED UNIT-COST

Lh—Hourly Direct Labor. From his general experience and what information he can gather from published data, the estimator is in a position to determine with fair accuracy between what limits he can reasonably expect to come on the item of direct labor, which is the fundamental labor charge and which ought to be nearly proportional to the actual amount of work accomplished.

L w and **m—Weekly and Monthly Labor.** This can be selected as a percentage of the item above mentioned, and depends very largely upon the local conditions, number of men employed, etc. Where there is a large amount of plant, such as steam shovels, hoists, drills, etc., it may run as high as 15 per cent maximum. For average work it is likely to be about ⅔ of this.

F—Superintendence. This is likely to vary from 10 per cent to 20 per cent of the direct labor pay-roll. It will be more on small work, and less on large work. On large work, it is generally too small for true economy.

M—Materials. The amount of these to allow for can be figured from the plans of the finished work. A percentage, generally not less than 3, should be allowed for loss in handling, shortage in shipment, etc.

S—Supplies. Such as coal, oil, waste, etc. This item should be carefully gone into, and rates obtained when the work is large or far from a base of supplies.

X—Miscellaneous. It is a practice of many estimators to add from 5 per cent to 10 per cent to their estimate for miscellaneous and contingencies. The more the detail of the estimate, the less the necessity for a large amount for this item. Miscellaneous items can cover possible inefficiency of laborers, strikes, raise in rates of wages, or unforeseen contingencies. From 5 per cent to 20 per cent of estimated labor cost is a fair allowance. It is an item used to insure against oversight or ignorance in making up an estimate. On materials the prices of which can be obtained before putting in a bid, there is no necessity for these.

I. ESTIMATED TOTAL UNIT-COST

The estimator is now prepared to group all of his total unit-costs under the following headings:

F—Field.
U—Sub-contract.

Sub-letting often results in low cost of work, because a sub-contractor who gives all his attention to the work can frequently get a small job done to better advantage than a large contractor who has not so much time to devote to details. One contractor can generally manage several sub-contractors on a job much more satisfactorily than several independent contractors can be managed by an engineer or architect.

It is then necessary to decide upon the percentage to be added for overhead charges. These can vary from as low as 4 per cent to as high as 22 per cent, depending upon the kind of organization and the distribution of expenses. It will be noted that a number of the items under classification III are overhead; and it is well to itemize as many of these as possible in order to make the percentage to be added include as little as possible, and thus be nearer the truth.

P—Profit. The estimator can figure his grand **total of cost,** to which should be added a percentage for **profit.** On small work where the risk is large, this should be high; and on large work where the risk is small, it may be as low as 10 per cent when there is competition. The profit should not only take care of the risks of the business that cannot be or are generally not included in the above items; but it should also take care of the compensation to the stockholders, or to the contractor himself for his time and skill and risk in organizing the business and keeping it going. Thus, on certain work, 25 per cent or 30 per cent is not an excessive profit.

Hints on Estimates

Don't forget that rates of wages are lowest in dull times and in winter, and highest in boom times and in summer.

Remember that an allowance for discounts is not operative when payment is delayed beyond the time limit.

Repairs on bargain-counter plant may be three times as great as on first-class new equipment.

Depreciation is affected by a multitude of conditions, and estimates of the amount for this item should not assume too high a figure for scrap value.

The interest on plant goes on whether the plant is working or not.

If the non-paying part of a job has to be done first, interest on the loss will run to the end of the contract.

In estimating the cost of transportation, give special attention to the character of available roads, the direction of the proposed traffic, and the time of year.

Insurance against accidents depends upon the riskiness, not to the plant, but to the men.

After making an estimate in detail, lay it aside for a day or two if possible, forget the figures, and then go over them again critically.

If someone else is going to carry on the work, take his personality into account in making an estimate of how much his work is going to cost.

Check up an estimate against average contract prices, selecting particularly contracts where the conditions are well known, and selecting the contract bids from firms of experience in the line of work in question.

CHARMING LITTLE STORY AND A-HALF COTTAGE.

LONG KEY OCEAN VIADUCT ON KEY WEST EXTENSION OF FLORIDA EAST COAST RAILWAY.

Reinforced arches and side walls complete, ready for filling with rock and earth for roadbed.

Check over the bidding sheet to see that it compares with the estimate.

A long and big job can be estimated on more safely than a short and small one, since the accidental conditions on big work are more likely to balance themselves.

It is not wise for the contractor to figure on making money out of lawsuits as he can generally make a good deal more money by doing construction work on a square basis than he can by providing a job for his lawyer.

For trench machine work, from $7.00 to $10.00 a day should ordinarily be added for rental. Also add the cost of the sheeting, plank, and pumping. In estimating the cost of trenching work, look out for bowlders.

The worst estimate made upon even assumed data is generally a good deal better than guess.

To estimate the quantity of sheeting or of shiplap, calculate the exact surface to be covered, deducting openings; then add the following percentages:

	Sheeting	Shiplap
For floors	1/7, or 15 per cent	1/6, or 17 per cent
For sidewalks	1/6, or 17 per cent	1/5, or 20 per cent
For roofs	1/5, or 20 per cent	1/4, or 25 per cent

The cost of materials will vary from year to year. A study should be made of the characteristic fluctuations in prices, when figuring closely, in order that proper prices of materials can be determined for some time in advance.

For estimating cost of building work, the reader will also find useful hints and information in the following authorities: Arthur's "Building Estimator," Ketchum's "Steel Mill Buildings," and Kidder's "Architect's and Builder's Pocketbook." The prices of hardware may be obtained from "The Iron Age Standard Hardware List" or the catalogues of standard manufacturers. Current discounts, as well as current prices of material (as lumber, etc.) will be found regularly quoted in the standard trade journals; and different mills issue catalogues giving prices of mill work.

A MODERN RESIDENCE

As further illustrating the practical application of the principles of specification writing and cost estimating to actual instances of construction, we reproduce the **working plans, detailed specifications,** and **revised estimate of cost** of a moderate-sized up-to-date residence recently erected at Babylon, Long Island.

A photograph of the building is shown in the plate opposite page 1, in this volume; and in Figs. 1 to 8 the working drawings are reproduced, some minor dimensions only being omitted.

The house was both designed and built by Mr. E. W. Howell, who furnished the copies of the plans, specifications, and estimate for the purposes of this volume. All were prepared by the same person, the figures of the estimate as here given being revised on the basis of

actual cost. The cost of the various items would, of course, vary somewhat for a similar house erected in a different part of the country.

Specifications for Residence at Babylon, Long Island, N. Y.

General Conditions—

The building to be of dimensions shown by plans and figures of the same. If plans and figures disagree, the figures will have to be the guide.

The Contractor to provide all material and labor necessary for the complete and substantial execution of everything described, shown, or reasonably implied in the drawings and specifications in this part of the work, including all scaffolding, transportation, apparatus, and utensils requisite for the same, so that any work exhibited in the drawing and not mentioned in the specification, or vice versa, is to be executed the same as if mentioned in the specification and set forth in the drawing, to the true intent and meaning of the said drawing and specification, without extra charge.

All materials to be the best of their respective kinds, and all workmanship to be of the best quality.

The Contractor is to set out his own work correctly and is to give it his personal superintendence, keeping a competent foreman constantly on the ground.

FRONT ELEVATION

Fig. 1. Front Elevation of Residence at Babylon, Long Island, N. Y.

For photographic view see plate opposite page 1. Detailed specifications and revised estimate based on actual cost to builder, given in this volume.

Fig. 2. Rear Elevation of Residence at Babylon, Long Island, N. Y.

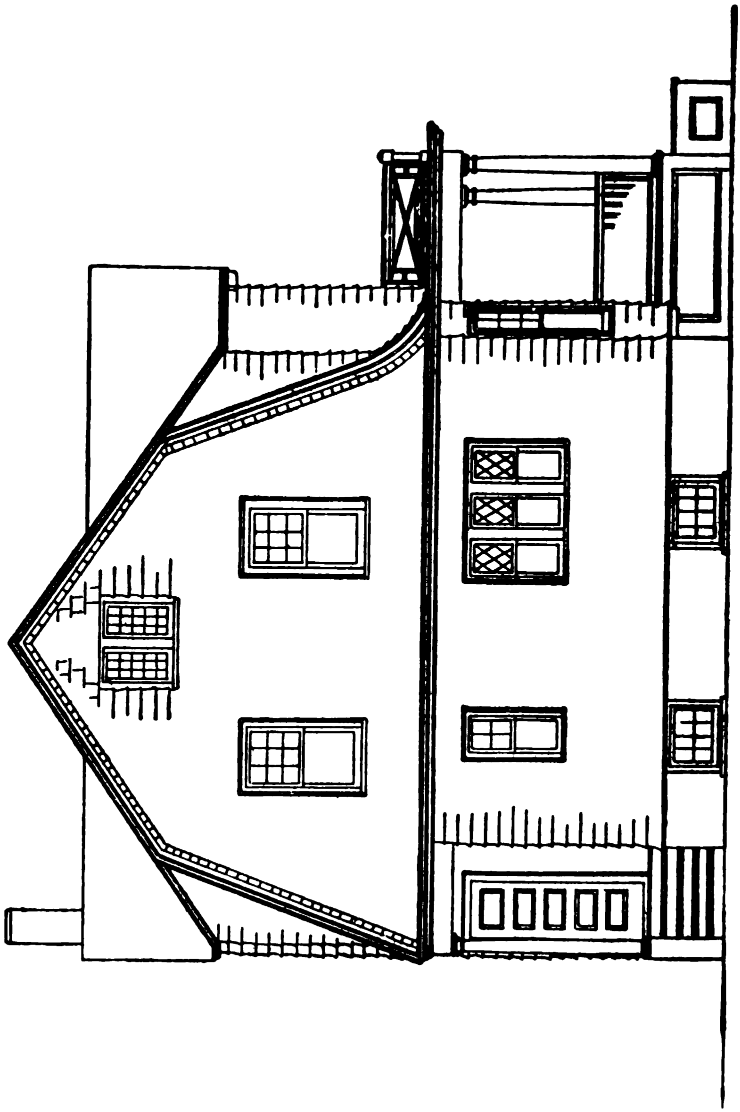


Fig. 3. North (Left End) Elevation of Residence at Babylon, Long Island, N. Y.

Fig. 4. South (Right End) Elevation of Residence at Babylon, Long Island, N. Y.

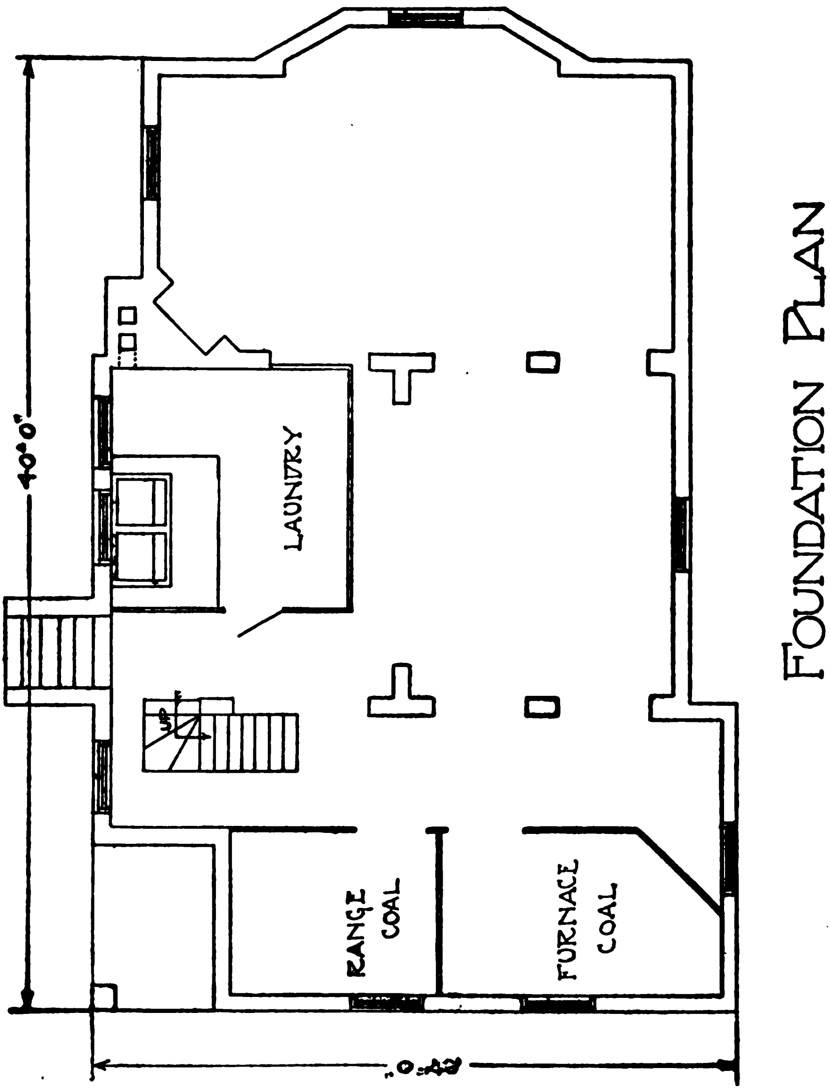


Fig. 5. Basement Plan of Residence at Babylon, Long Island, N. Y.

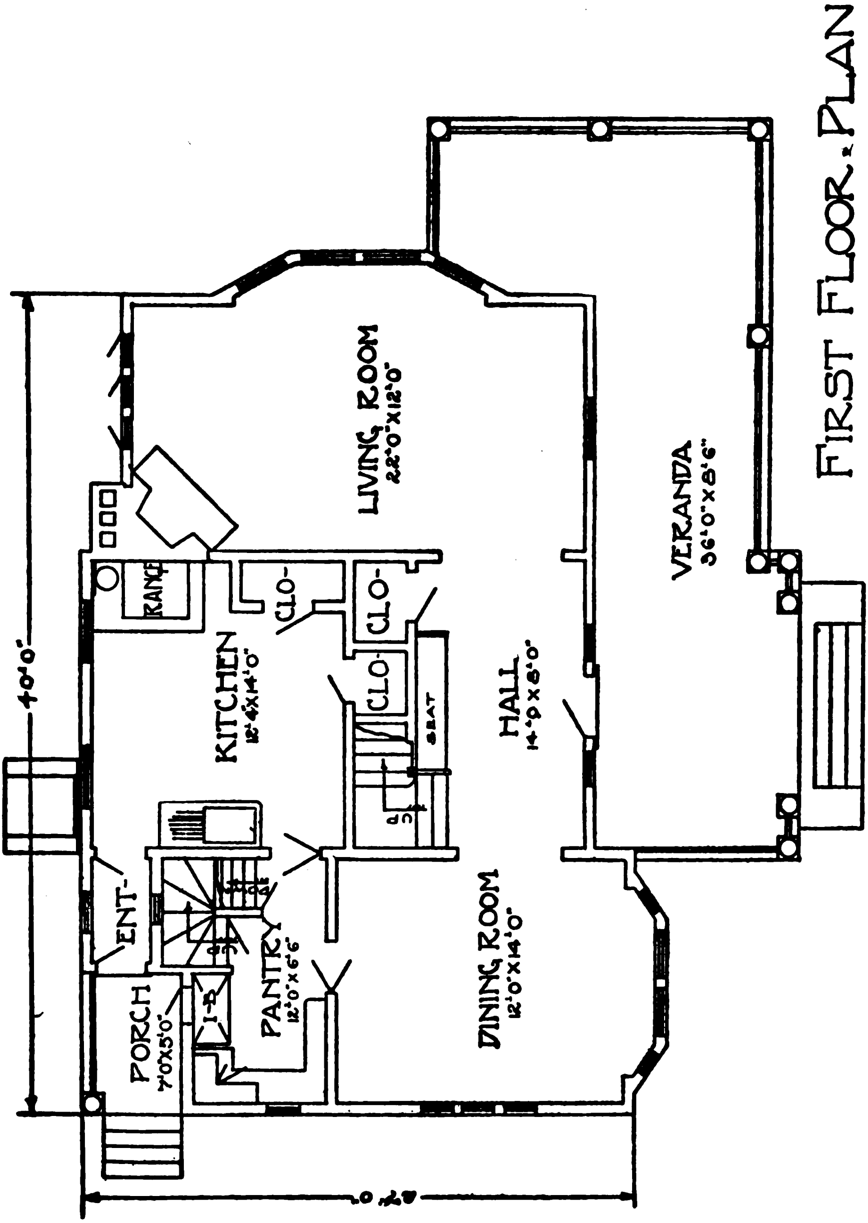


Fig. 6. First-Floor Plan of Residence at Babylon, Long Island, N. Y.

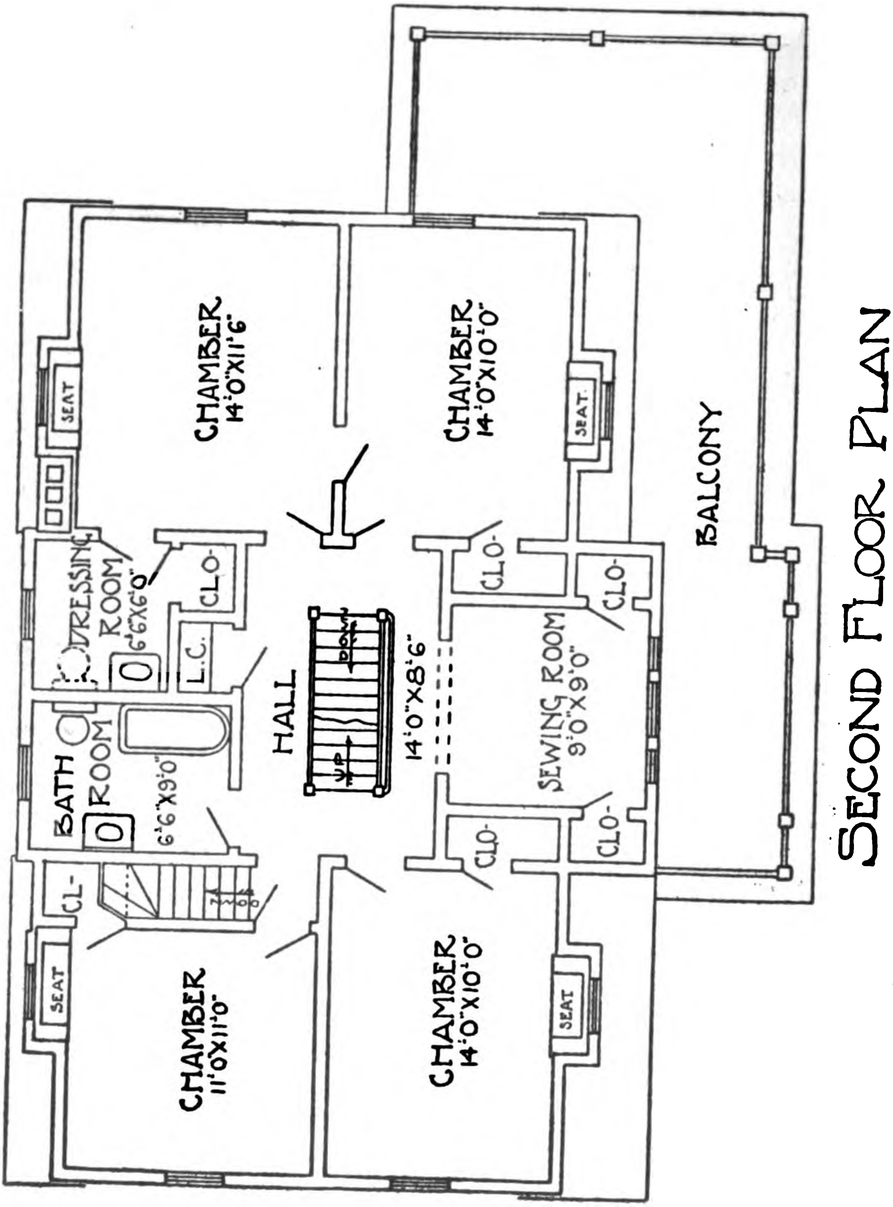


Fig. 7. Second-Floor Plan of Residence at Babylon, Long Island, N. Y.

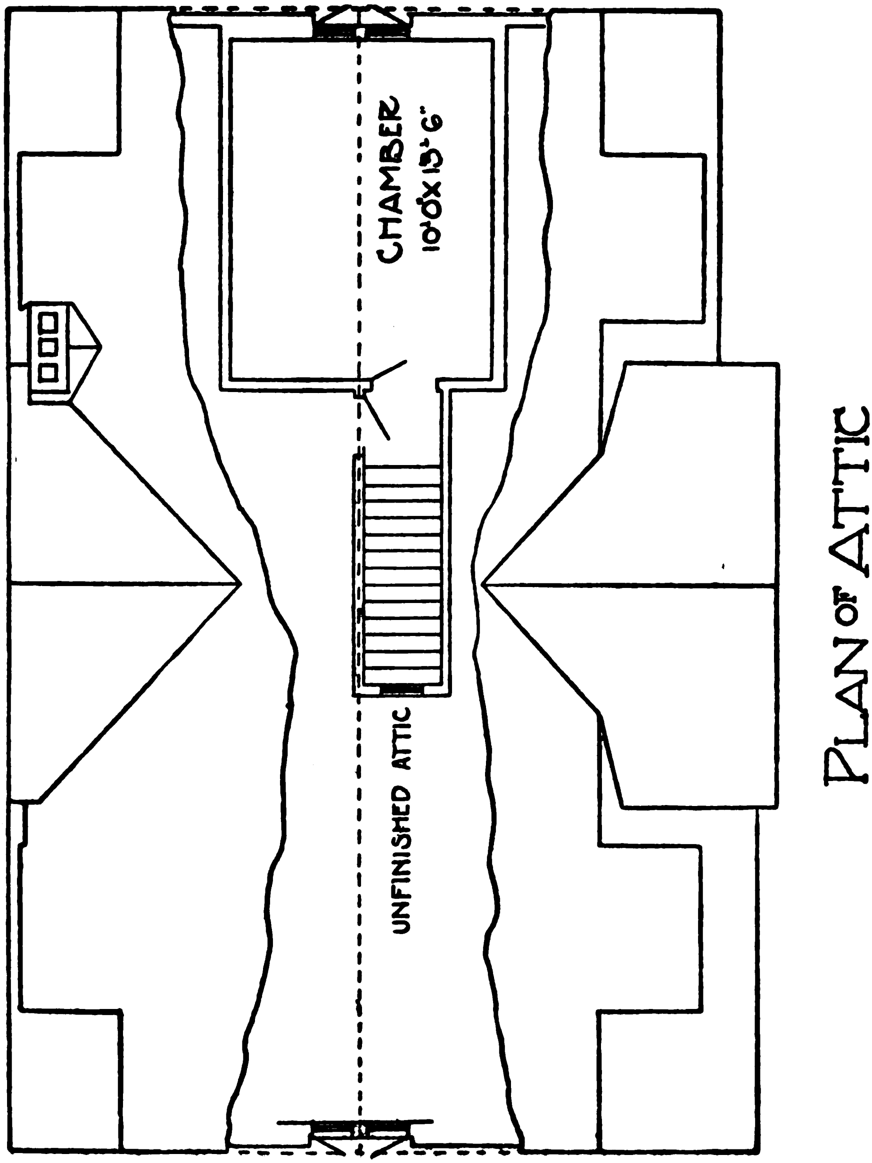


Fig. 8. Attic Plan of Residence at Babylon, Long Island, N. Y.

Should the owner desire to make any alterations during the progress of the work, he shall have the privilege so to do, which alterations shall not affect or make void this contract; and whether additions or deductions, they shall be appraised in accordance with the rate at which the work is taken, and the cost is to be either deducted from or added to the price as may be required.

Excavation—

All the excavating to be done by the Contractor. All the top soil over the entire space to be covered by the building, including the verandas, is to be taken off and stacked at nearby points for future grading. The sub-soil is to be kept separate, and stacked at convenient points for future grading.

Heights—

The top of foundation wall will be 4 feet above highest point of present grade. Other heights as shown on plans and specifications.

Foundation—

Building foundation walls of hard-burned North River or Long Island brick, laid in mortar composed of 2 parts Portland cement, 1 part Rockland lime, 3 parts screened sharp sand. Walls to be 8 inches thick, and 16-inch footing courses stepped out 2 courses. Corners to be built true and plumb, all joints laid close and straight, and neatly struck where exposed. All mortar joints to be thoroughly filled with mortar.

Chimney Foundation—

Build chimney foundation where shown, of concrete 6 inches thick, projecting 4 inches on all sides; concrete well rammed down so as to prevent any settling. The top of chimney footing to be 1 inch below finish of cellar floor bottom. Concrete composed of 1 part cement, 4 parts gravel, 3 parts sand.

Cellar Steps—

These to be 3 by 10-inch quarry-axed blue stone.

Concrete Cellar Floor—

Level off cellar bottom to proper depth, and cover with cement concrete 2½ inches thick, of 1 part Portland cement, 4 parts gravel, and 3 parts sharp sand, properly mixed, and well rammed in place. On this, lay a finishing coat composed of 1 part Portland cement, 2 parts clean, sharp sand troweled perfectly level and smooth to give a good wearing surface—all to be done in the best manner.

Chimney—

Build chimney where shown, of good hard-burned brick up to proper height above roof. Line flues with fire-clay flue lining. Flues to be 8 inches square. Fireplace flue to have 8 by 12-inch lining.

Chimney will have cement stone cap 3 inches thick, composed of 1 part cement and 3 parts clean, sharp sand; top to have a grade so as to carry water away from the flue openings.

Put in galvanized-iron pipe thimbles where shown, 6 inches in diameter for kitchen range, 6 inches in diameter for laundry, 8 inches in diameter for furnace in cellar. Also one thimble 8 inches in diameter for clean-out for furnace flue, set 18 inches above cellar floor.

All brick laid in good cement mortar as specified for foundation work.

Fireplace facing and hearth to be laid of selected common red brick laid in red mortar.

Piers—

Build brick piers for cellar where shown.

Cesspools—

Build 3 cesspools 7 feet in diameter and as deep as springs will allow. One cesspool to be connected with the laundry tubs only to have a leechy bottom. One cesspool to be made water-tight, and to be connected with grease trap and other plumbing fixtures. Ten feet away, build third cesspool with leeching bottom connected with tight cesspool with 5-inch salt-glazed earthen drain-tile, with quarter-bend turned down in tight cesspool.

Lay 5-inch drain-tile from tight cesspool, and connect with 4-inch cast-iron soil line 5 feet outside of foundation.

Also lay 5-inch drain-tile from laundry waste near foundation, and connect with laundry cesspool.

These cesspools are to be located about 30 feet away from nearest point of house foundation.

Cover cesspools with domed arches laid in Portland cement, and 3-inch cement stone covers with three 1-inch vent-holes in each.

Five feet away from house, build water-tight brick grease trap 3 feet in diameter, 3 feet deep. Cover this with cement stone as specified. Connect grease trap with main drain-tile in the customary manner.

Kitchen Hearth—

The kitchen hearth will be made of Portland cement concrete 4 inches thick, same as specified for cellar bottom.

Brickwork behind kitchen range will be carried up 6 feet high; also to extend around the corner in line with windows as shown. This brick breast to be laid up with close joints, rubbed down with soft brick, and painted 3 coats of paint.

Lathing and Plastering—

Lath all the rooms to be finished in first and second stories, also one room on third story, with best spruce wall lath, free from bark or knots, with 4 nailings to each lath, breaking joints every tenth lath. Cover all lath with rock wall-plaster put on according to directions furnished by manufacturers.

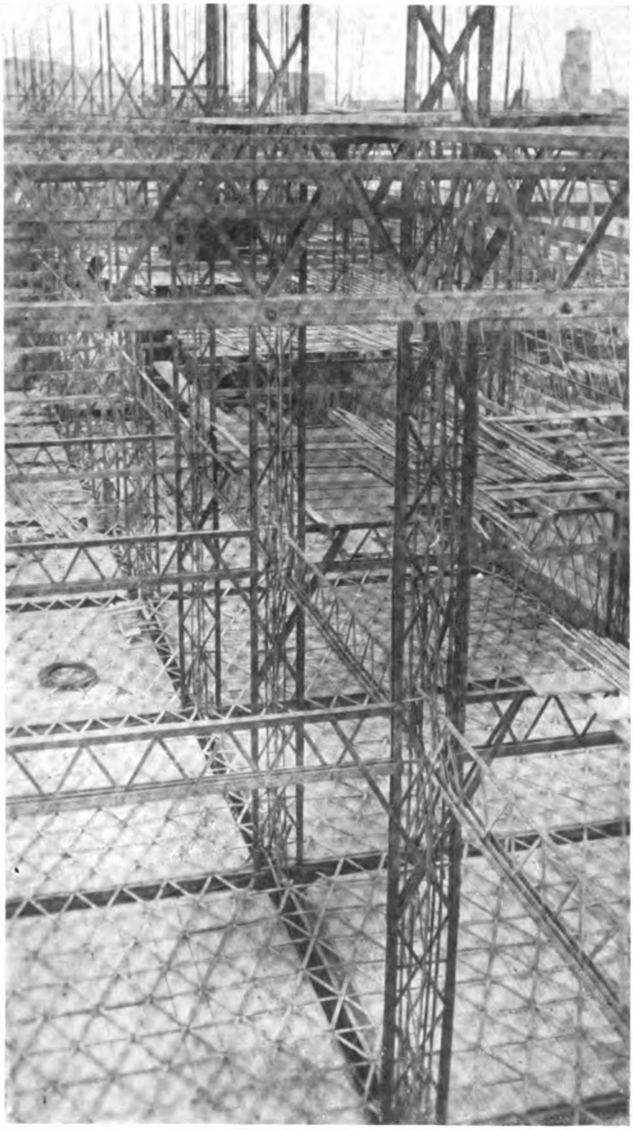
Finish all walls with best lime putty and plaster of Paris, 1 part plaster of Paris, 2 parts lime putty, troweled to a good, hard white finish.

All angles to be rodded straight and true. All work to be done in the very best manner; walls left in perfect condition on completion of building. Wherever finished rooms overhang the first floor, the beams are to be filled in with 2½ inches of mortar.

Timber—

All timber except where otherwise shown or specified to be square-edge spruce of first quality, straight-grained and well seasoned. All framed, mortised-and-tenoned, and spiked together in best workmanlike manner. Size of the principal parts indicated by the following:

Sills, 3 by 6 in.
Girder in cellar, 6 by 8 in.
Plates at 1st story level, 4 by 4 in.
Partition caps supporting beams, 4 by 6 in.
1st story beams, 2 by 10 in. on 16-in. centers.
2d story beams, 2 by 10 in. on 16-in. centers.
Ceiling beams over 2d story, 2 by 6 in. on 16-in. centers.
Posts, 4 by 6 in.
Veranda sills and plates and cross-sills, 4 by 6 in.
Veranda floor-beams, 2 by 6 in. on 18-in. centers.



FORM OF REINFORCEMENT USED IN CONSTRUCTION OF OWL BUILDING, SAN FRANCISCO, CALIFORNIA.

Mild steel flats punched at intervals and riveted to form lattice of triangular meshes. Girders have angle at top to take up web stresses.

FOUNDATION FOR TALL REINFORCED CONCRETE WATER TANK AT ANAHEIM, CALIFORNIA.

Foundation of concrete slabs 2 feet thick reinforced with ⅞-inch twisted steel.

Rafters on steep slope of roof, 2 by 4-in. spruce, 16-in. centers.

Rafters on flat slope of roof, 2 by 6 in., 24-in. centers.

Valley rafters, 3 by 8 in.

Floor-beams to be bridged in all spans over 8 feet, with 2 by 2-inch spruce bridging.

Studding for outside walls and interior partitions to be 2 by 4-inch hemlock, set 16 inches on centers, and doubled at all angles and openings.

Where floor-beams run in same direction as partitions, they are to be set double under each partition in each case. Where second-story rooms overhang first-story, nail furring on each side of beams 4 inches down, and lay a sub-floor.

Put 2 by 4-inch shoes under partitions where beams run in opposite direction to partitions.

Truss-brace all partitions over openings where necessary.

All necessary timber not specially mentioned, to be suitable sizes, and furnished in size by the Contractor as if particularly mentioned.

Sheathing—

All vertical walls, also steep slope of roof and veranda roofs to be sheathed with $7/8$ by 8-inch North Carolina pine, of good, sound quality, free from loose knots, splits, or shakes. Sheathing boards to be laid horizontally. All joints to be cut on studs, and all well nailed. Sheathing to be covered with .... black sheathing paper. Sheathing paper to extend under all window and door casings, cornices, and other places.

Roof—

The upper slope of roof to be covered with 1 by 2-inch spruce shingle lath laid 5 inches on centers, all well nailed to rafters.

Form valleys with 1 by 8-inch spruce or North Carolina pine valley boards. Cover all roofs to be shingled with first-quality 18-inch random-width Washington red cedar shingles, laid 5 inches to the weather, nailed with 4-penny galvanized nails.

All valleys shingled tight and step-flashed with tin.

Roof to be covered with .... roofing tin, rosined-soldered with flat lock seam joints.

Step and counter-flash around chimney and all other places where needed to make a water-tight job. All tin for flashings used, to be .... roofing tin painted both sides 2 coats before using.

Upright Finish—

The outside covering for vertical walls from sill to cornice lines to be covered with 6 by 20-inch cedar shingles, ... or ...... brand, laid 7 inches to the weather, nailed with galvanized nails. All lumber for outside finish to be of clear cypress, including all mouldings for cornices, piazza, plate casings, step planks, etc.

Veranda—

Foundations to be 5-inch yellow locust posts, with concrete footings.

Rear porch to be built as shown. Floors of 1-inch long-leaf Georgia pine, tongued and grooved, not to exceed 3½ inches in width, with edges painted before laying, closely driven and well nailed. Outer edge finished with nosing and cove. Steps built as shown, 1¼-inch treads, ⅞-inch risers, finished with nosing and cove, all set on locust post timbered and blocked in best manner.

Fur off veranda ceiling with 2 by 4-inch nailers spaced 2 feet apart; then ceil with ½ by 3-inch No. 1 beaded North Carolina ceiling; finish with deep bed-moulding and angle.

Lattice under veranda and porch with ¼ by 1½-inch cypress lattice strips, laid with spaces about 2 inches square, nailed to formings as shown in the usual way.

Build box ends for steps as shown.

Columns—

Veranda columns to be built-up columns 8 inches in diameter, made by .... Mfg. Co. or .... Mfg. Co.

Veranda top rail to be 2½ by 3-inch, bottom rail 1½ by 3½-inch, moulded cypress.

Balusters, 1⅛ by 1⅜ inches, cut with bird's mouth over bottom rail.

Balcony rail to be built as shown with top rail 2 by 3 inches, bottom rail 1½ by 3 inches, with filling-in rails 1⅛ by 1⅜ inches.

Balcony newels will be boxed newels 5 by 5 inches square, with base and caps as per details.

Have bottom of these newels carefully tinned around so that no leak will occur.

Cornice—

Form veranda cornice as shown, with 4-inch crown-mouldings, 1-inch soffits.

Form tin-lined box-gutter back of crown-mouldings, with sufficient grade always to drain dry. Main cornice to have 5-inch galvanized-iron eave-trough gutters No. 26 gauge.

Have 3-inch galvanized-iron rain-water leaders No. 26 gauge, to carry water to ground. Connect rain-water leaders with dry wells built of brick 3 feet in diameter, located at least 8 feet away from foundation of house.

Ceil underneath overhang of roof with 7/8-inch tongued-and-grooved beaded pine or cypress. The gable end of house and other places to have cornice consisting of 4-inch crown-moulding and 5-inch fascia as shown.

Window-Frames—

Cellar frames to be built of number and sizes as shown, of 2-inch rabbeted cypress. Cellar frames to be painted on all sides before set in wall.

Window-frame for sliding sash to be 1-inch jambs, 1¼ by 4½-inch casings, back-moulding ¾ by 1¼-inch, 7/8-inch sub-sill, 2-inch main sill, all put together in best manner. To have polished wheel-pulleys, pockets, weights, cords, and all necessary stops.

Frames for casement sash will be made with $1\frac{1}{4}$-inch rabbeted jambs, made in the usual manner for casement sash.

Doors—

Outside door-frames to have $1\frac{1}{4}$-inch jambs, 2-inch oak or ash sills.

Inside doors will have $\frac{5}{8}$ by $4\frac{1}{2}$-inch oak door saddles.

Flooring—

Throughout 1st and 2d stories (except in kitchen and rear passage), the floors will be double. The under-floor to be 1 by 8-inch tongued-and-grooved North Carolina pine laid diagonally, with floor-beams to be nailed two 8-penny nails to each bearing; all butt-joints to meet on timber bearing.

Rough floors to be snugly fitted around all partition studs, to make close joint with outside sheathing of building. Where the floors are doubled, the finish floor will be of best-quality $\frac{7}{8}$ by $2\frac{1}{2}$-inch comb-grained North Carolina pine flooring, very carefully laid, planed and scraped and sandpapered perfectly smooth, and to be treated with 1 coat of wood filler and 2 coats of floor wax, well rubbed between coats and finished with heavy floor brush.

Put rosin-sized building paper between double floors.

The floor in kitchen and rear passage will be of single floor laid with $7/8$ by 3-inch No. 1 North Carolina pine.

Throughout the attic, lay a floor 1 by 5-inch, tongued-and-grooved North Carolina pine, good, sound quality, free from loose knots or shakes, selecting the best for the finished room.

Finish around all rooms with $5/8$-inch quarter-round moulding laid in angle.

Build platform for laundry tubs in cellar where shown.

Partition for laundry in cellar will be built of 1 by 8-inch tongued-and-grooved and beaded pine set vertically, and to have a frame of 2 by 4-inch dressed spruce. Studs of sufficient number to make a good strong job.

Door to laundry will be a battened door, to be hung with 6-inch T-hinges, and secured with substantial rim lock.

Coal bins in cellar to have a strong frame built of 2 by 4-inch hemlock joists enclosed with 1 by 6-inch tongued-and-grooved sheathing, same quality as specified for attic floor.

Arrange slides for access to coal bins, with opening at bottom for shoveling coal.

Cellar Entrance—

The outside cellar entrance to be enclosed with hatch door made of 1 by 6-inch tongued-and-grooved beaded pine, with strong battens and formings made in the usual way, and to shed water.

Door to be hung on 16-inch hook hinges, to have galvanized-iron hasps and brass padlock.

Inside Finishing—

All door openings to be trimmed on 1-inch jamb with ½ by 3-inch stops planted on. Door trim to be 4½ inches wide, beaded and rabbeted; to have back-moulding ¾ by 1¼-inch and wall-mouldings ¾ by ¾-inch.

Windows trimmed on 1¼-inch sills, ⅝ by 4½-inch aprons; casings 4 inches wide to match door casings; ½-inch stop-beads. Back-bands and wall-mouldings, same as door trim.

Closets to have 4½-inch plain casings, and 6-inch base. Closets will have 6-inch hanging strips and shelves as may be directed.

Closet opening into 2d story hall will have wide shelf from floor to ceiling as may be directed by the owner.

Lay a 6-inch base with 1½-inch moulding on top in all rooms and halls that are finished.

Wall-moulding of trim to intersect with base-moulding.

Put up 1½-inch picture moulding around all principal rooms as may be directed.

All trim to be best, clear cypress and white-wood, thoroughly kiln-dried, and of even color, smoothly worked.

Lower hall, living room, and bathroom will be trimmed with whitewood; other parts of house to be trimmed with cypress.

Stairs—

Build stairs of whitewood from 1st floor to 2d story. The stairs leading from 2d story to attic, including level rails, to be of cypress; newels 5 by 5-inch, turned; rail 2½ by 3-inch, moulded; balusters, 2 to a step, 1⅜ inches in diameter, spaced on level of rail same distance as on steps. Paneled starting newel and hand-rail showing in first story, to be of mahogany; balusters of whitewood.

Stair strings 1⅛-inch, risers ⅞-inch tongued-and-grooved, blocked, wedged, and glued in the best manner, all of selected clear materials and thoroughly kiln-dried.

Build seat in reception hall where shown, with paneled riser, 2-inch plank, and hinge covers.

Also build seats as shown in dormer windows in 2d-story bedrooms, to have plain fronts and ⅞-inch tops with rounded edges and cove under. Lath and plaster to be carried down behind these seats. Make all air-tight.

Build rear stairs of North Carolina pine, 1⅛-inch strings, 1⅛-inch treads, ⅞-inch risers.

Build cellar stairs of North Carolina pine, 1⅛-inch treads and strings, no risers. Cellar stairs to have plain hand-rail.

Pantry—

Build up pantry as shown with counter shelf and shelves as may be directed; also china closet with glass doors where shown. Build three drawers under counter shelf. Put as many shelves in kitchen closet as may be directed by the owner.

Drain-board to kitchen sink to be $1\frac{3}{8}$-inch ash.

Doors—

All inside doors to be 5 cross-panel boards, with small lights of first-quality single-thick glass; large lights, double-strength first-quality glass.

Blinds—

Provide galvanized blind adjusters to all blinds that will not fasten back.

Casement windows will be hung with $2\frac{1}{2}$ by $2\frac{1}{2}$-inch galvanized-iron butts with brass pins.

Casement windows to have proper casement window fasteners.

Screens—

All windows and outside doors through the 1st and 2d stories, also servant's room and attic, will have .... hardwood screens, covered with black enamel, 14-mesh wire, to have suitable slides and hardware. Screens to be finished to correspond with the room in which they show.

Furnish and set in rear yard where directed, 4 turned chestnut clothes-posts, painted dark green.

The carpenter is to do all cutting necessary for the other trades throughout the building.

Mantel in living room to be of whitewood, cost not to exceed $25.00.

Painting—

All outside finishing lumber to be painted three coats best white lead and pure linseed oil paint, color as directed by the owner, including the veranda floors, porch steps, all cornices, belt-courses, blinds, piazza and balcony rails, window and door frames, etc.

All shingle work to be left without treatment.

Veranda and porch ceilings to receive two coats outside spar varnish.

Inside Finish—

All inside woodwork such as doors and upright trim, stairs, etc., to receive one coat of filler and two coats of good rubbing varnish. Should the owner desire to substitute paint in some of the rooms, three coats of paint are to be substituted. Lower hall, living room, and bath to be painted white.

All nail-holes and other imperfections are to be stop-puttied between coats. Putty to be tinted where necessary.

All knots and other imperfections in outside work to be filled with best orange shellac before applying paint.

Plumbing—

All material of the several kinds to be of the very best as called for in this specification, the workmanship to be first-class throughout.

Fixtures—

In the kitchen, set up 1 galvanized sink 21 by 36-inch, with galvanized-iron back, brass Fuller faucets, 1 hose and 1 plain, to waste through 1½-inch S lead trap. Also set up 3 ...... wash-trays on galvanized stands, plugs and chains of composition brass, and faucets to waste through 2-inch S lead trap.

Bathroom and Lavatory—

Set up in bathroom on 2d floor one 5-foot ......, roll-rim enameled bathtub complete, not decorated on outside. The fixtures to be nickel-plated and have unique waste through a ...... bath-trap.

Two ...... low-down water-closets, stained oak seat, cover, and cistern; brass floor flange connected up in best manner, with marble tops on tanks, and marble floor-slabs under each closet.

Set up in bathroom and lavatory, one each, 20 by 24-inch enameled lavatories, with plated waste and nickel pipes, with index composition faucets like No. ...., ...'s catalogue.

All fixtures to be connected with hot and cold water supply pipes.

Water Supply—

Main water supply will be ¾-inch galvanized-iron pipe, connected with main in the street, with shut-off box at curb, and run to front wall, and have shut-off valve on outside of cellar wall, with ¾-inch .... pressure regulator and 3-inch dial pressure gauge, in a convenient place in kitchen.

Leave out T-branch of main for future use, From this point in cellar, continue the line in a straight and uniform grade to supply all fixtures. Hot water will be run in the same manner to all fixtures. Each fixture or group of fixtures to have a shut-off, and to be properly graded so as to be entirely emptied at any time.

All water pipes to be neatly painted with aluminum bronze where they show in 1st and 2d stories.

Circulating Pipes—

Run a ¾-inch galvanized-iron pipe from top of boiler to bathroom, with proper grade so as to have a complete circulation.

The kitchen sink and wash-trays to waste separately into a grease trap connected to the soil line through iron pipe turned down 2 feet into grease trap.

Boiler—

One 52-gallon "extra heavy" copper boiler on galvanized stand, tube and couplings connected up to range water-back in best manner, with sediment cocks, etc.

Range—

Set up in kitchen where shown one ...... range, No. ...., complete, with warming shelf. Range to be left nicely blacked and cleaned.

Soil-Pipe—

The main soil to be 4 inches internal diameter, "extra heavy" cast-iron pipe. Soil to start at a point 5 feet outside of house foundation, and to run up through roof, taking in all fixtures through Y branches and 1/8-bend fittings. Leave branch for water-closet in dressing room. The line to have a house trap, and have fresh-air line 4-inch pipe to go from house line of same and run through cellar wall with suitable vent-caps. All joints in soil to be well rammed with oakum, and then to be run through with molten lead and well corked, to leave all joints perfectly smooth and clean.

Where soil-pipe passes through the roof, it is to be carefully flashed with 4-lb. sheet lead to make it perfectly water-tight. Have wire basket on top of vent pipe.

All fixtures to connect with the soil-pipe through lead wastes, with brass ferrules wiped on same.

All fixtures to be trapped and back-vented. The back-vent pipes to be 1½-inch galvanized-pipe for all fixtures except water-closet, which will be 2-inch galvanized-iron pipe.

All back-vents to be connected to main soil vent not less than 3 feet above the highest fixture.

Lead Pipe—

All branch lead soil waste and all lead bends shall be of the best quality and of the following weight per linear foot:

Size	Weight
1½ inch..........	3 lbs. 8 oz.
2 "	4 "
3 "	6 "
4 "	8 "

All connections between lead and iron pipes to be made with heavy brass ferrules set in the hub and corked tight.

All other lead joints to be wiped solder joints.

Test—

The plumber is to stop all outlets and inlets in the iron and lead pipes comprising vent and drainage, including all branches and connections, and test the job by filling the pipes with water to make sure there is no leak.

The outside of bathtub to be rubbed smooth, and painted 4 coats white lead paint.

Other exposed pipes to be bronzed or painted as may be directed.

Heating Work—

Furnish and set in most convenient place in cellar one No.........hot-water boiler, to have all necessary firing tools and cleaning brushes, and suitable smokepipe to chimney.

Water Supply—

Connection from the water supply of house is to be made to boiler through a suitable pipe with stop-valve in a convenient place for operation. The blow-off valve is to be placed at the lowest part of the boiler or pipe so as to drain out the system perfectly dry, and to be supplied with a hose nipple.

Heater Fittings—

Heater to be supplied with an altitude gauge, one thermometer to be placed in a prominent position on boiler for making observations.

Fittings—

All fittings throughout the entire work are to be of heavy pattern cast iron, no union couplings to be allowed. All pipes passing through floor or ceilings to be furnished with a suitable floor and ceiling plate. All horizontal pipes in cellar or basement are to be supported on strong adjusters of ...... or other approved pattern.

Radiators—

All radiators to be placed in the various rooms as hereinafter mentioned:

The 1st story hall and dining room, living room, 4 bedrooms on 2d floor, sewing room, bathroom, lavatory, and 3d story bedroom.

Valves—

All radiators to be supplied with a quick-opening radiator valve, nickel-plated, and nickel-plated union.

Also to have a nickel-plated air-valve of approved design, with a key to operate same.

Expansion Tank—

Furnish and place in most convenient position above highest radiator one galvanized-iron expansion tank of proper size, to have glass gauge, brass fixtures, and gauge-rods; also to have an overflow pipe to go out through roof or other suitable place.

Painting and Bronzing—

All radiators and exposed pipes above cellar to be neatly painted and bronzed in colors desired by the owner.

Heater to have a coat of black Japan varnish.

All exposed pipes in basement to be neatly covered with sectional pipe covering.

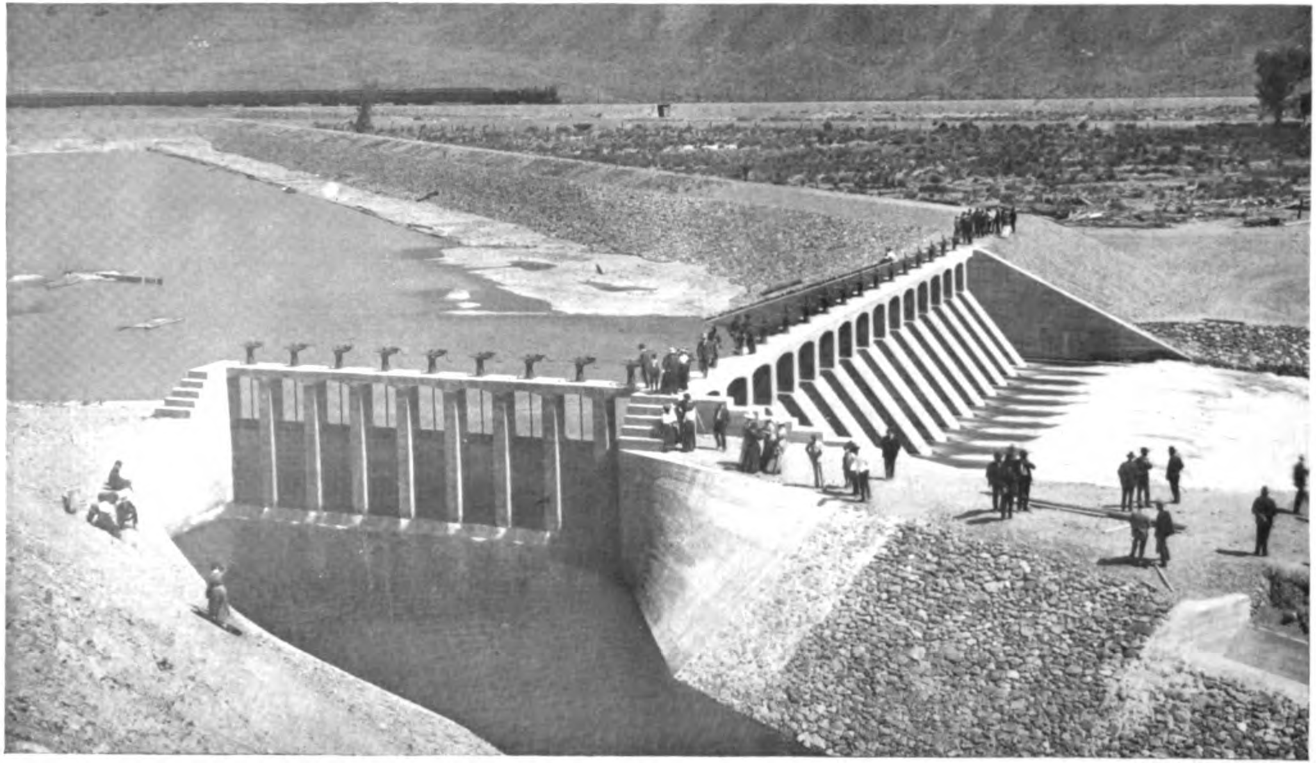
Heater to be covered with plastic asbestos cement covering.

Guaranty—

All material used in the entire construction of the heating plant shall be first-class. The entire job to be erected in a neat, substantial, and workmanlike manner, with pipes sufficiently large and capable of properly heating the rooms in which radiators are placed to a temperature of 70 degrees F. in zero weather.

Wiring and Fixtures—

The sum of $85.00 is to be allowed for electric light wiring and fixtures.



HEADWORKS OF MAIN TRUCKEE CANAL, TRUCKEE-CARSON IRRIGATION PROJECT, NEVADA.

The main canal, shown at left in foreground, will carry the water of the Truckee river to irrigate 350,000 acres in the Carson Sink Desert. Gates of great diversion dam, shown at right in background, are here open, allowing water to flow in regular channel.

Estimate of Cost for Residence at Babylon, Long Island, N. Y.*

Mason Work—

Excavating		$ 15.00
23,000 Brick in foundation, chimneys, and cesspools..	$10.00	230.00
56 Barrels Portland cement in above	1.75	98.00
16½ Barrels lime............	2.00	33.00
7 Barrels plaster...........	2.00	14.00
82 Bags prepared plaster...	1.10	90.20
2½ Bushels marble dust....	1.00	2.50
Plasterers' and bricklayers' labor on above..........		258.00
Mason laborers' labor		273.75
200 Face Brick.............		10.00
15,000 Wall lath............	4½	60.00
Lathers' labor		30.00
53 Feet 8½ by 13-in. flue lining	.28	14.84
20 Feet 8½ by 8½-in. flue lining	.25	5.00
72 Feet 5-in. tile to cesspool.	.12½	9.00
Two 5-in. bricks............	.47	.94
One 5-in. Y................	.65	.65
48 Pieces 4-in. tile to dry wells	.20	9.60
One 4-in. Y................	.50	.50
Two 4-in. bricks............	.38	.76

*This estimate does not include anything for "overhead" charges and profit; nor does it include the cost of making up the plans. Ten per cent would probably be a fair average for these items.

One 4-in. T................	.50	.50
Total mason work.....		$1,156.24

Carpenter Work—

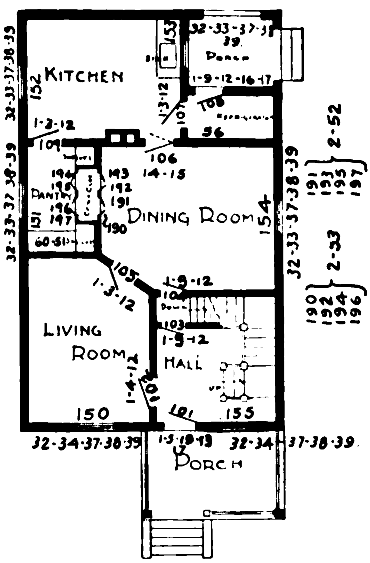
11,700 Sq. ft. timber...........	$30.00	351.00
775 Sq. ft. sheathing......	28.00	21.70
1,000 Sq. ft. roofing.........	3.00	3.00
6 Rolls sheathing paper..	.85	5.10
320 Shingle lath	8.00	25.60
12,400 6 by 20-in cedar shingles	17.50	217.00
17,500 18-in. Washington red cedar shingles	6.75	118.13
Window-frames		50.00
1,600 Feet 7/8 by 2½-in. C. G. N. C. pine floor, heart face	50.00	80.00
1,500 Feet 7/8 by 2½-in. C. G. Y. pine floor, heart face......	70.00	105.00
560 Feet ½ by 3½-in. clear N. C. ceiling	30.00	16.80
620 Feet 7/8 by 3½-in. clear Y. P. floor	4.50	27.90
Carpenters' labor complete at $3.00 per day.............		1,425.00
Exterior trim and columns....		285.00
Interior trim, sash, doors, and stairs		479.00
Interior screens		51.40
Sash, weights, and cord, nails..		53.00
Finish hardware		60.00
Total carpenter work...		$3,374.63

Tin—	
Tinwork and gutters	$ 61.00
Plumbing	584.00
Heating	468.00
Painting	195.40
Electrical Work	85.00

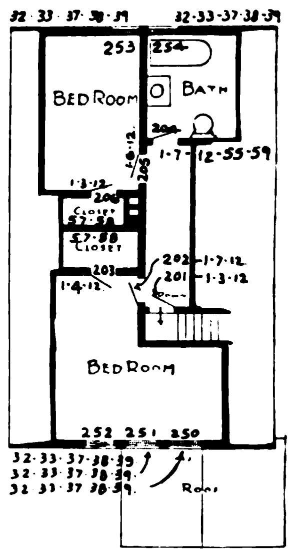
Summary

Mason work	$1,156.24
Carpenter work	3,374.63
Tin	61.00
Plumbing	584.00
Heating	468.00
Painting	195.40
Electrical work	85.00
Grand total of cost	$5,924.27

WORKINGMEN'S HOUSES BUILT OF SOLID REINFORCED CONCRETE.



FIRST FLOOR PLAN



SECOND FLOOR PLAN

HOUSE PLANS SHOWING LAYOUT OF HARDWARE ITEMS NEEDED.

PLATE 1—BUILDERS' HARDWARE.

Builders' Hardware

In that early stage of the art of building when it first became necessary, either from climatic conditions or for personal protection or convenience, to cover openings and entrances through the side-walls of buildings with some form of movable surface or grating which could at will be rigidly fastened in place, the use of a crude form of **builders' hardware** first became a necessity. Just as the wire nail of to-day has taken the place of the oak pin and hand-forged nail of one hundred years ago in construction work, so have the various forms of modern locks, bolts, and patented fasteners taken the place of the lock, latch, and bar fastenings of earlier days. In fact, times have changed as well as fastenings, and it is very doubtful if it would be a safe proceeding in our crowded cities to leave "the latch string hanging out."

While there has been a great change in the types and appearance of locks, latches, hinges, escutcheons, etc., the general principles of the original forms still remain. In fact, since the recent wave of enthusiasm over the old Colonial type of architecture obtained such a foothold, imitations of some forms of the hardware common in the early days of American history have appeared on the market.

Possibly this similarity of principle continuing through many years—and even centuries—is most strikingly brought out in **locks.** Historians tell us that even the earliest forms of locks, used at the time when the Egyptians were at the height of their civilization, are almost identical in principle with the modern lock. In the earliest form of lock—which, by the way, was made of wood—several small bolts were arranged to drop down from a part of the mechanism fixed to the door or gate into corresponding holes in a bar which slid through this fixed part. A wooden key of considerable size, depending upon the importance of the lock, was provided at one end with projecting pegs of different lengths, which were arranged to fit the holes into which the bolts fell when the lock was in place and to lift the bolts out of the way. Compare this principle with that of the modern cylinder lock with its various small pin-tumblers adjusted to fit the notches and points on a flat type of key.

The term "Builders' Hardware" to-day covers **all metallic mechanical fittings used in building construction. Nails, screws,** and **bolts** are used to hold together integral parts to form the whole. **Locks, latches, catches, bolts,** and **hooks** are used to hold temporarily some adjustable member of a construction in a fixed place for a certain purpose. **Hinges** and **butts** are used as a means of easily moving, by a swinging motion, some part of a structure which it is convenient to have in various positions. **Escutcheons, push-plates,** etc., form a protection from wear to the member on which they are used.

It is useless to try to describe standards in builders' hardware, since manufacturers of the same article use different patterns and even different materials for producing the same effect. For instance, locks, butts, and hinges may be made in various proportions and shapes, each having its distinctive object and merit, while, again, each type may be made of a variety of metals such as cast iron, wrought iron, wrought steel, brass, or bronze, the cost varying with both the type and the metal.

The metals commonly used in hardware are those just mentioned above. **Cast iron** plays an important part, especially in the cheaper grades of lock cases, butts, catches, casings for bolts, or in places where an ornamental design is wanted at a low cost. Cast iron takes lines in the pattern well, and produces sharpness of definition in the reproduction of fine work. The lack of strength in cast iron is a serious drawback and should be considered when using articles made from it in places where failure in the iron could cause damage or inconvenience. For some purposes cast iron is given a treatment in a special furnace which converts it into a semi-steel. It is then called **malleable iron.** This treatment toughens and strengthens the original casting, even to such an extent that it may be bent somewhat without breaking. Malleable iron is used in keys and bolts, and in cases for bolts where riveting or pounding is necessary, etc.

Wrought iron was one of the first metals used in the construction of hardware. It is still used to some extent in America, and to a great extent in foreign countries. The advantageous use of cast metals and pressed forms in producing a large number of like parts has displaced the old individual method of piece production, excepting in cases of special design where but one or a small number of pieces are wanted. For decorative work where much bending and welding of small parts is necessary, wrought iron is still used to advantage.

Wrought steel is a comparatively new material in the field, but is rapidly coming to the front as a constructive metal. Steel in sheets may be formed by the processes of die work into a large number of parts which formerly were cast or forged. The rolling of the steel from the ingot to the sheet increases its strength, thereby allowing strong and light articles to be made from it.

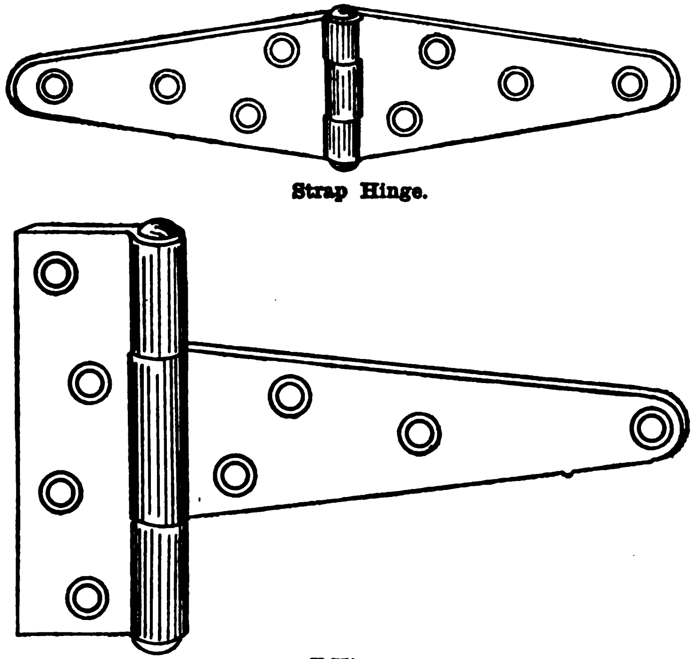
Brass and **bronze** are both copper alloys, brass containing about 65 per cent of copper, while bronze contains about 90 per cent. On account of the higher percentage of copper, bronze is more expensive than brass; and from the nature of the alloy—tin and zinc being the other materials used in bronze, while zinc and lead are used with the copper for brass—bronze is slightly harder and stronger than brass. As in the case of wrought steel, these alloys are rolled into sheets from the cast ingot, and may be pressed or formed into the various shapes desired for light-weight work. Where heavy or massive designs are desired, or where fine detail in decorative design is to be produced, these alloys in a cast state are rated as among the best.

The articles of builders' hardware used in an ordinary residence may be divided into the following classes:

1. Fittings for doors, blinds, and shutters;
2. Fittings for windows and transoms;
3. Miscellaneous fittings.

FITTINGS FOR DOORS, BLINDS, AND SHUTTERS

Hinges and Butts. Among the various **fittings for doors,** possibly the most important are the **hinges** or **butts** used in hanging the door in place. The term "hinge" properly applies only to one or the other of two forms—either the **strap hinge** or the **T-hinge** shown in Fig. 1. The old-fashioned hinge found now on old structures in some parts of the country, was a hand-forged strap with an eye turned up at one end to fit down over a pin in the end of a large sharp-pointed piece driven into the framework which was to hold the swinging member. This form of hinge is passing out of existence except for ornamental purposes; and even then, forms are often used which are fastened to the doors and casings in connection with the ordinary butt, giving the appearance of the old-fashioned strap.



Strap Hinge.

T-Hinge.

Fig. 1. Two Common Types of Cheap Hinges Used on Barns, Gates, Bulkhead Doors, etc.

The two forms of hinges shown in Fig. 1 are used on barns, sheds, gates, and in places where a cheap hinge is wanted.

Butt hinges—so-called from their location between the door and casing—are the common form of hinge used in building. The importance of choosing a good butt is not always realized, nor does the builder always consider the amount of wear and strain which comes upon this important piece of hardware. The satisfactory action of a door depends largely upon the hinges used for it to swing upon. These will be subjected to a certain amount of frictional wear, depending upon the location of the door and its weight. A very small amount of wear on the bearing surfaces of the butts on a door will be noticeable in a short time, from the door either sticking or sagging. To provide against this possible defect, butts should be chosen of sufficient size for the weight of the door; and care should be taken that the "thrust" on the bearing surfaces is distributed over a sufficient number of "knuckles" so that wear is not localized in any particular place. In butts of brass and bronze, or the softer metals, the wearing surfaces are protected by steel washers, and often by steel washers on the seat surface and steel cylinders surrounding the pins. Grooves or pockets are cut in the faces between the two rubbing surfaces in order to hold a small supply of some form of lubricant to lessen the wear. A type of **ball-bearing butt** has appeared on the market, its object being the same as in the cases mentioned above. It is a five-knuckle butt, with the ball-bearings placed on each side of the middle knuckle.

Butts for doors are of various types, and are made of various materials. Cast-iron butts are the cheapest and least durable. The use of this form of butt should be avoided whenever possible, and adopted only when the first cost of a house is considered. The damage and inconvenience which may arise from a broken cast-iron butt can hardly be estimated. Cast-iron butts come in all finishes, and are often bronze-plated to imitate solid bronze.

Wrought steel butts are possibly the best moderate-priced butts used. Ordinarily they are well designed, and the strength and durability of steel makes them appropriate for a great many uses. This material will also take all finishes, especially the Bower-Barff (see below under "Finishes for Hardware").

Cast butts of brass and bronze are used in heavy work, but are very expensive. Where a Bower-Barff finish is desired in massive work, heavy cast-iron hinges of good quality are used.

In all of the above metals, care should be taken to notice the thickness and weight of hinges, as there is a tendency on the part of some manufacturers to use too light metal in large butts. The cheaper grades of cast-iron butts—and, in fact, other articles of cheap hardware—are generally covered with quite elaborate designs and figures. Plain finish is in better taste, and almost without exception signifies a better quality of material.

The types of butts in common use are **loose-pin, loose-joint,** and **fast-joint butts.** The loose-pin butt shown in Fig. 2 is a good type of butt to use for ordinary house doors. The pin in this type of butt is loose, and may be lifted out when necessary to unhinge the door. As will be noticed in the figure, this butt has five knuckles, thus always providing two bearing surfaces in

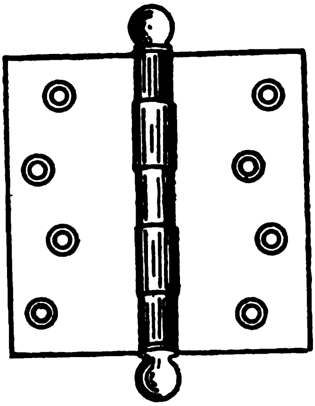


Fig. 2. Loose-Pin Butt.

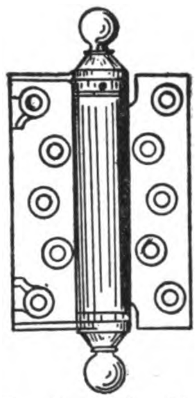


Fig. 3. Spring Butt.

each butt. It is also reversible; that is, either half of the butt may be fastened to the casing and will support the other half. Butts having less than five knuckles should not be used. Provision is made at the ends of the pins to prevent the pin from working up and out of the butt.

Loose-joint butts are the cheapest type of butt hinges, and are constructed on the principle already mentioned in connection with the old-fashioned strap hinge. One half of the hinge bears the pin, and the other half the sleeve which fits over the pin. This construction necessarily makes them non-reversible. The wear in this type of butt comes all on one surface. The door may be removed, when this form of hinge is used, by simply opening it clear of the casing and lifting it away from the pins. Care should be taken to notice whether right-hand or left-hand butts are needed, when using this type.

Fast joint-butts are similar to the loose-pin butt, with the exception that the pin is riveted firmly in place. This type is not often used on doors of any considerable size, on account of the difficulty met in removing a door. This style of butt has its advantage when horizontally placed butts are needed, since the pin cannot fall out, as might be the case if a loose-pin butt were used.

Ordinary butts used in building are square when open. When special forms are designated in catalogues—as a 3 by 2½ for instance—it means that the butt is 3 inches high by 2½ inches wide when open. **The first figure indicates height.** The common sizes for interior doors are the 4 to 5-inch sizes; while for heavier doors or entrance doors, the 5 to 6-inch sizes are used. In some cases where a light hinge would be sufficient to carry a door, but where the finish around the door prevents it from swinging clear back against the wall, it may be necessary to use a larger butt in order to allow the knuckles to project out far enough so that the door when opened may not strike. The rule is to allow the knuckles to project a little more than one-half the distance from the surface of the hanging stile, where the hinge is attached, to the surface of the finish on the casing on the knuckle side of the door.

While it is common practice to place only one pair of butts (two hinges) on an ordinary light door, the use of one and one-half pairs will give

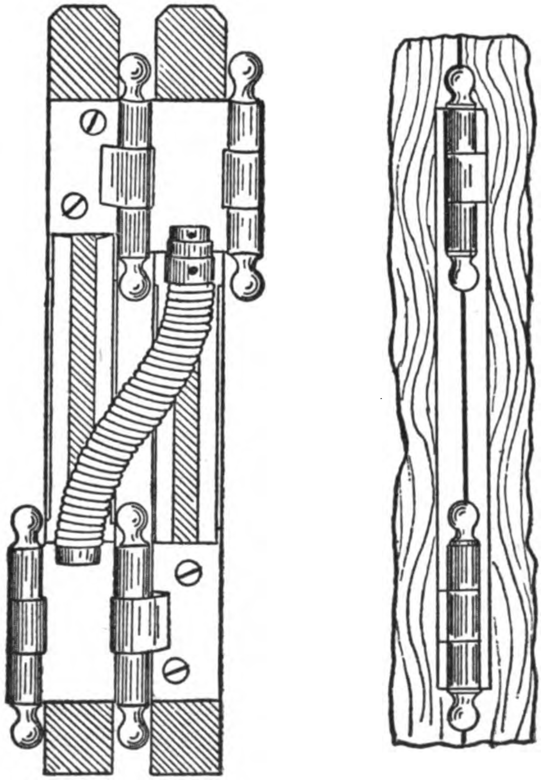


Fig. 4. Double-Acting Spring Hinge.

better results both in wearing qualities and in rigidity. The middle hinge prevents the door from springing. Large or heavy doors, or doors over seven feet high or four feet wide, should always have three hinges.

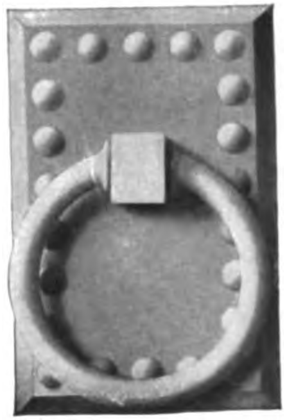
Fig. 3 shows a type of spring butt which is used on doors that are to be self-closing. This butt is useful for screen doors, or, in a heavier form, for light entrance doors. The constant slamming of doors fitted with such hinges is liable to rack and loosen the parts of the door. The tension in the spring of these hinges is adjustable for either slow or quick closing.

This form of butt is also doubled with another of the same kind by a connecting plate between the two spring cases, forming what is known as a **double-action spring butt or hinge.** These are used on doors which must swing in either direction, and yet remain closed when still. Pantry doors and doors between kitchen and dining room, often have this type of hinge.

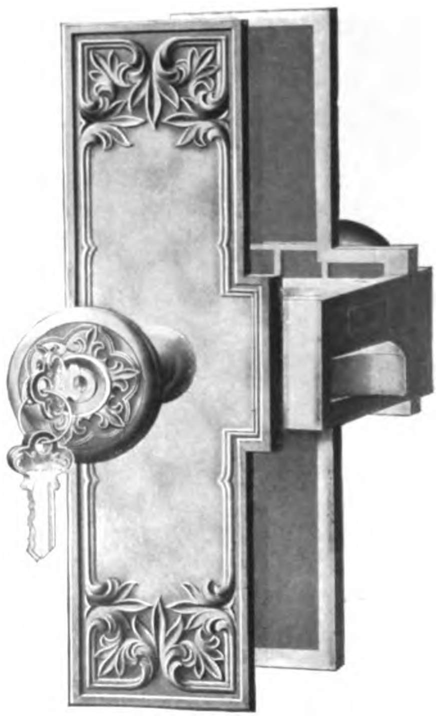
Fig. 4 shows a type of double-acting spring hinge for use on heavy entrance doors. This same form of hinge is finished without the spring, if desired. Double-acting hinges—especially of the spring type—are both heavy and expensive. The largest size of the kind shown in the figure weigh thirty pounds per pair and are listed at from $7.50 to $12.00 per pair.

Right and Left Hand. We have spoken in the preceding pages of **right-hand** and **left-hand** butts, and, as these terms will be used again in connection with locks, a few words of explanation will be in place.

Fig. 5 shows a floor-plan of a house, with the doors marked **R. H.** for right hand, and **L. H.** for left hand, as the case may be. The



Door-Knocker—Arts and
Crafts Design.



Door-Latch—Pure Colonial.

The Modern "Unit" Lock.

HOUSE HARDWARE ITEMS OF RICH DESIGN.

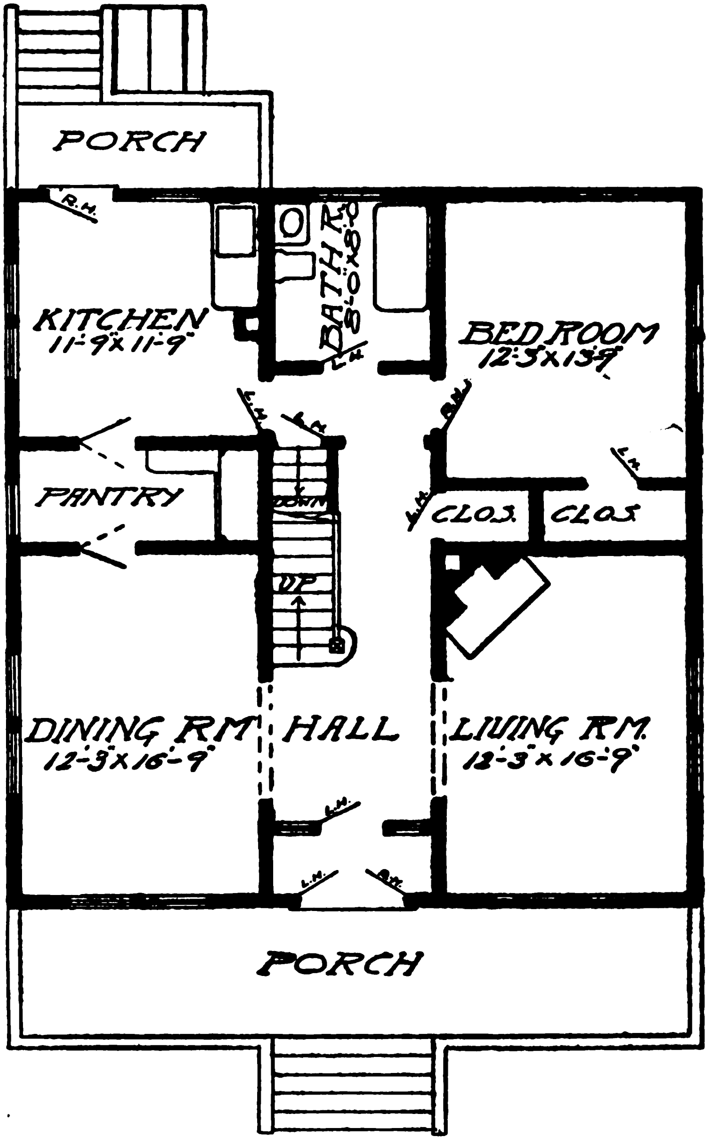


Fig. 5. First-Floor Plan of a House Illustrating Distinction between "Right-Hand" and "Left-Hand" Doors.

rules which govern the marking of this diagram are as follows:

The **hand of a door is determined from the outside,** this being the street side in case of an entrance door; the hall or corridor side, for a room door; and the room side, for a closet or clothes-press door.

In the case of a door between two communicating rooms, the outside is the side from which the **butts are not visible** when the door is closed.

If, when standing **outside** a door as explained above, the hinges or butts are on the right-hand side, it is a right-hand door; if on the left side, it is a left-hand door.

Latches and Locks. Now that we have our doors hung in place with the proper forms of hinges, the next step is to provide **latches** and **locks** to hold them closed.

Latches and locks are divided into two general types—either **rim** or **mortise.** Rim latches and locks are those which are screwed directly onto the stile of the door; while the mortise type are set into a cavity mortised into the stile and closed by the front plate of the lock or latch.

These are again divided into three classes—**common-grade, medium-grade,** and **high-grade.** The cheapest grade are the cast-iron rim latches and locks requiring no trimmings except knobs—which are either of iron, porcelain, jet, or mineral—and a small, round, japanned iron door-plate called a **rose.** While these locks present a fair appearance, their mechanism is generally very poor.

The medium-grade may have cases made of cast iron or wrought steel; but the working parts should be of bronze, brass, or steel. In mortise types, cast-iron fronts should not be used, on account of liability to breakage.

Rim locks are used in obscure places; but for general work, mortise locks should be used. A good medium-grade lock is a mortise lock of the lever-tumbler type, with either two or three tumblers, depending upon the grade of security desired. Steel keys are usually furnished with this grade of lock.

The high-grade locks are those of the **cylinder type**, and are made in both rim and mortise form. This class is generally used for entrance doors. The heavier and better-made **lever-tumbler locks** may also be included under this heading, when made with solid brass or bronze plates and bolts. These are more commonly used for interior doors.

One of the largest and oldest lock-manufacturing concerns recommends the following locks for various parts of the house:

For **main floor swinging doors**, 4 or 4½-inch two-bolt knob locks.

For **sliding doors**, 5½-inch locks, containing dead-bolt, and a pull to withdraw door.

For **bedroom doors**, a 5-inch, three-bolt knob lock, the third bolt being a thumb-bolt operated from the inside;

or, for cheaper construction, a 4-inch two-bolt knob lock, with separate thumb-bolt if wanted.

In case of **communicating rooms**, a thumb-bolt operated from the opposite side of the door may take the place of the dead-bolt in the three-bolt knob lock.

Closet doors may have a 4-inch two-bolt knob lock, with trim on both sides or only on the outside, as depth of closet will permit.

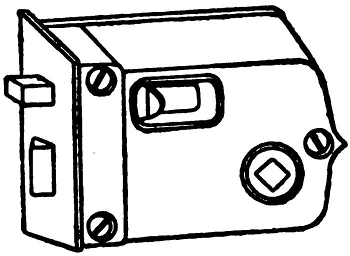


Fig. 6. Rim Knob Latch.

Basement and attic doors may have 3½ or 4-inch mortise locks of a cheaper grade than used in other parts of house.

Bathroom doors may have any form of good knob lock, but should be fitted with a thumb-bolt either as a part of or separate from the lock.

An ordinary type of cast-iron rim knob latch is illustrated in Fig. 6. This shows the thumb-piece and slide-bolt for locking from inside. This particular lock has a reversible bolt so that it may be used on either right- or left-hand doors. Many claim that non-reversible locks are generally stronger than the reversible type.

Fig. 7 shows a type of cylinder rim **night-latch,** which can be operated from the outside only by use of a key.

There is a type of dead-locking rim night-

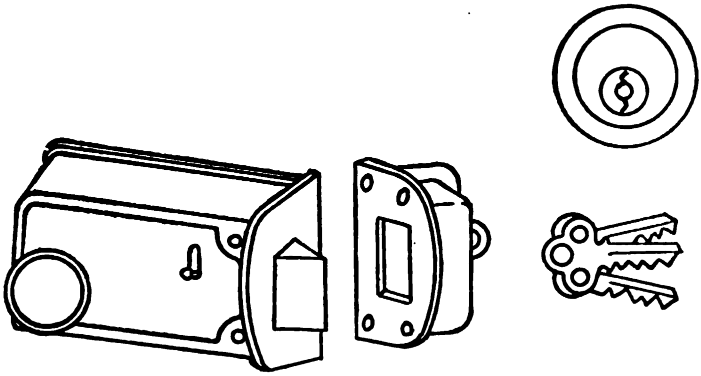


Fig. 7. Cylinder Rim Night-Latch.

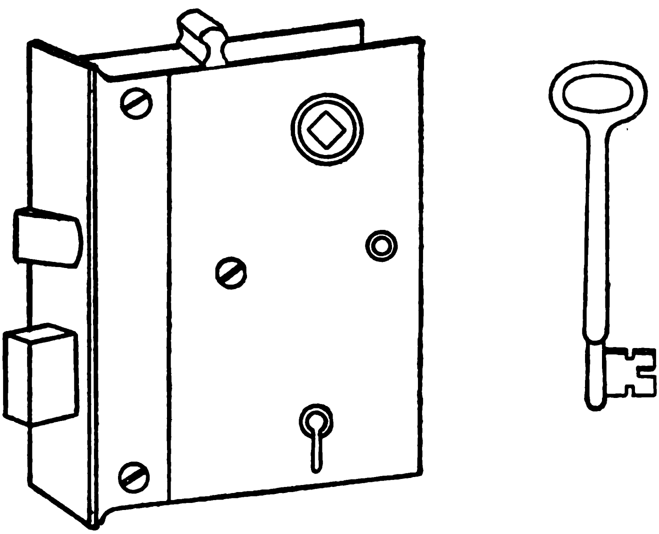


Fig. 8. Rim Knob Lock.

latch which acts normally as a spring latch, but, if attacked with tools through the crack of the door, a safety device dead-locks the bolt and prevents its retraction except by the knob or key. This lock is especially intended for entrance and office doors liable to attack by thieves.

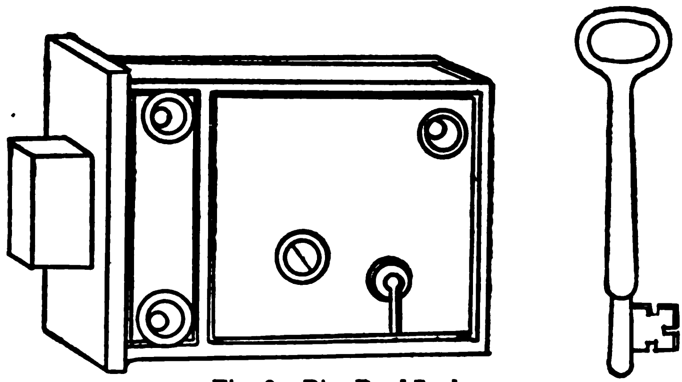
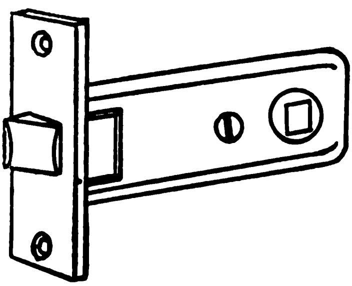


Fig. 9. Rim Dead-Lock.

Fig. 8 shows a form of upright rim knob lock with one tumbler and stop on latch. This is a low-priced lock. The same form of lock is made up in a horizontal form for use on doors with wider stiles.

Fig. 9 shows a form of rim dead-lock. These vary in price from $2.25 per dozen (list price) up to $97.50 per dozen, thus showing the variation existing in this class of hardware.

In comparison with the previous figures of rim latches and locks, we now have the mortise type. Fig. 10 shows a good type of mortise knob latch, the mode of applying same having been already explained.



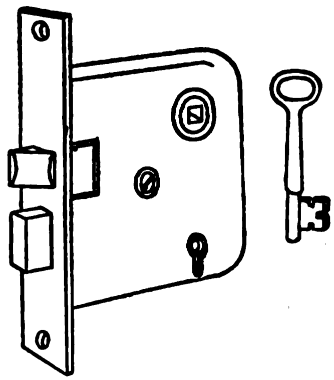


Fig. 10. Mortise Knob Latch. Fig. 12. Mortise Knob Lock.

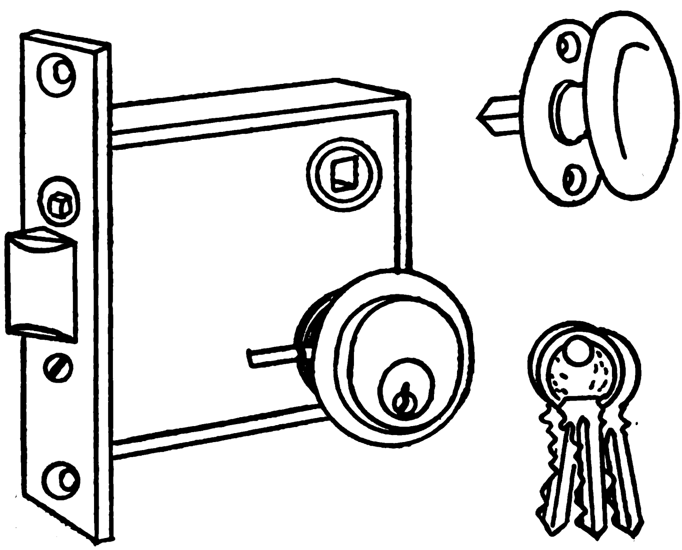


Fig. 11. Mortise Night-Latch.

Fig. 11 shows a type of high-grade mortise night-latch which is operated by key from the outside and knob from the inside; while Fig. 12 shows a three-tumbler iron case mortise knob lock of medium grade. This lock has cast bronze front and bolts, and wrought bronze strike.

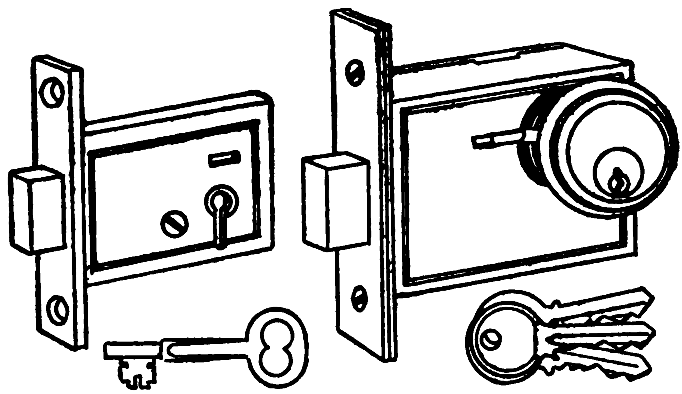


Fig. 13.—Mortise Dead-Locks.

Fig. 13 shows two examples of mortise dead-locks—one of the lever-tumbler type, and one of the cylinder type.

In choosing locks for doors, it is good policy to buy a good, substantial product. Simplicity in action, combined with strength and small size, is the chief requisite. Large, ornamental locks and fittings on small doors are just as much out of place as small, cheap locks on massive doors. Although the cylinder type of lock presents a rather difficult task to the lock picker, the manufacturers themselves agree that **any lock with a keyhole can be opened by skillful persons.** Locks may have a good moral effect on the populace at large; but a burglar's "jimmy" knows no morals. Therefore a good, plain, heavy, compact lock answers every practical purpose as well as one of more intricate design.

The distance between the center of knob and front plate of lock should be about 3 inches.

The latch and bolt in a good lock should be heavy, and preferably of brass or bronze. The bevel on the latch should be of such a shape that, as the door closes, the latch will be easily depressed by the strike without binding or catching. The usual form is that of a smooth curve beginning at the lock front and extending to the outer point or end of the latch.

Although most locks and latches come with the beveled latch-bolt in reversible form so that they can be used on either an in-opening or out-opening door, it is better to specify at the start just which form is desired. For doors opening inward, the bevel of the latch bolt is spoken of as **"regular."** For doors opening outward, it is called a **reverse bevel** bolt. This condition should be noted in connection with the hand of a door when taking a list of the latches and locks needed in a house. The strike for a mortise lock may be the same for either case, but it is not so always and therefore should be noted. For rim locks, the two strikes are quite different.

Many locks are reversible for use on both right- and left-hand doors; but ordinarily a lock is either right-hand or left-hand, and should be specified as such in each instance. Reversible types of locks are not built as strongly in most instances as the straight type.

Keys. Keys vary from the cheap cast-iron type, which should be avoided, to the high-grade flat or corrugated nickel-bronze key with gold-plated bow. Malleable iron, steel, bronze, and brass are all used, and all good. When a series of locks of a certain type are to be used in a building, it is convenient to have them **master-keyed,** each lock still having its individual pass key. This often saves trouble and expense in case of a lost key. The drawback in such a system is the possible loss of the master-key, which would mean replacing all locks concerned in order to insure safety.

Fig. 7 shows a common form of lock **strike** for rim locks and latches; while Fig. 14 shows two types used for mortised locks. The strike for a rim lock is screwed direct to the casing to line up with the lock on the door stile; while, for a mortise lock, the strike is set into the side of the casing. Ordinarily there is a projecting lip which guides the latch into its proper hole and prevents wear upon the woodwork.

Fig. 15 shows a common type of **sliding-door set.** This shows the lock bolt and also the disappearing pull.

A sliding-door latch without the lock is also on the market. This is worked by a lever fitting into the space allowed for the flush pull.

In choosing the trim for locks and latches, care should be taken that the general appearance of the **knobs** and **escutcheons** corresponds with that of the doors on which they are to be used. While plain types are greatly to be recommended for ordinary work, outside or en-

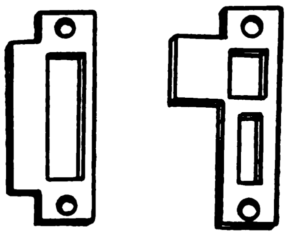


Fig. 14. Lock Strikes for Mortise Locks.

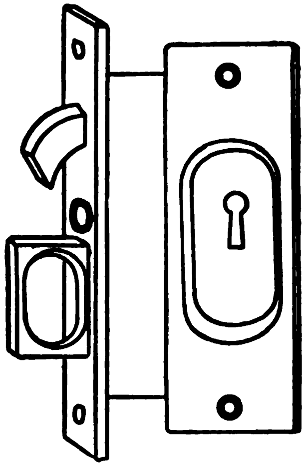


Fig. 15. Sliding-Door Set.

trance doors will often permit of the use of some simple design on knob and escutcheon which adds to the general effect.

Knobs are made of a variety of materials—wood, iron, cast brass, cast bronze, glass, pottery, spun brass, etc. The best grades of knobs are cast from brass or bronze, and are generally about $^{3}/_{16}$ of an inch in thickness.

A close competitor to the cast knob is a composite knob made by spinning a thin shell of brass or bronze over an interior shell of wrought steel. This makes a good serviceable knob with the strength and appearance of the cast knobs. Often the steel shell is omitted, the spun casing of brass or bronze being used alone. A knob of this type is liable to become indented from blows, thereby presenting a poor appearance.

Cast-iron knobs are used with the cheaper grades of locks, and are usually of some ornamental design. While they are generally serviceable, their use is not recommended on good work. Wood knobs are but little used, except in the cheaper classes of work.

Pottery knobs are divided into three common classes: **Porcelain,** the ordinary white knob in general use; **mineral,** a brown-colored knob; and **jet,** which is of a deep black color. These are used on cheap grades of hardware and will ordinarily stand but little service. The shanks to such knobs are made of cast-iron or steel. Glass knobs have glass tops with metal shanks, but are expensive when a good quality are used. For ordinary cases, knobs should not be more than 7 inches in circumference.

Spindles which connect the knobs with the latch or lock, are of two general types: the **straight bar** spindle, and the **swivel** spindle. The bar spindle is made either as a bar with small tapped holes near each end for the insertion of a small screw in the shank of each knob, or by the placing of three parallel bars together so that they form a square bar, the middle bar acting as a wedge against the other two. The solid bar spindle has the defect of seldom having the screw-holes occur just where they are needed for a proper adjustment of the knobs. Small washers are inserted along the bar to make up for this inequality of spacing. The result is that the knob is either too tight to work as it should, or so loose that it rattles.

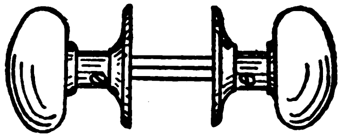


Fig. 16. Door-Knobs.

The bar built of three parts is more satisfactory in that the knob can be adjusted in any position by means of a set screw, and the friction resulting from the wedge-like action of the parts will hold it securely after it is once set in place.

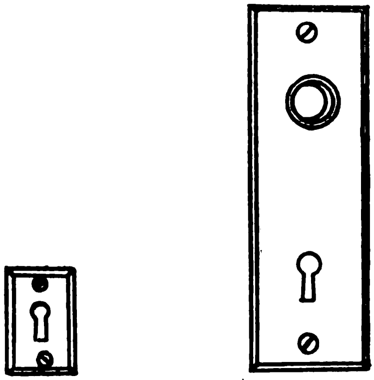


Fig. 17. Escutcheons.

Another advantage of this form of spindle is that if the set screw loosens at all, it is noticed from the slipping of the knob; while in the solid spindle, the set screw generally drops out and is lost before the knob actually comes off.

The swivel spindle is similar to the ordinary spindle, with the exception of a swivel-joint located in the middle of its length. This spindle is used on locks where stop work changes the latch into a lock. The outside knob cannot be turned, while the inside can still be turned at will.

Fig 16 shows a pair of ordinary door knobs with spindle and roses for use when no escutcheon plate is used. The roses are omitted when knobs are used with regular escutcheons as shown in Fig. 17.

In some of the heavier and more ornamental lock and latch sets, forms of lever handles and T-handles take the place of knobs. These are not common in general residence work, except in the case of very light catches and fastenings for cupboards, etc.

Fig. 17 shows two forms of **escutcheons**, one for a keyhole alone, and the other a combination for keyhole and knob. When the combination type is used, care should be taken to see that the projecting rim shown in Fig. 17 around the hole for the knob shank and spindle is at least 1/4 of an inch long, and that the knob shank fits it closely. This allows for a good stable bearing surface for the knob shank and prevents a loose and sagging knob. Care should also be taken that the plate is of sufficient length so that the screws which hold it in place will clear the mortised cavity in the door stile. Otherwise they would have but slight holding power.

Push plates and **kick plates** are another form of trim used on doors which are either of considerable weight or subjected to frequent and hurried use. Fig. 18 shows an ordinary plain form of push plate. The use of such plates gives protection to those parts of the stile and bottom rail which are most subjected to wear.

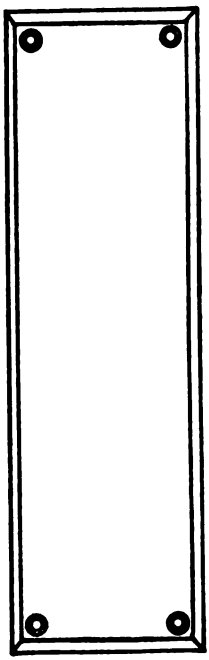


Fig. 18. Push Plate.

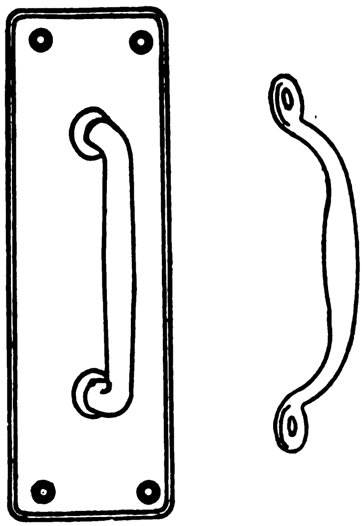


Fig. 19. Bronze Door-Pulls.

Figs. 19 and 20 show two forms of **door-pulls** for use on heavy doors or on doors which are not provided with latch and knob. Fig. 19 represents a high-grade form of pull made from wrought bronze; while Fig. 20 shows a cheap iron type which is used on barns and rougher work.

An old form of **door latch** which is often used now on unimportant doors and where appearance is not of great importance, is a type of **thumb lift-latch.** This consists of a thumb lever pass-

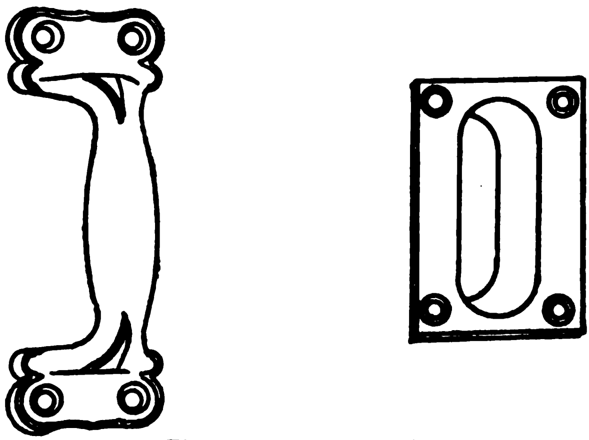
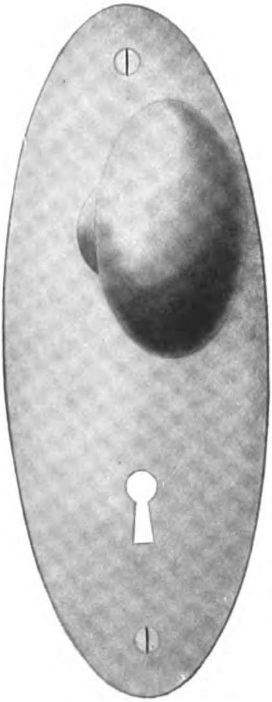


Fig. 20. Iron Door-Pulls.

ing through a slot in the top part of an iron or brass handle similar to Fig. 20. The raising or depressing of this thumb lever from the inside or outside of the door lifts a flat bar, pivoted at one end, from a catch (fastened to the casing) in which the other end rests.

Fig. 21 illustrates an ordinary type of **screen-door catch** which is fastened directly to the rim of the door. Other more expensive types do away with the inside knob, substituting a lever handle in its place. Mortise types of this catch can also be obtained.



Puritan Design, Dull Brass Finish—Very Rich.

Graceful Flower Motif—Bronze Finish.

DOOR-KNOBS AND ESCUTCHEONS OF RICH DESIGN.

COZY, WELL BUILT FRAME HOUSES FOR WORKINGMEN AT GARY, INDIANA.

Floor plan reversed in every second house.

As a means of protection from the inside, **mortise door-bolts** are frequently employed. As seen in Fig. 22, these consist of a stout bolt en-

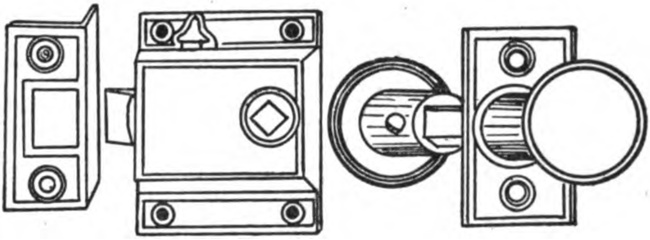


Fig. 21. Screen-Door Catch.

closed in a case and mortised into the stile of the door, the front plate fitting flush with the edge of the door, with a corresponding flat strike sunk into the casing. The bolt is moved by a cog movement through a distance of about 3/4 of an inch by turning the knob shown. This knob,

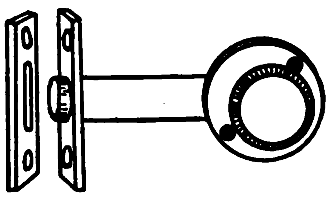


Fig. 22. Mortise Door-Bolt.

with its rose, is placed on the inside of the door.

Foot-bolts and **chain bolts** are used with double doors to secure one half of the door in place while the other is free to open. As the name implies, the foot-bolt is used on the bottom rail, while the chain-bolt with its chain hanging down within reach is fastened to the top rail. These bolts, of course, are for inside use.

A lighter form of bolt used more commonly in cabinet work is shown in Fig. 23. This is known as a **flush bolt.**

Figs. 24, 25, and 26 show three other forms of bolts in common use. The **barrel bolt** shown in Fig. 24 is one which is familiar to everyone.

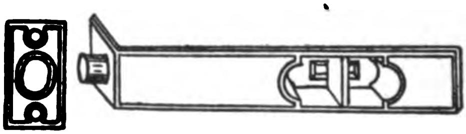


Fig. 23. Flush Bolt.

This is made in all lengths from 2 inches up to 8 inches. The 8-inch bolts are made of wrought iron in the better grades, and weigh about 16 pounds per dozen.

The **square** and **neck bolts** shown are used for the same purposes as the barrel bolt. The

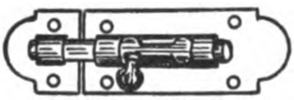


Fig. 24. Barrel Bolt.

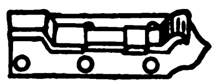


Fig. 26. Neck Bolt.

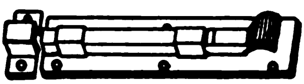


Fig. 25. Square Bolt.

square bolt has a shoulder, shown in the figure, which, when the bolt is shot into position, is forced outward by a spring back of the bolt bar, and prevents the bolt from sliding back from the strike without first depressing the rounded end of the bolt.

In the selection of any of these types of bolts, several points should be borne in mind. Bolts are mainly intended as a means of protection and can be operated solely from the inside of a door. Therefore strength is the factor to look for, combined with ease of operation.

The metal casing which holds the bolt, and the strike or keeper which receives it, should

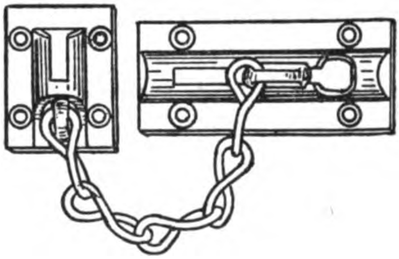


Fig. 27. Chain Bolt.

both be of good material, as strongly put together as possible. Flimsy or thin materials which will bend or break as soon as force is applied to the bolt, are useless in such a location. Another point to notice is the manner in which the bolt is moved. The metal knob shown on the barrel bolt in Fig. 24 furnishes a good grip for the fingers, while the slide shown in Fig. 23 would not be suitable on heavy bolts which are liable to stick or bind. Such bolts for doors are usually provided with knobs or levers which present a good grip.

Tapered end bolts are advised in cases where a drawing together of the fastened parts is desired, but these generally require an application of considerable pressure.

When it is desired to leave a door ajar for purposes of ventilation, and still have protection in the form of a fastener, the device shown in Fig. 27 is frequently used. This consists of a strong, light chain with a slide attached to one end which fits into a special slot in the metal part screwed to the door. The other end of the chain is connected to a plate which is screwed to the casing of the door. The length of slot and chain are such that the slide cannot be removed from the slot without shutting the door to at least a very narrow crack, thus preventing a person from the outside from inserting the hand and removing the slide.

Often it is desired to have a door held open either full back or at some particular angle. When such is the case and the use of hooks is to be avoided, the device shown in Fig. 28 may be used. This consists of a barrel form of spring bolt fastened to the bottom rail of the door and provided with a soft rubber tip which may be replaced when worn out. The bolt is held up by the spring, when not in use; and when pressed down by the foot, it locks. To release the bolt, press on the plate surrounding the bolt. The length of this bolt is 7 inches.

Fig. 29 shows a form of **door-spring** which is often used where spring butts are not desired and where a door is desired to be self-closing. The same disadvantage remains in the use of this spring as was referred to in the case of spring butts. It is often better to use an ordinary form of coil door-spring which can be hooked on or disconnected at will.

A device which will prevent the slamming of doors and still preserve the self-closing feature,

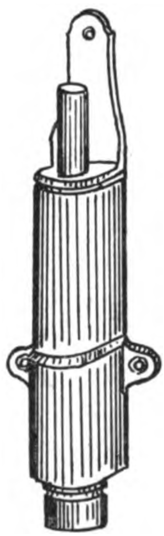


Fig. 28. Door-Holder.

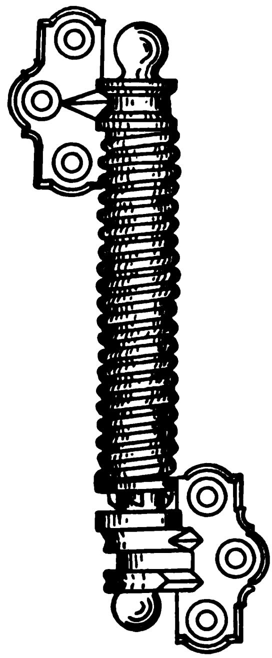


Fig. 29. Door-Spring.

is shown in Fig. 30. This represents one of many types of combined **door-spring and check** which are on the market. The check principle is embodied in the action of either a liquid or pneumatic piston which allows the spring to act gradually in shutting the door. The cost of such checks varies from $1.25 up to $13.00 for the heaviest forms. This spring check is fastened to the top of the door and is generally reversible, but it is better to order them for right- or left-hand doors as desired.

Fig. 31 shows a common form of door-stop. The use of such devices, either in the plain wood form shown here or in the more expensive metal stops, is recommended as a preventative against unsightly marring of walls by the striking of

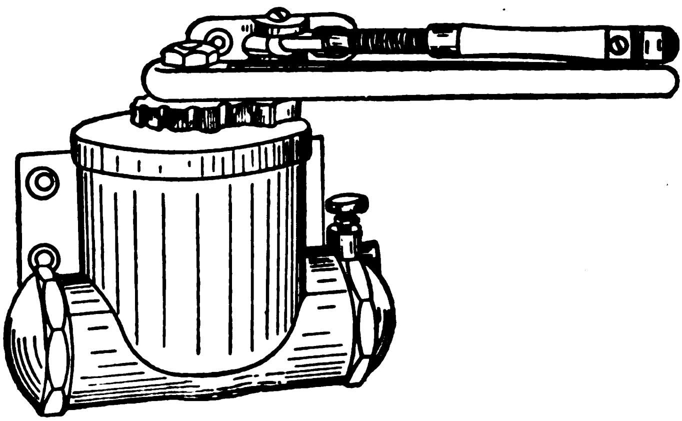


Fig. 30. Door-Spring and Check.

door-knobs. Another form is often screwed into the floor, thus permitting a heavy door to swing back only through a desired angle.

Sliding doors may be moved either by the old method of rollers or sheaves fastened to the bottom part of doors and running on a light steel rail sunk in the floor, or by the use of **overhead hangers** as shown in Fig. 32. These hangers run on an overhead track supported in a special recess over the door. The track on which the rollers run is made of steel covered with strips of wood to make the action noiseless. Ball-bearing journals are also used for this same purpose. The fitting of sliding doors should be left to

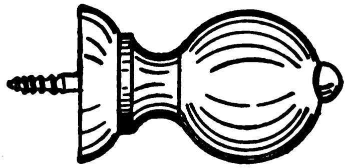


Fig. 31. Door-Stop.

mechanics practiced in this particular line of work, as an ill-fitting sliding door is a source of constant trouble.

The **hardware for blinds** is of a simpler nature than that just described for doors, and is

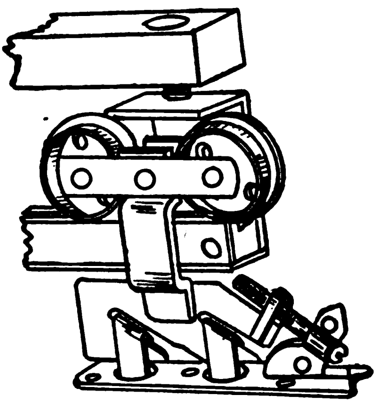


Fig. 32. Sliding-Door Hanger.

comprised mainly of butts, fasteners, and adjusters. The butts used for blinds are either of a type which permits the blind to be hung from its side like a door, or to be swung outward at the bottom like an awning. Figs. 33 and 34 show two types of cast-iron **blind-hinges** which are commonly used. These are very unsatisfactory on account of their liability of failure in high

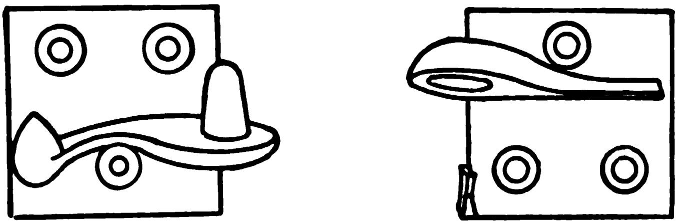


Fig. 33. Blind-Hinge.

winds or when subjected to slamming action. A wrought-iron or wrought-steel hinge is to be preferred, and can be easily obtained at practically the same price. The hinges shown in the figures are to be located on the side of the blind. The

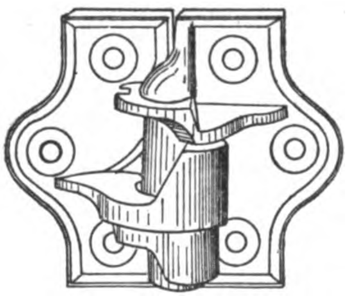


Fig. 34. Gravity Blind-Hinge.

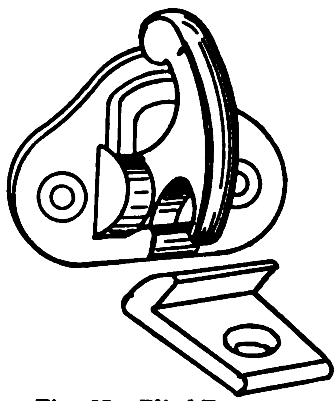


Fig. 35. Blind-Fastener.

awning hinge referred to is not considered suitable for use on any but light narrow blinds. Fig. 34 is known as a **gravity hinge.**

Fig. 35 shows a fastener used to secure blinds in place when closed. The upper part is to be fastened to the blind, and the lower to the sill. The fasteners commonly used to hold the blind back against the wall with the old style of wrought-iron hinge, consisted of a revolving leaf on the end of a pin. The pin was driven into the woodwork of the wall, and the leaf turned up over the edge of the blind. Other devices, such as flat springs along the bottom edge of the blind which catch over a notch on the end of a projecting wall-pin and are released by depressing the spring, are also used when necessary.

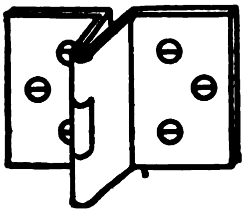


Fig. 36. Angle Butt for Shutters.

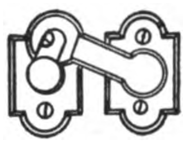


Fig. 37. Shutter-Fastener.

Various types of **blind adjusters** are on the market. The object of such appliances is to hold the blinds firmly in one of a given number of positions. They may be swung nearly open or held firmly closed as desired. The principle involved in one form is the location of the end of a rod, one end of which is pivoted to the blind, and the other is bent over so as to be inserted in any one of a number of holes in a metal piece which is screwed to the sill near the center of the window. Another small fitting on the inside face of the blind is located in such a manner that the bent end of the rod may pass through a lug on the fitting, and then into the piece on the sill, thus holding the blind firmly closed.

For **shutters** or **inside blinds**, the forms of butts or hinges vary from the ordinary butt up to the so-called **shutter flaps**. Fig. 36 shows a form of angle butt which is used when a shutter has three folds. The purpose of the construction of this butt is to allow the folds to take such a position when open that they may fold together compactly into the window frame.

A form of light bar for holding shutters closed is shown in Fig. 37. One half of the fitting is attached to a leaf on one side of the shutter, while the other half, or pin, is attached to a leaf on the other half of the shutter. On three-leaf shutters, it is advisable to use a form of flush shutter bar, unless proper space is left when the shutter is folded.

A great variety of shutter knobs are available; but as such knobs are quite prominent, they should be substantial and of good design.

FITTINGS FOR WINDOWS AND TRANSOMS

The hardware for **windows** and **sashes** is not quite as extensive as that for doors, but is of about equal importance. Windows, unless carefully made and fitted, are likely to be a very weak point in building work. Sashes which bind or sag are bound to cause trouble; therefore the correct use of all possible means of preventing such occurrences should be attended to. A sash properly fitted at the start and balanced by the use of proper weights held by cords or chains running over well-made sash-pulleys is generally a success. These pulleys vary somewhat in design, from the ordinary rough cast-iron types which turn on a pin, up to the cold-rolled steel type with ball or roller bearings. Fig. 38 shows a **sash-pulley** of the ordinary type. The face of the pulley housing is usually of iron or steel, but may be made of bronze in some of the more expensive forms.

The face of the pulley housing is set in flush with the face of the pulley stile, thus setting the bearing center of the pulley wheel back into the weight-box. In order that the weight may hang properly from the cord or chain running over the pulley, the diameter of the pulley should not be less than 2 inches at the bottom of the groove in the pulley. This not only allows the weight to hang in a position in which it will not be scraping against the side of the weight-box, but also prevents the continual bending of the sash cord or chain over an arc of small radius, which is injurious to either cord or chain. Care should also be taken that the pulleys are smooth on all surfaces where the cord touches, and that they fit closely in their housings.

While **braided cotton sash-cord** is used for nearly all light windows, plate glass and heavy windows should be furnished with chains running over a special pulley having a square groove instead of the rounded one in general use. This allows the chain to fit the groove and prevents wear from a continuous effort to adjust itself to the pulley.

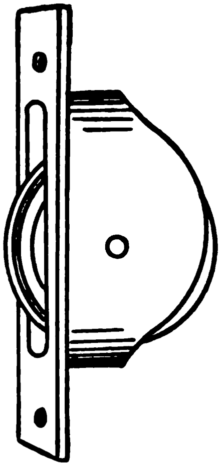


Fig. 38. Sash-Pulley.

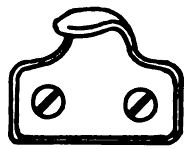


Fig. 39. Sash-Lift.

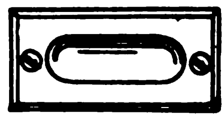


Fig. 40. Flush Sash-Lift.

Fig. 41. Bar Lift.

The ordinary **sash weights** are made of cast iron, and weigh from 3 to 20 lbs. They run from $1\frac{1}{2}$ inches in diameter to 2 inches, and from $5\frac{3}{4}$ inches in length to $25\frac{1}{4}$ inches. When a heavy weight is desired in a small space, lead weights are often used.

Many patented **tape sash balances** are on the market, and, when fitted to carefully weighed sashes, are guaranteed by the manufacturers for a considerable term of years.

The effort expended in lifting a properly balanced sash is not great, yet some device which can be gripped quickly and securely is desired. Fig. 39 shows a small **sash-lift** which is satisfactory for light windows. This lift is made in all metals and finishes from cast iron to solid bronze. If a flush lift is desired, Fig. 40 shows a good type.

In case of heavy sash, the lift shown in Fig. 41 is commonly used. Two of these handles are often fastened to the under side of the bottom rail of the upper sash for use in pulling down large upper sashes. Another device which can be used for this same purpose consists of a small metal socket inserted in the top rail of the upper sash. A metal hook fastened on the end of a pole is placed in the socket when it is desired to pull down the sash.

In choosing a form of **sash-fastener**, the two points which should be considered are its capacities for protection and for the drawing together of the upper and lower sashes. From the protective side, it should not only be of substantial build, but should be constructed so that it cannot be worked by inserting an instrument through the crack between the upper and lower sash. In fact, there are few if any of the sash fasteners which are used to draw together the two sashes which will resist any great pressure applied from the outside. Their design on the principle of the lever pivoted on one sash is a point of weakness.

The type of fastener shown in Fig. 42 is considered to fulfil the requirement of drawing the two sashes closely together to prevent rattling and leakage of air, and, if secured by substantial screws, is probably as safe as any of this type of fastener. The cam action shown also forces

Fig. 42. Sash-Fastener.

both top and bottom sashes to a close fit in the window-frame at top and bottom.

Fig. 43 shows a type of sash spring-bolt which was used at one time as a protection, and also as a means of holding a sash without weights at any desired height of opening.

Many patented forms of fasteners which are applied to the side rail of a sash are to be had, but their merits in many cases are doubtful. One form of side rail fastener which allows the

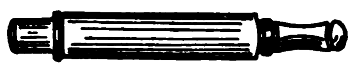


Fig. 43. Sash Spring-Bolt.

sash to be raised by inches and held in place at each point, consists of a bar fastened to the side rail of the top sash and containing pockets cut to fit the head of a spring bolt which is fastened to the top of the bottom sash. By pulling this spring bolt clear of the first pocket, the lower sash can be raised a few inches for ventilation and held in this position by the bolt head entering another pocket in the bar.

For **cellar windows**, which are generally hinged at the top of the sash and fastened at the bottom, Fig. 44 shows a common form of fastener. These windows should swing inward, and are in most cases provided with a hook

Fig. 44. Cellar Window Fastener.

which can be fastened into an eye in the woodwork of the floor above. The turning part, as shown in the figure, is fastened to the sash, while the catch is fastened to the sill or frame.

Another form of fastener consists of a swinging bar pivoted like the cam in Fig. 44. In this fastener the bar part is fastened to the sill or frame, and turns up over a plate having a handle connected and fastened to the sash. This affords a handle for raising heavy sash or starting a sash which has stuck.

If a single sash window hinged at the side is used, a **casement adjuster** should be employed to hold the window at any desired angle of opening. These adjusters consist of a pivoted bar and a clamp. The pivoted end of the bar is screwed to the bottom rail of the sash, while the clamp is made fast to the sill. Such a window should be arranged so as to swing outward, and care should be taken that the clamp is always tightened on the adjuster.

Special bolt fasteners are used in this type of sash. They are of both rim and mortise type.

When swinging **transoms** over doors are used, they are either **top-**, **bottom-**, or **center-hung.** For top- or bottom-hung transoms, regular butts are used; but when center-hung, a type of sash center as shown in Fig. 45 or Fig. 46 is necessary. It is generally believed that a center-hung

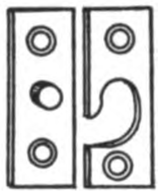


Fig. 45. Sash Center.

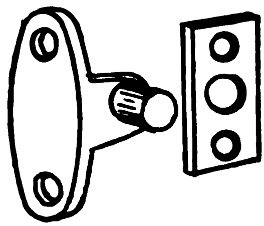


Fig. 46. Sash Center.

transom is the most satisfactory form, especially as far as the action of the transom lifter is concerned. With top- or bottom-hung transoms, the lifter often gives trouble on account of having to lift the weight of the transom sash. This is avoided in a well-balanced center-hung transom as shown in Fig. 47.

A common form of **transom lifter,** and one which embodies the general principles upon which most of the types on the market are founded, is shown in Fig. 48. An inspection of this figure together with Fig. 47 will explain the mechanism very clearly—a sliding rod passing through guides screwed to the door casing; a pivoted arm connected to a plate fastened to

GROUP OF FRAME HOUSES FOR WORKINGMEN AT GARY, INDIANA.

Comfortable, roomy design. Variety of roof treatment prevents monotony.

RESULT OF INSUFFICIENT FILL FOR CONCRETE SIDE-WALK.

RESULT OF LAYING SIDEWALK DIRECTLY ON THE GROUND.

the transom sash; and a clamp at the lower end of the rod to hold same in any position.

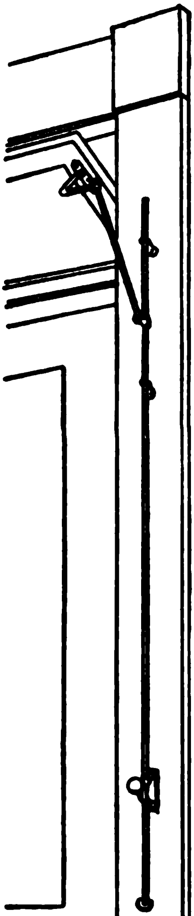


Fig. 47. Center-Hung Transom.

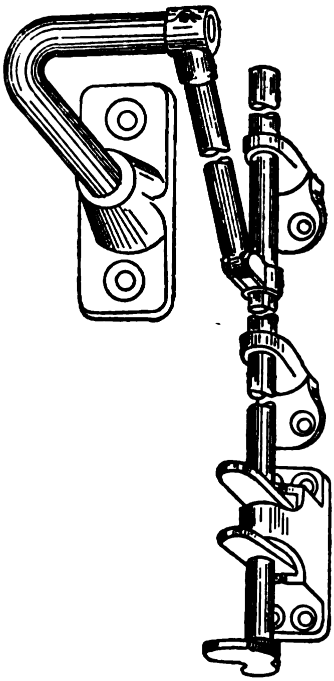


Fig. 48. Transom Lifter.

Fig. 49. Transom Catch.

Although the clamp at the bottom of the rod on the transom lifter is supposed to hold the transom shut, such is not always the case. Fig. 49 shows a catch which represents one of many types used to hold the transom sash shut when such a device is needed. These have but little strength as a protection, and are mainly used to hold the transom closed.

When a transom is not fitted with a lifter and is hinged at the bottom, a form of transom chain consisting of a 14-inch long chain with an attachment at each end for fastening to the door casing and the transom rail, is used to hold the sash in its opened position.

MISCELLANEOUS FITTINGS

Nails, screws, screw-eyes, cup-hooks, staples, and **screw-hooks** are too familiar to everyone to need description. It may not be out of place to suggest that the common round form of wire nail is in most cases preferable to the square cut iron nail. It drives cleaner and holds better. The wire nail is also made with a small head for use in work where the nail-head is to be countersunk and concealed. Where nails are to be driven through work and bent over or clinched on the opposite side, a softer wrought-iron nail should be used.

Fig. 50 shows a few forms of **coat, hat, hall tree, ceiling,** and **towel hooks.** These hooks come in all finishes, and are often formed in very elaborate designs. For ordinary use in closets where a number of hooks are to be placed close together, the ordinary wire hook formed with long hook above and shorter hook below gives good satisfaction. A ceiling hook of this same construction may also be used.

A good fastening for a cupboard door is shown in Fig. 51. This is known as a **cupboard-**

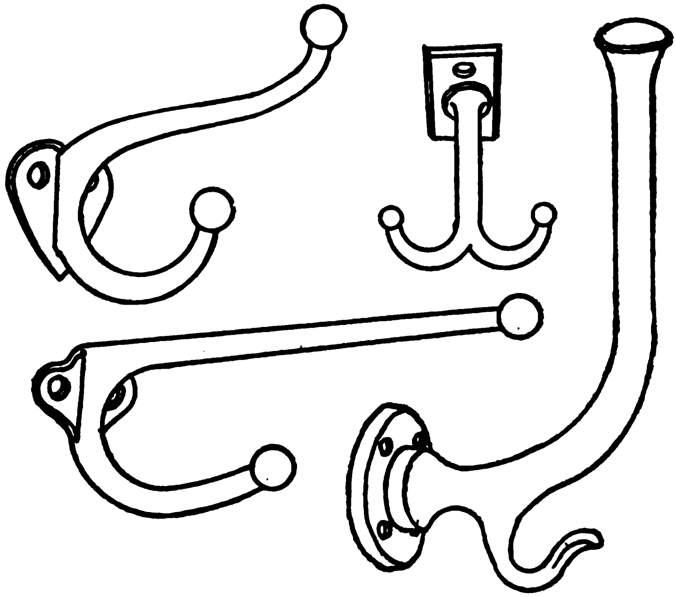


Fig. 50. Various Forms of Hooks.

turn. These come in all metals and finishes and in plain and ornamental designs. The mechanism consists of a spring bolt or catch operated by turning the knob shown in the figure. A **cupboard-catch** which resembles the preceding figure with the exception that the knob slides instead of turning, is also made.

Turn-buttons, consisting of a short metal bar pivoted at its center and mounted in the center of a split metal plate, are convenient for holding small doors or a hinged sash.

A form of **cupboard-latch** which resembles in principle the ordinary door thumb-latch can

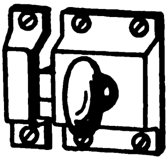


Fig. 51.—Cupboard-Turn.

also be used. In this fastening, a small knob takes the place of the thumb-lever in the large door form of latch.

A combination of knob and catch consisting of a pivoted lever which protrudes through a cupboard door, its hooked inner end falling over a strike, and having a knob on the outer end, makes a simple and secure fastening.

As a substitute for a bolt to fasten the standing part of a double door in closets and wardrobes, a form of fastening known as a **knee-catch** or **elbow-catch** is used. This consists of a lever bent to a right angle and pivoted at the bend. One end of the lever is formed into a catch to engage with a strike placed inside the closet. The other end is fitted with a spring in such a manner that when the door is closed the catch drops over the strike and cannot be released without depressing the spring end of the lever.

The bent lever part of the fastener is screwed to the door.

For **lavatory** doors a form of **latch** is used, consisting of a plate in the middle of which is pivoted a flat latch-bar with a small knob at the outer end. When closed. this latch-bar swings

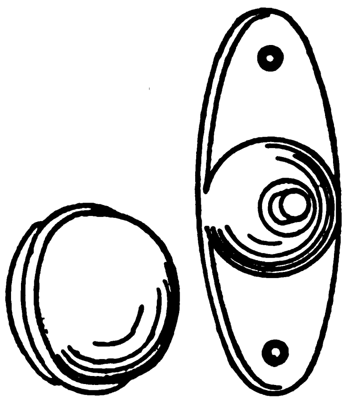


Fig. 52. Door-Bell.

down into a small bracketed arm which forms the other part of the locking device.

Hinges for water-closets should be of heavy construction and made of brass or bronze. A type of double hinge is frequently used.

Any type of good heavy hinge may be used **on refrigerators.** Brass or bronze is preferable on account of its non-rusting qualities. Many forms of refrigerator locks are sold; but most of them serve only as a lock or latch and do not fulfil the important object of keeping the door closed tightly so that no warm air can leak in. The form of latch to be preferred is one that forces the door shut as the bar of the latch sinks into its holder.

While **card frames** for use on doors, **hall mail-boxes, letter-hole plates, speaking-tube whistles,** etc., are all comprised under the heading of "builders' hardware," the types are so common that they hardly need comment.

Fig. 52 shows a neat and convenient type of **door-bell** for use when the regular push-button electric bell is not desired. The push-button shown in the figure is the end of a rod which engages with a series of cog wheels controlling the action of the striker, all encased in a neatly finished bell-metal or steel case, as shown to the left in the figure. This case forms the gong. This bell gives a good ring similar to that of the regular electric bell.

FINISHES FOR HARDWARE

Finishes for hardware vary all the way from a coat of ordinary paint up to gold plating. The cheaper forms of butts, locks, hooks, etc., are **japanned.** This process gives a satisfactory wearing coat which looks well and is a good protection against rust. When plain hardware is to be used it is commonly **buffed** by the use of a rapidly revolving emery wheel. The finer the wheel the higher the grade of surface. Very bright surfaces are produced by the use of a cloth wheel saturated with rouge.

When iron or steel hardware is used, it should be protected in some manner from the effects of rust. Japans, lacquers, and even paints or varnishes, are used for this purpose. **Plating** with copper, brass, or bronze is effective, and even dipping in a copper solution or in molten tin is resorted to as a protective coating.

The **Bower-Barff process** is one of the best finishes for indoor hardware, but is not suitable for exposed outdoor work. The process consists of a chemical change in the outer surface of the iron or steel, effected in a high temperature furnace. The result is a permanent lustrous black color which needs no additional protective coating. While this finish is almost unexcelled for interior work, yet, when exposed to the action of dampness in unprotected locations, rust forms in the small pits which are liable to occur during the process, and spots develop which in time cause the skin of the finish to flake off around the spots, thus leaving the metal unprotected.

For cast or wrought brass or bronze, the natural surface polished or subjected to the action of a sand-blast forms an attractive finish. In places where wear and handling are not excessive, a coat of colorless lacquer may be given to prevent tarnishing. Fancy finishes are given to brass and bronze by the application of chemical solutions which, instead of coloring the surfaces, really discolor them. These finishes do not wear well when handled.

Gold and silver plating are used in some cases in high-class work and parlors, libraries, halls, etc. Gold-plating, varying in thickness according to the use of the article plated, is a permanent finish which requires no care or cleaning.

For plated articles which are handled but little, a thickness known as **single plate** is all that is necessary. For knobs, handles, etc., a thickness known as **triple plate** should be used.

Silver-plating wears well, but should be used only on plain surfaces which can be cleaned easily. The action of sulphurous gases tarnishes silver, and articles coated with such a plating are subject to constant attention.

SELECTING AND BUYING HARDWARE

When it comes to the selection of the hardware for a house, the question as to whether cheap, medium, or high-grade material shall be used depends largely upon the character of the house, and whether it is for private use or for sale or renting purposes. If for private use, the difference in cost between a cheap grade of hardware and a medium grade, with some of the more important articles such as locks or butts of high grade, will be more than offset in the long run by the wearing qualities of the goods. Broken hardware, aside from the replacing value, is often expensive and troublesome to renew.

Care should be taken in choosing the types of locks, butts, etc., used as the general finish of the house should determine largely the size and design to be purchased. Catalogues of the different manufacturers usually explain in detail the finishes and characteristics of their different articles, and it is considered to be good policy to use the line of some reputable concern throughout the entire work. This insures harmony in design, and prevents confusion in fitting pieces in their proper places.

If possible, procure samples of each article to be used, and examine carefully before buying. The experience of an architect who has handled the same line of goods in other residences is valuable. See the actual articles under similar circumstances, and note the conditions of wear and appearance.

When listing the hardware needed, a careful list should be made, containing the name of each article, the quantity desired, any necessary features which it must possess which are out of the ordinary, and its exact location in the house. Costs may now be easily arrived at by making up this list in the cheap-grade, medium-grade, and high-grade qualities. Then, by finally deciding upon a combination of articles from the three lists, the cost may be kept within desired bounds.

A plan of each floor of the house showing locations of doors, windows, closets, etc., may be used to advantage in connection with such a list as that just mentioned. Each door or window should be given a number which will serve to locate the hardware on the list when tagged with a similar number. It is good policy to give each different article on the list a number to designate what the article is, and whether it is for a door, window, transom, miscellaneous, etc.

In the following example articles for doors are numbered from 1 to 30; for windows, from 30 to 50; and for miscellaneous articles, from 50 upwards. First-floor doors are numbered from 100 to 150; first-floor windows, from 150 to 190; and closets and cupboards from 190 to 200. Second-floor doors are numbered from 200 to 250, etc.

On the plan, at each door, window, closet, or other place where hardware is needed, insert the number standing for the article needed at that place. In that way the number of pieces of each article desired can be readily counted up on the plans.

The plans shown in Plate 1 (opposite page 229) are marked in the way indicated. From the list of articles following, numbered as suggested, a **quantity sheet** has been made up. This sheet is only approximate, as its sole object is to show the method to be followed.

HARDWARE FOR DOORS

1—Loose-pin, wrought steel, Bower-Barffed, butts with tip, 4 in. by 4 in.

2—Loose-pin, wrought steel, Bower-Barffed, butts with tip. 2 in. by 2 in.

3—Knob latches, R. H.

4—Knob latches, L. H.

5—Knob latches, stopwork and pass key, R. H.

6—Knob latches, thumb-bolt, R. H.

7—Knob latches, thumb-bolt, L. H.

8—Knob latches, dead-bolt, R. H.
9—Knob latches, dead-bolt, L. H.
10—Brass knobs.
11—Mineral knob.
12—Jet knob.
13—Chain bolt.
14—Double-acting butts.
15—Push-plate.
16—Heavy iron bolt.
17—Push-button for electric bell.
18—T-hinge, 14 in.
19—Padlock and chain.
20—Heavy iron thumb-latch.

HARDWARE FOR WINDOWS

31—Fast-pin, plain steel butts, 3 in. by S in.
32—Pulleys, 2 in. on running face.
33—Sash-lifts, hook.
34—Sash-lifts, handle.
35—Cellar window fastener.
36—Wire hook and eye.
37—Sash lock.
38—Sash cord.
39—Sash weights.

MISCELLANEOUS HARDWARE

51—Drawer pulls.
52—Cupboard spring catches.
53—Elbow catches.
54—Loose-pin butts, with tips, 3 in. by 3 in.
55—Towel hooks.
56—Coat hooks.
57—Wardrobe hooks.
58—Wire closet hooks.
59—Toilet-paper holder.
60—Hinges for flour bin.

QUANTITY SHEET

Number of Door	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Notes
Basem't Door	3															1				1	
Area way Door																		2	1		
101	3				1					1			1				1				
102	3			1								1									
103	3								1			1									Reverse Bevel Latch
104	3								1			1									Reverse Bevel Latch
105	3		1									1									
106														1	1						
107	3		1									1									
108	3								1			1				1	1				
109	3		1									1									Reverse Bevel Latch
										Pairs		Pairs		Pairs				Pairs			
201	3		1									1									
202	3						1					1									
203	3			1								1									Reverse Bevel Latch
204	3						1					1									
205	3					1						1									
206	3		1									1									Reverse Bevel Latch
Total	45	..	5	2	1	1	2	..	3	1	..	13	1	1	1	2	2	2	1	1	

No. of Window	31	32	33	34	35	36	37	38	39
6 Cellar Windows	12				6	6			
Scuttle						2			
150		4		2			1	15	4
151		4	2				1	15	4
152		4	2				1	15	4
153		4	2				1	15	4
154		4	2				1	15	4
155		4		2			1	15	4
250		4	2				1	15	4
251		4	2				1	15	4
252		4	2				1	15	4
253		4	2				1	15	4
254		4	2				1	15	4
Total	12	44	18	4	6	8	11	165	44
								Feet	

Location	51	52	53	54	55	56	57	58	59	60	2
Pantry	12									1	
Bath Room					6				1		
190			1								3
191		1									3
192			1								3
193		1									3
194			1								3
195		1									3
196			1								3
197		1								Pair	3
Back Entry						6					
Chamber Closets							24	24			
Total	12	4	4	..	6	6	24	24		1	24

SPECIFICATIONS

Specifications for hardware generally form a part of the general specifications, but may be omitted and the selection reserved by the owner or architect. There are a great many plans governing the specifications when inserted, among which are the following:

1. Hardware specified definitely;
2. Hardware covered by a fixed allowance;
3. Hardware covered by allowing a fixed sum per opening.

Forms of specifications should be drawn up by an architect who is familiar with such papers. Contracts for furnishing the hardware, either by the contractor or by a dealer or manufacturer, may be obtained in blank form ready to fill in. These are carefully worded and cover the legal side of the transaction.

SIMPLE FORM OF CONTRACT

For small dwellings, when the quantity and value of hardware involved is small, the following brief form may be used:

Contract for Furnishing Hardware

Contract made this .... day of ...., 19.., between ...., Owner, and ...., Contractor. The Contractor agrees to furnish, and to deliver at ...., all of the hardware stated below, according to instructions, drawings, and specifications made by ...., Architect, for the sum of . . . . $. . . . . The hardware covered by this contract is as follows:

(Here insert specifications.)

The Owner agrees to pay the Contractor the said amount of . . . . , $. . . . , as follows: . . . . .
. . . .
The Contractor agrees that all hardware covered by this contract shall be of standard quality, material, and finish; that delivery of the same, complete, shall be made within . . . . weeks from the date when he shall have received all necessary instructions and detailed information; and that the decision of the Architect as to any and all questions relating thereto shall be final and binding upon the Contractor.

Miscellaneous Cost Data

As the prices of labor and materials not only vary considerably in different localities, but are constantly shifting in the same locality, the reader will understand that it is impossible to give any quotations of prices that will be reliable as of permanent or universal application. Any quotations given must be taken merely as proportionate, to be used in comparison with known quantities and methods.

The successful estimator requires more than mere accuracy and quickness in figures. Experience and good judgment, familiarity with all the complicated details of the particular job in hand—these are factors of inestimable value, and they are qualities of an indefinable and intangible nature. The contractor should subscribe for the leading trade journals covering such portions of the construction field as he is interested in, and should keep an eye on **current prices and discounts.** He should also make it a practice in every case to file away his estimates, whether his bids based on them have been successful or not. If successful, he can compare his estimated costs with those of actual construction; and if unsuccessful, he can broaden his grasp of things by noting in what items his estimates have been too high or too low. In the preparation of future estimates, he will have at hand a great mass of data that will be of practical service. In every case he must acquaint himself with conditions, prices, and discounts current in the local market.

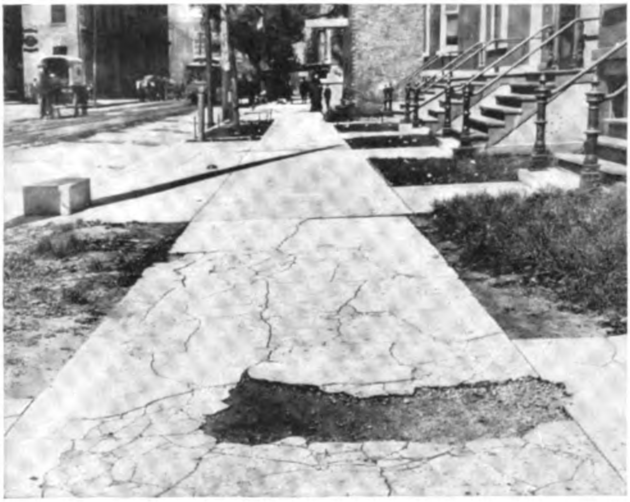
Under the limitations above outlined, the reader will find of much practical value the following paragraphs and quotations,* based on a general review of prices prevailing during the past four or five years:

The cost of a structure is a function of the number of pounds of steel or cast iron, the number of cubic feet or yards of masonry, the number of bricks, the number of feet of board measure, the number of square feet of paving, of linear feet of handrailing, etc., that go to make up the whole. An estimate of the cost requires careful calculating of all of these, as well as a knowledge of a fair unit-price at which they can be put into the structure.

Cost estimates must be based on **unit values.** The accuracy of the estimate will often depend upon the particular unit at which the estimate starts. The cost per unit will depend upon the particular plant or equipment employed and its fitness to handle the work most economically.

The plant or equipment needed to do a piece of work should be selected with a view of the size of the work and the time in which it is to be finished. Large equipment cannot, in general, be used economically on a small job, and small equipment cannot be used economically on a

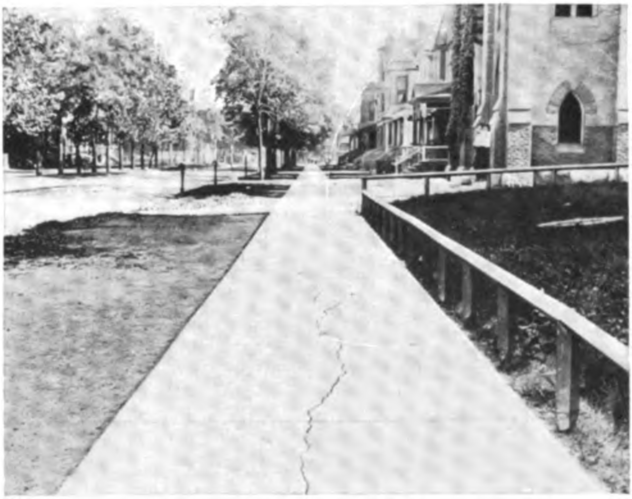
* From "Concrete," by Edward Godfrey.



DISHONEST, SKIMPY WORK IN CONCRETE SIDEWALK CONSTRUCTION.

RESULT OF BUILDING CONCRETE CURB DIRECTLY ABUTTING AGAINST WALK.

CONCRETE WALK DESTROYED BY EXPANSION.



CRACK IN CONCRETE WALK RESULTING FROM POOR FOUNDATION.

large job. The size, for example, of a concrete plant, should be such that its normal daily capacity is about equal to the amount of concrete that it is desired to turn out per day. For maximum economy, a plant should be employed continuously. If stops must be made to wait for forms to be put in readiness, or for other causes, the concrete will cost more than if the work of the concrete mixing can be carried on continuously.

For small concrete jobs, such as pavement work, hand mixing is more economical. Small batches may be mixed with a hoe or shovels in a box. Half-yard batches should be mixed on a platform by at least two men with shovels. The platform may be made of a steel plate or of boards placed with close joints on a frame.

A typical gang, mixing and laying one-half cubic yard batches, is the following: 1 foreman, 2 men delivering sand and stone, 1 man delivering cement, 2 men mixing, 2 men delivering concrete, 1 man tamping. At $3.00 per day for the foreman, and $1.50 per day for each of the other men, the cost per day of the gang is $15.00. The gang should turn out about 20 to 25 cubic yards per day. This is a cost of 75 to 60 cents per cubic yard for labor.

A typical gang for mixing and laying by hand cubic yard batches, is as follows: 1 foreman, 3 men delivering sand and stone, 1 man delivering cement, 4 men mixing, 3 men delivering concrete, 2 men tamping. The cost of this gang at the same wages as above is $22.50 per day. They should turn out about 40 cubic yards per day, making the cost of labor 56 cents per cubic yard.

The above examples give about average conditions, and show the cost of labor on hand-mixed concrete in heavy work where mixing and laying can go on continuously. If labor is cheap (and efficient), the unit-cost may be less, and vice versa. If materials can be deposited for easy handling, as when they are laid close to the mixing board and need only to be measured, the unit-cost will be reduced accordingly; whereas long hauls or high lifts, either before or after mixing, will add to the cost very materially. If the gang cannot be continuously employed, costs may be two or three times as much as the above. Concrete deposited in narrow forms will also cost more per cubic yard than in massive work.

With mechanical mixers, the cost of mixing concrete will be less than by hand-mixing, though the extra cost of skilled workers to run the engine and mixer helps to balance the costs. Batch mixers should turn out about 20 batches per hour.

Current prices for which similar work is being done in localities situated about the same distance from the source of supply, afford a sound basis upon which to gauge the cost of work. It is best for the engineer not engaged in the estimating of cost to the contractor or manufacturer, to use as a base the unit-cost of work in place, rather than to analyze the elements that go to make up the cost, such as material, labor, freight, hauling, profit, etc. The contractor's profit is an elastic factor, depending upon the size of the work, the risk, and many other considerations. The cost of manufacture is variable. Some shops can make heavy work cheaper than others, while others can handle light work more economically.

It is not the purpose here to analyze the cost in shops and mills, so much as to give more general data for determining the probable cost of ordinary building and bridge work, as well as to point out some of the special cases where costs are apt to be more or less than the average. Average costs will prevail near the railroads and within radii of 50 or 100 miles of the commercial centers. Freight rates average about 3/4 cent to 1 1/2 cents per ton-mile. Long pieces requiring several cars and not weighing enough to load them to their normal capacity will cost more per ton than materials that can be shipped in full carloads. Partial carloads are charged at a minimum carload rate—say one-half of the capacity of the car. Where more than one car is required, one car is charged at this minimum rate, and each other car at one-half of this amount, if the actual weight of the material shipped is not over that total.

Hauling under ordinary conditions costs about 50 cents per ton for structural material.

The actual cost of hauling crushed stone 1 1/2 miles in some macadam paving, was found to be

26.6 cents per ton when drawn from the crusher bins, and 31 cents per ton when drawn from the piles. The contract price was 32½ cents per ton.

The hire of a dumping wagon and team and driver is about $4.00 per day; that of a horse and cart and driver is about $3.00 per day.

The actual cost, with stone free at the quarry, of laying macadam pavement (5-inch layer, large-sized stone, rolled; 2½ to 3-inch layer of medium-sized stone, sprinkled and rolled; about ¾ inch of fine screenings, sprinkled and rolled) was 42 cents per square yard. The average weight of stone was 3 tons per square yard. ("Engineering News," Oct. 8, 1903).

The actual cost of quarrying and crushing stone in the above-mentioned work was 42 cents per ton, in which coal delivered cost $4.00 per ton; a driller, $1.75 per day; helper, $1.50 per day; engine man, $2.00 per day.

The cost of mixing materials and laying the same in making the Buffalo breakwater was as follows:

Laying materials	17.4 cents per cubic yard
Mixing materials	12.9 " " " "
Placing mixed materials	14.6 " " " "
Total	44.9 cents per cubic yard

Sometimes the gravel and sand for a piece of work can be found at or near the site, thus greatly reducing the cost of concrete made of the same.

Bricks may be hauled direct from the works, without the expense of loading and unloading on cars.

Extra hazardous work should have something added to the estimated cost to allow for the risk taken by the contractor. Work that must be finished in a short time should have the estimate increased, especially if a penalty attaches for failure to complete by a specified time. If the season is a poor one for the class of work, still more expense is liable to be incurred. Erecting bridges over streams in flood-time may be attended by serious difficulties and expensive delays.

Large contracts, as a rule, cost less per unit than small ones. The placing and removing of the contractor's plant on a job often requires considerable time. If the magnitude of work does not justify bringing labor-saving machinery to the site, the extra labor will make the smaller job more expensive. Large orders of materials may be placed at lower rates than small ones.

Where labor is the principal item of cost in any work, less certainty can be expected in the estimate of the cost, whereas materials that are regularly manufactured should vary but little in cost.

There are some general rules that will be found very useful in making a rough estimate of the cost of structures and checking against large errors in more careful estimates.

The cost per square foot of area covered by a building having practically one floor will be nearly constant for different sizes of buildings of the same class.

Higher buildings will have a cost per cubic foot nearly constant for a given class of building.

For ordinary lengths of spans, the cost of reinforced concrete bridges per square foot of floor does not vary much.

The cost per square foot of the area covered by buildings of the World's Columbian Exposition of 1893 at Chicago, for nine of the principal buildings, varied between 75 cents and $2.35, and averaged about $1.50. The Administration Building cost $9.18 per square foot. The cost per square foot under roof of eleven of the principal buildings of the Louisiana Purchase Exposition of 1904, at St. Louis, Mo., varied between 61 cents and $1.49, with an average of $1.12. Festival Hall cost $5.23 per square foot; Fine Arts Building (Central Building) cost $9.88 per square foot; U. S. Government Building cost $2.31 per square foot. The eleven buildings at St. Louis had timber framework. The Chicago buildings had steel frames. The Fine Arts Building at St. Louis is permanent and fireproof. The U. S. Government Building had steel arches. The cost of the steel work alone was 65 cents per square foot.

The cost in 1903 of a large reinforced concrete factory building was 6.4 cents per cubic foot. This was for the building alone, not including installation of plumbing or furnishings.

Mr. H. G. Tyrrell ("Railroad Gazette," Vol. 37, No. 18) made camparative estimates of a large factory building designed to carry 100 lbs. per square foot of live load (six stories and basement), and found that a building of heavy wooden interior construction with brick floors, and cast-iron columns in the lower two tiers, would cost 6.2 cents per cubic foot, or 83 cents per square foot of area of floors; the same building with concrete-steel floors on a steel framework would cost 10.2 cents per cubic foot, or $1.36 per square foot of area of floors. This did not include furnishings or stairs.

The cost of a reinforced concrete power building per cubic foot above ground was 7.7 cents (see description, "Engineering Record," April 15, 1905, p. 438). The total cost of this building was $250,000.

The cost of a brick building with slate roof on timber will probably be from 8 to 14 cents per cubic foot of its volume.

The cost of a mill building with sides and roof of corrugated iron will probably be from 75 cents to $1.50 per square foot of plan.

The cost of apartment buildings and department stores as usually constructed will be from 20 to 30 cents per cubic foot of volume.

Office buildings will usually run from 30 to 60 cents per cubic foot.

City dwellings will run from 10 to 30 cents per cubic foot.

Brick veneer dwellings will cost about 8 cents per cubic foot.

Window and door frames as ordinarily made for mill buildings, cost about 25 cents per square foot in place, estimating the dimensions out to out of frames. Galvanized-iron louvers of No. 18 iron cost about the same.

The cost of furnishing clips and rivets and putting up corrugated iron, is about $2.00 per square of 100 square feet.

Erection of plain structural work costs $9.00 to $10.00 per ton; of framework of office buildings, $10.00 to $12.00 per ton; of mill buildings, $11.00 to $15.00 per ton. Complicated work of many small parts and light tonnage, such as angles and tees for roof tile, may run as high as $28.00 to $30.00 per ton to erect. Bridge truss work will cost $15.00 to $20.00 per ton. These figures include furnishing falsework, also the painting.

The painting of structural work costs about $1.00 per ton for each coat.

The driving of field rivets costs from 5 cents to 20 cents each, depending upon the accessibility of the rivets and the number of times that scaffolds must be moved in a day. A riveting gang costs about $8.00 a day. For ordinary work, 12 cents per rivet is a good average.

The hire of an engine and derrick is about $30.00 per week. That of an engine and concrete mixer is about the same. This does not include any men to operate the same.

The hire of a road roller, with coal and operator, is about $12.00 per day.

The hire of a work train and crew, coal, etc., is about $22.00 per day.

The cost of galvanized structural work is about $20.00 a ton.

The cost of corrugated steel roofing or siding per square of 100 square feet, at 3½ cents per pound for material and $2.25 per square for erection and painting, is about $11.75 for No. 18, and about $9.00 for No. 20. Galvanized roofing at 1 cent extra for galvanizing, would cost about $14.50 for No. 18, and about $11.00 for No. 20 per square erected.

The cost of concrete-steel roofing on 15-foot spans is about 25 to 30 cents per square foot, exclusive of covering. Concrete-steel floors for ordinary loads on spans 8 to 10 feet cost about the same. Heavy floors cost 30 to 40 cents per square foot. Cement finish on floors costs 7 to 10 cents per square foot.

The cost, in 1903, of a 54-inch self-supporting steel stack 110 feet high of 5/16-inch, ¼-inch, and 3/16-inch metal, including ladder, painted on outside, with base casting, but not anchor bolts or foundation, was $1,200. Breeching of 3/16-inch metal, 5 feet in diameter or oblong and same area, cost $9.00 per linear foot.

The cost in 1902 of a stack 10 feet inside diameter and 180 feet high, of porous brick, was $7,375, not including foundation. A 125-foot by

6-foot porous brick stack, including foundation, will cost about $4,000. The cost in 1903 of a reinforced concrete stack 150 feet high, 6 feet inside diameter, including foundation, was $3,800. The contract price in 1907, of a reinforced concrete stack 166 feet high, 8 feet inside diameter, was $4,100.

The cost of a 118,000-gallon concrete-steel pipe, with inclosing tower, at Hull, Mass., was about $12,000 (see "Engineering News," Vol. 52, p. 596).

Mr. H. G. Tyrrell ("Railroad Gazette," Dec. 30, 1904) shows that the costs of the parts of single-track steel trestle for E50 loading, towers 30 feet between bents, at 3½ cents per pound for girders, 4 cents per pound for bents and bracing, and $10 per cubic yard for concrete, are as follows:

Cost of Steel Trestle 120 Feet High per Linear Foot

Length Intermediate Span	Spans	Bents	Traction Bracing	Piers	Total
30	$15.15	$45.2	$15.2	$12.0	$87.55
60	21.77	39.2	13.0	8.0	82.57
100	30.09	32.0	10.8	5.5	87.39

In the Proceedings of the American Railway Engineering and Maintenance of Way Association (Vol. 2, p. 139), it is stated that the cost of ballasted trestle on the A. T. & S. Fé Ry., 2 examples, averaged $12.66 per linear foot, divided as follows: Treated piles, $5.02; lumber, $5.01; bolts, $21.00; cross-ties, $24.00; ballast, $285.00; labor (all kinds), $1.89; creosote, $0.005.

Mr. J. C. Bland, in 1891, found the estimated contract price of single-track timber trestle was, in round numbers, nearly equal in dollars per linear foot to one-half of the height of trestle in feet out to out of cap and sill. In this the floor-deck alone was $4.22 per foot of track, and piles $3.00 each, both increased by 20 per cent for the contractor's profit. Timber in place was estimated at $52.00 to $55.00 per thousand feet B. M., contract price.

A number of examples of the cost of railroads are given in "Railroad Gazette" (Sept. 7, and Oct. 26, 1906), as follows:

First Case—No tunnels, few bridges, along river, considerable cut and fill, single track, $26,300 per mile.

Second Case—Along river, heavy cuts, some bridges, single track, $37,014 per mile.

Third Case—Cuts and fills, bridges, tunnels, single track, $60,628 per mile.

Fourth Case—Heavy crossings, double track, $76,336 per mile.

Fifth Case—Heavy crossings, double track, $105,186 per mile.

Sixth Case—Detour around large city, double track, $50,000 per mile.

In the foregoing the cost includes preliminary surveys, clearing right of way, roadbed, ties, rails, ballast, side tracks, but does not include real estate, stations, equipment, or signals.

Following is a list, alphabetically arranged, giving prices of various materials and work, to be used as a guide in estimating the cost of structures. These are taken largely from current price lists and contract prices as published in engineering journals, and in general indicate prices prevailing in 1904 to 1907.

Asphaltum—Ventura and other California asphalts, \$20.00 to \$23.00 per ton at New York; Trinidad refined, \$22.00 to \$25.00 per ton; Venezuela asphalt, \$25.00 to \$60.00 per ton; Bermuda asphalt, \$25.00 to \$35.00.

Brick—At yards, per thousand, common soft, \$5.00 to \$7.00; hard, \$7.00 to \$9.00; vitrified (hard-burned), paving common, \$8.00 to \$12.00; special, \$15.00 to \$20.00; select red, not pressed, \$8.00 to \$10.00; pressed, \$14.00 to \$18.00; Roman, \$30.00; firebrick, \$14.00. Freight on bricks is about \$2.00 per thousand for 50-mile run.

Bronze—Phosphor, in place, about 40 cents per pound.

Cast Iron—Pig iron, \$19.00 to \$22.00 per long ton.

Cast-iron counterweights, 1½ to 2 cents per pound, delivered.

Cast-iron pipe, \$33.00 to \$38.00 per ton, delivered; laid, \$38.00 to \$45.00 per ton.

Standard and plain castings, 2½ to 3½ cents per pound in place. Special castings, large orders, 3 to 5 cents per pound in place; small orders, 5 to 10 cents.

Cement—Portland, \$1.50 to \$2.00 per barrel, 400 pounds. Rosendale, 80 cents to $1.00 per barrel, 300 pounds.

Large users of Portland cement pay less than $1.50 per barrel for domestic brands. On small orders, freight and handling increase the cost.

Cement Finish—Portland, mortar ½ inch thick, 50 to 80 cents per square yard.

Clay—Fireclay, dry powder, $1.50 per ton, delivered on cars; calcined fireclay, $3.00 to $4.00 ton.

For puddle, $1.50 per cubic yard, delivered.

Concrete—Natural cement, $3.00 to $5.00 per cubic yard in place.

Portland cement in large mass, easily deposited, $4.00 to $7.00 per cubic yard. Walls requiring difficult forms, $6.00 to $8.00 per cubic yard. Tunnels, etc., $10.00 to $12.00 per cubic yard.

The cost of 1:3:6 Portland cement concrete may be analyzed as follows:

1 cubic yard broken stone	$2.00
½ cubic yard sand	.50
1 barrel cement	2.00
Mixing and depositing	.50
Total	$5.00

This is with the use of a mechanical mixer. Hand-mixing would probably cost from 70 cents to $1.25 per cubic yard.

Reinforced concrete, including steel, usually costs from $10.00 to $20.00 per cubic yard. Concrete should be estimated at $5.00 to $10.00 per cubic yard in place; steel, about 2.5 cents per pound in place (plain structural steel); forms, 5 to 10 cents per square foot. The unit-cost of concrete will depend upon the difficulty of handling and placing.

Copper—14 to 15 cents per pound.

Curb—Cement and sand, 1:3, 25 to 50 cents per linear foot, about ½ cent per square inch of section per linear foot, in place.

Sandstone and limestone, 50 cents to $1.00 per linear foot, in place.

Bluestone, $1.00 to $1.50 per linear foot, in place.

Granite, $1.00 to $2.50 per linear foot, in place.

Curved curbs, in stone, 20 per cent to 10 per cent extra.

Resetting curb, 10 to 50 cents per foot.

Dredging—Soft material, 12 to 30 cents per cubic yard; gravel and hard material, 30 cents to $1.00 per cubic yard. In "Engineering News," Sept. 20, 1906, a report is given of some dredging done by the U. S. government engineers with hydraulic dredges (New York Harbor) which cost only 5.274 cents per cubic yard.

Excavating—In earth, large masses, above water, 25 to 50 cents per cubic yard; below water, for piers, $1.00 to $5.00 per cubic yard; in trench, earth, 50 cents to $1.00 per cubic yard; loose rock, $1.00 to $2.00 per cubic yard; hard rock, $1.00 to $3.00 per cubic yard.

Steam shovel work costs about 12 to 20

cents per cubic yard. In "Engineering Record" (Vol. 54, p. 732), some data are given from a paper by Mr. John C. Sessor on steam shovel work on the C., B. & Q. Railway. On one job of 251,711 cubic yards, 1,104 cubic yards was moved per 10-hour shift. The cost was as follows: Equipment, 1 cent; steam shovel service, 8.9 cents; temporary trestle, 3.6 cents; track and track work, 5 cents; supervision and engineering, 0.2 cent; total, 18.7 cents, all per cubic yard.

On another job of 188,240 cubic yards, 946 cubic yards was moved per 10-hour shift. The cost was as follows: Equipment, 1½ cents; steam shovel service, 9.6 cents; temporary trestle, 3.1 cents; track and track work, 4.2 cents; supervision and engineering, 0.3 cent; total, 18.7 cents, all per cubic yard.

The Illinois Central Railway estimates excavating in earth, in jobs below 50,000 cubic yards, to cost 25 cents per cubic yard, and in larger jobs 20 cents per cubic yard, adding in both cases 1 cent per cubic yard per 100-foot haul.

A committee report of the Roadmaster's and Maintenance of Way Association, published in the "Railroad Gazette" of Oct. 31, 1904, and in "Engineering News" of Oct. 27, 1904, gives the following as the cost of ditching cuts and widening embankments:

By wheelbarrows: 12.2 cents per cubic yard, plus 31 cents per cubic yard per 1,000-foot haul for common loam, or 7.3 cents extra in bad, wet material.

By push cars: 19.1 cents per cubic yard where material is unloaded by shovel, or 15.9 cents where unloaded by dumping box or similar arrangement, plus 33.4 cents per cubic yard per 5,000-foot haul.

By machine ditcher: 22 to 30 cents per cubic yard, the latter figure being for a 15-mile haul in loam. In wet or bad material, add about 4.5 cents per cubic yard.

The same report places the cost of team work with scrapers at 14 to 25 cents per cubic yard; and of ditching by casting, in fair digging, where one cast will place the material in suitable final location, at 10 cents per cubic yard. Much valuable information is given in this report.

Fence—Board, 50 cents to $1.50 per foot.

Filling—Earth, material at hand, 20 cents to 50 cents per cubic yard.

Flag Stone—In place, $1.00 to $3.00 per square yard.

Forms—Allow 5 to 10 cents per square foot for concrete forms, depending on whether lumber is dressed or not, and on number of times it can be used.

French Drain—50 cents to $1.00 per linear foot.

Fuel—Hoisting engines, etc. Allow 1/3 ton of coal per 10 horse-power per 10-hour shift.

Gravel—In bank, 15 to 20 cents per cubic yard; f. o. b. cars, 35 to 40 cents per cubic yard; freight for 50-mile run, about 75 cents per cubic yard; hauling, 25 to 50 cents per cubic yard.

CRACK IN CONCRETE SIDEWALK CAUSED BY TREE.

RESULT OF NOT PROTECTING THE EDGE IN LAYING CONCRETE SIDEWALK.

Usual price, delivered, about $1.00 per cubic yard.

Lime—Common, barrel (250 pounds), 80 cents; finishing, $1.00; per ton at works, $3.75; delivered, $6.00.

Lead—Pig, about 4.6 cents per pound; lead pipe, about 5 cents per pound.

Masonry—Rubble, dry, $2.00 to $5.00 per cubic yard; in mortar, $3.00 to $8.00 per cubic yard. Coursed rubble, large stones, $5.00 to $8.00.

Brick, common, $6.00 to $10.00 per cubic yard. Cost of lime mortar per cubic yard of brickwork, about 60 cents; of cement mortar, $1.00 to $2.00.

On the basis of $7.25 per thousand for red brick, $2.50 per barrel for cement, $1.25 per barrel for lime, $1.25 per cubic yard for sand, assuming a mason at 65 cents per hour, with help at 37½ cents per hour, to lay 1,200 bricks in 8 hours, a brick wall 13 inches thick will cost about 40 cents per superficial foot. With pressed-brick face, the cost will be about 50 cents per superficial foot.

Bridge pier, sandstone or limestone, $8.00 to $12.00 per cubic yard.

Ashlar, sandstone or limestone, $12.00 to $20.00 per cubic yard. Granite, $20.00 to $30.00 per cubic yard.

Dressed bluestone, for steps, etc., $1.00 to $2.00 per cubic foot.

Mineral Wool—Slag, ordinary, per short ton,

$19.00; selected, $25.00; rock, ordinary, $32.00; selected, $40.00.

Paint—Prepared, $1.00 to $1.50 per gallon.

Paving—Asphalt—In 44 cities in North America, the cost of asphalt paving, including 4 to 6 inches of concrete, varied between $1.43 and $3.25 per square yard (see "Engineering Record," Vol. 43, No. 8). It is estimated that the cost of guarantee for the first five years is 3 cents per yard, and for the second five years is 15 cents per yard. The Congressional appropriation bill allowed $1.80 per square yard to be paid for asphalt pavements in Washington, D. C. ("Engineering News," Aug. 13, 1903).

Asphalt block, $2.00 to $2.50 per square yard.

The division of the cost of asphalt pavements is about as follows: 2½ inches of surface, 67 cents per square yard; 2 inches of binder, 13 cents per square yard; 6 inches of Portland cement concrete, $1.00. Total, $1.80 per square yard.

Brick work only, 15 to 20 cents per square yard.

Brick, 4 inches of brick on 3 inches of sand, 65 to 85 cents per square yard; 4 inches of brick on 6 inches of natural cement concrete and 1½-inch cushion of sand, $1.20 to $1.60 per square yard; sidewalks, 2 inches of brick on sand, 50 to 80 cents per square yard.

Cobblestone, 80 cents per square yard.

Concrete sidewalks, finished with mortar of sand and cement, granite screenings and cement, etc., 10 to 25 cents per square foot. Mortar finish alone, 5 to 15 cents per square foot.

A common contract price for concrete sidewalks, small jobs, is 15 to 20 cents per square foot. Large paving work can be done at an actual cost of about 10 cents per square foot.

Macadam, stone free at quarry, 8 inches depth, 40 to 50 cents per square yard; including cost of stone, 8 inches depth, 60 to 90 cents per square yard; 12 inches depth, 90 cents to $1.30 per square yard.

Stone blocks on broken stone base, $1.50 to $2.00 per square yard.

Stone blocks on concrete base, $2.00 to $3.50 per square yard.

Wooden blocks—4-inch creosoted yellow pine blocks on 1 inch of sand over 6 inches of natural cement concrete, $2.25 to $2.35 per square yard. Cost of 4-inch creosoted yellow pine blocks, f. o. b. cars, about $1.70 per square yard.

The following analyses of the cost of brick and stone block paving are taken from "Engineering News," July 24, 1902:

"The following is a summary of the cost of paving with brick laid on edge, wages being 25 cents per hour for pavers and 15 cents for laborers:

Cost of Brick Paving

	Cost per Square Yard
57 "pavers" at $10 per M	$0.57
Hauling 1½ miles over earth roads	.06
Laying pavers, including labor of grouting	.08

0.18 cu. ft. = 1/150 cu. yd. of grout*	.05
1-36 cu. yd. sand cushion at $1.08 a cu. yd	.03
Plank to protect concrete	.01
Total net cost	$0.80
Add about 19 per cent for profit	.15
Contract price	$0.95

"To this, of course, must be added the cost of grading and cost of concrete foundation."

On block paving "we have for the total labor cost:

	Per Sq. Yard
Loading and unloading, inclusive of lost team time	$0.10
Hauling 1 mile	.05
Distributing blocks	.03
Laying	.06
Filling joints	.06
Foreman at 40 cts. per hr., 30 sq. yds	.13
Two water and errand boys	.07
Total labor	$0.50

Cost of Medina Block Pavement

	Per Sq. Yard
1/3 cu. yd. street excavation	$0.15
6 in. concrete foundation	.50
1-18 cu. yd. sand cushion in place at $1.08	.06
Medina block (6 in.) f. o. b. Albion, N. Y	1.15
Freight to Rochester	.07
Unloading, hauling, and laying	.30
1.5 gallons tar at 10 cts. a gallon	.15
1-50 cu. yds. sand for joints	.02
Total	$2.40
Add for contractor's profit	.25
Total cost	$2.65

*1 part Portland cement to 2 parts sand.

Cost of street paving in 30 cities in Wisconsin per square yard (see "Municipal Journal and Engineer," Nov., 1905)—asphalt, $1.80 to $2.19; bricks, $1.00 to $2.19; macadam, 25 cents to $1.30; wood block, 60 cents to $1.97.

All-concrete roadway paving has been found in several cities to cost 14 to 18 cents per square foot. At Jackson, Mich., some street paving having 3 inches of gravel, 6 inches of 1:8 cement and gravel, 4 inches of 1:3 cement and ½-inch crushed granite, mixed quite wet, cost 18 cents per squqare foot (see "Concrete Engineering," Dec., 1907, p. 205).

Piles—Driven and cut, ordinary lengths and sizes, spruce, 20 to 40 cents per foot; long, driven and cut, $6.00 to $10.00 each. Shorter piles for trestle bents, $3.00 to $5.00 in place.

Piling—(Nov., 1907). Spruce, ordinary cargoes, 6 to 7 cents per foot. Oak, 14-inch butt, 40 to 50-foot, 19 cents per foot; 50 to 55-foot, 22 cents per foot; 55 to 60-foot, 23 cents per foot; 60-foot and up, 25 cents per foot.

Pine, 60 to 65-foot, $8.50 each; 70 to 75-foot, $10.50 each; 80-foot and up, $16.00 each.

Concrete piles in place, about $1.00 per linear foot.

Pipe—Vitrified pipe, 8 inches in diameter, 15 cents; hauling, ½ cent per foot; laying, 1½ cents per foot; cement, ½ cent a foot = 17.5 cents a foot in trench already dug. For 12-inch pipe, the cost is about 35 cents per foot total ("Engineering Record," March 10, 1906, p. 350).

Railing—Gaspipe, 2-rail, 50 to 75 cents per foot; 3-rail, 75 cents to $1.25 per foot.

A substantial bridge railing costs about $1.50 to $2.50 per linear foot. Cast-iron newel posts, about $10.00 each.

Roofing—Four layers of felt paper covered with pitch and gravel, or pitch and slag, 4 to 6 cents per square foot.

Slate, 7 to 13 cents per square foot. Slag, 4 cents. Tin, 8 to 10 cents. Shingles, 7 to 10 cents per square foot.

Tile, Spanish, $9.00 to $12.00 per square of 100 square feet.

Sand Blasting—(Cleaning)—Large contracts, 1 to 3 cents per square foot (see "Engineering News," Vol. 47, p. 324).

Sand—Building, 20 to 25 cents per cubic yard in bank; f. o. b. cars, 40 to 50 cents per cubic yard; freight for 50-mile run, about 75 cents per cubic yard; hauling, 25 to 50 cents per cubic yard. Usual price delivered, about $1.10 per cubic yard.

Seeding—In grass, $25.00 to $75.00 per acre.

Sewer Pipe—Laying and cementing in trench already dug, small sizes, 15 to 25 cents per foot; large sizes, 50 cents to $1.00 per foot.

Cost of pipe per linear foot, 5-inch, 5 to 7 cents; 10-inch, 15 to 20 cents; 15-inch, 25 to 40 cents; 21-inch, 50 to 75 cents; 30-inch, $1.00 to $1.70; 48-inch, $2.00 to $3.00.

Shrubs—50 cents to $2.00 each.

Sodding—In country towns, 7 to 10 cents per square yard; in cities, 25 to 50 cents per square yard.

Steel—Structural, material only, 1¾ to 2¼ cents per pound. Erected and painted, 3 to 5 cents per pound.

Castings, in place, 5 to 10 cents per pound.

Rails, new, $28.00 per ton, f. o. b. cars; old, short pieces, $14.00 to $14.50.

Scrap, structural, $14.00 per long ton.

Stone—Wholesale rates, delivered at New York, price per cubic foot:

Nova Scotia, in rough, 90 cents; Ohio freestone, in rough, 85 to 90 cents; Minnesota freestone, in rough, 90 cents; Longmeadow freestone, 85 cents; Brownstone, Portland, 60 cents; Brownstone, Belleville, N. J., 75 cents to $1.00; Scotch redstone, $1.05; Lake Superior redstone, $1.10; Granite, rough, 40 to 50 cents; limestone, buff and blue, 80 cents; portage, $1.00; Caen, $1.25 to $1.75; white building marble, $1.25 to $1.75; Wyoming bluestone, 90 cents; Euclid bluestone, 90 cents; crushed stone, $1.40 per net ton, f. o. b. cars New York City. (May, 1904).

Tarred Paper—1-ply (roll 300 square feet), ton, $32.50 to $35.50; 2-ply (roll 108 square feet), 55 to 60 cents roll; 3-ply (roll 108 square feet), 78 to 80 cents. Slater's felt (roll 506 square feet), 75 cents. R. R. M. Stone Surfaced Roofing (roll 110 square feet), $2.75.

Tar—Regular barrel, $2.25; oil barrel, $5.75; coal tar, gallon, 8 cents.

Ties, Railroad—Untreated, cedar and spruce, 40 to 60 cents each; oak and yellow pine, 60 to 80 cents each. Returns from thirteen of the principal American railroads show the cost of their ties to vary between 35½ and 81½ cents each.

Tooling—Bush-hammering concrete surface, 2 to 5 cents per square foot.

Transporting—The cost of picking up materials such as sand or stone, and hauling them a moderate distance in wheelbarrows, is about 20 to 25 cents per cubic yard. With wagons or carts, the cost is about 15 to 23 cents per cubic yard.

Treating Wood—Cheaper processes, 5 to 10 cents per cubic foot. Creosoting, 20 to 60 cents per cubic foot.

Railroad ties, 20 cents each, up.

Creosoted yellow pine in place costs, including cost of wood, $65.00 to $80.00 per 1,000 feet, B. M.

Trees—$1.00 to $5.00 each.

Wood—Prices per thousand feet of board measure, May, 1904.

Hemlock, rough, in lengths up to 20 feet, $17.00 to $19.00. Lengths 22 to 40 feet, $3.25 to $7.00 additional.

Pine, yellow (long leaf), building orders, 12 inches and under, $20.50 to $22.50; 14 inches and up, $26.00 to $29.00; 1¼ and 1½ inch wide boards, $28.00 to $30.00; 2 inch wide plank, heart face, $30.00 to $31.50.

Yellow pine, of heavy construction, in cargo lots, delivered New York City, $22.00 to $25.00.

Spruce, random cargoes, 2-inch cargoes, $18.00 to $21.00; 6 to 9-inch cargoes, $19.50 to $21.50; 10 and 12-inch cargoes, $21.00 to $23.00.

The framing and placing of wood in a structure costs $5.00 to $15.00 per thousand feet of board measure.

White oak timber in wharf construction costs $50.00 to $60.00 per thousand feet in place.

Bridge timber in place, per thousand feet, white oak, $40.00 to $50.00; yellow pine, $35.00 to $45.00; hemlock, $22.00 to $30.00.

More than half the cost of wood is generally due to freight on account of the long distances between the centers of greatest supply and greatest consumption.

GENERAL INDEX

The Roman numerals indicate the volume number.

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