CONTRACTORS AND BUILDERS HANDBOOK

WM. ARTHUR

THE CONTRACTORS' AND BUILDERS' HANDBOOK

By

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PREFACE

THE CONTRACTORS' AND BUILDERS' HANDBOOK is divided into three parts. The first deals with the Contractor as a Business Man; the second, with the Contractor as a Constructor, which is not a trained architect, by any means; and the third, with the Contractor as a Citizen and Taxpayer. The titles of the chapters show what subjects are considered to be of most value to him in his various spheres.

The business affairs gone over in the first book have to be attended to by every contractor. He has to deal with architects and owners; he has to buy from supply men; to keep at least some record of his work in books; and to pay for insurance and bonds. After reading the part on liability insurance he is more apt than ever to attend carefully to this branch, for here neglect may be ruinous, no matter how carefully other arrangements are made, and other parts of a business carried through.

In the second book the contractor can find certainty, instead of what he often makes guesswork, on plain construction. It is written in a way to be easily understood. There are many books with formulas that might as well be written in Latin as English, so far as average contractors are concerned. Yet such men have done a great amount of plan drawing and building independent of an architect, and will go on doing so for quite a long while to come.

It is believed that Book II is of much value to constructors of this kind. It is true that we have more than 30,000 architects, draftsmen, and designers; but there are between 600,000 and 700,000 carpenters; 250,000 saw-mill, planing-mill, and other wood-workers; 17,000 masons; 40,000 plasterers; and 300,000 iron and steel workers. Thousands of these men make plans; and probably half of the active builders do so at one time or another. By following the instructions in Book II they will put up at least safe buildings. The plans for the artistic ones will continue to be made by the "regulars."

The third book is given over to subjects that are specially interesting to the building fraternity, and yet are of a broader scope than anything dealing with strictly technical work would be.

There are no men who can help to fight the terrific fire waste better than builders, and it is necessary to keep them acquainted with the actual situation that is a disgrace to the United States.

The educational chapters will be found interesting and useful. There is no good reason why the building business, in one branch or another, should pay such a heavy proportion of taxes and get such little recognition from the high school and library authorities.

In the city of New York alone, for example, we are told in *The Building Age*, January, 1910, that the sum of $446,428,657 was expended in building during four years. In the same publication for February, 1910, we are informed that the total figures for fifty cities for 1909 were $719,189,175. In Greater New York alone the total was $272,175,754. The architects, contractors, supply men, and tradesmen who handle that immense amount of business can have any kind of schools they please, if they work and fight for them as the farmers did for their agricultural colleges until they had to be established.

The chapter on Big Contracts is to show that the men of old were greater builders than we are. We outshine them in other ways.

OMAHA, NEBRASKA, January, 1911.

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BOOK I

THE CONTRACTOR AS A BUSINESS MAN

CHAPTER I

RELATIONS BETWEEN THE CONTRACTOR AND THE ARCHITECT

In college athletics we hear frequently of team work, when the men play together to the best advantage. They have to be reasonably well matched. The Percheron and the thoroughbred do not keep good step.

This is the difficulty with the relations of the architect and the contractor, if we are to believe all we read. The one, we are sometimes told, is of blooded stock, and the other is great of girth and heavy of foot. According to good authority the builder is "rough and materialistic."

It is clearly difficult to make such a team trot well abreast, but sometimes a little give and take smooths over difficulties.

Builders should remember that the authorities in Belgium, at the International Congress in 1903, defined an architect as "An artist, a gentleman, and a man of affairs." Some contractors, in their wrath, would occasionally demur, and say that certain architects are anything but gentlemen, especially when they had finished a losing contract for them.

Young Architects. — One of the banes of a contractor's life is the architect newly let loose from school and full of educated ignorance. When the experienced architect deals with the experienced contractor they make about the best team that can be looked for in the building line, and usually they get along with little friction. But the young one may or may not have that great gift of common sense. No one can be more merciless than a theorist. Any architect, by a theoretical enforcement of all the provisions of his specifications, could ruin an ordinary contractor in a few jobs.

Different Tasks. — An architect's business is to design a building, and tell how it is to be built; a contractor's is to execute the design according to the drawings and specifications. The two spheres are interrelated, but different, and a special training is required for each.

Plans and Plans. — There is no trouble in working from the plans of a good, sensible architect; there is not only trouble but occasionally dismay in looking over some of the triumphs of the Beaux Arts heroes. They know too much for the average pocket-book, but time improves them.

The Two Kinds. — The "self-made" architect is not nearly so well trained as the one from the schools, but he is often more human, as it were. He will admit the possibility of being mistaken; he is willing to listen to a suggestion of change for any good practical reason; while the graduate would only give the order, "This is the way; walk ye in it." With him there is nothing to arbitrate.

Closed Shop. — Contractors have to be careful how they attune themselves to the men who in reality furnish them work. Of the open shop the architect can easily make a closed shop to the contractor by refusing to allow the latter to figure in his office or, without going so far, give such short time on plans, or lay down such conditions as to make a careful estimate or fulfillment of a contract next to impossible. For thousands of years there has been trouble on this earth, and most of it comes from the abuse of power, on a large or small scale. It can be exercised on the basis of an eighth of an inch to the foot, so to speak, as well as full size. Architects are human.

In a large city where there are many offices this course does not matter so much, but in a small town where there are only a few it is in reality an exercise of the boycott or the blacklist. In such cases it may be that the builder is at fault, or the architect may be too domineering and exacting.

Between Two. — The architect occupies a difficult position in one way: he stands between the owner and the builder, and while willing to do some things that the builder might desire, is held in check by his client. For example, it is rather unpleasant for a contractor to make up an estimate and put in a bid, yet never find out how his figures compare with those of his competitors, at least through the medium of the architect's office. The owner may want as few people as possible to know what his building is going to cost. He may be afraid of the assessor. As a matter of fairness, all bids should be opened and read in the presence of the bidders. It is the right way to do business. When a contractor finds that certain of his brethren always get the best work in an architect's office he should not waste his time there. Lightning does not ALWAYS strike in the same place; and neither do certain men ALWAYS have the lowest bids.

List of Bidders. — An architect can select a list of contractors he wishes to give him an estimate on a building, and the one who puts in the lowest bid is entitled to the work. Either this is true, or he should not be asked to waste his time making up the figures.

Too Many. — Like men in other lines, an architect has to learn to say no. Some of the magazines get five thousand MSS. in a year, while only about one in twenty can be published. The supply outruns the demand. So with building contractors. Half a dozen proposals are enough on any building, yet there are often a score of men who are willing and anxious to estimate on the work. On account of the time it would take, if for nothing else, an architect has to decline to give his plans to everyone who applies for them.

Kind of Bidders. — But there are other reasons for refusing plans than the time one: every architect for the sake of future business has to try to get contractors to do his work without making trouble on account of liens, bad workmanship, high charges for extras, and disputes of one kind or another. In time he weeds out those who have made him trouble in the past.

An Opening. — But, again, lest anyone should think that there is no chance of starting in a small contracting business for himself under such conditions and showing his ability and worth, it should be remembered that most architects, on at least fifty per cent. of their work, have clients who want $1.23 worth of building for $0.99. With an owner like that on one side, and an architect after his commission on the other, and both looking for a third who thinks that twice two make five, there is no reason for discouragement.

No matter how obliging an architect may be he finds it hard to supply this $0.99 trade; and instead of taking his list of bidders who are comparatively well off, and not inclined to take contracts unless they get a reasonable price, he looks around among those who are starting in business and anxious to get any kind of work that offers more than wages, and more anxious still to get a footing in a good office. It is usually later on that they discover that twice two make only four—probably when a suit for personal damages is started and they have no insurance. So that the field is always open.

Blame. — When disputes and mistakes do come up it does not always pay the contractor to swallow the blame unless he is clearly responsible. It is just about as well to let the architect have his share and take the chance of his frown. In nine cases out of ten, however, the best way for everybody is to make the least of the trouble. But the poor contractor should not always be obliged to pay the piper if he has not ordered the dance.

The way out of mistakes is often decided by personal temperament. In certain European countries, where the newspapers are censored, there is always something appearing that displeases the authorities, and rather than have their necessary editors jailed, each office has a "jail editor," the man who takes all the blame and gets the cell and the bread and water. If a contractor feels like taking everything that comes in this way he would probably end either in the poor farm or like the old Scotchman who told his son that he made his fortune, "By bowing, sir; by bowing."

Details. — One of the recurring troubles of a contractor is an armful of elaborate details made out after the contract is signed, sealed, and delivered. On a plan drawn to a scale of one-fourth of an inch to the foot, or worse still, one-eighth, a few light spider web scratches may mean $100.00 to the square inch. The only right way is to give out the details with the main plans when the figuring is being done, but in the hurry of the owner to get his building started this is often quite impossible, and the estimates must be made from the regular scale drawings.

Most architects are reasonable enough to understand this situation, and either let stonecutters, planing-mill men, cornice makers, and others know what is expected, or else give numbers in millbook, dimensions of stone, and so forth; but there are also the other kind of artistic gentlemen who, for the sake of enhancing their own reputation, rather like this blindfold method. After a contract is signed they give their gargoyles and poppyheads, their machicolations and lacunars, their deep-cut moldings and projections, their consoles and entablatures, until the unfortunate contractor's head swims, and he feels sick clear down to the pit of his stomach. What is it but a sort of legalized robbery?

If a contractor, and especially a young one, is making an estimate on a building from the usual scale drawings, he is quite within his rights when he asks the architect what the details are to be. No reasonable architect will refuse to give information; if one of the wrong kind should be met, the best thing a contractor can do is to leave the plans behind him, or else put in such a figure as to make himself safe.

It should always be remembered, however, that no verbal information has any binding force after a contract is signed. The plans and specifications, as interpreted by the man who made them, and who is not likely to point out his own mistakes and prejudice the owner against himself, make up the final authority.

Standards. — Of course, on the majority of buildings the details are well enough understood. If the sizes of stone moldings, wood casings, cornice, and other parts of the building are given, the particular shape of the molding does not matter so much. Any one of half a dozen styles may be chosen, as the one costs no more than the other. With special work it is different.

Time. — In all cases an architect should give out details as promptly as possible. Stone yards and planing-mills can not be expected to lay aside the work they are engaged in just as soon as a set of details for another building is presented. Each job must, as a rule, take its turn, and an architect should not hinder a contractor by making it impossible for him to get his work started.

General Clauses. — Another great trouble comes with the specification. It is clearly impossible for an architect to specify every little item in a building, and he is often driven to what the politicians call glittering generalities. "According to the satisfaction of the architect," "In a first-class workmanlike manner," "Materials of the best quality," are a few, and there are many others of a like nature. After a time the contractors come to understand what these expressions mean. They are not to be literally understood, but are put into the platform to catch votes. The character of the office from which the specification comes has to be considered, and the estimate made out to suit. But it would be easy for an architect to put a stricter construction on his generalities than the one understood.

A first-class quality of work in a western village or mining camp would not be accepted as such in a large city; and what suits in an ordinary city could not be made to pass in a millionaire's palace on Fifth Avenue, New York, where the masonry is as fine as that on the best government work, and the woodwork has to be as good as cabinet finish.

It is clearly impossible to make any standard from such clauses, and in dealing with a new architect a contractor should be careful to find out just about what is expected. This is especially the case with the young ones. It would be ruinous to finish an ordinary building according to the method of the palaces: yet if the bricklaying, stone-cutting, sand-papering of the wood, and the quality of the painter's work were to be carried out as some clauses in a specification, rigidly interpreted, would have it done, there would be no escape. "Everything in connection with the building must be of the best material and workmanship." Well, what does that mean? Almost anything, according to the views of the architect.

What is Included. — Then come the usual clauses saying that the job is intended to be complete in every part, and that if anything is shown on the plans, even although it is not called for in the specifications, or vice versa, it must be done. Coming or going the idea is to catch the contractor.

In the west, at all events, the plumbing fixtures, just to give one illustration, are shown on the plan, but not included in the general contractor's bid, because nothing is said about them in the specification. The plumbing is let in a separate contract.

Can the general contractor be held to put in the plumbing?

Not unless it is specified. Yet the fixtures are shown clearly enough. Of course the contract usually provides that the contractor is to finish just such and such parts of a building, and omits plumbing, heating, or any work that is let separately; but if a man puts in a bid and does not clearly specify what he is going to do he might get into trouble, not, indeed, with such a clear case as plumbing, but with some items of lower cost that might be held to belong to the general contract. As will be found in a later chapter, a bid is virtually a contract as soon as it is accepted.

These all-embracing clauses are necessary, in a way, because no man or woman can possibly specify every trifling item in a building; but it is equally clear that whatever is not indicated by the plan as structurally necessary should be mentioned in the specification, if it amounts to anything at all.

Nine times out of ten the owner will get a cheaper bid if everything is clearly understood and not left to guesswork; for in this case the contractor has to guess high enough to protect himself.

Long Specifications. — This does not mean that specifications a mile long should be made, for too large a volume of instructions and warnings are apt to frighten bidders into making higher bids than are necessary.

System. — Government specifications are usually numbered line by line; and an index is a valuable feature of others. By these or like methods it is easy to refer to any clause or subject. Ordinary architects cannot be expected to do this kind of work, for they are not paid enough for it.

Precedence. — The specification describes the quality of the work and materials, and the sizes are given on the plans, but in case of any discrepancy the former takes precedence.

Combination. — Some railroads make both plans and specifications of the drawing sheets themselves. Bills of the material required are also put on in this way. When many buildings are to be erected at different times and in different parts of the country this is an economical way, when the work is done by the company itself, as it saves a great amount of labor, but the method has disadvantages.

Contracts could not be let by it, as the specification is not nearly complete enough; and it makes no allowance for improvement in building. It is too much trouble to change tracings, and wood wainscoting is put on kitchens and halls long years after all progressive cities have banished such work from their codes, and substituted the more sanitary plaster which becomes as hard as a rock; and the most expensive white pine is called for in an age when it has long been a luxury. If a contractor runs across any sheets of this kind he should be careful. What was, is not always what is.

Certificate of Payment. — An architect must give a contractor a certificate of payment as the work progresses, according to the contract. If he does not, the contractor may sue him, or sue upon the contract. It is usually a good idea for the architect and owner to make the payments as large, and to turn them over as promptly, as possible to the contractor, if he is reliable, and they should choose only such a one to do their work. He is thus able to pay his bills and do more business on a small amount of capital. But if every payment is made as small as possible, and is held back to the last minute, then the trouble starts for the man of limited means. In other words, it pays to work with instead of against the "other party to the contract."

FORM OF CERTIFICATE

Some architects have an excellent system of making out their certificates of payment. They have printed forms that are made out somewhat on the following lines:

OMAHA, NEB., June 8, 1910.

Order No. 4 on J. B. Brown, Owner.

This order certifies that J. B. Smith, contractor, is entitled to $3,000.00 (three thousand dollars) on his contract with J. B. Brown, for building described in Uniform Contract, dated November 20, 1909.

Total amount of contract	$30,000.00	
Extra No. 1, Jan. 3, 1910	450.00	
		$30,450.00
Deduction No. 1, Jan. 3, 1910		180.00
Statement at this date		$30,270.00

Total value of work in place, June 8, 1910, $20,500.00.

DATE	ESTIMATES	RESERVE	AMOUNT PAID
No. 1, Dec. 18, 1909	$2,400.00	$240.00	$2,160.00
No. 2, Jan. 8, 1910	3,300.00	330.00	2,970.00
No. 3, Feb. 7, 1910	5,800.00	580.00	5,220.00
No. 4, Mar. 1, 1910	3,000.00	300.00	2,700.00
No. 5, June 8, 1910	6,000.00	600.00	5,400.00

Total amount paid up to June 8, 1910 $18,450.00

Total balance $11,820.00

It is a good idea to have on each estimate sheet a record of all the estimates previously paid, but on some buildings this might run out to too long a column. Letting the top part of the foregoing form remain unchanged, a shorter one might be arranged in this or some similar way:

DATE	ESTIMATES	RESERVE	AMOUNT PAID
Nos. 1, 2, 3, 4, as dated	$14,500.00	$1,450.00	$13,050.00
No. 5, June 8, 1910	6,000.00	600.00	5,400.00

Total amount paid $18,450.00

Total balance $11,820.00

Each architect can work out a form for himself that may suit his requirements better than the foregoing suggested one. Blanks are, of course, left for names, dates, and amounts.

A receipt should also be made out and signed by the contractor. It should run along the following lines:

OMAHA, NEB., June 8, 1910.

Received payment No. 5 of $6,000.00 (six thousand dollars) from J. B. Brown, owner, for partial payment on building described in Uniform Contract dated November 20, 1909. The attached statement is accepted as correct at date of June 8, 1910.

J. B. SMITH, Contractor.

Superintendent. — When an architect has too much work to attend to himself, he hires a superintendent to oversee the outside part of it. The duty of the superintendent, divested of all round-about palaver, is simply to see that the plans and specifications are followed, and to assist in the interpretation and enforcement of any matters not clearly understood or disputed. But while he stands in the place of the architect, the final appeal is to the latter. Festus may lay down the law in Cæsarea, but Cæsar sits in Rome.

Little Caesar. — In government and state work, however, the superintendent has almost unlimited power. Ordinarily, we cannot sue the state without the consent of the legislature, and who wants to wait till it meets, even if sure of obtaining consent? This means that almost everything has to be submitted to. Unless there is a reasonable and competent man in charge this condition is apt to be at times rather annoying. When he is merely elected on some political ticket the builder has small chance of any relief, and his bank account suffers. As the state usually makes out its own building contracts, and makes them one-sided, there is no chance of arbitration on any disputed question. There is nothing to arbitrate. For this reason, state and government contracts should never be taken at a close margin.

An Architects' Union. — In 1897 there was a license law for architects enacted in Illinois, and the endeavor has been made to get other states to fall into line. In 1909 the builders of Texas got together to oppose such a law for that state. Contractors sometimes make plans themselves, and earn a few dollars in that way.

An eminent writer has said that, given the proper percentage, men will commit murder for profit; and saying nothing whatever of the past history of our race, but looking merely at the list of 500,000 killed and mangled in the United States every year, when three-fourths of the butchery is unnecessary, and merely allowed to save money, we are forced to conclude that the writer was not so very far wrong.

Here, then, is the core of this question. Architects do not want to commit murder, but they want all the business they can get, and if they can establish a "closed shop" instead of the present "open shop" in most states, they will have better chances. But that means, as a rule, that contractors will have to give up their plan-drawing, or else pass the examination.

There are good features in such a law, and good reasons why it should pass. It would guarantee a safer class of construction than we sometimes see. Of course safe enough construction can be had in another way, that is, by laying down such provisions in the building codes, and making such a general law for the state as would embrace all towns and villages that have no regulations but the will of the owner or builder. This would insure good structural work, and, generally speaking, the license law does not go into the artistic side of architecture, but is chiefly concerned with questions of strength and sanitary safeguards. If it was not a matter that touched the pocketbook, there is no reason why contractors should not stand in favor of such an enactment in all states. They really have enough to do in their own sphere without entering that of the architect.

But touch the pocketbook and you touch the heart, or rather the stomach and all the auxiliary, subsidiary, and accessory muscles, chords, and nerves related thereto. This is why contractors oppose an architects' union. They do not want to miss the chance of occasionally making a few dollars themselves, and they are not to blame. Do men not commit murder for money—in a civilized way, of course?

Contractors have found out that dollars do not grow on trees like apples. It costs $40.00 to become an architect in Illinois, and an annual fee of $5.00. This would buy a barrel of flour, some nice oranges, a hat with a feather in it, and quite a few other little nick-nacks. These United States have been built up to a considerable size without such a law, and why not just proceed along the old lines?

Of course those who are practicing architecture previous to the passage of such a law are allowed to continue without an examination by paying $25.00.

In every county where the architect erects a building in Illinois, he has to have his license recorded at the courthouse, and this means more fees and annoyance. It is surprising how anxious men are for a closed shop, a monopoly.

A fine of $50.00 to $500.00 per week is the penalty for drawing plans without a license in the territory already closed. Bricklayers and carpenters may be bad, but architects are merciless.

Of course any builder may still make plans if he puts up the building himself with his force. He cannot practice architecture as an architect does, however.

A union means war, in a sense. It means an organization principally for the benefit of its members, and only incidentally for the benefit of the public. All physicians have unions, and so do lawyers and preachers. Certain conditions must be complied with before one can practice medicine, law, or preach. Rules are laid down for the members. No matter how good a lawyer you may be, you cannot take cases until you have been admitted to the bar, or union. Such is the law, or custom. Of course professional men would like to have the public believe that they are on a much higher plane than mere ordinary mechanics, but the principle of their union is the same as the ones we hear more about.

Incompatibility. — In general, fair treatment of an architect or superintendent is met in a like manner. But it must be remembered that there are people who can no more get along well together than cat and dog. In cases of this kind the best way is to conclude that in such a globe as ours, about 8,000 miles in diameter and 25,000 in circumference, there is vast room for growth and unlimited chances for avoiding each other if we are so disposed. "It was held," says a New England historian, "that persons who could not get on comfortably with their neighbors should seek other neighborhood."

Acceptance. — It is a good idea to get a written acceptance of a building from an architect. Of course the final payment settles the question, but a written acceptance is sometimes useful, though seldom given.

Bad Foundations. — A contractor is sometimes held liable if the foundations sink and the building goes to pieces. This is one reason why a written acceptance is valuable. According to some of the courts a contractor should know his business well enough not to build a poor foundation. Seeing, however, that he does not make the plans, nor figure up the weights, nor proportion the footings, his best course, in doubtful cases, is to get the architect to authorize him in writing or before witnesses, to go ahead with the work. In ordinary dwellings a 17-inch base on good soil will carry twice the weight that is ever likely to come upon it; but some soils are so bad that they would not properly support a hencoop.

Bribery. — This is one subject that would be pleasanter to leave untouched. Architects of a certain class are sometimes bribed by contractors. From of old it has been held that a man cannot touch pitch without being defiled; and neither can one man bribe another without paying the penalty himself. Crime and punishment, Mr. Emerson told us, grow on the same stem. If you pluck the one, the other has to come with it, whether you believe it or not. The chain fastened to the wrist of the slave has the other unseen end linked safely around the arm of the slave owner. This is the law. You might as well attempt to pull the stars from above you as to try to change this law.

Once upon a time there was a golden image set up in the plain of Dura, and everybody had to fall down and worship it or face punishment. Our new idol now is "Business," and "Success" as expressed in dollars. Success is pleasant, and it it natural to work and wish for it; but if it has to be based upon bribery one is better working in a ditch at ditch wages.

If you should happen to run across *Everybody's Magazine* for October, 1907, you will find a story of charges for extras that will make the most hardened contractor gasp. One of the men connected with the business has since committed suicide, and there have been more than one who went to the next world unbidden rather than stay here and face his record.

Photographs. — The camera is being used by the large construction companies more and more to keep down disputes, if possible, or to make ready for them if they do come; and also to show progress. On two time jobs I had a few photographs taken, and that settled all talk of penalty, for the owners were at fault.

The contractors on the new Cook County Poor Infirmary, at Oak Forest, Ill., took fifteen photos, twice a month, of the twenty-two buildings. They are 7″ x 9″, and there are altogether about 350 of them, bound and ready for use or reference at any time. Do not forget the photographer. He may save you from architect and owner.

CHAPTER II

RELATIONS BETWEEN THE CONTRACTOR AND THE OWNER OR REAL ESTATE AGENT

"Never build before you are five-and-forty; have five years income in hand before you lay a brick; and always calculate the expense at double the estimate."

Knowledge. — The average owner does not know nearly so much about building as the architect, and for this very reason is occasionally harder to deal with. With an owner, you may sometimes find it an easy matter to charge a tolerably heavy price for an extra, while looking as innocent as possible, but the rule works the other way also. You may be giving A. B. C., the owner, a reasonable price and the best of workmanship, but he has to take everything "upon suspicion," as it were, while the architect understands the situation. The owner may sometimes even believe that the two building allies are in a conspiracy to divorce him from some of his ready cash, when they are doing everything in their power to treat him fairly.

There are many things about a building to a person unfamiliar with it that do not seem quite right, and yet are so. I once had a man tell me that the kind of mortar he was acquainted with had a white color, and while the dark stuff I was using might be all right, he did not like the look of it. It was good cement, and for the purpose was twice as good as the lime mortar. He was getting a better job than he understood.

Quality. — Then, the timber may have some harmless wind shakes that look rather dangerous; and an occasional soft brick put in the center of a 21-inch wall gives rise to a dread that the weight above will crush it to powder; and so on in many ways.

Some owners who have built have been cheated, and it is a good old proverb that says, "Once bit, twice shy."

The dangers of inferior material and workmanship are, of course, principally in the lump sum contract, and with irresponsible contractors. If the owner takes the other kinds of contract, or deals with the right man under any kind, the risk is done away with.

Reasons. — Both architect and contractor should explain, as far as they can, why such and such qualities are used, and give the reasons for a high price. Take as an illustration, quarter-sawed flooring. Whether of yellow pine or oak it is much higher in price than the ordinary flat-grain material, but it is superior in quality. When an owner is shown that the edge grain yellow pine will wear down clear to the bottom without slivering, and is told of the waste necessary to manufacture it by first quartering the log, he understands why it is used and why the price is high, and is satisfied. There are a score of features all through a building that may be explained to an owner in this way.

Time. — One of the principal troubles between a contractor and an owner arises with the time taken to complete the contract. The owner, once he has finally concluded to build, wants his building just as soon as possible, and not unfrequently a little sooner. That he himself may have let months of good weather go past unused while he played seesaw does not count. After the order is given he wants results. He usually forgets that the contractor wants his profit at the earliest possible date also, and that he has no particular object in delaying work, but every incentive to complete it. It sometimes happens, however, that a contractor is pushed on other contracts, and has an insufficient force on the one belonging to A. B. C., the unfortunate victim, in which case he has just cause of complaint.

Good Construction. — But every builder knows that delays, unless too serious, are really to the advantage of the owner. I remember going to look at a building in the city of New York. A water tank had been filled on the roof when the walls were green, and the structure went to pieces. When story after story is added too quickly on a masonry building there is no time given for the materials to get the necessary bond, and the natural result follows when the load goes on top of the soft mass. In many cases the green walls are swung out of line through neglect of bracing, and sometimes the whole building is thrown out of plumb. The famous leaning tower of Pisa was built plumb, but the ground yielded. Our masonry will not hold together like the old kind.

No stronger buildings than the new reinforced concrete ones are erected, but quite a number of them have collapsed before they were finished. The usual reason was the removal of the forms too soon. Concrete goes on hardening for three years, but we pull out the supports in three days, and then hold up our hands when the dust flies and our work falls.

All this haste does not pay an owner, but he insists upon speed, and quite often the trucks are bringing in the goods to overload the warehouse at the one door while the bricklayers are going out the other.

She. — It is the same with dwellings. In this case the WOMAN is the one who is to blame. She is in a great hurry to get into the new home. The one she is in may not be up-to-date any more than the dress of Abraham's day would be, and naturally she wants to get up with the procession. It is a laudable enough feeling, but when she insists upon rushing the work too much she is apt to have to pay a rather heavy price in the end for the "style" we all more or less like. There is no danger of collapse here, as a rule, but damp is the enemy.

Time Limit. — There is another kind of a time limit than the one the owner likes to set. This is the one the contractor should look out for. Prices rise sometimes. A few weeks or a few months may make quite a difference in the cost of the materials for a building. As a bid is practically a contract when it is accepted, it is not well to leave it too long in the hands of an owner or architect unless the bidder is sure of his ground. No one should expect a bid to hold good for more than, say, a month, and if a decision is not made before that time the contractor should protect himself. The best and easiest way is simply to set a time limit in the bid, if there is any risk of a rising market.

Quality and Damp. — When a contractor is behind time on a dwelling house he is really adding to its value. Before plastering he is giving the timbers time to dry, and after all we have discovered with our dry kilns and so forth, there is nothing that equals air-dried lumber. When every joist is green the trouble comes when the heat is turned on for the first winter. Contractors have seen the shrinkage scores of times. The joists shrink, the plaster cracks, and if the wall paper is on that cracks also, an opening appears at the base, and the joints of the woodwork open. It is provoking, but green lumber and not the contractor is to blame. If it is said that he should buy only seasoned stuff, he might reply that it would be well to put this down in the specification. It is often found there, but everyone understands that if this provision were really enforced a much higher price would have to be paid for the lumber in a building. In rush seasons buildings often have to be held waiting for lumber. It comes soaking, and it is a case of take it or let the building stand. If the dry lumber clause were put in all specifications and rigidly enforced, the cost would soar in quite a few dwellings. The next best thing to do is to let the air get a chance of doing its old-time beneficent work.

Yet the WOMAN keeps hammering away at the contractor to get the plaster on, and the wood finish on that as quickly as possible. The plaster should be bone-dry before the finish is put on. Millwork and hardwood floors are often ruined beyond hope of repair when laid in a damp building. Fine millwork absolutely will not hold together when put on damp walls. The contractor is not to blame when he refuses to put it on. It comes out of a dry kiln in the first place, and a warm mill in the next, and the change is too great. The enemy is not cold air, but dampness.

Strict Construction Versus Equity. — The question of time causes endless friction and petty quarreling between the owner and the contractor. Of course, the contractor should not sign time contracts that are too limited, but when a man has a wife and ten children depending upon him he has to shut his eyes and gulp down many other things besides the raw oysters that his soul loves.

Technically, legally, the owner is right and the contractor wrong in this matter of building, sadly behind time set for completion; looked at in the broader sense, with an eye to the structure as a permanent and expensive investment, the contractor is really doing the owner a service. It takes time to season lumber and make good workmanship.

Payments. — When an owner pays a certain proportion of his contract price, he understands and the contractor understands, that the right proportion of the money is to be turned over to the supply men and subcontractors. To take the money given by one owner to pay bills for the work of someone else is, generally speaking, dishonest. A strict mathematical line cannot be always drawn in the matter, for there are occasions when a temporary shortage will justify the contractor in making Peter pay Paul; but Peter does not want it done in that way. He likes to have his own bills paid with his own money.

Payment for Extras. — In most cases it is best to decide the price of extras before going ahead, and to get a written order for them. The amount settled on should be paid for in full as soon as the work is done, or at the first payment on the main contract afterwards. There is no reason for reserving ten or fifteen per cent. on extras. The owner is safe enough with this reserve on the original amount of the contract.

It is bad practice to put off the settlement for all extras until the completion of the building. This course often means a fight. With the ten or fifteen per cent. reserve in the hands of the owner, the contractor is at a disadvantage. A quarrel over a fifty dollar extra might give an owner who wanted an excuse the chance of delaying a settlement for years. As things are now in most states a court fight carried to the limit means several years. Extras should, if possible, be settled upon before execution. "Short accounts make long friends."

Keys. — Some of our church friends have a good deal to say about "the power of the keys." Contractors also have their key disputes. Is it legal to hold the keys and refuse admission to the building until the last payment is turned over or arrangements made for it? The general conclusion is that this should be done only as a last resort.

I once tried the key method on a bank building, under dire threats of some subcontractors who had part of a balance of about $18,000 coming to them. The bankers, who knew of other tricks than those relating to discount and interest, wrote to the hardware firm and got duplicates, moved over their bullion, notes, and wastepaper baskets, and one morning when I went down to keep watch and ward, I found the front door open and the bank doing business, not at the same old stand, but at the new one. The payment was made shortly afterwards without any trouble. After all, there are better methods than the one that relies on the "power of the keys."

Borrowing. — But it should also be remembered that many a contractor has been put out of business by an unscrupulous owner who got into the building and then told him to go ahead and sue, or file a lien, or do anything else he pleased. A lien would draw interest at, say, seven per cent., and probably having already borrowed all that the building would stand, the owner made up another loan from the builder. With the delays possible in our "technicality" courts, it often takes years to get a decision, and in the meantime the builder may be seriously embarrassed, for it is not always possible to borrow money on the security of a lien. It is sometimes impossible to do so on government bonds.

Security. — Herein is a strange anomaly: The owner asks the builder for a large bond, yet the latter may have the more property of the two; why should he not get a bond in return that the owner would pay the amount of the contract as agreed? It may be said that the building is security, but so are the buildings that the contractor owns on his side of the question; and besides, what use has a contractor for a church, a hospital, or a large dwelling? The storekeeper may have many suits of clothes in his window, but if he sells none he has to go out of business. A contractor's business is to build houses—usually for others.

When a builder has any doubt about the ability of an owner to pay as agreed upon, he should ask that the money be deposited in a bank, subject to the certificates of the architect, or have some such arrangement for certainty of payment as the work progresses. There is no sense in going into trouble with open eyes.

Public Work. — When the public is the owner, as in government, state, county, and municipal work, payment is generally sure, but in some cases it is a long while in coming. Contractors should inquire if the warrants given are accepted on a cash basis at face value. A lien cannot be put on public work.

Commission. — When we come to the real estate man as an agent of the owner there arises another little complication.

A percentage is expected on all work done. This is legal enough and proper enough under certain conditions.

When our western boom burst in the nineties I went to a large city and opened a jobbing shop. A real estate man gave me a small piece of work as a starter, with a promise of more. The whole thing ran to only a few dollars, and when the bill was presented, he told me that I had forgotten his commission of ten per cent. I began to write it at the foot of the bill when he stopped proceedings, and said that he did not want it that way, but added to each item so that his name and commission would not appear at all. I refused to so arrange it, and that ended my dealings with him and also all prospect of work among his class.

Since then I have been shown printed rules of a real estate exchange governing the conduct of the members, and the ten per cent. commission is there. Why not? Whether the agents get ten per cent. or twenty per cent. is a matter for them and the owners to decide. This charge is, of course, in addition to their regular charge for taking care of the property and drawing the rentals. If the owner is willing to pay it, the percentage is just as legitimate as the other one charged for selling the property.

But if the commission is proper, why is it not put in the bill the same as any other item? Why leave that particular one to an understanding between the agent and the contractor? Why hide it? Where does the owner come in, except as to paying the bill?

A contractor in making out bills of this kind should either mark down this percentage the same as anything else, or try some other work for a living. He is making it more difficult for every honest contractor to do business.

It must sometimes amount to so much as to make a plain statement look a little off color. The jobbing contractor has often to do so much for ten per cent. himself that it may seem a little unreasonable to both him and the owner to turn over a like amount to the agent for doing practically nothing, but if both the others are agreeable that settles the matter for the contractor. It is none of his business. His part in it is merely to add the commission in plain black figures at the foot of the bill, coupled with the name of the happy man who gets it. In remodeling and heavy repair work all we can do is to extend our congratulations to the much abused middle man. Here, if nowhere else, "he gets what is coming to him."

Temperament. — In public work one has to be careful of the kind of men he is going to deal with. Some of them are elected for only short periods and are so filled up with a sense of their greatness that they can feel the earth tremble as they walk. Not a few contractors have gone to figure work of this kind, and after "sizing up" the situation have refrained from putting in a bid. If on state work, you cannot sue and have to swallow whatever comes along. It is well, therefore, to find out before going ahead whether you must deal with reasonable men or with little czars.

CHAPTER III

RELATIONS BETWEEN THE CONTRACTOR AND DEALERS, AND SUBCONTRACTORS

Change of Front. — When you give a man power you soon find out what he is made of. When dealing with an architect or an owner the contractor has had to be reasonable, because the power lies with those who give him orders and pay him for his work. With the supply men and subcontractors he is on another footing. He is now a man to be handled with gloves.

Try, Try Again. — Some general contractors have acquired the habit of thinking that a subcontractor's time belongs to them. When an architect keeps them figuring for a long period without results, and they instinctively know that something is wrong, they see the injustice of the situation; but when they take a subcontractor's or supply man's bid, make up their totals, get the contract, and refuse to turn over the share of it that morally belongs to those who have given them figures, the status seems to be changed. The right kind of contractors do not do this, but some wax rich on the practice. Fair treatment pays in the long run. What is known as "peddling of bids" does not pay,—except in money quite often.

Fairness. — After a contract has been let on the basis of the accepted figures of supply men and subcontractors, a general contractor has, in a sense, no moral right over this part of the work. Of course he is right in demanding security, if he wishes, that the others shall be able to deliver their part of the work; but that being understood, he is morally held to give it to them without deduction from their figures, except that he may ask them to cut off something from their total if he has had to reduce his own. But in no case are they obliged to do this. He should first get their permission before doing any cutting.

In some cases the actual figures do not always decide which man is entitled to the work, but in most they do. There may be other reasons. Properly, however, the time to find out those other reasons is when making up the total of a general proposal. It might be found out, for example, that some subcontractor had quarreled with the owner, and that the latter would not allow him to lift a hand on another of his buildings, or that the subcontractor's son had eloped with and married the owner's daughter, and that her father "had it in" for anyone of the other family. Why should a general contractor put his head in a hornets' nest? In some cases his wise course is to go to the subcontractor and tell him that in ninety-nine cases out of a hundred they stood together, one and indivisible, but in this particular case he had to refuse to run the risk.

Written Bids. — All subcontractors should give written bids to the general contractor, and they should be made out "in accordance with the plans and specifications." Otherwise a subcontractor might say that he did not include this, that, or the other item that a general contractor has to be responsible for. Some subcontractors seem to think that there is a hoodoo in pen and ink.

Payments. — Supply men are usually rich enough to lie out of their money for a longer time than subcontractors, who, as a rule, require their share as soon as the owner gives the total of the architect's order to the general contractor. This does not mean that the supply men should not get whatever they are entitled to as well as anybody else, for they should, but merely that they are better able to stand any delay than the ordinary subcontractor.

An Example. — One of the leading business men of Chicago, who told the story of his rise from a $65 start to handling a large annual trade, let us know one of his favorite methods of getting ahead. It was to keep the big supply men in his debt, and thus to make them as eager to see him forge to the front as he was himself. They wanted their money.

This plan will work when only a few try it, but suppose everybody fell into line, what kind of a condition would it soon bring about in the business world? It would really be doing business on someone else's money. But if enough supplies were sold to justify it, many a rich dealer would be well enough pleased with the arrangement, as the wholesalers were in the case above.

One or Many? — Perhaps a hint may be had as to one way of succeeding in contracting from the method of the Chicago business man. He interested the wholesalers in his success; and if the general contractor can interest all of the subcontractors by some method by which their pocketbook would not suffer, he might obtain a force that would push him forward. Here comes up the question discussed in another chapter as to whether it is best to do all the work in a contract oneself, and thus cut off every profit, according to the Standard Oil method, or spread it out and interest others in one's success.

Borrowing Money. — Does a banker come under the head of a supply man? In a book of this kind that seems to be his proper place if we are to recognize him at all. He supplies money.

A great American orator once said that no business can continue to pay ten per cent. on borrowed money and live. It is, therefore, not considered wise to borrow too often at this rate.

There are some who never borrow, like the Frenchman in the novel. He paid cash for everything and kept his head straight. But some troubles came up that threatened to conquer him, and he went to the banker for a loan. That awakened suspicion at once. His principle of never borrowing was well understood, and the banker correctly reasoned that there was something seriously wrong when he wanted it. The loan was refused, and the blow fell.

I have read of others who, understanding this principle well enough, borrow from the bank when they do not require money, pay promptly, in order to make a reputation for themselves, and in case of a crisis they thus get a heavier loan than they are really entitled to. This is not dealing altogether fairly with the banker. If everybody else played a game of deceit the business world would not hold together. The banker has to rely upon the honesty of his customers as well as they have to rely upon his when they intrust him with their money, and things would move smoother all around if we exacted about the same fair dealing from ourselves as we demand from him. Many a man holds up his hands in astonishment on reading of a dishonest banker who himself has been practically lying to that same banker for years.

The best principle would seem to be to borrow when you really want the money, and be honest with the man who holds about the most responsible position in our modern life. A bank failure can wreck things in general quicker than anything else short of a cyclone or earthquake.

Like to Like. — The relation between the contractor and his subordinate tradesmen and dealers are not nearly so formal and hidebound as those between him and the architect, the superintendent, or the owner. They are all birds of a feather in this combination.

Uusually there are no contracts between the lumbermen, millmen, and other dealers, and the general contractor. The figures, often verbally given, are held to be sufficient for him.

CHAPTER IV

RELATIONS BETWEEN THE CONTRACTOR AND HIS WORKMEN

Courtesy. — The Chicago merchant alluded to in the last chapter says, with respect to the handling of men, that we hear so much about, " I treat all my employees with respect. I believe in hiring good help and paying good salaries. As I walk through the different departments in my store my employees do not have to feel that they must brace up because the boss is coming around. They would far rather have me at home than abroad. I tell every man at the head of a department, ' Be kind to the help under you. Do not speak to them in any other way than I speak to you. Handle your help so that they will respect you, and so that they will regret your leaving my employ.' "

Captain " Bill " Jones was Carnegie's best superintendent, and had thousands of men under him. With his experience for a guide, he said, " All haughty and disdainful treatment of men has a bad effect upon them——" since they are men and not dogs, presumably.

One railroad man, whose books are known all over the world, said that there is one true test by which you can tell a gentleman, and that is the way he treats those under him.

Now all this seems to be so reasonable that it would not be necessary to add more but for the fact that another method of treatment is getting to be somewhat too popular. It is the domineering kind, ending in strikes, quarreling, and general disorganization which, in the long run, is rather severe on the pocketbook.

The Other Way. — For example, one writer says about handling men in engineering and building work, " It requires the same severity of discipline, the same show of harsh exterior, the same proneness to find fault rather than praise, in order to spur every man to action, as it does to spur the laborers under them to action."

I do not believe this tyrannical course is necessary. A disgusting, discouraging fault-finding should be looked upon rather as an evidence of weakness and incompetency in the man at the end of the whiplet. Too many men have succeeded, in all lines and scales of business, the other way to make any doubt possible on this point.

Waste. — What is the object of all this slave-driving policy, this ferocity of production? More wealth added to the public pile? Yet the incompetent management of industry is such now that in a single average year there are unnecessary fires enough to destroy one-third of all we build, when the other consequent totals of waste are added to the fire loss proper. The severity, and harsh exteriors, and fault-finding are not required so much for workingmen to-day as for so-called "business men," who are responsible for this delirium of waste.

This fire bill is only one item of our national waste that is so great that some able men say that one-half of our effort might as well be considered lost. What is the use of producing more merely to destroy it? Yet we have the Legree type who seem to think that the whip is the only weapon that keeps a manual worker at his task. No wonder there are strikes all over the land.

Manhood. — One of the first things that all should understand is that the American republic is founded upon the theory that men are capable of governing themselves. This was a startling departure from the old system which, in many European countries, classified them as subjects fit only to be governed from above. There are some who sneer at this idea in the business world, but even in their pride of place they should remember that the republic they live in is founded upon precisely this theory—that the common man is better fitted, taken all in all, for running this government than the trained statesmen of the old style who used their power generally for their own selfish advantage.

A Contrast. — Having quoted what might be called the American system as set forth by the Chicago merchant, it is but right that we should go to this same city for what, according to temperament, might be called poison or antidote. This is a fight thousands of years old, and not a mere temporary local question. As such it is worth some attention.

To set the other view in contrast some extracts from a Chicago publication are here given:

"The majority of common laborers are like overgrown babies. . . . Minor cases of injustice may occur, but it is a free country. Aggrieved men have always the privilege of quitting."

Yet the republic itself must be governed by the "overgrown babies." It is not free as yet, in many ways, and an arrogant invitation to anyone to quit will not have a tendency to improve either man or country.

"A first-class foreman is generally 'Mr.' to his men. The feeling of the men may be one of respect, but it is certainly not love. . . . Good foremen are as scarce as hens' teeth, and it is unfortunate that the majority come from walks of life that forbid any intimacy or great show of friendliness on the part of their employer. Few of them are strong-headed enough to stand it. It is a fact that a foreman is seldom worth his salt after the second job. . . . A foreman should be spoken to only twice if he is not giving satisfaction. The second reproof to be in the form of an invitation to 'come to the office.'"

Now, the "name" business does not seem to cut much figure in some cases. "Bill" Jones got results and also "Charlie" Schwab. Yet many a "Mr." is an expensive luxury. He is so impressed with a sense of his own importance that he is not good for much else than strutting. After a long experience in building I am forced to admit that the "front" name is more popular than the frilled one, yet the masonry and woodwork go into place quicker than they do on not a few structures where all the formalities are observed in a style that would delight Alphonse Gaston, Esquire.

The personal, friendly element does count for quite a good deal, and while a man may keep up on a pedestal and aloof from those under him if he chooses, that is not a sign of pre-eminent ability, but often of mere snobbery and educated ignorance. Abraham Lincoln did not fear contact with ordinary mortals.

Two of Mr. Carnegie's managers, Mr. Schwab and Mr. Corey, illustrated, according to a magazine writer, the two different systems. Mr. Schwab was magnetic, and much of his success was owing to his personal acquaintance with the men whom he knew as Tom or Jim, as the case might be, and who—dreadful thought!—spoke of him as "Charlie." Mr. Corey followed the other method of close analysis of costs, and men were to him No. 124, or 2546. Each was successful, but which represented the highest ideal in a republic? Does it need Mr. Carlyle to tell you once more that the civilization never yet endured which was based on the idea of so much money on Saturday night, and hand-washing afterwards?

The old European idea was that statesmen were hard to find, but the American republic provided millions of them. The old idea is that foremen are hard to find also, but this is only one more decaying superstition.

Which. — You have now been given the two theories of "handling men," and this, in the often quoted phrase, being a free country, you can choose whichever you like best. The severe one is apt to have more strikes in its train, and to cost more money. After all, men are human, and cannot be dealt with like commodities.

Engineer Folly. — Somehow or other, an unusually large proportion of engineers proceed on the domineering plan. Perhaps it is because of handling so many men on earthwork, sewers, railroads, and such heavy undertakings that they take the Asiatic instead of the American view of industry. Of late years southern Europe and Japan have sent us shiploads of what some call undesirable citizens, and it may be that the tripod men have come to believe that all manual workers are of the same caste; but most of what they hold as to the value of harsh treatment will never succeed with American tradesmen on buildings.

Day's Work. — It should be understood that this better method of treatment does not mean that men should be allowed to loaf and neglect their work. I do not believe in that kind of friendliness. I compiled "The New Building Estimator" for the express purpose of keeping track of the amount of work a man should do in a day on a building. All that is meant is that a good day's work may be had from a man even if you treat him as a fellow "human," and not so much in the No. X—546, Shelf 24 style.

Wages. — In several cities there have been strong objections made to the payment of wages in checks by tradesmen, in the first place, and also by others not directly affected. The Chicago Federation of Labor has asked for payment in money, and so have many other bodies.

In many ways this is the easiest method for the contractor, and also the safest, in that it gives him a record of payment to each man, in addition to whatever other entries he may have in his books. He gets his own payment in checks, and he is but giving to his men what he gets on a larger scale from the owner. This seems fair enough—but he can bank in the middle of the day, and on any day of the week.

The trouble comes for a workman when he tries to get his check cashed. All merchants do not care to take them, and cannot afford to keep cash enough on hand to do so, as there are still a few burglars in the land, and the bank balance may be low. The banks, even if open on a Saturday afternoon, are probably distant from the building. Savings banks take care of this trade by usually keeping open when the other banks are closed, but when a man is working on the outskirts of a city he does not feel like using up part of the only afternoon in the week he has for himself, and he becomes dissatisfied with the arrangement.

The best way seems to be payment on the job in cash. The unions have properly settled the place of payment as the building upon which the men are working, but still accept checks.

Robbery. — Of course, there is the danger that a contractor may be robbed of his cash between the bank and the buildings. There is an insurance company which sells insurance against this danger, but by the time a contractor insures everything, it costs, in the phrase of some of them, " like the Sam Hill." With many of them the profits are not any too great as it is.

Saloons. — The saloon men are always ready to cash checks in their headquarters. This is one reason why so many object to such system of payment. They very properly do not want to go near saloons, and still less buy the goods, which is, of course, expected when the checks are cashed. Employers might easily arrange this matter. Some of them pay cash in the saloon itself. It is a good way for a contractor to advertise his own cheapness. Liquor is frowned upon by too many railroads and large corporations in this electric age to make it safe to tamper with, unless a man is catering to the saloon and brewery trade, and wants to put up their buildings.

Weekly Pay-day. — In cities this is firmly established, but in some country districts payment is made only once in two weeks. The weekly pay-day is better in the building trades whatever it may be in some others.

If a subcontractor, for example, objects to a general contractor keeping back his share of the estimate, and thus doing business on money not his own, the same man should see that if he keeps back the whole pay-roll more than a week, he also is working with money that belongs to others.

Large corporations pay their employees only once a month, and the arrangement is suitable enough, but when they employ building tradesmen they usually have to follow the weekly custom.

Profit Sharing. — There are some manufactories which carry out a system of profit sharing with good effect, but it does not have much of a foothold in the building trades. Men change too frequently from one employer to another to make it work.

It is rather an interesting fact, however, that Leclaire, the founder of the profit sharing system, was a house painter. He made it work well. Possibly not by "firing" men so much for a slight fault as by handling them in the better way that makes firing often unnecessary.

Waste. — There are men who never seem to care whether they use the right kind of material or not. If they want a small stone they cut a large one to suit; and a long timber is easily made a shorter one. They should be watched.

CHAPTER V

READING PLANS AND SPECIFICATIONS

"Let a man learn as early as possible honestly to confess his ignorance, and he will be a gainer by it in the long run; otherwise the trick by which he veils it from others may become a habit by which he conceals it from himself."—*On Self-Culture.*

By Doing. — "Reading and writing come by nature," was the saying of the man in the play who did not know how to do either. They do not come in this way, as our teeth do, but they can be learned. There are various ways of learning them.

An American statesman told his countrymen, with respect to the resumption of specie payments, that the way to resume was just to resume. So we might say that the way to read plans is just to read them. When this is sufficient, why read page after page of instructions? I found the method to work in my case—why not in yours?

If you want to learn to swim, do you stay in your room and read books about this art which "once learned is never forgotten?" No; you go into the water and strike out for yourself, less gracefully than an ordinary everyday, vulgar little frog, it is true, or a dog, a horse, or even a cat, but nevertheless you DO strike out, and in time you come to trust the water and yourself.

Stickability. — We hear a good deal about ability, and we should like to possess it, but not so much about stickability, which we may all have to a greater or less extent.

Once about thirty of us were gathered in a class to learn shorthand, less well known before the age of the typewriter than now. We listened to a plain, straight-from-the-shoulder talk from an enthusiastic teacher. He gave us a message of encouragement, which is about the only kind that is worth anything at all for those who are trying to learn, and far ahead of severity and harshness. He said that there were three styles taught, and his plan was to plunge his students into the reporting or highest style and be done with it. As the greater always included the less, so this style carried with it a knowledge of the baby versions.

This made us swell our chests and feel like writing a hundred words a minute before we had seen the first stroke. If only two of us ever kept up our studies long enough to make a workable success of the art, it was not the want of ability on the part of the others, but of stickability alone. It is pleasant and easy to write this book by the system I learned as a boy.

Attacking Plans. — So with respect to reading plans and specifications, all I have to give to any novice is a message of encouragement, and to tell him not to be afraid of actual plans which are as easily read as any baby versions of them are, all coupled with the advice to cultivate stickability, and not be afraid to show ignorance by asking questions. An architect or builder of any account will be glad to explain difficulties. If he refuses, the reflection is on his character and not on that of the inquirer.

Li Hung Chang was a famous statesman as far back as the time when General Grant visited China; and later on when he came to this country and saw Grant's tomb he distinguished himself chiefly by asking questions.

It is a sure way to gain information of some kind, and that is something we all need, for if Mr. Edison, the famous electrician and poured-cement house man can say that, according to his opinion, we really know just about one-billionth part of one per cent. about anything, then ordinary people need not be ashamed to ask the better informed for enlightenment. If the first question does not bring the desired information, succeeding ones will, for in desperation the busiest man will either "fire" you or answer to get rid of an interrogation point.

Breaking Rules. — "How are you going to find out what the rules of the House of Commons are?" asked a follower of Mr. Parnell when the latter was engaged in his stormy work. "By breaking them," was the answer. That is also a certain way of finding out an architect's rules.

Among the first plans I worked from, there was Tr shown after all the door sizes on the second floor plan. I did not know then that this meant Transom; and the partitions were finished and plastered before the error was discovered. I broke the rules, was shown my mistake, and paid for it by getting my hair and lungs filled with plaster and plaster dust in making things right. It is a sure method, but sometimes an expensive and inconvenient one. After that I always watched carefully for Tr. It was to me more important than the Mr. alluded to in the last chapter. Plaster dust is disagreeable.

Anyone. — There is no carpenter, bricklayer, plasterer, plumber, teamster, or man with the hoe who may not, if he pleases, learn to read plans as easily as he reads a newspaper or this book. The creation of plan readers may be difficult in Asia, under the old beliefs, but not in the United States now. There is nothing mysterious about the work, and there is no sense in trying to make it appear so. It is a message of encouragement that this chapter brings, an order to attack what might be termed the "reporting style" of the plan business by reading all the actual plans one comes across and scores of others in the trade papers, until the work becomes as easy as laying brick or driving a nail. One of the best ways also is to make plans oneself, no matter how rough they are at first. The REASONS for the RULES unfold themselves as the work proceeds.

Advantage. — It should be remembered, too, that tradesmen, in general, have a clear advantage over draftsmen. There are many of them so unacquainted with the manner of putting a building together that they work half by guess and half by knowledge. The tradesman does the actual work and knows why such and such details are used, and why the construction has to follow certain lines.

Trade Papers. — One of the best ways of learning how to read plans is to take a good trade paper. Almost every number of some of them contains house plans, elevations, sections, and details, and by careful and constant study, any tradesman can master plan reading in this way quicker than he can by taking time to go through long-winded instructions about something that, with practice, is as easy as reading ordinary print. As with everything else, practice is necessary until a workable perfection has been attained, and once this point is reached, the art of plan reading stays with its owner.

Of course a contractor pays men to do a certain amount of work, and cannot afford to have them pass their time reading plans in working hours, but the trade papers give every opportunity for exercising in this art in the evenings. The man who understands plans is undoubtedly of more value to a contractor than the one who does not.

A Few Hints. — The plan gives the size of rooms, the thickness of walls, and shows if they are solid or hollow on a masonry building, indicates the position of the chimneys, ordinary openings, sliding-doors, and French windows; shows the distance and size of piers, and marks with dots what is either above or below the floor line, as girders below, and brackets or overhanging cornice above, when necessary to show this. This dotted work in the case of beamed ceilings may be very expensive, and has to be watched.

Stairs that meet on the plan are broken off, and an arrow used to show which goes up and which down, and as there are a few architects who do not know how many risers it takes to give headroom, a contractor has to watch the stair arrangement, for changes that cost money are sometimes necessary on this account.

Soil-pipes are dotted in below the basement floor, and drains from the downspout to the street or cistern. It is important that the contractor should see how deep these have to be.

Roofs. — The roof plan is sometimes given on ordinary houses, and must be in large ones. A common method is to dot it in on the second floor or attic plan.

Elevations. — The elevations give a picture of the building based on the supposition that the eye is always on a level with every part shown. It is thus different from a perspective, which should be the same as a photograph. There are often not more than two elevations given.

Sections. — In order to understand these drawings it is necessary to see on what line the section is taken on the plan. All heights of stories, window-sills, spacing of joists, bridging, thickness of walls, position of girders, and everything that can be seen by supposing a great knife to be slashed down through the house as through a cheese from ridge to the footings is shown. The sectional drawings often require more attention than either the elevations or plans, which are usually self-explaining.

Details. — These drawings are so much larger than the others that their meaning can scarcely be misinterpreted. In some cases, as for stonework or millwork, they are made full size.

Scales. — I worked for several years making plans for buildings mostly on a scale of one-eighth of an inch to the foot; and some of one-sixteenth on account of size. It would have been impossible to use a scale of one-quarter inch, for this would have made a sheet in some cases ten feet long, and it was considered best not to break the drawings. But for buildings of ordinary size a scale of one-quarter inch should be used. It is unfair to contractors to make them puzzle over hair lines on an eighth scale if one twice the size can be used.

Specifications. — The old proverb says that familiarity breeds contempt, but it is not wise for a contractor to become so familiar with specifications that he neglects to read them carefully. After I had read so many that the sight of one was wearying to the eyes, I once overlooked a few words as to the quality of flooring in a six-story building, and the bill came to about $150. The plan deals with sizes, but the specification tells of quality. So far as the plan is concerned one does not usually find out if the inside finish is to be yellow pine or mahogany. A single sentence may make a difference of $1,000. Therefore, do not neglect to read all that your friend, the architect, says to you.

CHAPTER VI

THE PREPARATION OF ESTIMATES

Architect's Scale. — Before taking off any quantities from the plan every contractor should get what few of them have— an architect's scale. This is a better instrument for the work than a two-foot rule. The figures are all marked, ready for use, and there is no necessity for multiplying $11\frac{1}{4} \times 4$ to find that the total is 45 ft. on a quarter-inch scale.

A plain boxwood scale costs about 90 cents at an ordinary store, but the mail order houses charge only about half that amount. The ones with celluloid edges may be bought for $1.50 up. They are worth the extra money. The flat ones are serviceable enough, but the triangular style has more scales. There is the natural scale, divided into sixteenths; $\frac{3}{32}$ and $\frac{3}{16}$; $\frac{1}{8}$ and $\frac{1}{4}$; $\frac{3}{8}$ and $\frac{3}{4}$; $\frac{1}{2}$ and 1; $1\frac{1}{2}$ and 3-in. to the foot.

Method. — As a general rule, it is better to take off all the items on a plan before figuring up the cost. The desk or table can then be cleared off and room secured for millbooks and catalogs.

EXCAVATION

On the supposition that a contractor is going to estimate all the work himself, the proper place to begin is with clearing off the lot, and the excavation. Old buildings may have to be removed, or trees cut down before the spade goes in the earth. Each job has to be considered by itself.

Sizes. — The size of the main part of the building is taken over the footings shown on the section, and not merely over the basement walls, and about a foot more added each way to give room for laying brick or putting in concrete. This method is continued over each part of the building, and after the areas have been added, the whole sum is multiplied by the depth and divided by 27 to get the number of cubic yards. The total is then multiplied by the unit price, which may be 15 cents or ten times as much, depending upon conditions.

Even the exact sizes cannot be always relied on. I have often seen banks cave in, and add twenty-five per cent. to the total.

Mud. — Then water may arise, and there is a mud puddle to contend with. The measurement may be taken off accurately enough, but falling banks and mud may add fifty per cent. to such work as heavy piers. Sheet piling has often to be used to keep the earth back.

Rock. — But instead of mud there may be rock to blast out. This shows how much the character of the soil has to do with excavation, and how exact sizes may have to be largely increased in soft soil.

Levels. — Another trouble is with the depth. In a prairie country the lots are usually level, but sometimes in all cities there are lots whose surface is very irregular. An architect occasionally gives the levels at selected stations, and the contractor can figure from them with more safety than by guessing for himself.

Extras. — The extra depth required for footings, boilers, furnaces, chimneys, outside stairs, window areas, cisterns, cesspools, must be estimated separately.

Thermometer. — There is a danger from the weather in excavation. A rainstorm may cause the contractor a heavy loss; and if the work has to be done in winter, and the ground is frozen, only about half a day's work is obtainable from the men.

Sheet Piling. — At the time of making the estimate it should be noted whether sheet piling is likely to be required, or pumping; and the length of the haul should be taken into account, or anything out of the ordinary run of digging a hole in the ground and throwing the material on the bank.

Guessing. — As an encouragement to inexperienced excavators I may state that I once saw bids from half a dozen old contractors on a large amount of work, and they ran all the way from 30 cents per cubic yard to $1.

Flushing. — With plenty of fall and permission from the authorities it is sometimes possible to flush out excavation into the sewers at a cheaper rate than by the ordinary way of working.

PILING

If piles are used the number may be easily counted, and the borings given by the architect or the engineer determine the length. For some years I spaced enough to hold up an average city.

A man from Amsterdam once astonished his hearers by saying that he came from a city that was built on the tops of trees. Trees are falling into disfavor for this purpose now, if we are to believe the fire-proof men who fight against wood piles and the grillage that is often spread on top. They prefer concrete all through. Their objection is to splintering of the head and shrinkage of the timbers, but if good piles are used and carefully driven, the heads are preserved intact, and the grillage cannot shrink much if below water, where it ought to be to keep it from rotting.

A contractor's business, however, is to count his piles, to see what kind of wood they are to be, and to what depth they are to go, not from the surface of the ground, but from the water level. If grillage is used it can be easily seen and the quantities taken off.

Concrete Piles have an advantage in that they do not require to have the heads below water level, but may come clear to the surface of the ground. Lengths must be figured to suit each case.

SEPARATE ITEMS

Excavation, plastering, painting, or anything else after being figured up should be double lined at the end, and not carried forward into any other item. That is, the totals should not be carried from page to page in an estimate book, but each item should be left by itself to be added at the end to the summary. It is best to make estimates in a book, preferably a loose-leafed one. They are handy to refer to.

CONCRETE FOOTINGS

Next after excavation and piling, if used, come the footings. If they are of concrete the exact cubic contents are taken and expressed in cubic feet or yards, as the local custom decides.

Measurement. — The system of measurement all through "The New Building Estimator" is based on actual quantities without doubling corners and such extras. I know of a case where a long dispute went on over large concrete work on this question. The contractor, of course, wanted every corner doubled. An understanding should be had on this point before going ahead.

Perch. — Do not use it for any work. Let it die. It has made too much trouble. In some parts it means 16½ cubic feet, in others 22½ and 24½ or 25 are also used. There is too much chance of misunderstanding. The contractor who is used to allowing 16½ may put in a bid on that basis, calling it a "perch," and find that the state law or custom where he is figuring away from his home may compel him to give 25. A cubic yard or foot is always safe. It would really be better if we could all get accustomed to use cubic feet, as they do in Chicago and many other places, for the work of turning into cubic yards would not then be necessary.

Superstructure. — If the superstructure should happen to be of concrete, reinforced or otherwise, the actual cubic contents should be taken off in the same way as for the basement, regardless of double corners and openings, and the unit price set to suit the class of work. The actual cost of a million dollars' worth of buildings of this class is given in detail in "The New Building Estimator."

BRICKWORK

Measurement. — In this class of masonry the same system of taking actual contents only is followed, and multiplying the cubic feet by 22½ to get the number of brick in wall measure. The actual number of brick required is different according to size.

This question is gone into in detail in my "Estimator," where 23 pages are given to brick alone, with allowances for mortar, mortar color, pressed brick, chimneys, cesspools, boilers, and the cost of labor.

Extra Care. — With straight brickwork the measurement is simple, and the laying goes forward without much trouble, but with mantels, cornices, corbels, fancy molded pilasters, paneled work, and so on, the estimator has to be very careful. The cost of the molded brick is high, and the labor may run beyond all reason at the present rate of bricklayers' wages.

Soft Brick. — It is easy enough for an architect to say that no soft brick will be allowed in his work, but often difficult for the contractor to get hard ones. I was once sent about eight hundred miles to examine a kiln of brick held at $11 and worth, in an ordinary market $1.74, for hencoop foundations. There were few I could not break with my hands.

Suppose a contractor can only find this kind locally, and has to haul hard ones several hundred miles?

Theory. — Once when I was building a schoolhouse a paper came out with headlines that were too large, "ROTTEN BRICK IN A WALL." There were a few, but they were in the center, where they did the most good and the least harm. It is not easy in some sections where the clay is poor to get brick of the right quality. After all, what harm do a few soft brick do in the center of a 17-inch wall? They will bear ten times the weight that will ever go on them. The danger lies rather with the poor mortar used. If extra good mortar is specified allowance should be made in the estimate for it.

STONEWORK

Rubble. — This work also should be estimated by the cubic foot or yard, and not by the perch or cord. Take only actual contents, and price accordingly.

There need be no trouble in measuring up the contents of a wall of a certain length, height, and thickness. It is merely a matter of applying the multiplication table.

Heights. — The heights of all stories in a masonry building should be taken from top to top of joists, because the walls are often thinner on the top stories, and the thick wall should go to the top of the joists to keep them in place, provide better anchorage, and block fire.

Ashlar. — This work is usually taken by the square foot instead of the cubic foot, and figured on the average thickness. Some courses are made thicker than others for a bond. At the openings, the depth of the reveals often make thicker stones necessary. The area of an ashlar front is easily enough figured up.

Odd Work. — The trouble comes with something else than plain ashlar. It is the heavy entablatures, the round and square columns with their capitals, the molded belt courses and sills, the arcades, battlements, buttresses, and recessed work, finials, brackets, and everything of a special nature that has to be watched and priced to suit the style given by Angelo Wren, the celebrated architect. The safest way for a young estimator, and an old one also, at times, is to get a bid from a stone contractor, or rather from several who may differ thirty per cent. from each other.

Sills. — Ordinary door and window-sills are priced at so much per lineal foot.

Flagstones are estimated by the square foot, according to thickness.

Washing. — In all masonry buildings washing down and pointing has to be included at so much a square foot.

Floors and Walks. — These are estimated by the square yard, and can scarcely be missed. If the floors are plain, the price ought to be easily set, but gutters, ridges, troughs, and such work often raise it to twice the plain figure.

ACTUAL MEASUREMENT

Why is it better than the old trade rule system? Let us look at the question.

Variation. — In the first place, the trade rules are different in almost every state. Missouri used to have, and may still have, special laws enacted by the legislature as to measurement, and other states may have the same thing. Under such laws the only way is to go ahead, in default of special agreement, and follow them. This means confusion all over the country in what should be as simple as the multiplication table. We are getting too close together to have so many different rules. There has long been a fight to standardize the bushel weights in various states, and other measurements; and builders ought to fall in line with their work. In the case of railroads running into several states there is too much annoyance with various trade rules, and actual quantities only are recognized.

I know that the system of measurement is for special work like corners, openings, angles, corbels, and so on, where extra time is required. The extra cost is put in the measurement instead of the price.

Time. — Another trouble is in the waste of time in getting the actual quantities required. When I was estimating railroad work there would come special "rushes" when a complete bill of material had to be got out on short notice. By the trade rule of estimating so much for each opening, according to size, doubling corners, allowing half the thickness of one wall where another runs into it at right angles, taking projections, cornices, pilasters, in such and such a way, and so on to the end of the dismal chapter of "exceptions to the general rule" that are worse than those of our old grammars, I had to figure once to get the wall measure, then go over the whole building again to deduct the area allowed for the openings, corners, and so forth, in order to get the actual number of brick required, the actual yardage of plaster, for the number of lath and tons of material, and I finally threw up the useless work. I have found large brick contractors who have done the same thing.

Contractors like this system on account of the possibility of getting larger prices for extras. For the main contract they would just as soon figure by taking actual quantities and raising the price. The owner does not understand nor approve of this trade method.

Water. — The supply for masonry must be attended to. If a well has to be sunk the allowance should be made.

Hauling. — The question of hauling is often of great importance. How far, what kind of roads, what rate for teams, and such matters must not be neglected. I know of one contractor, up to that time successful, whose pocketbook was emptied by his having to build a short section of a railroad to connect with the main line. That item, and too low figuring on the rest of the work, landed him in the courts and trouble.

CARPENTRY

Direction. — It is not always easy to find out at a glance in which direction an architect wants the joists and rafters to run. When there is any chance of mistake it should be marked with an arrow.

System. — Of all the methods of arriving at the cost of carpentry the most accurate, if the slowest, is to take off the lumber, and allow the labor at so much per thousand feet, board measure, or per square. The square method is safe for old contractors.

Framing. — All plain structural material is easily seen and taken off. The principal difficulty is with the roof, where there is apt to be a good deal of waste on cut up work. This is easier done by the square. An easy system of measurement is set forth in my "Estimator." There, also, may be found all the allowances for extras required for siding, flooring, shingles, and other materials. It is not necessary to reprint them here.

Slow Work. — On a frame house it is a tedious business to take off all the lumber, and after some experience, a good many contractors resort to the square system. Studs, sheathing, paper, siding, are all figured up at a certain rate for a square, and then the surface of the building taken in the same way. So with floors and roof. This ought to be safe, for there should be enough profit to cover any little mistakes; but competition is so strong in this class of work that the lumber bill is usually taken off and sometimes figured down to the lowest basis.

Millwork. — The ordinary contractor usually leaves millwork for the experts, but the experienced one knows that they sometimes differ so much that he might just about as well risk making the estimate himself.

The difficulty is with special work made to details, and not with the stock lists. Millbooks are given to contractors, and when they know the discounts, there is little trouble with doors, sash, and ordinary materials. The mail order houses send a millbook to anyone. They give net prices without freight.

A full list of prices to assist the contractor is given in "The New Building Estimator"; and special work attended to as far as it can be.

Hardwood Floors. — So much of this kind of finish is now done that the contractor should be careful about his figures. When labor will run to $15 per square all over a first floor, the total cuts into the allowance in the estimate in a discouraging way.

STRUCTURAL STEEL AND IRON WORK

Here, again, on a job of any size, the builder is safer when he gets a complete bid from the iron contractor. The latter does not usually include anchors and the lighter items.

Columns and Beams. — Of course, on plain columns and beams anyone with a table of weights can easily get the cast iron, and the weight of the beams is marked per foot. If the price is known at the point of delivery there is no occasion to go to the foundry for a figure.

When a contractor figures the work himself he is not tied to anyone, and if he gets the contract may look where he pleases for a cheap sub-bid.

PLASTERING

This work, if plain, is about as easily figured as anything can be. It is but a question of finding the number of square yards. Even this labor may be dispensed with, for in my "Estimator" there is a series of tables with the number of yards all figured out for several thousand different sizes of rooms, and different heights from 7-0 to 12-0. By using this system there is less chance of mistake than with the old method.

The openings had to be included in the tables, for no two rooms are the same, and only straight walls and ceilings could be figured. The price may be arranged to suit.

PAINTING

After a general contractor takes off the square feet of ceiling, floors, siding, roofs, and other large surfaces in a building, he already has a good basis to work on for a paint estimate. He knows better than the ordinary painter where to look for the work. From the beginning he should make up his mind to figure his own plaster, paint, and such work, if plain, and take the chance of getting his figure cut by the subcontractor. It takes too much time to run around for figures, and sometimes the ones got by telephone are not stood by. The wires or something else may be crossed.

This does not mean that he should necessarily do his own plastering and painting. That is another question.

After a few houses have been built the paint estimate may often be decided upon without any figuring.

HARDWARE

It is rather a tedious matter to take off hardware that differs in every room of a large, fine house. The better plan is for the architect to specify a certain sum for this, and let the owner select it. If this is not done, and fine hardware is specified, the safest way is to make out a list and have it figured, or get the manufacturers' catalog, with a discount sheet. This is not usually sent out to any but retailers.

For ordinary houses contractors can often guess at the right amount, or allow so much per opening, after the nail and bolt allowance is settled. Sometimes the profit on the contract has to suffer a little to make up for any deficiency, but not much on such a small item.

RATE OF PROFIT

All through this matter of estimating we run against one strange fact. It is, of course, best to know exactly what every item costs, but it is a little inconsistent to find trifles estimated down to the last cent and then a guess made at a profit ranging all the way from five to ten per cent. If willing to gamble at such a wide margin on the profit, why not just a little on the hardware or painting to save the time and complete the bid?

NET COST

I prefer the system that first gets at the net cost all through and then adds the profit in a lump sum at the end of the total estimate. Others put the profit on each item as they go along.

ROOFING

This branch is estimated by the unit of a square of 100 square feet, or a space equal to 10 by 10 feet. Slate, tile, shingles, and patent roofs of all kinds are taken in this way.

Plumbing. — The usual practice is to let plumbing and heating separate from the main contract. If they have to be included, the general contractor gets a bid from the men who handle these lines.

If he figures the work himself and there are long lines of water pipe, he should be careful about the weights per foot, as they vary considerably. He should also get the local list of sewer pipe. There is a western and an eastern list.

Special Work. — Other necessary parts of a building contract, like galvanized iron, tiling, and fire-proofing, are usually figured on by subcontractors, and bids given to the general contractor for his total.

The prices of such work are given in the "Estimator," and labor costs as well, so that anyone may make up estimates for himself, subject to such changes as his experience in his locality sees to be necessary. Lumber, for example, is cheaper in Washington and Georgia than in Nebraska or Kansas; and slate is cheaper in the eastern states than on the Pacific Coast.

Making up Bids. — Get the actual cost of lumber, concrete, plaster, and all factors of a bid, and add as much percentage for profit as the local conditions will allow. It will not be too much where there is any competition.

The system we see recommended in some engineering works of putting down at least 4 per cent. for office expenses, 4 per cent. for foreman, and anywhere from 15 to 30 for profit cannot be followed for ordinary building work. At most, 10 is allowed and this has to cover everything. Many would be well pleased to do plain work for 6.

Low Bids. — On the other hand, it is not wise to go too low. The "plungers" often startle us by making large fortunes, but most of them fail.

Putting in Bids. — Hand in a bid before the time set for the opening. Many hold theirs back till the latest hour, and this is sometimes a wise course.

Subcontractors should get their bids in to a general contractor in time for him to make up his total. He is often embarrassed by having to wait, and takes risks by sometimes using a sub-bid that is not altogether clear. Suppose the subcontractor cannot be found by person or telephone, and the main bid has to reach the architect in half an hour, what is to be done? If the general contractor puts in the bid and the subcontractor backs out, what then? As will be found in another chapter, a bid is virtually a contract as soon as it is accepted, and the backing out course can only be done with the permission of the owner, who may like to see a low bid from a responsible man. If a subcontractor cannot trust a general contractor with a bid in time for the latter to make up a safe total and get any explanations that are necessary, he ought to refuse to have anything to do with him.

It is worse than provoking to have a complete bid all made out and have to wait to the last minute for a certain figure. All the other careful work is useless without that figure, and the hour of opening bids is close at hand, yet one man will often delay everything. General contractors are not to be blamed if they give up the system of relying upon others and figure their own work.

Bids should be typewritten if possible, but the figure counts for more than the style. Subcontractors should give written bids to general contractors just as the latter have to do to the architect or owner. A bid, if accepted, being an enforcible contract, why should the one who supplies a part of it not be liable for that part just as the other is for the total? A verbal bid is enforcible, but requires witnesses, while a written one is clear in itself.

Extras. — There are always some extras to be taken into consideration. If you add them all someone else will get the contract.

There is the question of heating in winter, for example. Someone has to pay for it. Which one?

Then there are sheds for lime and tools; and also one for the hoisting engine, if there is one. There may be a sidewalk to put around the building, or a fence; trees might have to be protected. In some cases there might be storage to pay on millwork. In others depreciation of machinery might have to be taken into account. There might be legal expenses; there would be washing of windows to some extent, and cleaning up around the building. There might be a rise of wages consequent upon the formation of a labor union in non-union territory. There would be a telephone and office rent, and so on to the end of the possible extra list.

If everything is added, as it should be, then the profit must be cut, or else the bid might as well not be put in.

Quantity Surveyors. — At least one large New York firm has quantities taken off by its office force, and submits them to subcontractors for prices. This saves giving out plans and waste of time of subcontractors, all taking off the same items. The system has a good deal to commend it.

When from six to ten general contractors and several times as many subcontractors sit down to one poor set of plans, it means that a great deal of brain matter is wasted. There is too much duplication of effort. The problem of the twentieth century is to be the elimination of waste.

We have not yet come to the system, although it has long been in force in England. There have been court fights over the question as to whether the quantities are to be considered reliable documents, and whether the builder should get extras if they are not complete. The general understanding is that they are only guides, and that the contractor must look over the plans himself, or else put in a high enough profit to cover any deficiency.

As a general rule, the surveyors take off quantities carefully enough for any contractor. A good plan might be to have two sets of quantities made, and use the one as a check on the other. Two men would thus do the work of thirty or forty.

CHAPTER VII

BUILDING CONTRACTS

Mortgages. — Every time a builder signs a contract he places a lien, as it were, on his property, if he has any. Many of them know this, and keep their property in their wife's name, so that in case of trouble it will still be in the family. Reversing the idea of the man in civil war days who was willing to sacrifice all his wife's relations on the altar of his beloved country, they are willing to sacrifice everybody else's property to keep their wife's safe.

Variety. — If a thousand lawyers were gathered together, and each asked to make a building contract, there would be at least 999 varieties, and many of them would be so one-sided as to be dangerous to all except the man who paid for the legal work. If you can, therefore, hire a lawyer to make your contract, and try to persuade the owner to sign it as it stands. The owner would likely object, and here we come to a conflict of interests, to two men each trying to "get the best of the deal."

Uniform Contract. — Architects and contractors had so much of this kind of work, and so many court disputes over building contracts that they finally drew up an instrument which they copyrighted in 1893 under the name of "The Uniform Contract." It is recommended for general use by the American Institute of Architects and the National Association of Builders.

This contract has been used ever since it was issued with increasing satisfaction to builders all over the United States. They do not have to take it to a lawyer for examination before they sign it. They know that it has been tested and tried by scores of lawyers, and by an army of architects, contractors, and owners. It is fair to all sides—as fair a contract as can be devised. It is not perfect, for almost any lawyer could pick flaws in it, but it is the best obtainable and it is always ready and always safe.

Two Sides. — Many an owner would like an instrument that favored him more, but human nature is apt to forget that there are two parties to a contract, and that the one has rights as well as the other.

One Side. — It is not a just contract that gives the sole power of settling disputes to one party. A man is likely to settle most of the disputes in favor of himself or the one who pays him. If it is replied that men are fair enough to do right, it might be held that the best way for them to show their fairness is to be willing to submit disputes, if necessary, to arbitration. How would it do, for a little variety, to make the contractor the sole judge of disputes in state or railroad contracts?

Loss. — I remember, when I was working as a journeyman for a firm of contractors, that the owner furnished part of the material for a large building. He failed to get it for a long while after it was required. In the meantime the millwork came and had to be stored and paid for. The banker, who was at fault, instead of paying the contractor for loss of time charged him interest on the money he had to borrow to pay for the millwork. The Uniform Contract provides that the owner must reimburse the contractor for such loss. It is an instrument that works both ways.

Payment. — The final payment on a building has to be made in a certain number of days after completion, under this contract, but the owner is entitled to keep back as much money as will clear any liens or just claims.

Insurance. — The owner also takes out full insurance in his own name and in the name of the contractor against loss or damage by fire, for materials already in the building or on the premises.

Best Contract. — This U. C. is the best for a contractor. It costs only fifty cents for twenty-five copies. This is surely a cheap enough rate for legal work. It is now (1911) sold only by E. G. Soltmann, 125 East 42nd Street, New York. It was formerly handled by *The Inland Architect*.

Owner's Side. — The interests of the owner have been taken care of by the architects.

Blanks. — Of course blank spaces are left for a description of the building, architect's name, and other matter that is different for each particular building. A legal description of the property should also be inserted in the usual manner. Two copies should be made out—one for the owner, and the other for the contractor.

Subcontract. — The success of the U. C. has been so gratifying that the Builders' Uniform Subcontract has been drafted on the lines of the older one. This is for use between the general and the subcontractor.

Signed Contracts. — It is better to have a signed contract for a building than to go ahead without one. It is true that many buildings are erected simply on the basis of the contractor's bid, made out "according to the plans and specifications of the architect"; but when copies of an excellent contract are so cheap, why not use them? A bid is seldom made out with the idea that it is of itself to take the place of a formal contract, or it might have several conditions in it that are usually lacking. What provision is made for insurance, and who is to pay for it? In how many days after the building is accepted is the final payment to be made? How much of a reserve is there to be? There are a score of questions that might come up and cause friction.

Danger. — But even with the U. C. there may be danger. Safety lies in the printed part which is always the same, and is only three sheets long; but the blank spaces may be filled up in such a way as to lay the contractor by the heels. Is time enough given for the completion of the work? Do you wish to so subdivide the time as to say that each story shall be finished, or the roof put on, or the plaster completed at a certain date? A contractor might be hindered on one story and make it up on the next.

How do you wish the payments to be made? Whenever a heavy bill of material is put in place, or a brick story is finished, or at the end of each month? What reserve are you willing to stand? Would you be willing to hang yourself if the building was not finished for a month after the time set? Sometimes contractors become sarcastic and say that any kind of a contract that is presented will be signed by their simple brethren.

Specifications. — Occasionally unreasonable conditions appear in the specifications. The only safe way is to state in the bid that such and such provisions will not be carried out, and if the contract is awarded, what is seriously wrong can be pointed out. As a bid is a contract, it is bad policy to put it in "according to plans and specifications," and then try to change what does not suit before the contract is signed. If your bid is based on the conditions laid down, what right have you to expect them to be changed?

It should be remembered that after a contract is signed an architect has no right to change his own specifications. In the U. C. both plans and specifications are accepted as a part of the contract, and they must be signed and thus identified.

Properly speaking, a specification should not encroach upon the contractual field at all as some of them do. The acceptance of unreasonable conditions here may nullify much of the advantage of having a good contract form.

This whole business would seem to be a kind of a three-linked chain. The plans make the first link; the specifications describe their quality; and the contract, as the third link, binds the whole together.

Talk. — Probably in about a thousand years some contractors will come to understand that verbal agreements with an architect are not worth the breath that made them after the contract is signed, and the plans and specifications thus accepted. An architect may be held, even after the contract is signed, for a verbal interpretation of any technical phrase, or something of that kind he has given; but the plain intent and meaning of the plans and specifications govern, and no contractor should feel hurt that they do, regardless of what he has been verbally told.

CHAPTER VIII

NATURE OF CONTRACTS

Stated, or Lump Sum. — The ordinary contract is for a lump sum, and the contractor can gain or lose much or little as he may. He agrees to complete the building for so much, usually gives security that he can do so, and that ends it,—or rather begins it.

When the bids are opened under this system the contract is supposed to be awarded to the lowest man, who makes what he can out of it. From this time on his interest is to make as much as possible, and the owner's is to get a good quality of workmanship in a reasonable time.

Opposing Interests. — Of course, the character of the builder is a good asset. It would not be right to say that it does not matter whether he makes good work or not, pays his bills or leaves liens behind him, and completes his contracts in somewhat near the specified time; but all this being remembered, it is yet true that the interests of the owner and the contractor, under the lump sum system, are opposed to each other. After the figures are set the one wants to give as little as he can, and the other wants to get as much as possible.

Total Cost. — In spite of this, the lump sum contract has a strong hold upon the public. If a man is going to invest a large sum of money in a building he wants to know before he goes ahead just how much it is going to be. One hears of merchants who have been ruined by outrageous bills for extras through incomplete plans and specifications. You can not blame an owner if he wants assurance from a reputable contractor that his building will not overrun a certain amount of money. He can then allow beyond the face of the proposal any reasonable percentage which may be looked for on account of changes or extras. This stated, or lump sum, system has endured for centuries in spite of rascally contractors and grasping owners.

Percentage Plan. — This system makes the contractor secure, but is sometimes rather costly to the owner. The men occasionally find out that it is a time or day labor job, and act accordingly. But they forget that by making such work expensive they lessen the demand for it, and increase the demand for the harder work under the lump sum contract. The temptation under the percentage plan is to make the work as costly as possible, for the higher the cost, the greater the percentage the contractor has for his own pocket, and human nature is not yet perfect. The undertaker has, of course, to look grave under all circumstances, even while business is "rushing." But away deep down? Eh?

Mutuality. — But the interests of the two high contracting parties are closer together than under the stated sum system. The buying of the material alone, or the opportunity to get it bought according to his wishes, for one thing, soothes the owner; and if he wishes he can put on twice as many men to hurry up the work as the contractor could afford to do. He pays the bills. Under the lump sum the contractor does not want the owner to know anything about the price of material, for there is, or should be, a profit on that as well as on anything else.

Contractors like this plan, and it is a good one, but owners are not favorably disposed towards it, unless one here and there who wants good materials and workmanship in a permanent investment.

Amount. — The percentage varies. Ten per cent. on the actual cost is a sort of a standard, and sometimes as low as six is gladly accepted on plain work. These figures do not include office expenses. There is no risk of losing money, and the percentage is often cut to the owner's advantage.

On alteration and repair work this is really a much better arrangement for both parties than the first plan. It is hard to figure some changes. I heard yesterday of two bids on alterations. One was for $22,000 and the other for $13,000.

Cost Plus a Fixed Sum System. — This is the system that Mr. Gilbreth is making popular, and whatever may be said of it otherwise, he does not let it suffer for lack of advertising. He insists that it is the only proper form of contract, and that there should not be any guaranteed maximum of cost in connection with it.

The owner states the amount he proposes to invest, and the contractor states how much he wants for the use of his organization, machinery, tools, etc. Of course, the contractor can look over the plans for himself and see if the owner's estimate is about right before giving his figure.

"The lump sum contract," says Mr. Gilbreth, "is a license to support lawyers and a privilege to pay court costs, and if there were no more lump sum contracts, one half of the lawyers would have to abandon their calling for some other work."

This exponent of the Cost Plus System says that the right name for the lump sum contract would be, "The lump-sum-plus-extra-work-plus-time-extension - plus - lawyers'- bills" contract. Many a man has signed such contracts, and many a square mile has been covered with work done under them, without thinking that there was such a long name hidden near.

"The entire theory of the Cost Plus a Fixed Sum contract," says Mr. Gilbreth, "is that the owner shall have his own way in any and all matters pertaining to his work. He shall have the right to decide what materials shall be bought, and whether or not they shall be bought of the lowest bidder. He shall have the right to have the contractor put on as many or as few men as the owner wants, regardless of whether or not there are strikes. His decision shall be final regarding the paying of bonuses for the quick delivery of material, and his decision shall be final on all matters pertaining to the conduct of the job."

This entire fixed sum, whatever it is, must be net profit, without deduction for office expenses, or anything else.

Profits. — But Mr. Gilbreth is wrong in saying that lump sum contractors figure on two profits—first, the regular one, and second, the one for risk, on account of unfavorable circumstances that may develop. Alas, and alas! There is by far too much competition for any such heavy profits in ordinary building work. One profit is all that it will stand, and very often that one is not so large as it should be.

Comparison. — It is not likely that this plan will supersede the old lump sum one, but nevertheless it is a good way of doing work, perhaps the best of the three systems. No matter how things go, the owner knows that the contractor will make only a certain amount of money. He is interested in keeping costs down; there is no desire for extras, but rather a hope to finish without them, for they delay the happy hour when the last installment of the money will be turned over; where there can be no quarreling over the price of extras a better feeling exists; and if the owner is rich enough to pay cash for his materials he may get the trade discount—but this applies as well, of course, to the percentage plan.

Time. — Another advantage is the gain in time. The work on the foundation can go ahead while the plans are being prepared for the upper stories. So also under the percentage plan. But under the lump sum they must be complete before contractors can make up their figures; although the basement is often let in a separate contract to hurry things up.

Hobson's Choice. — Mr. Gilbreth will not take any other kind of contracts. He is afraid of being led into temptation. He says, "We found that there was a tendency to put our best superintendents and our apprentices who could do a man's work for an apprentice's pay, and our best plant on lump sum contracts, and the second-class foremen, 'old pensioners,' and the rest of the plant on the Cost-plus contracts. To do away with this 'tendency,' we made it an iron-bound rule to take no more lump sum contracts under any conditions whatever, regardless of how much profit there might be in them, and we will not award a subcontract for labor or material on the cost-plus basis if the subcontractor has any lump sum contracts being constructed simultaneously."

There you have it in white and black—the Cost Plus being white as the newly fallen snow, and all other systems black as the raven.

Few contractors can afford to say that they will not take contracts except upon one system. Most of them are ready to take it on any system that promises good results,—lump sum, percentage, cost plus, or catch-as-catch-can.

Maximum. — It is all well enough to say that no guaranteed maximum figure shall be given, but men with a few dollars short of a million simply cannot afford to go blindly into any building project. They must know how much it is going to cost. It is idle to say that an architect's figure should be sufficient. An architect is not a contractor, and is not held financially responsible if his estimate is exceeded twenty-five or fifty per cent. His commission is paid on the percentage plan, and by the rules of the largest association of architects this plan is the only one he is allowed to follow.

Mr. Gilbreth says that the "fixed sum" to be paid is fixed in a guaranteed maximum contract only in case the maximum is not reached, and thus the interests of the parties are once more opposed, as in the lump sum system. Every change in the plans brings up the question of extras, and the lawyers have to be brought in.

Choice. — Merely for the independence of unnecessary control many a contractor would prefer the old-style lump sum if he had his choice. He has been accustomed to take responsibility for his estimates so long that he is not afraid to continue. If he loses, that is his own business, and so likewise if he gains.

Public Work. — As things are now arranged practically all city, county, state, and national work must be done under competitive bidding. This means the lump sum contract.

Average Bid. — Once, away back in a town by the name of Timbuctoo, Africa, we shall call it to avoid Anti-Trust declamation, contractors became tired fighting one another and competing in a world where combination is gaining ground every day. The Geniuses among them evolved the system of the Average Bid. Before the actual bids were handed in there was a sort of a séance among the bidders, and the figures were laid down, *cartes sur table.*

Supposing there were half a dozen bids, they were added together, divided by six, and the one nearest the average made out the winning bid, which he handed in to the architect with as grave a visage as the circumstances called for. The other bids were raised above the average one and put in with a gravity that did not have to be assumed. No returns were expected.

This was but a variation of the unjust straw bid style. In taking bids, the implied understanding is that there is to be an honest competition, and this was not.

The arrangement fell to pieces after several jobs had been captured by "scabs" outside the union. One of the amusing things we run across to keep us cheerful in this world on a rainy day is the sight of some contractors denouncing labor unions. As the proverb says, it makes a difference whose pig is stuck.

Fair Value. — Probably this average bid is nearer the true value of a building than either the lowest or highest, but if an owner can get a responsible man to put up his building five or ten per cent. lower than the average he does not care to enter into academic questions.

Trusts. — In spite of the denunciation of trusts we hear on all sides this incident shows that even in Timbuctoo the desire for a kind of a trust is not unknown among those who hate the large ones. It makes a WONDERFUL difference whose pig is stuck. Trustification is the system of the hour, and is going to increase. Farming and building would seem to be two great industries that are hard to trustify.

Unit Price. — Sometimes the work is done on a unit price of so much per thousand for brick, per yard for plaster and paint, per pound for steel and iron, and so on; but if an owner is not accustomed to trade methods of measurement he is apt to have a much larger bill than he expects. He should specify actual quantities and measurement only.

Official Schedules. — A variation of the unit price idea is found in the system that some engineers have of making out a schedule of the costs, adding a certain amount for builder's profit, and then putting the total at 100. Bids are taken on this basis, and the nearest to the figures get the contract.

In New York, August, 1907, a building costing $160,000 was let by the city to a contractor on this basis. The average of the bids ran to 99.3 per cent. of the engineer's figures, which are given to the bidders. The lowest was 92 and the highest 111.

Like the surveyor's quantity system it is a good plan to save reckless bidding, but the difference between 92 and 111 is large enough to satisfy everybody. This is a public recognition of the Average Bid, and justifies the course pursued in Timbuctoo back in the last century. Africa led the world then. We are slowly coming to her ideal.

Unfair Bidding. — When the unit price system is followed there have been many cases where the contractors put in the Unbalanced Bid with which all states, counties, and cities are more or less familiar in tenders for groceries, printing, and everything else.

If a bidder suspects that there is to be a much larger quantity of plaster, suppose, than what is called for on the schedule he can put in a price on some other items below what they are worth, if again he is sure that far less of them will be required than is listed, and a very high price on plaster. He can thus bring his total lower than that of the competitor who gives a fair price on each item. When he gets the contract, he loses on, say, 100 yards of paint which he does for 3 cents, but makes it up on 100 yards of plaster at 83½ cents. Of course there must be enough of the small items listed to cover the difference. Cases have been known where, say, 2,000 yards of paint were listed in the schedule, while those on the inside knew that the authorities would do only 100. And so on with other items.

The engineering system alluded to above is a good check on any work of this kind. It is easy enough to establish a fair price for every item, and hand it out on a basis of 100. Then bids below a certain percentage would be thrown aside.

The original idea in Timbuctoo was to set a certain percentage above or below which all figures would be discarded. *Delenda est Timbuctoo!*

CHAPTER IX

GENERAL CONTRACTING OR SUBLETTING

Sharing Nothing. — It is said that one of the maxims of the Standard Oil corporation is to allow a profit to nobody in the business of refining oil. The large building contracting firms follow this system, as a rule, by hiring mechanics directly, and putting a competent foreman over them, with a superintendent over all.

Sharing Part. — Another method commonly in vogue among general contractors is to make their own estimates, and after they receive the contract, sublet the most of the work, often retaining for themselves only the masonry, if they happen to be bricklayers, or the carpentry if they are carpenters.

Sharing More. — Still another method, and probably the one most relied on all over the land, is for the general contractor to estimate the work for his own trade, and take bids on all the other branches before he makes up his total.

Subletting may, of course, also be done under the cost plus and the percentage plans discussed in the last chapter. After the general contractor settles with the owner, he turns to the subcontractors and arranges his contracts with them.

Profit and Loss. — Each system has its good and bad points. There are many who would like in their little spheres to be as the Standard Oil is nationally, in this respect, but they lack the necessary capital, and rebates are not so popular as formerly. And so it is that the local minnow cannot always follow the course of the national whale.

To keep vaulting ambition from o'erleaping itself, one of our commercial agencies reports that a very large percentage of failures in business come from the attempt to do too much on too small a capital. Why should anyone ruin himself financially in trying to grasp too much? For the majority of beginners especially, the live and let live policy is clearly the most advisable. With more experience and larger capital they may come to the time when they can grasp every loose dollar they see.

Advantage. — Of course, the advantages of the first system are not altogether confined to the opportunity of making more money than is possible under the subletting plan. When a subcontractor handles a part of the work there is often friction as to when certain things shall be done, and the main contractor is occasionally held back by waiting on an indispensable, though often a small item; while the man who sublets nothing can manage to suit himself, and his interest will not permit him to hold up a complete building waiting for a carpenter contractor to lay some joists, or for a few bricklayers to build a wall story high.

Risk. — Then there is the risk of the failure of subcontractors avoided under this plan. No matter how careful a general contractor is with his own estimates, if he bases three-fourths of his bid on the accepted figures of subcontractors there is always a danger that someone will go by the board and fail to complete his contract.

Surety Bond. — It may be replied that by taking a bond from a subcontractor this risk might be avoided, and probably it is true, but as a practical matter it is safe to say that in nine cases out of ten bonds are not asked from subcontractors by those who have to give a bond themselves to finish the whole building. There is a happy-go-lucky method of doing business among men who are so well acquainted with each other as contractors are, and the legal side of the question is usually overlooked. The general contractor is tied up as hard as the lawyers can do it; but while subcontractors know this, many of them would feel hurt if asked to give the same security on a part of the building as the owner demands on the whole. The safe course is to deal only with men who have some property in their own names, and not in those of their wives, and character enough to make good any loss, sooner or later.

Liability. — A much more serious danger than that of failure is that from fire and accident, especially the latter. A general contractor is usually included in any damage suits against a subcontractor. This subject is discussed in another chapter.

Friction. — Another risk eliminated by one contractor handling everything is that due to the human nature that we all more or less have. Some men take to each other as David and Jonathan or Damon and Pythias did; others meet, and in their dislike for each other seem to forget that they belong to the same race. While, theoretically, the owner and the subcontractor are supposed to have nothing to do with each other, as they are only connected through the general contractor; as a matter of fact, they meet and sometimes fight over extras, delays, the quality of the work, or the finding of the North Pole, in default of anything else. The chances of disagreement are lessened when only one man or firm deals with another.

Supplies. — But even the largest firms cannot manufacture all their materials. They, in their turn, have to deal with supply houses and lumber companies. Steel rails, lumber, plaster, stone, plumbing goods, marble, elevators, and other materials are seldom made by any building firm.

Good System. — The next best system is for the general contractor to make his own complete estimates, and sublet after he gets the contract. He can then get lower figures than when merely putting in a bid and taking his chances with others on getting the work.

Risk. — By this method, however, there is a chance for a general contractor to occasionally lose a contract that he might have had by taking some extra low figure from a subcontractor; but, taking it all around, there are chances that he himself might make a lower figure than anyone else, and thus get the work.

Beginners. — The best system for the young contractor is to be modest at first, and to take bids from the various tradesmen. By this system a fair idea of costs will gradually work itself in on the mind, just as spelling is usually better learned by reading than by rote, and when experience has done its work the other way of estimating the complete structure can be adopted.

Dividing Up. — Another system is for the owner to give out his work in detail. The contractor for each branch thus deals directly with the owner. He would sign the Uniform Contract instead of the Subcontract, as with a general contractor.

This is a fair system, and in some parts of the country it is closely adhered to. The carpenter, for example, takes only the woodwork, and thus gets a smaller profit on the contract, but he can attend to more buildings with his capital. The owner has to see that each one has liability insurance instead of the general contractor only under the other system.

There is sometimes trouble caused by delay. The one blames the other and there is no expert like the general contractor to crack the whip and settle disputes.

Day's Work. — Still another system is for the owner to buy his own material, put foremen in charge, and do the work by the day, or rather the hour, which is the unit in all building work. He can thus secure a good quality of work, but if the wrong kind of men are dealt with the pocketbook has to suffer. I once knew of a case where the labor on brickwork for a very rich owner cost $29 per 1,000 instead of less than one-fourth of this, which would have been enough for a contractor.

Experience. — A contractor should not undertake to do work outside of his own trade until he has a reasonably fair idea of what an average day's work is for a mechanic in other trades. A good foreman helps wonderfully, but it is safer when the contractor knows a little himself.

Two Ways. — An endeavor has sometimes been made by Builders' Exchanges to have bids taken either complete or separately, but not both together. In other words, if A. B., the owner, wanted his work done by a general contractor only, he would take complete bids; but if he wanted to let it out to subcontractors, he would have to take bids only from them and not from the general contractor at the same time.

In a way, this is reasonable. It is easy enough for an owner to gather sub-bids together and show to the general contractor that his total is greater than the sum of his separate bid and the combined sub-bids. He naturally has to add a profit for handling all the other work and being responsible for it. If the owner chooses to take the responsibility for the execution of the work, fire risk, damage suits, liens, delays, and other troubles incident to the business, then he should deal directly with the subcontractors, as a matter of course, but not expect the general contractor to risk damage suits and endless trouble for nothing. Many an owner has found out that it paid him to have a responsible general contractor between him and the deep sea. Others of them see through the game well enough; they want all the security, but want it for nothing. They want the carpenter to be content with the profit on the carpenter work alone, but like a good fellow to be responsible for all the other branches, and save the owner from a summons to answer a suit for $25,000 damages for a man killed when putting on $23.50 worth of tin.

CHAPTER X

METHOD OF WORK

Starting. — When the contracts are awarded, the next thing is to start the building as promptly as possible.

Laying out Work. — For cottages and small buildings an engineer is seldom required. The contractor lays out the lines himself. In cities the sidewalks give a straight line, on at least one side. This is accurate enough for practical purposes, and the front of the building is laid out parallel with it at the required distance back. Temporary stakes are then driven far enough outside of the sides that the digging will not disturb them. A line is stretched across the front and tied to the stakes, and the side lines are run down at right angles to it, or "square" from it, according to the width of the building. Then the rear line is stretched across parallel with the one on the front.

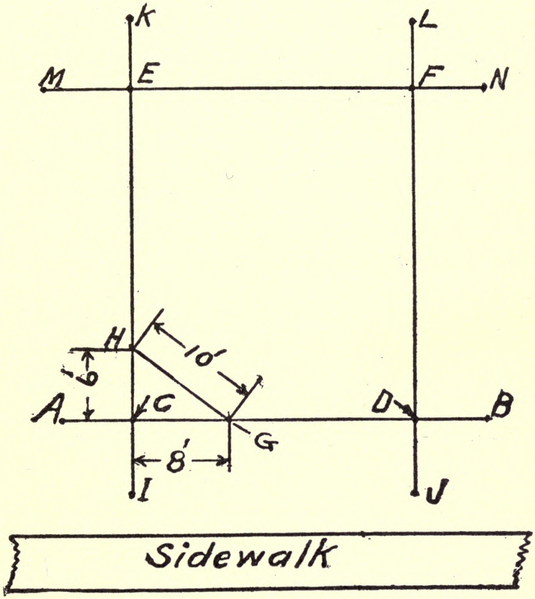
This finishes the main part of an ordinary building, and the offsets and angles are measured from it.

Stakes. — Any kind of a strip of wood is suitable—1 x 2, or 2 x 2. They should be driven in, clear of any excavating line, so that they will not be disturbed.

Squaring. — Most carpenters know how to square the corners by using a 10-ft. measuring pole. The diagram will explain the method. The line AB is laid out parallel with the sidewalk at the right distance back for the main front wall of the house. The stakes are driven at A, B, and a mason's cord stretched. On this cord, stick in a pin at C, where the corner of the house is to be. Measure off the width of the house and put a mark at D, or stick in another pin. From C to G, mark off 8 feet. Run down a side line from C to E, and let it stretch over far enough to reach I and K. Make the line fast to a temporary stake at C, or hold it fast there by the hand, and mark 6 feet down to H. Take the 10-ft. pole, and with one end at G swing it round until the 6-ft.

point just touches the other end. The line CE will then be square with the line AB. Drive stakes at I, K, and make fast.

This gives the two main lines, and the rest is easy. The distances are just measured from them. The ground is marked



for digging, the lines removed, but the stakes I, J and K, L; A, B and M, N are left to get the exact lines when the brick-work begins.

The engineer proceeds in another way, and drives a nail in the top of the stakes to keep the exact lines.

Projections. — For bay windows and such work a template is often made so that the mason may have a good guide to go by.

Level. — A builder's level is a useful instrument around a structure of any size, as it saves leveling by the ordinary straightedge, and is more accurate.

Lot Line. — When a building is to come close to, or on the lot line, the only safe way is to get an engineer, and preferably one acquainted with the city data and all the mistakes in street lines, lots, and so on, to give the exact position of the corners. In some cases where "spite work" has had its innings, brick walls have had to be chiseled off when they overlapped on the other property. Courts have had much to do with this lot line question. Never build on the line without first getting a good engineer. It is too dangerous.

Footings. — It is not safe to run over even for the footings, no matter how advantageous it may seem to be, without a legal agreement giving permission for the extension.

Telephone. — If the building is large and far removed from the business center of town or the supply yards, it pays to put in a telephone. It sometimes saves its cost in a week.

Tool House. — A tool house and a lime house are built if the size of the building justifies them. In rainy climates the roof of the lime house must be protected.

Water. — Connections must be made by the plumber in cities, and a supply provided for in country districts.

Excavation. — Contractors prefer, as a rule, to let out the excavation to a local man who has his own teams, plows, scrapers, and labor force accustomed to the work.

Liens. — Some of the grading contractors have to be watched to see that they pay wages as they should, or else there may be a crop of liens to harvest.

Delivery of Material. — As large a supply of material as possible should be assembled on the ground ready for the men when the excavation is finished, but not so much as to make rehandling necessary. Many a foundation has been blocked for weeks waiting on a few frames, ironwork, or something of that kind.

Placing of Material. — Brick, lumber, and such heavy stuff can sometimes be so placed around a building as to avoid long wheeling or carrying; and the lime house should be placed in a position where the whole building can be best served. In cases where a hoist is used, this is close to the opening leading to it.

Power. — On a building of such size as to make use of a motor or hoisting engine, brick, lumber, frames, steel beams, and other materials should be placed where they can be most conveniently fed to the machine.

Number of Men. — In the "Estimator" the amount of concrete that men can mix, of brick they can lay, and the proportion of laborers required for bricklayers and plasterers are given, and this gives a fair idea of the number of men required to finish a foundation in a certain time.

Forms. — If concrete is used for a base and the ground is soft, or the top of the walls comes higher than the banks, forms must be set up. Occasionally the inside of the wall only is planked up, and the concrete is then poured in between the solid bank and the wood; but some authorities object to this, and want the wood on both sides.

Bolts. — I have come to respect bolts more than I used to. In a frame building it is often necessary to build them in at the right height to receive the sill.

It would be a good idea in a masonry wall to build in bolts to hold back each side of a door frame. The ordinary anchors cannot be tightened up if the frame bulges out in the center. Why not just build in a bolt to draw it back against the masonry at any time?

Wind. — In stormy countries it is to the interest of the contractor to see for himself that there is a wind stop around all frames, and that the mortar is slushed carefully in. Why have the ill-will of an owner over such a small matter as that?

Joists. — While the masonry has been going on the carpenters have been getting ready all the heavy framing, in order to waste no time with laying off the masons. It is often possible to get one side ready and turn the gang over to that while the other is being prepared.

The walls are run up, the roof put on, the sash put in all in the ordinary course that every carpenter knows, and that need not be gone over here.

System. — The business world of our day is full of "System"; indeed, we hear so much about it that it is a matter of suprise that any work can be got done, for every energy would seem to be required to systematize things. There are quite a number of slick gentlemen who are making a good living working this "system" fad by day and by night in relays, and like the apostle, they magnify their calling. We cannot blame them too much.

Yet the regular workers on a building have forgotten more about how it should be done than the system mongers have ever learned, with their three turns to the right for one to the left.

Delay. — It seems to be almost unavoidable at the end. Some trifling order may be placed in the east for a particular installation, and no amount of system will force a rich manufacturer to lay aside his regular orders and take up a small one earlier than its time on the list; or the finished hardware is still in the factory, in spite of the fact that the order had been given months ahead of the date when it was likely to be required. Patience is an excellent virtue, but a rather trying one for the owner who wants his building, and for the contractor who needs the reserved percentage to fill a gap elsewhere.

CHAPTER XI

BUYING OF MATERIAL

Modern Ways. — Buy cheap and sell dear is the old motto; but buy cheap in large quantities and sell cheap is the one that is making the department stores and mail order houses of our time so large. This system has revolutionized things in the last quarter of a century. The country stores that used to charge an unreasonably high rate of profit are now forced by the new competition to keep within reasonable bounds.

Building Material. — There are at least two mail order concerns in Chicago that send all kinds of ordinary building material, including lumber and millwork, anywhere within the borders of the United States and Canada. Stone and brick are not sold in this way just yet, but they may be soon.

Another firm in Iowa sends lumber and millwork anywhere.

The two great mail order houses in Chicago recently received 18,000,000 letters in one year, and they contained $77,000,000. They sent out 4,000,000 catalogs. Their orders have doubled in three years. They are worth watching.

High Prices. — It used to be the case that the country builder was at the mercy of the local supply houses, but now if he cannot get a reasonable figure from them he can try Chicago or Iowa.

A Scale. — I never had occasion to buy from these great houses except once as a trial test. An architect's scale, for which the local price was $2.50, and the special rate to draftsmen, $2, I got for $1.40. It had the same maker's name upon it, and was of good quality.

Local Interest. — Now, it is much better for contractors, farmers, and others to purchase everything they can from the local dealers, for a gain of $50 in a lumber bill might cause the loss of a contract to build the lumberman's house, but the situation is such now that no one need pay unreasonable prices, and that should be understood.

Cash. — But all dealings with these supply houses have to be on a cash basis. It is well to remember that the local lumberman will frequently discount a bill two per cent., or more, and thus cut down the cost of the lumber. If the one is priced on a cash basis the other should be also.

Method. — The way to buy building material then, it is clear, is to follow the method of the great department stores and mail order houses, and buy cheap in large quantities. Advice of this kind is like telling the average man to go to Europe, as the Atlantic is free to anybody. Certain conditions must be fulfilled before the Atlantic can be crossed; and a large bank account is necessary to buy an order of corresponding size.

Monopoly. — It used to be rather difficult for a contractor to get a car of lumber or millwork directly from the saw- or planing-mill, for the local men held the whip over the railroad and the wholesale dealer. They had to choose between the regular demand of the lumbermen and the occasional order of the tradesmen. Naturally they stuck to their best customer.

Stone. — This material is now manufactured so much by saws that it ordinarily does not pay the contractor to have anything to do with cutting it. The best plan is to go to the yards and purchase it ready to set in the building. On work that has to be hand cut, however, many contractors follow the custom of cutting the stone at the site of the building.

Plumbing. — The supplies for this trade are sold only to the men in the business, but here, again, the mail order houses break the chain and sell to anybody. The trouble in some cities is that only a licensed plumber can do the work, and they insist upon buying the supplies themselves. There is a profit in the material.

Bills of Material. — After a contract is signed a complete bill of material should be made out for those parts of a building that are not to be sublet. With brickwork or masonry the danger is not so great if more than what is called for on the first list is required, for the brick are usually bought at so much per thousand, and the cement, sand, and lime at an agreed unit price; but the lumber and millwork bill should be complete, as extras run higher than the prices set on the main contract when the dealer is naturally anxious to secure the trade. Properly, the rate for extra lumber should not be higher any more than for extra brick. If so, why?

Paint supplies, hardware, and such items should be bought in one bill for the same reason that better rates are thus obtained.

Quality. — Serious trouble is sometimes caused on account of the quality of the material sent to a building. Brick and cement are sometimes rejected by the car-load; lumber is graded differently in various sections of the country, and an architect's specification is not always clear. He gets confused with the grades as well as the rest of us. The Forest Service, Washington, D. C., sells for fifteen cents a book of 126 good sized pages entitled, "Rules and Specifications for the Grading of Lumber." A good deal can be packed in 126 pages, and our memories are short.

This book gives the grades all over the United States, and if a contractor is estimating on work far away from the field to which he is accustomed he should make sure of the grading of the lumber. The architect's idea and his own may be entirely different.

F. O. B. — In buying heavy material it should be carefully understood whether the price is at the point of purchase or Free On Board, that is, with freight paid, at the job. Sometimes supply men send cars to the job, and the contractor has to pay the freight, to be later deducted from the subcontractor's price. This means that the contractor must have money to pay with before he gets the material in the cars.

Point of Purchase and Time. — It is not always safe to buy materials too far away from the job, especially for a time contract. The dealer does not usually bind himself to time as you do. All the risk he takes is your frown, which does not amount to much.

I have seen buildings stand for a couple of months waiting for special lumber when the general contractor was held by a time contract. The penalties are not usually exacted, but a settlement may be refused until some deduction is made. The owner has his side of the question to consider. He may be paying rent that he expected to save.

Payment. — The time of payment to dealers should be understood. It generally is when the contractor gets an estimate on the material supplied.

Lien Law. — The danger comes when the time for filing a lien expires. This law gives the dealer security on the building, but he must file his claim in a certain number of days after the delivery of material. The contractor can delay proceedings by ordering a 2″ x 6″ scantling, or 100 brick, or a sack of cement, and thus bring the last delivery up to date. In general, dealers are reasonable with contractors, for their own interest makes them so, apart from other considerations.

CHAPTER XII

BEST PAYING WORK

Under the percentage or cost plus plans all work pays well. Here we deal with the work mostly done under the lump sum system.

Houses. — Beginning with dwellings, the ordinary road for a journeyman who starts contracting is to small business buildings, and from these on to larger and larger ones.

Details. — There is no end to the trouble connected with the construction of private houses. From the time the brickwork begins to the putting on of the hardware there are many details to attend to. Contractors do not like this work if they can get a plainer kind. Some of them are afraid of women, who watch the new houses and suggest too many improvements.

Competition. — As almost every bricklayer and carpenter starts on this class of work the competition is severe, and the prices are low.

Brick Stores and Flats are next, and are much more desirable. There are fewer competitors, and they know better what work costs. Prices are consequently a little higher, and not only so, but the details are practically all the same. One floor after another is laid out according to the same plan, much less watchfulness is thus required, and the risk of mistakes greatly reduced.

Schools are of the same nature, for almost every room is alike. The work is straight, and as large certified checks are often required with bids, this keeps out some undesirable competition and gives an opportunity of getting a better price.

Great care should be exercised in making out a bid with a certified check, for in case of mistake it is sometimes hard to get it back, and as the bank deducts the amount from the contractor's account, he is sometimes likely to be embarrassed for ready money if it is held up for months. In state and government work a surety bond is occasionally called for instead of a check, and the cost should be added to the estimate.

Best Work. — Then come business buildings, offices, warehouses, hotels, and such structures. This is really the best class of work to engage in, but requires capital. The structures are large and the details are often heavy and plain. It is all straight sailing, for brickwork, cut stone, girders, joists, doors, windows, and steel beams are all about the same. If the work is in the popular style of reinforced concrete construction there is likely to be even a less departure from plainness, as that is almost an essential part of such buildings.

Undesirables. — Some contractors fight shy of putting up a building for an architect while others are fond of that kind of work, which would seem to indicate that there are men with different views in the business.

Contractors have also a kind of prejudice against church buildings. They have to pay the current rates for material and labor on churches as well as on saloons or warehouses, but somehow the building committees are inclined to ask for and expect cut rates, and also a little donation for the good of the cause in settling up.

All this might be taken as a part of the day's work, but final payments are often unreasonably delayed, owing to the inability to collect the subscriptions which make the building possible.

Contractors cannot afford to neglect this field, however, for there is a great deal of such building done. During the first nine months of 1909, for example, $13,000,000 worth of churches were built or planned in the fourteen southern states alone, if we include the District of Columbia, Oklahoma, and Texas. Ninety were built in the latter state, at a cost of $2,500,000. There are many steers in Texas, but also quite a few churches.

Capital. — In purchasing material we saw that the rule is very plain. It is, Buy cheap in large quantities. It is easy enough to point out what kind of work pays best also, but in both cases a good sized bank account is required before going far.

Jobbing. — There is a large field here for those who like to make the old look new. Almost all buildings need to be repaired or changed in course of time, in one feature or another. Each new tenant has some special requirements.

Customers. — If a good class of owners is found the work pays well enough, but it needs more attention than new work, and is often made up of such small items as tries the patience. A man may have to be sent several miles to rehang a door or plane a sash. The work of itself is probably not worth more than fifty cents, but the time going and coming, and the necessary profit on the transaction runs up a bill that is often unsatisfactory to the owner.

Slow Progress. — Another unpleasant feature is that jobbing is different from new work in the time taken. At the end of the week there seems to be far too little done. The contractor cannot help this, and neither can the men. It belongs to the nature of the business.

Collections. — Besides other troubles there is often too much time taken in collecting a small bill. Often more time is wasted than the profit amounts to.

Yet, with all its disadvantages, there are firms in large cities that do nothing else than jobbing, and they make it pay well. They have to charge high prices, and consider not merely the time at the work itself, but going and coming, telephone rent, shop rent, insurance, and everything else but sentiment.

Tips. — One unpleasant feature of the business in very large cities is the necessity for tipping. Some of the underlings in large establishments can help or hinder considerably, and rather than be annoyed by them contractors have been known to slip a few dollars into their uneasy palm to get the work done quicker and cheaper.

Prospects. — Some good contracts may come through the acquaintance made in jobbing. For this reason many keep on with the work even when they do not expect to make much profit out of it directly.

Location. — A shop in the central part of town is better than one on the outskirts, but now that we have telephones the difference is not so great as formerly. But most of the trade comes from the thickly settled districts, and the headquarters should be near them, and also near the hardware and other stores.

Government Work. — Another class of work that lies outside the field of the ordinary contractor is that done by the national government or state. It requires more capital than many have, and the conditions are stricter than with commercial building. The superintendent has more power, and there is less chance of appealing from his decision with success, and none to take the injustice to law.

It often happens that officers of the army, navy, or some other branch of the government are appointed as superintendents, and they are better acquainted with quite a few other things than with buildings. There is an excellent field here for those with plenty of capital. They have the satisfaction of putting up a class of buildings that will last, and the competition is with men who usually take work only for a good price.

Unchanged Conditions. — The government must treat all alike, and thus cannot change conditions as readily as a private owner can do. The idea is to do the work according to the rules laid down by the United States, as represented by certain humans who eat bread like the rest of us; and we must put in bids and carry through the contract as they want and not as we think best. If the contractor refuses to go ahead the government will put men in to finish the work at his expense or that of his surety. He has no lien, and the bond required is about fifty per cent. of the contract price. An amount per day is stated as liquidated damages in case the work is not finished in time.

Advantages. — On the other hand, the plans and specifications are clear, and the details are plentiful and complete; the time and amount of payments are settled beforehand and sure; and the reserve is usually only ten per cent.; if the contractor really gets "stuck" he is paid for the materials delivered on the ground as well as installed in the building, in order to help him out with ready cash. It is rather a poor idea to get too low on government work, however. It should either be figured high enough to cover all contingencies or let alone.

CHAPTER XIII

SPECULATIVE BUILDING, OR READY-MADE HOUSES

Dangers. — Many people now buy their houses as they buy their clothes—ready-made. They make their money begin to draw interest or save rent within a few days after it is paid over instead of waiting for several months before the house can be finished. They gain by this course, but honest contractors know that they also lose something. They do not know the quality of the material in the house and whether there is enough of it in places that are covered; and the painter has often to be called back in rather too brief a period.

Profit. — Some contractors make fortunes in this line of work. They are subject to no owner's whims and interferences; and in general they are independent of an architect. If they do hire one they can set aside his ideas whenever they are so disposed.

Method. — The method followed by many in cities is to buy cheap lots and borrow money from the loan association to erect the building. The purchaser usually pays to the builder the whole selling price, less the loan from the association, which he assumes. The builder, with his money in his pocket, is then free to go elsewhere and erect another house, or several.

The purchaser pays $1.10 per hundred dollars of the loan per month. This extinguishes principal and interest in about ten years. Thus if the amount borrowed was $1,000 the monthly rate would be $11. Most of the loans are paid in about seven years.

Expenses. — Of course the owner has to take care of the house, pay the taxes, repairs, and other expenses, and he has also to stand the usual depreciation of property. Nevertheless, tens of thousands of people get homes in just this way, and there is thus a large field for a builder.

Cheap Work. — One of the best equipments of a speculative builder is an easy conscience. There are some of them who do good work, but most of it is of an inferior quality. They paper the walls, however, and thus hide some defects.

If this class of building is well done it will cost just as much as that built under other methods, and the price will have to be raised to suit. The idea in buying these houses is too often to get a cheap bargain, and the house itself has to suffer.

Buying. — Here the caution about buying material, given in another chapter, is applicable. It is to buy cheap in large quantities. The speculative builder usually does buy cheap, and hire lower priced men than the large builder is allowed to on account of the labor unions. Most building of this kind is done by a volunteer force, as it were, and not by the regulars; and the conditions that are almost forced upon the larger contractors do not usually apply to the builders of ready-made houses.

Risk. — There is the risk that the houses may not sell. One sees some that stand for a whole year vacant and unsold. The monthly payments to the loan company have still to be kept up, however. The contractor who is short of money ought to be sure of his sales before going too deep.

Real Estate Men. — Some real estate firms do a very large business in this line, but they have better facilities for making sales than a builder, for it does not pay him to sell through others and thus cut the commission out of his profits.

Abstract. — As the customers of a speculative builder are almost sure to ask for an abstract of title, no land should be bought without one brought up to date. It is better to have the title guaranteed by a company that makes a business of doing this work. This, however, is one of the things that is usually left undone.

Lot Values. — In buying property it should be remembered that lots in an ordinary residence section never increase beyond a limited value. Where houses are built close together, as in the poorer sections of a city, the price of the lots after reaching a certain figure remains there. The trolley car gives a chance of a better lot further out for less money.

Location. — The character of the neighborhood should also determine to a large extent the cost of the building. Roughly speaking, the following table gives an approximate idea of what the value of a residence should be in proportion to that of a lot.

LAND	FRONTAGE	COST OF RESIDENCE
$ 250	30 ft.	$1,000 to $1,500
500	30 ft.	1,800 to 2,500
1,000	40 ft.	3,000 to 4,000
1,500	50 ft.	4,500 to 5,500
2,000	50 ft.	6,000 to 8,000

Tract of Land. — The speculative builder who can work on a large enough scale can determine the character of a whole neighborhood by buying a sufficient acreage to control the development himself. This is where large profits are often made, not merely on the cost of the houses, but on the rise of the land in value. In this field, as in so many others, the man with money can make money.

Depreciation. — If a contractor puts up a building for rent he should remember that there is a law of depreciation. From 1½ to 3 per cent. has to be charged off the value of the property, and repairs, insurance, and taxes have to be considered. When the probable vacancies are taken into account, the net return is not so much more than can be had by investing in city bonds or mortgages, which mean less trouble.

Houses, we know, should not decay so soon as they do, if they are well built and taken care of, but we have to average things up in general, and remember that no one takes as good care of your house as you do yourself.

CHAPTER XIV

OFFICE EQUIPMENT

Growth. — The city of Omaha in which I write has about 125,000 people, not including South Omaha with about 26,000 more. The first postmaster of Omaha died only a few years ago, and his office was in his hat. He used to carry around the letters for the town there, and hand them to his constituents as they met. In this case a big head would have been a better equipment than it usually is.

Many a contractor of our day has an office in his inside pocket. He is afraid to use the hat around a building. This means that a good deal of business may be conducted on a very small equipment. It is but right that we should start out on that basis.

System. — The "system" men are hard at work after even the small contractor. It is well, but do not spend $1.43½ to keep track of 98 cents. It does not pay. Too much system is like having ten trowels to lay 1,000 brick. All system and no results comes to be like a Spanish dinner—all tablecloth, and nothing to eat.

Somewhere between the style that carries everything in its hat and the other that works by too many rules is about right. A top heavy system is out of place for a light business. When working on a plant for railroad shops I saw that the Motive Power people put in 100-ton cranes to lift locomotives and carry them to any place desired. Some heavy cranes have what are called auxiliary hoists to take up light weights. It does not pay to turn on the power for a 100-ton crane to lift a wheelbarrow. Paving stones should not be used to kill flies, nor sledges to drive a tack; and neither should the small office be run on the same lines as the large one.

Beginning. — Begin on the auxiliary hoist business, and nothing will hinder you from looking forward to the time when you will be a 100-ton contractor with a splendid system made out to suit your own wants.

Stationery. — About the first thing needed, even in a small business, is some printed matter—envelopes, letterheads, and cards. A fairly good quality of material should be used, but nothing too expensive. In spite of the paper manufacturers, and the printers, contractors know that the size of the bid is the main thing, and not the kind of paper it is made out on.

Safety: Exchange. — If an office can be afforded to begin with, it is a good idea to get one in a fireproof building. Rents are high in such places, and all over the country contractors have found it a good plan to join together in an exchange where there is plenty of room and each one gets a mail box. The average builder has to spend too much time on his outside work to require a large office. An exchange satisfies his requirement better than an individual office would, for there is always a secretary to attend the telephone, and it serves as a meeting place with subcontractors, and thus saves time. The cost is much less than on the individual system.

It is also a safe place to keep records if the building is fireproof.

Books. — Another advantage of an exchange is that a good library can be looked through to settle any trade question or get information. Not that a library will help a contractor to make more money; in fact, in spite of the college advertisements, it is probably true, as a well-known stone mason said nearly a century ago, that the fewer books a man is acquainted with, the more money he is likely to make. He concentrates his mind on one subject instead of spreading his attention over many. The real money-maker is like a hog—he roots always in the ground. His snout is not turned after air castles. When a crown is presented to him in the heaven that all good contractors are going to, he will be caught, as usual, looking down and not up, looking in and not out, and thus reversing the good Chautauqua motto, and shaming the trade.

But the trade books save time, and this is as good as money. There are "Sweet's Index," "Arthur's Estimator," many lumber reckoners, and other valuable tools of trade. For example, there is an "Expeditious Measurer," by Nash, that gives the cubic contents of stones of all sizes. It is a time saver for those who have to figure up stone in the usual way.

This is an age of electricity, vacuum cleaners, flying ships, and many other wonders, and why waste your brain matter figuring up stone, lumber or plaster if someone had tabulated it all for you? I once bought a lumber reckoner with tables figured up to 100 pieces, and instead of doing the work myself I merely turned over to the right page. To figure up stone by the duodecimal or any other method, and lumber in the usual way is like carrying up brick in a hod. We now use motors and hoists.

Dictionary. — A good unabridged dictionary is sometimes useful. In cities we see old editions sold for a dollar.

A Thousand Authors. — Every contractor should write a book of his own. It would be called a Price Book. Prices would be jotted down and dated, and in course of time a book of this kind would be valuable, especially when one went away from home and catalogs, or had to make an approximate estimate for an architect on plans that could not be taken out of his office. The removable leaf book is an improvement upon the ordinary style.

Equipment. — There is no limit to what might be purchased, and the system men are making matters worse every day. A contractor could soon make a showroom of his office if he bought everything that was recommended to him.

More Safety. — Most of them, however, if they do not have an office in a fireproof building, should have a safe, or at least a safety deposit vault which costs only from $3 to $5 per year. Is it worth while to risk valuable papers for such a small amount?

We might change the form of the old question and ask, When is a safe not a safe? The answer would be, When it gets into a fire, if we accept the U. S. Government report at San Francisco. The tenants would have been better without safes, according to the expert. They merely gave a false feeling of security. He says, "The only vaults I saw that came through a really fierce fire without damage were those built of brickwork. Even these vaults did not always protect their contents, however." The same thing happened at Baltimore.

Safe Vaults. — I have drawn plans for vaults with two 9-inch walls and an air space between, and considered them safe enough, but not since reading the San Francisco report. Each wall ought to be at least 13 inches thick, laid in Portland cement mortar, with a 2-inch air space. The roof should have 13-inch arches covered with heavy concrete. This would cost probably $100 extra on a fair sized vault, but why build one at all unless it is to be safe?

Raising the Limit. — When we draw a check we limit the amount, but there are men whose business is to raise our limit. They change the figures and the writing. It is sometimes easily done. They even perforate more figures, in front or behind those already on the check. Perforated checks are at least an additional safeguard, but cases have been known where the perforations have been filled.

Limit Line. — The best device for preventing check raising seems to be a limit line, such as, Not over twenty dollars. When acid proof ink is pressed into the slits that are cut out it is practically impossible to change the figures.

Risk. — The danger is greater than is imagined. In 1908 the sum of $5,000,000 was stolen by this means. A cypher added to 7 makes 70, and ty put on the end of seven makes the job complete. Yet the treasurer of a large railroad company told me in October, 1910, that he had never seen a raised check presented among tens of thousands of good ones.

Examples. — In 1903 a check drawn for $100 was raised to $8,100. The man who drew it found his account $8,000 short at the end of the month. He sued the bank, but the courts held against him. That experience cost him $8,000 and legal expenses.

The law is that the bank is responsible for the payment of a forged check, but not for a check correctly signed. If the amount has been raised that is held to be owing to the carelessness of the man who drew the check. He should have protected himself.

In another case, interesting to contractors, a Chicago cement company drew a check and had it certified for $27, and it was raised to $27,000. It was dated January 29, 1909. The check raisers then drew $17,000 from the account. In this check after "Twenty-seven" a long blank space was left, and then "and $\frac{no}{100}$" in the usual way. In the space considerately left for him before the "and," the artist merely put "Thous.," and this, according to the rules of the spelling book, made "Thousand." There was also a space left between the $27 and the $\frac{no}{100}$, and it was filled in with "000," which made everything correct according to Hoyle, the great authority on banking.

In the $100 check the same method was followed. Too much space was left between the $ and the 100, and the 8 just fitted. The writing "One hundred," instead of being kept as closely as possible to the left hand end of the check was put in the center, and a long line drawn before, as well as after it. Part of the line was removed with acid, presumably, or probably with ordinary ink eradicator, and "Eighty" filled in. This is the new "Black Art."

Paper. — We are told that no kind of paper protects against this work. Burglary used to be the favorite way of getting money illegally,—that is, outside the realms of "high finance,"—but forgery and check raising have taken the place of that risky business. Only a few years ago there used to be more cases of burglary than forgery; in 1908 there were seven cases of forgery and check raising to one of burglary. Like lightning, this affliction might never affect you, but it might strike to-morrow.

Drawing Checks. — While the artists seem to be hard to beat we might at least observe a few ordinary precautions in drawing checks, and not lead them into temptation.

First of all, write heavily. Do not make a check payable to bearer if it can be avoided. It may be lost; it may get into strange hands.

Do not leave a blank space after the name so that "or bearer" may be added. Either spread the name out to fill the space or use heavy lines.

Put the figures as closely after the $ mark as they will go. Write them so closely together that "1" cannot be put in between. After the amount put the fraction hard against it, and put it "plumb." Thus it would be $\frac{no}{100}$, $\frac{13}{100}$. $\frac{87}{100}$, or whatever the figure was, and not no/100, 13/100, 87/100. In the last style the figures before the 100 might be erased and give room for one or two to be added to the main amount.

Of course, after all is said, we must remember that ordinary ink can easily be taken off. The old joke used to be "Everything is burnt except the policy," and the new trouble is that everything can be taken off except the signature. How is a banker to know that you do not have a clerk to fill out the body of the check, as many have, and leave only the signature for yourself? The difference in writing is no guide for him. The signature only counts.

Machine. — A limiting machine costs about $30 to $35. All Builders' Exchanges might easily have one.

Procuring. — Sometimes the mail boxes of a business district are rifled to get checks; and pay checks for workmen fall into other hands than those they are meant for. This is one of the disadvantages of paying by check. When you give a check to a business firm you know that it will go straight from it to the bank, but it is different with the others.

An Ohio bank gave a stranger a draft for $10, and had to pay $10,000, and "go busted." A bank in Chicago paid $15,000 on a western draft that was made out for $3.

Files. — A few cases for letters are desirable. They do not take up much room, and letters filed, preferably according to subject, are easily found. Of course, when there are many dealings with one particular firm, they might be filed under its name.

When a letter is taken out for some time, a "dummy" should be substituted, with date and name or initials of one who received it. In large offices only one person is allowed to touch the files, so that letters and drawings may not be misplaced. In an office where there are several thousand drawings and as many letters, one put in the wrong place may mean a search of days.

System. — It would save much trouble when writing to large firms with several departments to use a different letter for each subject. One envelope might be used for several letters, if necessary, but an order for toilet soap should not be put on the same page as one for millwork. Elsewhere it is stated that two mail order houses received 18,000,000 letters in a year. Those who have seen the great plants in Chicago know that they carry on an immense business. One department opens the letters, but they have to be distributed among many, and it is better to address the right one. So with railroads, wholesale houses, and other great establishments. If you wish to save time send your communication to the right place.

Then with hundreds and thousands of letters to file, large firms have numbers or alphabet letters to guide them to the filing case. In replying to any such letters reference should be made to the number or whatever it is. How would you like to search through such files to get the original letters to which yours is the reply? Probably you waited two months before answering. But if you put down the signs at the head of their letter—X—D, 2385—they will place you in three seconds.

Typewriter. — As already noted, the amount of the bid is what counts, and not the quality of the paper or the Spencerian brand of the writing; and while a typewriter is desirable for making out bids, etc., it is not really necessary. Nevertheless, it looks "business-like," and $25 will buy a second-hand one.

Copy. — By using a machine, a carbon copy may be made of all bids and important correspondence. It does not need the court records to inform us that human memory is short. A short record is valuable, and carbon copies are easily made.

An Adding Machine is not seen so often as it should be. For some years, in a railroad office, I was one myself. A few departments get expensive machines and merely press a key to get a column of correct figures, but builders are not among the elect. There are machines which sell for several hundred dollars and others for $25. Addition is a dangerous thing for a contractor to trifle with.

Card Index. — Under proper conditions a card index is useful. It can be made a permanent Price Book that has to stay in the office of the contractor.

There are contractors who have a great deal of information in their possession, but they cannot find it. It is buried in the mass of dead records. When Oliver Goldsmith got some money, he used to roll the gold pieces around his room so that some of them might fall into the chinks of the floor, or behind the rotten wainscoting. Then when he ran short of money, he went down on his knees and searched. When he found a coin he rejoiced with great joy. Many contractors are like Oliver. They get valuable information and scatter it they don't know where. Then comes the search. There is a better way.

Telephone. — A "phone" is usually considered necessary in these days. When the builders join together in an exchange one phone serves for the whole crowd.

CHAPTER XV

BOOKKEEPING

Learning. — During the evenings of one winter I went to a business college to learn the art of keeping books. The system followed was double entry. I used it for several years, and found it to work well, but there is more trouble connected with it than is altogether agreeable for a busy contractor who cannot hire a clerk.

The Trial Balance has to be taken off whenever a squaring up is desired, and Justice with the scales in her hand is not more exacting than a trial balance in double entry bookkeeping. Much time is wasted in hunting for the few cents that seem to be anywhere but where they should be.

There is a book entitled, "Fifty Rules for Errors in Trial Balances," and a five-foot shelf might be filled with others on the same absorbing question. What requires so much elaboration and attention is too complicated for a man who has a gang of tradesmen waiting for him. It does not pay to lose $10 to get an error of 5 cents rectified.

Theorists. — The business colleges give too much detail. What is needed is a simpler system than they teach. The question is not, "How much clerical work can I use?" but "How little can I get along with?" Now, the double entry system is the best to be had, for it checks as it goes. The accounts must balance. But a small contractor does not need it, and probably nine out of ten use a simpler method. All that is required is a system of record, and sharp eyes can see that the balance is maintained, although there is no check as in the double system.

Variety. — There are a thousand and one variations of the systems. Each business house has some pet one of its own. What is set forth below is merely for a suggestion. Each one can figure out something for his own use that may be better or worse.

A Type. — For an illustration of a record system one building will do as well as another. What serves for a $2,000 one will also work for another that costs $200,000. Let us take one at $2,300, as fewer figures will be needed than with a more expensive structure.

We shall assume that the general contractor takes this frame house in the way they are often taken, that is, including everything except plumbing and heating.

Opening of the Books. — This is supposed to be something dreadfully mysterious. When his sister asked the little boy for the core of the apple, he replied, "There ain't goin' to be no core." So here, there ain't goin' to be no opening.

Put your name and address at the beginning of the books that they may be identified, deposit your money in the bank, which gives a bank book as a record of cash on hand, and the books, and you are ready for business. We proceed as below, after supposing the contractor to be as far along as his 14th contract. The 1st or the 50th would be handled in the same way.

Day Book. — First of all, the contractor should have a Day Book, or Blotter, in which he should set down EVERY item. Ink should be used, if possible, but pencil is often made to serve. Pencil marks can be erased, however, and an erasure should never be seen in a set of books, on any system. If a mistake is made, a line should be drawn through it, so that the writing may still be seen, and no erasing done, or the judge in court will hold against the records.

A Ledger is also required, and that is all. After the contractor gets further along he can start a double entry system with Day Book, Journal, Cash Book, and Ledger.

Cash. — It is a good idea to keep all cash transactions separate, and a column is used for that purpose.

Contract No. 14. — Suppose, then, that a carpenter contractor receives a contract for building a house for J. B. Phidias. The Uniform Contract is used, and that is a good record. Indeed, when we consider bank book record, contract records, bids, monthly statements of dealers, and time book, we could almost safely follow the plan that some pride themselves upon, and keep no books. We might let the others, who have more time, do that for us.

Starting. — On any page of the Day Book, and on any side, if it is wide enough for a double column, we can begin to make our entries. If one side is not wide enough to hold the two columns, we can carry the writing clear across to the other. If you open an ordinary book, you will see that printers always put the even numbers of the page on the left hand side, and the odd on the right, just as in this book, for example. We should open the Day Book and make our entry on the even number side, and carry it across to the odd number side, in case the one page was not wide enough for the two columns. This looks plain enough.

CONTRACT NO. 14

Nov. 2, 1909.	Signed Contract No. 14 with J. B. Phidias	$2,300.00
" " "	Bought lumber for No. 14 from M. A. Pinchot....	430.00
" " "	Signed Uniform Subcontract for masonry on No. 14 with B. A. Brick	240.00
" " "	Let contract for excavation on No. 14 to J. P. Trench at 30 cents per yd.	
" " "	Let contract for millwork on No. 14 to O. F. Oshkosh	200.00
" 3 "	Signed U. Subcontract for plaster on No. 14 with R. S. Acme...........	149.50
" " "	Bought bill hardware on No. 14 from E. F. Sargeant	59.50
" " "	Signed U. Subcontract for paint on No. 14 with O. B. Murillo	151.00
" " "	Let contract for electric wiring on No. 14 to W. A. Ampere	36.00
" " "	Let tinwork on No. 14 to O. S. Taylor	43.00

Nov. 3, 1909.	Bought mantel and hearth set for No. 14 from O. N. Nelson	$48.00	
" 6 "	Paid for carpenters' wages on No. 14		$ 16.40
" 13 "	Paid for carpenters' wages on No. 14............		43.20
" " "	Paid B. A. Brick on No. 14		100.00
" 20 "	Paid for carpenters' wages on No. 14		48.00
" 25 "	Rec'd from J. B. Phidias on No. 14		320.00
" 27 "	Paid for carpenters' wages on No. 14............		30.20
" 30 "	Paid J. P. Trench for excavation on No. 14 in full, 100 yds. at 30 cents		30.00
" " "	Paid to M. A. Pinchot on No. 14...............		100.00
Dec. 4, 1909.	Paid for carpenters' wages on No. 14.............		34.10
" 7 "	Agreed on price of Extra No. 1, on No. 14 with J. B. Phidias (masonry at stair)..............	34.20	
" " "	Gave stair extra masonry on No. 14 to B. A. Brick	24.30	
" " "	Bought office supplies (charge to No. 14)		1.05
" 11 "	Paid for carpenters' wages on No. 14		27.80
" 17 "	Paid B. A. Brick on No. 14		68.00
" 18 "	Paid carpenters' wages on No. 14................		21.00
" 24 "	Rec'd from J. B. Phidias on No. 14................		450.00
" " "	Paid M. A. Pinchot on No. 14................		120.00
" " "	Paid carpenters' wages on No. 14		21.00

Dec. 31, 1909.	Paid for express on No. 14		$ 1.30
" " "	Bought extra lumber on No. 14 as per bill rec'd from M. A. Pinchot....	$13.20	
Jan. 4, 1910.	Paid R. S. Acme for plaster on No. 14..............		100.00
" 8 "	Paid carpenters' wages on No. 14		16.40
" 13 "	Rec'd from J. B. Phidias on No. 14		380.00
" " "	Paid O. F. Oshkosh on No. 14		100.00
" " "	" O. S. Taylor on No. 14		35.00
" " "	" W. A. Ampere on No. 14		30.00
" " "	" O. B. Murillo........		70.00
" " "	" E. F. Sargeant......		20.00
" " "	Deducted from B. A. Brick contract on No. 14 for basement floor..........	17.00	
" " "	Deducted for change in basement floor from contract on No. 14 with J. B. Phidias	15.00	
" 15 "	Paid for carpenters' wages on No. 14...............		85.00
" 22 "	Paid for carpenters' wages on No. 14...............		93.00
" " "	Rec'd from J. B. Phidias on No. 14		600.00
" " "	Paid M. A. Pinchot on No. 14		80.00
" " "	" O. F. Oshkosh on No. 14		40.00
" " "	" B. A. Brick on No. 14		30.00
" " "	" carpenters' wages on No. 14..................		30.00
" 29 "	Paid carpenters' wages on No. 14..................		8.50
" " "	Rec'd payment in full from J. B. Phidias on No. 14..		569.20
" " "	Paid M. A. Pinchot in full on No. 14		143.20

Jan. 29, 1910.	Paid O. F. Oshkosh in full on No. 14	$60.00
" " "	Paid O. S. Taylor in full on No. 14	8.00
" " "	Paid W. A. Ampere in full on No. 14..............	6.00
" " "	Paid E. F. Sargeant in full on No. 14..............	39.50
" " "	Paid R. S. Acme in full on No. 14	49.50
" " "	Paid O. B. Murillo in full on No. 14	81.00
" " "	Paid B. A. Brick in full on No. 14	49.30
" " "	Paid O. N. Nelson in full on No. 14.................	48.00

REMARKS

Lists as Records. — Bills of material are bought from lists made out and kept by the contractor. There is no use repeating these in the books. Any extra received during the month may be considered as bought in a lump, and set down without being detailed out, like the item of $13.20 on December 31. This may have come on various dates all through the month. The lumberman does his daily bookkeeping, but the contractor can take advantage of the summaries at the end of the month and enter the complete item at once. So with hardware or anything else. Even if bills are sent upon delivery it is easy enough to let them accumulate. The dealer will not forget the total when the time comes.

Number. — The advantage of setting a number to a job is that it can be easily identified in this way, and a number is far shorter than a name. In the illustration above only one building is listed, but there might be two or three going on. Numbers 11, 12, 13 would thus have to appear all through mixed in the Day Book with 14, and they must be kept separate. But while this number is put in the ledger heading of the account of Phidias it is not in that of any of the others, because the chances are that while there may be only one contract with Phidias, there might be several with dealers and subcontractors, and the heading of No. 14 would not suit if 12 or 15 had to appear also.

Everything. — Each item, no matter on which job, should be marked down in this Day Book just as it comes up under the date, and by using numbers there is no danger of getting things mixed. Sometimes, as with giving out contracts on November 2, and making payments on January 29, a good many entries can be made for the one job, and this is better when it can be done than mixing numbers.

Everything must be carefully checked off from the Day Book to the Ledger, or Statement, or Master Card, for there is no safe check like the double entry one here. An item of wages, for example, might be in the Day Book and not be transferred to the Master Card. In such a case the profits would look larger than they really were.

In getting monthly statements contractors should insist that extras should appear by themselves, and not mixed with the main bill. There is no occasion for having anything more to do with that till the settlement at the end. If the separate items on a main bill are charged to a contractor as delivered he has quite a time identifying them and finding out if they are charged in detail as they are as a whole. He should, of course, pay on it as he gets his estimates, but refuse to dissect it to please any bookkeeper. I once had a long struggle with one of this kind.

Ledger. — Now comes our "Ledger," or rather, our Statement, for it is not a ledger. One was prepared and thrown aside for this book. To be of any value to busy contractors this suggested plan must be simple and take little time.

At the end of each month, or as often as desired a "balance" can be worked out in the following way:

DATE	NAME	CONTRACT NO. 14 AND EXTRAS	AM'T REC'D TO DATE	BALANCE DUE
Jan. 1, 1910.	J. B. Phidias	$2,334.20	$770.00	$1,564.20

The same form suits for the subcontractors, but the number of the contract may vary in the heading, as they may have several contracts going on with our supposed general contractor.

DATE	NAME	CONTRACTS AND EXTRAS	AMOUNT REC'D TO DATE	BALANCE DUE
Jan. 1, 1910.	Pinchot on No. 14	$443.20	$220.00	$223.20
" " "	Brick on No. 14	264.30	168.00	96.30
" " "	O. S. Taylor on No. 14	43.00	.....	43.00
" " "	Carp'r wages on No. 14	.....	241.70	.....

This system is carried down until each name is taken care of. If several buildings are subcontracted for by Taylor, suppose, the entries can be made on the same sheet. Thus No. 15 would come below 14, and lower numbers, like 12, would come before it.

NAME *James B. Phidias, Contract No.* 14. ACCOUNT NO. 81.

ADDRESS *Chicago, Ill.* SHEET NO. 1.

DATE		ITEMS	PAGE	DEBIT	DATE		ITEMS	PAGE	CREDIT
1909					1909				
Nov.	2	Contract		2300 00	Nov.	25	Cash		320 00
Dec.	7	Extra, No. 1		34 20	Dec.	24	"		450 00
					1910– Jan.	13	Deduction		15 00
					"	13	Cash		380 00
					"	29	"		600 00
					"	29	"		569 20
				2334 20					2334 20

NAME *M. A. Pinchot,* ACCOUNT NO. 82.

ADDRESS *Chicago, Ill.* SHEET NO. 1.

1909					1909				
Nov.	30	Cash on 14		100 00	Nov.	2	Lumber on 14		430 00
Dec.	24	" "		120 00	Dec.	31	Extra on 14		13 20
1910– Jan.	22	" "		80 00					
"	29	" "		143 20					
				443 20					443 20

A separate sheet could be made out for each job, but this would not show the amount connected with each name. Small contractors do not carry on so very many jobs at the same time. Even with half a dozen jobs one sheet like the above could be made to serve. There might be that number of entries under Pinchot, for example, for jobs running from 14 to 19, and to find out his balance it would only be necessary to add them together.

Ledger. — If desired a Ledger Statement could be made out for any account that has many entries. The foregoing form is suitable. But this would just be for convenience in seeing how things stood under one name separate from the others.

Checks. — When they are returned from the bank, paste them in the stub book, and thus establish another record that is not hard to keep.

MASTER CARD OF NO. 14

Nov. 2, 1909.	Contract price			$2,300.00
Dec. 7, 1909.	Extra, No. 1	$34.20		
Jan. 12, 1910.	Deduction No. 1	15.00		19.20
Total of contract and extras				$2,319.20
Nov. 2, 1909.	Pinchot		$430.00	
Dec. 31 "	Pinchot extra		13.20	
Nov. 2 "	Brick		240.00	
Dec. 7 "	Brick extra	$24.30		
Jan. 13, 1910.	Brick deduction	17.00	7.30	
Nov. 2, 1909.	Oshkosh		200.00	
" 3 "	Acme		149.50	
" " "	Sargeant		59.50	
" " "	Murillo		151.00	
" " "	Ampere		36.00	
" " "	Taylor		43.00	
" " "	Nelson		48.00	
" 30 "	Trench		30.00	
Dec. 7 "	Office supplies		1.05	
" 31 "	Express		1.30	
Total carpenters' wages			474.60	$1,884.45
	Profit			$434.75

Master Card. — When some large builders finish a job they make what they call a Master Card. This shows how a contract "panned out." It gives a concise statement of everything in connection with it. The foregoing one shows No. 14 in detail.

Expenses. — There might be deductions to be taken from this. Part of the office expenses if more than one job was going on, that is, if there was an office; liability and fire insurance, if the owner did not take the latter out as agreed in the U. C.; the purchase of tools, if charged in proportion against the job, which is not the usual custom on small work; and other little incidentals.

Loose Leaves. — If from this auxiliary hoist system of bookkeeping the contractor should go forward to the 120-ton crane one—for some of the cranes took that load—the loose leaf ledger should be considered. It is getting more popular every year. It is easier handled than the ordinary book, and a leaf can be taken out and replaced without any trouble. When a contract is finished, and there are not likely to be any more dealings under that name, the sheet is put out of the way in a binder, and one does not have to turn it over as long as the book lasts. Only open accounts are handled.

Another advantage is that one does not have to estimate how many pages to give to the letter "E," for example, or S, or W. There is usually waste of space in a bound ledger by a bad estimate, or special requirements, such as a car-load of Smiths coming to town. Then when the bound ledger is filled and there are many open accounts in it, they have all to be transferred to the new one. There are no such transfers necessary in the loose leaf book.

If an account runs for a long while it is kept up by numbering the sheets, as Sheet 1, Sheet 2, Sheet 3, and so on; and only the last sheet need be handled, as the others may be put in a binder in the fireproof vault.

A Card Index Ledger is also used. It is on the same system as the loose leaf one.

CHAPTER XVI

ABOUT KEEPING COSTS

No System. — I remember a contractor who kept from forty to fifty houses going up, and he could never tell how he came out on each building. He followed the lump system so much that he lumped everything together, heads I win, tails I loose. He " went broke."

Too Much System. — There is another kind of a class arising to vex our souls in these days. They time men with stop watches like horses running a race. The motions of a bricklayer's elbow are photographed, and, as a matter of course, his rear elevation snapped at the same time; and thousands of pictures and buckets of " data " are filled, indexed, cross-indexed, tabulated, and even published to startle a somnolent world.

Between. — Somewhere between these two extremes is a safe place for a contractor who knows his men and what they should do in a day. It is long since that shrewd business man, Benjamin Franklin, told us that the eye of the employer is worth a good deal. He does not need a stop watch.

This does not mean that he should not keep a reasonable account of the quantities handled, for he should, but it does mean that there is a limit to that. There are too many men with only a clerical experience laying down heavy tasks for backs that, after all, are just flesh and blood.

The Quality. — Some engineers have taken to this system with a fondness that is pathetic; and they know best how their large undertakings should be handled; but their system is not required, and could not be afforded for the average building of the average contractor.

In truth, after a long experience among engineers and their methods of handling building work, I discovered that their labor costs anywhere from 20 to 500 per cent. more than a builder could or would pay.

As a general rule, I should say that for grading, heavy excavations, heavy concrete, pile driving, and whatever is done by common laborers, the engineer is superior to the building contractor, because he does far more of that work and is familiar with the machinery and the methods of handling it. This means an engineer of experience.

But when we reach high priced building tradesmen, the engineer, nine times out of ten, is a failure. His "force bill," as he calls it, runs outrageously high.

Luxury. — The kind of an organization that seems to be necessary for the engineer is out of place on ordinary buildings. On their large contracts they have chief engineer, assistant chief engineer, resident engineer, superintendent, manager, foreman, sub-foreman, timekeeper, sub-timekeeper, chief clerk, under clerks, chief cook, ordinary cook, and a little regiment of bottle washers. About one week of that system would land a poor building contractor before the U. S. Commissioner in bankruptcy.

An Example. — Looking back over such a city as this one of Omaha, which I have seen grow from 25,000 to five times as much, it is really surprising to consider with what little amount of record keeping, bookkeeping, and general red tape all the buildings have been erected. It is safe to say that on four-fifths of the building work of the United States the stop watch system is of practically no account. The men are watched by the "boss" on the job. This cannot be done by the large construction companies, for they have buildings going on all over the country. They are on the border line that separates building of the ordinary type from engineering, and require their own record system.

Foremen. — We are told that foremen on engineering work cost from 5 to 15 per cent. of the total wages paid; on a small building the foreman works with the men. On a large one his brains have to do more than his hands.

Office Expenses. — Again, we learn that on engineering work office expenses are from 4 to 8 per cent. of the total cost. This continent has been covered with buildings from the Atlantic to the Pacific with very little office expense.

All this illustrates the difference between engineering and the common type of building work. The necessarily elaborate organization of the one is sharply contrasted with the compulsory simplicity of the other.

How Much. — About how much cost keeping should be done by a contractor carrying on a few buildings, and on the ground himself every day? It goes without saying that a separate account should be kept of the different items, such as plaster, painting, and tinwork. I have seen large buildings erected where no one could tell how much each item cost by itself.

Excavation. — If a contractor does this himself, at the close of each day he should make a fair estimate of the amount of earth displaced, and by dividing it by the total wages he can get close to the price the work is going to cost him. Special work, such as clearing off a lot and cutting down trees, should have been allowed separately and checked as it goes on. A few days before I wrote this I saw two men cut down a maple about 2′-0″ in diameter, and the work took them about a day. To cut it up in 2-ft. lengths meant another day, but a contractor can sometimes get his trees cut down for nothing for the sake of the wood.

Average. — Work goes a little slower just when it begins or ends, and the first day's output is likely to be smaller than the general average will be later on.

Filing. — The cost of the complete work should be filed with the rate per yard and the wages per hour. It is then ready to refer to for any other excavation in that neighborhood, or under the same conditions elsewhere.

The time should be kept on special work such as filling in around the building or sloping off.

Concrete. — There might be quite a difference in excavation owing to the nature of the soil; but the placing of concrete should come nearer to the average maintained over the country. Full figures are given in the "Estimator" for all kinds of work done by hand or machine.

The size of the building has to be taken into account. On a small amount of work the men hardly get warmed up to it before they have to quit. The price per yard is naturally a little higher than on large jobs.

Averaging. — After allowing for the time required to make mixing boards and get started, an average can be struck at the end of the day's work and the unit price established.

The amount of stone, sand, and cement should be noted on several jobs until the contractor knows what is required. After that he can let the record business die a natural death, so far as this material is concerned.

Forms. — This work is dangerous. In the "Estimator" the actual cost of many jobs of form work is given, and in such detailed shape that it would apply to millions of dollars' worth of contracts if necessary. The detailed figures are from the leading construction companies of the United States. The cost of labor, lumber, nails, concrete, placing steel on reinforced concrete buildings—all these things are set down. Do not trifle with form work. You cannot expect to equal the record of the companies which make a specialty of the new kind of structures, but it is well to know what their forms cost them. You have then a fair guide to watch the ones you make.

Masonry. — Foundation rubble should be measured by the cubic yard and watched each day so that the contractor may not find out too late that the cost is going above the estimate. We do not need to follow the slave-driving policy to let any loafer know that his quantities are being watched.

The materials remain close enough to require no watching after the contractor gets acquainted with the business. The time is the vital point.

Brickwork. — This is easier measured than complicated form work. There is no trouble in seeing if the men are doing what they should. I have seen many returns from brick buildings where the labor ran far above what it should have done. It was not checked in time as it ought to have been. The time is given in the "Estimator" for all classes of work.

Carpentry. — A fair idea of the time taken on plain timbers, planking, sheeting, shingles, floors, etc., should be noted as the work goes on. But if a contractor is around among his men his time is worth far more in guiding them than in watching how many minutes it takes to lay each particular joist. At the end of the day this can be done, averaged over the total.

A good carpenter contractor KNOWS by his experience better than the roll-top desk experts how much material is being handled and whether the men are speeding up, sleeping, or averaging fairly well.

The quantities of material required for given surfaces do not vary much, and, after a certain experience, any record system is merely a waste of time. Since the time of Rameses a flooring board of a certain width covers a certain surface; and the allowance for waste, is it not set forth in the "Estimator"? There may be a danger of stealing in some localities, but apart from this or anything of a like nature, the quantities are what our engineering friends call "constants."

Finish. — On inside work this personal watchfulness applies even more than on the kind already noted. In some buildings there are so many different kinds of openings and odd work that to keep an account of finishing them would be merely piling up useless records. The same style might never come up again, and when it did, we could shut our eyes and risk it. One of the amusing men in this business is he who says he can tell just exactly what some special design will cost for labor.

Standards. — Of course, on large business buildings with all the openings about the same size or style, a record is of high value. By averaging the time we can get good figures for such another structure.

Lathing and Plastering. — The measurement of the work of these trades is simple, and the amount to be done per day is set down in the "Estimator" for metal and wood lath; and divided for first, second, and third coats on plaster.

Painting. — A good foreman is better than a record system on this work, unless it is of the plainest kind. More time might be wasted in measuring the other kind than the results were worth. A record can be kept on plain outside work, and floors, doors, and plaster in the inside, but when we come to moldings, grilles, balusters, and such special designs, it is of more importance to see that the men keep busy than to try to measure the surface they cover.

Filing. — What is useful in time records should be filed, and also what is special relating to material. What does not come under these heads should be thrown away. There are some establishments that would be much benefited by a fire that burned half their records and "data."

There is such an infinity of detail about building, however, that no one should trust to memory alone, but should record whatever is of value to supplement a card index, price book, and "The New Building Estimator."

Time Sheets. — In a small business it is not usual to have time sheets, but it is necessary in a large one. During my apprenticeship I had to fill one out at the end of each day and hand it to the foreman. The name of the job was given, the kind of work done, and the number of hours occupied at it. This was essential in the large establishment where I worked, with saw-mill, planing-mill, joiner shop, and buildings going on, to find out how each contract came out. It is a good system when the business gets large enough to justify it. But a contractor himself could not find time to do the clerical work and attend all the circus parades at the same time.

Cutting Down Costs. — Every contractor wants his labor done at as cheap a total as possible. He thus makes larger profits. This is a legitimate desire. But it should be remembered that if by some miracle men could do twice as much, the work would be figured at half price, and things would simply be as before. Profits would not be any greater.

One method of reaching low totals that has finally struck the building trades seems to me to be entirely wrong. Others think it right. This is the "athletic contest," when one gang of men is pitted against another and the whip cracks for a start. Even flags are used, large and small, to wave from the building with the best record on straight work done in a day, where several buildings are going on at the same time.

An Example. — If you will read *Munsey's Magazine* for June, 1906, you will find an account of how Andrew Carnegie "goaded the heads of all departments into a still more frenzied race for dividends." "Faster, faster," he cried, and made them presents and criticised their slowness.

During all that time he was making 40 per cent. on his investment. It is an old trait of this race that sickening greed would not be pleased with 400 per cent., although human flesh and blood was driven to the limit to make it.

In the number for July, 1906, we are told that Mr. Carnegie "stimulated competition almost to the point of ferocity." "Every job was a race."

There are men who think that such ferocity is unworthy of this republic, and there are others who believe in it. In 1908 or 1909 the "Pittsburg Survey" was made possible by money furnished by Mrs. Russell Sage. The other side of the 40 per cent. business was shown. It is a terrible story. If men are to be driven like slaves, and the end is to be such contrasts, they are finally going to shut their teeth and put a stop to it, and to several other things at the same time.

I have been among tradesmen all my life. My advice to the flag heroes would be, Stop it. Bad as a loafer is there is yet a worse on this earth.

Instead of driving furiously like Jehu, the son of Nimshi, how would it do to save the fire waste of several hundreds of millions a year? There is not much sense in producing at a faster and faster gait merely to burn.

CHAPTER XVII

BUILDERS' LAW

"Experienced contractors will bear the writer out in saying that more contractors have been ruined because of legal difficulties than by reason of physical ones."—*The Business of Contracting,* McCullough.

Authorities. — Upon slight notice any lawyer could gather together a score of fat volumes of court decisions relating, in one way or another, to buildings. All that will be found in this chapter are a few "pointers" to keep builders away from law as much as possible.

Danger. — It has been said that the only proper way of doing business now is with a lawyer looking over your shoulder to keep you straight. It was for this reason that the Uniform and Subcontracts were so strongly recommended in a former chapter.

The Commas. — Not long ago there were some criminals in Missouri convicted of stealing from the city of St. Louis, and sentenced to the penitentiary. They were released on an appeal. The judge found that "the" was missing from one part of the proceedings, and that in another part there was an "e" too many. Some day the people will sweep this kind of law where it belongs.

This instance, out of many of a like nature, is cited to show contractors that "law" is an uncertain thing to tamper with. If possible, keep away from it.

It also means that any of the following laws in this chapter may be upheld or set aside according to the humor of a judge. If he wants to set them aside he can find a reason easily enough.

General. — First of all, for reference, we shall set down a few laws that apply to all businesses alike.

One of the first principles laid down in the usual schedule printed is that ignorance of the law excuses no one. Contractors should remember that. Yet in 1909 a man in Kansas was sentenced for an offense against the postal laws after the local postmaster had told him his matter was mailable. It is sometimes hard to know what the law is, even when ignorance of it leads to punishment.

The law compels no one to do impossibilities.

It is a fraud to conceal a fraud.

A signature made with lead pencil is good in law.

A returned check is not a receipt; and a receipt for money paid is not always conclusive.

A principal is responsible for the acts of his agent.

An agreement without consideration of value is void.

An oral, or "word of mouth," agreement must be proved by evidence, but a written agreement proves itself. This is why general contractors should not be expected to take sub-bids orally. They should get written bids.

A contract made with a minor is voidable.

State Laws. — A reasonable familiarity with the laws relating to building in the state in which work is done is almost necessary. In Missouri, for example, the legislature settled the questions of measurement of quantities.

Legal holidays should also be noted. There are no national legal holidays, not even on the Fourth of July, or Thanksgiving. So far as the president's proclamation goes, Thanksgiving is legal only in the District of Columbia and in the territories. So far as the United States are concerned a contractor need observe no holidays in the various states; and when working for the United States on ground to which they have legal title, he is independent of the state government. But it is well to see if the number of hours per day that may be worked is not specified. The eight-hour day is general, and, in most U. S. work, compulsory.

The hours allowed on state work should also be noted. Machinery that costs a heavy price may be workable only eight hours instead of ten as expected.

CONTRACTS

A proposal, or offer, or bid, of a contractor is the first step towards a contract. This tender put in may be withdrawn at any time before it is accepted. No matter if the architect refuses to give it up, if the demand for its return before witnesses or in writing is made before its acceptance, the contractor cannot be held to enter into contract.

Verbal Bid. — If a bid of this kind is made it must be accepted at once, or the contractor cannot be held. If it is accepted at once, or in writing, he can be held. There may, of course, be a time set within which the contractor will enter into contract, as with an option given on property, for example, but when that time has expired without acceptance the contractor is free of all obligation.

Unless there is some consideration paid, the party giving an option on real estate, etc., is not bound, but can sell the property to anyone before the time specified.

Acceptance. — If A mails an acceptance of a bid or option from B, the time is dated from the hour of mailing and not from the time that B receives the letter. Although B may already have sent away a letter withdrawing his offer, he is held to enter into contract if A's letter was mailed before he received the notice of B's withdrawal. But if A has set down any new conditions, then B is clear. The acceptance must come on the basis of the offer.

Government Work. — So important is this letter of acceptance that in government work it is referred to and made a part of the formal contract; and the letter of proposal is also thus mentioned. It is therefore necessary that everyone sending in a proposal should understand that he is held to complete the building if it is accepted.

Bids are Contracts. — This shows that for all practical purposes bids are really contracts as soon as they are accepted. If you have made some mistake and the owner wants to take some "snap judgment" on you, as it were, all he has to do is verbally to accept your bid or mail you a letter accepting it as it stands, and you are held to carry through the work. But a conditional acceptance by A does not bind B.

I once had to back out. The carpenter labor was carefully figured, but not included in the total. On the same building another contractor had backed out, owing to some mistake, and when I went to the architect as No. 2 with one more tale of sorrow he was not in the pleasantest humor, for his commission was vanishing out of his sight. I could have been held. So look out for your bids.

A building contract is an agreement between two or more parties, and may be either written or verbal. What you do when you mail or hand in a bid is to perform your part of the contract, and naturally as soon as the owner agrees with you the bargain is made. You can hold him, and he can hold you. It is a pity if one contractor has left out all the great plate glass front, and another has forgotten that carpenters need money on Saturday night, but the owner thinks you competent to do what your bid says and will be much obliged if you will go ahead.

Title. — The person who signs the contract for a building with a contractor must have the title or lease to the ground upon which the building is to be erected. Otherwise the contractor may lose all he puts in it. All permanent structures belong to the freehold, or land, and cannot be taken off. To a layman, this seems a severe and unjust law, but it is well that contractors especially should understand it. Even if some of them built a frame house on the wrong ground it would not be quite so bad if it could be moved off, but our legal friends have us tied up rather tight on this proposition. Therefore, do not build on the wrong ground, or you may not only lose the structure, but the real owner may sue you for damages to his property. He may not like your style of architecture.

Before signing a contract with anyone be sure that one has a clear title to the ground.

It often happens that a man's wife owns the lot, and the contract for a house should really be made with her; yet in some cases when the husband is, in the old phrase, a man of substance, the contractor signs with him. It is a bad practice; but the supreme court of Florida has held that if the wife has knowledge of the erection of the building, and does not dissent, but acquiesces, the property may be sold to pay the agreed price. When in a case of this kind a woman comes around and accepts things as they are, and probably gives the contractor instructions, she is really held. But in nine cases out of ten why sign a contract with a man to build a house for him on a lot that he does not own? The proper thing is to tell him that you would much prefer to have his wife sign.

Corporations can make contracts only within their charters or statutory powers. The proper officer should sign them, and it is better that he should use a seal.

A railway is not usually chartered to build churches, for example. It is therefore unwise to build a church for a railroad unless you are sure it has authority to expend its revenue in this manner. Some of its stockholders who did not believe in churches might get out an injunction and keep the contractor from his money until the title of the drawings could be changed, making it a storehouse or boiler shop.

Illegal. — A minor, drunk person, or person of unsound mind cannot make a contract. When making one with those who cannot read, are blind, deaf, or otherwise defective, it is well to have good witnesses. Married women, in most states, can now make contracts. We are making strange progress! A husband cannot sign a contract for his wife in states where she can sign one for herself without her permission. This, however, would not prevent him from signing a contract for a house on her land, if the builder was willing to take chances, but she could stop the erection of the structure.

Legality. — The object sought in a contract must be legal. If structures of a certain kind are forbidden in a state it is not legal to put them up, any more than it is to build a wall of less thickness than that specified in the building code.

Fraud will void a contract.

Sunday. — You can certainly agree to do anything on Sunday, but contracts should not be signed then, as they cannot be enforced, except in possibly a few states.

Severity. — The Builders' Uniform Subcontract has one strong point in its favor that keeps a general contractor on the right path. It is not severe. Do not attempt to make a severe contract, or the courts will not uphold you. Even if you have power, that thing that has been so often the bane of the human race, do not, in the vernacular, "be a hog." Be fair, and it pays.

Partial Performance of a contract will "bind the bargain." Do not start the excavation and then discover that you have forgotten the west wall. It is then too late to cry quits. It is sometimes possible to back out on a bid, but a little more difficult after the work is started. The great men who never make a mistake smile at you for years for anything of this kind.

Breaking of a Contract. — If the building has to be stopped, and there is no provision in the contract for such a contingency, a fair compensation may be agreed upon by the parties for the work done, but the nature of the arrangement must be exclusively for compensation to one side or the other, and not as a penalty, or anything in the nature of a penalty, for the courts would not uphold that.

Stoppage. — If the work is stopped on the owner's account the contractor cannot always recover the profit he might have made. Railroads arrange for the stoppage of their work at any time by putting the right kind of a clause in the contract; and the provision is also inserted that the contractor shall receive only that proportion of the total profit which the part of the structure already erected bears to the whole. In other words, if the building is half done, the builder will get half the profits, and so on.

In the Uniform Contract if the contractor does not keep on sufficient men, or neglects to abide by the decision of the architect, the owner can enter upon the premises, set the contractor aside, and take matters into his own hands. No more payments are made to the contractor till the building is finished, and if there is any money left he gets it; if there has not been enough to finish he has to reimburse the owner.

Written or Verbal. — If the work is not to be begun before a year the contract must be written, and, in case of misunderstanding, this means printed or typewritten also.

When printed forms are so cheap, it does not pay to go ahead on a verbal contract. Who knows the amount? Suppose one of the parties should die, will the heirs, assigns, administrators, and the rest of them take the word of one interested party as to how much the contract ran to? There may be no book record. More than likely, the owner who goes ahead in this loose way is just the one who would keep no record. He could trust his own memory well enough, but in case he died, what then?

Payments. — There is one point that is worth attention with respect to payments, and that is, whether the material delivered on the ground is to be paid for. Most of the states, and occasionally, the United States, do this.

There seems to be no good reason why an owner should not pay for at least certain materials. He has a bond to secure him, in case of any misgiving as to whether they will ever be installed in the building. In the case of stone, brick, heavy lumber, steel and iron, and certain kinds of millwork that will not deteriorate under the weather, payment might be made upon delivery, especially if it could not be put in place for several months, as in northern climates in winter.

The owner, of course, does not wish to pay out money so soon, especially if he is borrowing and paying interest. The point is worth watching when signing a contract, however, for in some cases a reasonable arrangement can be made.

Partial Payments. — Unless a builder is rich he should not sign a contract that does not provide for partial payments as the work progresses, but makes payment only when the whole structure is completed. The want of some trifle may delay completion for a couple of months, or the owner may make a dispute over one matter or another and hold back a settlement.

Ironclad Payment. — Do not sign a contract providing that nothing whatever shall be paid on a building unless it is finished on time. That is too much of a gamble, and the finishing of a building is not a sure thing.

The Installment Plan. — It is generally stated in a contract that no partial payment given as the work progresses is to be considered an acceptance in any manner of any part of the work. It has been held by the courts, however, in an agreement to pay for a building in this way, that, upon the owner's failure to meet one of the stipulated payments, the contractor could abandon the contract and recover the profits he might have made by completing the entire structure. One judge might give such a decision, but the next one would be likely to overturn it as "unconstitutional."

Time Dangers. — A fair rental for the property for the time the owner has been held out of it after the set date is the standard penalty for delay. It is seldom enforced, for the owner usually breaks the contract on his side, in one way or another, as well as the builder.

In a time contract additional orders for extras may give cause for annulling the agreement, and especially if the extras are heavy; but an order for extras does not necessarily waive the time condition.

Reasonable Time. — Even if no time of completion is laid down, the contractor must use reasonable diligence to finish the building without delay. If he does not, the owner can sue him and recover damages.

On the other hand, if the owner block the way of the contractor the latter can recover reasonable damages—after probably an unreasonable time should he go to law. In such a case, too, there can be no penalty taken from the contractor even if it is provided for in the contract. The owner must keep up his end of the agreement, or he cannot hold the contractor.

Number of Days. — If the number of days is specified in a contract see that they are working days, or days that men can work, which is better. There might be rain or zero weather, or legal holidays, when the wages were doubled; and Sundays might be included.

Time Penalty. — It must not be supposed that a time contract cannot be enforced, although it seldom is. It must not be supposed, either, that an allowance for extension will be given at the end unless the contractor has applied for it as specified. Even if an owner waive the limit on account of extras, the building must be completed within a reasonable time after an allowance is given for the additional work. Unforeseen difficulties, no matter how great, do not relieve the contractor from his contract obligations. He must carry them out, unless this is rendered impossible by an act of God, the other party to the contract, or the law.

Insurance, Cyclone, etc. — If a building has been destroyed by earthquake or fire, suppose, no matter if there has been no insurance, the owner can recover the amounts paid on installments to the contractor, who has agreed to turn over a complete building, or part of one, as in the case of a subcontractor dealing with the owner, and must do so if this is possible. The risk lies with the contractor, who should insure against it.

In the court of appeals of Maryland, a contractor who suffered tried to have the storm which blew down his nearly completed building construed as an act of God, and thus lay the loss on the owner, but the decision went against him, although a provision about "an act of God" was in the bond which he furnished.

In a way, this is fair. The question is, Are there companies which insure a contractor against such and such a risk? If so, then why did he neglect to take out insurance? Why should the owner suffer because of his carelessness? Probably even if there were no such companies the courts would hold as this one did. The contractor risks his property that he will do what he agrees. The owner is entitled to expect him to do so.

All Insurance. — A contractor should insure against fire, flood, cyclone, earthquake, boiler explosions, or falling walls next door to his contract, sinking foundations, personal liability, robbery of wages as he carries them from the bank, and everything else that the insurance companies can be found to insure. If he does not he takes the risk. Ignorance of the law excuses no contractor. In many cases he must "put up or be shut up."

Authorities. — As usual, there is a mass of law and evidence connected with this subject of responsibility, but the leading rule is this:—"If a contract is entire and indivisible for the erection and completion of a certain building, for a certain price, and the structure is destroyed, whether by fire, lightning, storm, or defective soil before completion, the loss falls upon the builder; but if the contract price is to be paid by installments as certain specified portions of the work are completed, and the house be destroyed during the progress of the work, the builder is entitled to all the installments then due, the only loss which falls upon him being for the incompleted portion upon which he may be engaged at the time of the fire."

This does not do a builder much good, for few contracts are so taken. If a house was let in, say, four contracts, there would be a chance for the contractor. Thus, it might be arranged to make one complete contract for the basement; another for the first story; the third for enclosing; and the fourth for finishing. The contractor might never leave the ground, but each contract would be considered complete by itself.

Suppose that he is working on No. 4, and fire destroys the whole structure. Then the owner would lose all the value of the three first contracts, and the contractor would lose whatever was done on the fourth only. Instead of a "separate and indivisible contract" being made for the complete structure, four such contracts are made, and naturally each contract has to stand on its own feet. After the first three are finished the builder has nothing more to do with them.

Not one building in a score is taken that way.

Repairs. — Do not sign a contract to keep a building in repair for six months or a year after it is turned over to the owner, or, if you do, have it clearly understood what repairs mean. Should the building fall, or get washed away the courts may compel the contractor to rebuild it and put it in the original condition. Such a case was decided with respect to a bridge that was washed away in a flood. It would seem to any ordinary mind that an agreement to keep in repairs would be understood as attending to any minor defects that developed, but would not mean that the contractor was responsible for the whole building, or structure. Law is a funny thing.

Poor Foundations. — It has been also held that if a building goes to wreck because of poor foundations the contractor is responsible. As already said in another chapter, about the only safe course is for a contractor to get a written order from an architect to go ahead, as the ground is satisfactory. This would put the responsibility where it belonged—if the courts accepted the order as constitutional.

Underpinning and Shoring. — In general, a specification must say what is to be done, although no builder expects a detailed reference to every trifle. If this is neglected, the contractor is not held to perform work, although it is shown on the plans, in spite of the time worn clause to the contrary.

But the courts have held that a contractor putting up a new building by the side of an old one must protect the old one by shoring it up, underpinning it, and leaving it in good condition.

If a contractor runs against any danger of this kind, his best method is to state in his bid just what he proposes to do, and to see that the matter is properly fixed in the contract.

Acceptance of Defective Work. — If the quality of the work is not up to the standard set in the plans and specifications, the owner MAY accept it, but pay only what it is worth.

On the other hand, he may be so disgusted as to order the entire building torn down and rebuilt. If the builder will not do that, the owner can order him to remove his material from the land, in which event the builder will have no claim for the cost of the work done.

As may be seen by this, it is rather dangerous to supply workmanship or material of too poor a quality.

In certain cases when the owner takes possession of the building and begins to use it, he is held for payment, although he may deduct for inferior work. But in other cases, even taking possession does not mean that payment has to be made. The owner must pay when he gets what he agreed to pay for. That is what he is entitled to. It is dangerous to try to make him accept less.

Acceptance of a Building. — In *The Building Age* for February, 1910, we are told what constitutes acceptance of a building. Taking of the keys by an owner, or occupation of the building, while strong evidence is not conclusive. These acts must also be coupled with some act or language from which acceptance may be reasonably inferred. This principle has been decided by the highest courts of nearly all the important states, including Massachusetts.

The use of a building when the builder stops working on it is not an acceptance where the contract expressly provides that only an order for final payment shall be considered an acceptance. It has been decided also that occupation only waives unintentional omissions unsubstantial in their nature, for which due allowance can be made to the owner. Where defective performance is not the fault of the builder, acceptance may be implied from possession and occupation, notwithstanding a protest from the owner.

It has been decided also that where the owner of a building in the course of erection takes possession of and occupies a portion of it, and afterwards takes possession of and occupies the whole building, there is an acceptance.

A notice from an owner to a builder that he will complete unfinished work and deduct the cost from the contract price is an election to accept it, subject to the necessary cost of completion.

I never had any trouble getting a building accepted without ceremony. With the fine legal points that the lawyers gather around every corner one can never tell "where he is at."

They catch him coming and going; on foot or on horseback; and he is lucky if he escapes with his hide.

"We Do Not Substitute." — A contractor must, as far as possible on all work, and especially on government work, use the material specified, and not use what he thinks is "just as good," without permission from the architect or owner.

The supreme court of the state of New York let a builder understand this in 1907. He substituted what was just as good, and probably better, in some cases, but he had no right to do so. One kind of sash cord was specified, and he used another; and so on, all through. He landed himself in trouble for no good reason.

Simple Simony. — If a builder takes a contract upon an architect's representations that certain quantities are sufficient for the work, or that a certain amount of labor will finish it, and finds out that it takes more, no extra payment need be allowed. Builders are supposed to have cut their eye teeth.

Completeness. — A contract must be entirely finished. A contractor cannot expect a settlement before it is. This does not mean, however, that some trifling omissions can prevent a settlement of the main contract.

Extras. — If the contract provides that extras are to be done only upon a written order of the architect, then, by all means, get one or leave them alone. An architect who knows what the contract provides for has no right to ask or expect anyone to go ahead without such an order. There are two sides to a contract.

Profit. — The general rule for profit on extras, if we are to believe the specifications, should be the same as that on the main contract. It is customary to charge more,—a good deal more, in many cases. Those who say that lumbermen and hardware men should sell extras on the same basis as the main bill, just like a brickmaker with brick, forget the rule when their own turn comes.

It does not pay to charge too high a price, but the owner should remember the possibility of a damage suit for $25,000. An accident may happen on an extra as well as on the main part; and when a builder gets the chance he tries to even up some of the incidental expenses. In case of any effort to limit the profit on extras when the contract is signed the proposal might be made that the owner would be responsible for all accidents or deaths happening on them.

Old Structures. — If the specification or contract makes no reference to old structures on the ground, they become the property of the contractor.

Sizes. — Market sizes of lumber, etc., will be upheld by the courts. If 2-in. lumber is wanted it must be carefully specified as such, for the trade size is only 1¾. A 2 x 6 is only 1¾ x 5½, and so on. It is not, therefore, enough to call for a 2 x 6, but is necessary to say that market sizes will not be accepted, but that full sizes are to be used. This means quite an increase in price. In millwork it is easier to get the exact sizes marked, although $\frac{13}{16}$ always comes for ⅞. Full sized lumber not only costs more to saw, since it is special, but is heavier, and the freight costs more.

Allowances. — Sometimes certain amounts are specified for work that cannot be detailed in time, or for some such reason. The contractor does not have to expend more than the allowance, no matter what detail the architect may present afterwards. This is from the supreme court of Illinois. It seems an unnecessary ruling; but probably some architect had been at the old game of trying to build up a reputation for fine work at another man's expense, and the latter had to stop it.

Patents. — In government and railroad work there is usually a clause putting all the responsibility of using patented articles, and of defending any suits for their infringement, upon the contractor. No matter if such articles are called for in the architect's specification, the contractor should make himself sure that they can be used without liability to himself. The architect cannot be held responsible; it is the contractor's business to find out how things stand.

Adjoining Building. — As already stated at UNDERPINNING, the contractor is responsible for the safety of the adjoining building. At this writing, February 5, 1910, the subject was brought up before Omaha builders once more, just as it is at one time or another to builders in all parts of the land. A 16-story building, going up at the side of one of two stories, put too much weight on the old wall, and about $1,000 worth of it fell in the jewelry and piano department. This also gives a chance for damage suits. It so happened that the people inside of the store were in the rear at the time, or some of them might have been killed. An interesting question is, Do contractors have liability insurance for men not in their employ?

LIENS

Variety. — The laws relating to liens in one state may differ in some important parts from those in another. Only a few general principles can be laid down.

Personal Responsibility. — Some contractors would like to see all lien laws abolished, and the building business conducted upon the same principles as the wholesale grocery one. Then the contractor would be selected according to his reputation for fair dealing and responsibility. As it is, the material men, while naturally anxious to deal only with reputable contractors who pay promptly, are willing to supply almost anyone with what he needs, and if he does not pay they can come back on the property.

The dealers object to taking away this good security; the mechanics consider that their wages are also more certain under this system; and between these two powers and contractors who like the present status, the lien laws remain on the statute books.

Character. — Much trouble is avoided by building only for those upon whom one can rely. While contracting I never had occasion to file even a single lien. After finishing a contract for one man who was rather "shaky," and getting settled with difficulty, he started another large building, and asked for figures which were not given. The building went up, and every contractor who did any work had to file a lien, fight for years, and pay legal expenses to get a small part of his money. The loan ahead of the contractors was too large.

Amount. — In some states the amount of the lien has to be at least $25.

Who Can File. — Any supply dealer, contractor, subcontractor, or one who furnished labor or material on the building, in carrying out a contract or agreement with the owner or his agent has a right to a lien on the building, in so far as such owner may himself have the title. Thus a mortgage comes ahead of a lien if filed before any work whatever is started on the building; and the amount of the mortgage has to be deducted before finding out how much interest the owner has in the property. This interest only would be subject to the lien.

Put in Place. — The supreme court of Michigan has decided that a lien cannot be filed on materials ordered but not used in the construction of the building. Special millwork might be all prepared and even delivered on the site, but if not installed when the crash came there would be no claim.

The Property Held. — The lien attaches to the property at the time of filing, no matter who owns it. It is the property itself that is held, and not the person who may have owned it when the work was done. This is why it is dangerous to buy property without finding out if there are any liens on it.

Time of Filing. — In most states a mechanic or laborer, supply dealer, or subcontractor, must file a lien inside of thirty days after the work is done or material furnished. The general contractor usually has twice as long, and this, of course, applies to subcontractors when they sign a contract directly with the owner. A general contractor can sometimes extend his own time if he has been wise enough in doubtful cases to do that which he should not have done by leaving undone that which he should have done; and, as already noted, he can help out a subcontractor by ordering a small amount of material or labor.

Filing. — If a lien has to be filed, the best way is to go to a lawyer and have him make it out. Good blanks may be found, and the services of a lawyer dispensed with, but the filling out has to be carefully done. A legal description of the premises must be given; the name of the owner or person in possession of the property, such as lessee, whose agreement with the real owner may oblige him to pay all taxes and take care of all suits; the amount of money claimed; when the money is due, and to whom due; the residence of the claimant; and probably a certificate of baptism. Do not leave out the "the" in any place, or put in an "e" too many, for the St. Louis boodlers went free on this account. We should always remember that the Englishman in the novel was not far astray when he said, "The law is a hass."

Action. — After filing a lien, action must be taken to foreclose it inside of a year unless the lien is continued by an order of the court. The right to file is lost if the thirty or sixty days, or whatever the period is, are allowed to pass without filing.

Waivers. — When an owner borrows money to build, the loan companies naturally try to get in ahead of anybody else, either by filing their mortgage first, or by getting the contractors and material men to sign waivers of their right to file a lien. This is a species of what has been called "contracting out," or individual setting aside of statute law. Generally speaking, it should not be allowed. If the law is good it should stand for everybody, and it should be presumed to be too good for any one man to set it aside.

The lien for wages would still stand, for it is seldom that each worker is asked to waive that.

The taking of a note from an owner for the amount of the claim is held, as a rule, to waive the right to file a lien.

First Claim. — All work on a building takes precedence of the mortgage filed after the first spadeful of earth is turned up on the contract. Thus, the brickwork might be finished before the mortgage was filed, and the plaster afterwards. Nevertheless, the plaster would come in ahead of the mortgage.

PARTNERSHIP

Responsibility. — Each individual is responsible for all the debts of the firm unless the articles of agreement set a limit.

This means that if C has no money or property, and D has $10,000, either in the business or in property outside of it, and anything goes wrong that requires $10,000 to satisfy the claim, D loses his whole amount.

D might avoid a danger of this kind by special articles of agreement putting his liability at whatever amount he thinks fit. But if he should set a limit of $1,000, suppose, the bonding companies would refuse to go on a large bond, and he would have to restrict himself to smaller and less profitable contracts. Then his credit would not be so good with the dealers. If he is not willing to risk his own property, why should they risk theirs on his good faith? If it is said that character as much as the amount of capital determines credit, the material men might fitly ask what kind of character it is that keeps its own property beyond the reach of danger and risks theirs. If he is afraid of his partner, C, he should separate from him.

Specials. — The statutes of the state must be complied with in order to avoid danger in limited or special partnerships. Corporations are organized on this basis of limited liability. Each one is responsible only for the amount of his stock. This is why so many firms are incorporated. Yet about 4,000 incorporated firms let their rights lapse in Nebraska in the end of 1909 rather than pay a small tax levied on all corporations. They did not seem to think the corporate form of doing business as worth the difference asked for above the untaxed partnership.

Nominal. — There is what is known as a nominal partner. That is one who lends his name to help out a firm, but has no real interest in it—except that he is liable for all debts and contracts.

A Silent Partner may keep his connection with the firm silent enough, but if it becomes known he also is held for all debts and contracts.

Dissolution. — After a man has left a partnership he should not allow his name to be used in it unless by special agreement which should be filed for public record.

Responsibility. — The acts of one partner bind all the others; and this goes so far that if a man deceives outsiders and gets them to advance money or anything of that kind under the impression that it is for the firm account, yet be only for his own advantage, the other members of the firm are held. Their business was to have held such a man by a rope, if necessary, and not turn him loose on an unsophisticated and credulous public. They are held and duly bound to the public for the character of this member of their firm. For this reason, good character is an important asset in a partnership. When partners become suspicious of each other, it is time to dissolve.

Commercial Paper. — If one member signs his name to notes or such negotiable papers that bear on their face to be for the benefit of the firm, all the partners are liable for the payment. The private notes of a partner may also be charged to the firm unless those who buy them are informed that they are created solely on individual account. But one partner cannot bind the firm by a deed, which must be signed by all.

Confusion. — Each partner should, as a rule, keep an individual account as soon as sufficient money is on hand.

It is not wise to separate $123.13 into several accounts, however.

Beginning. — Articles should be drawn for partnership, and should not be signed till the partnership funds are in the bank. The partnership begins upon the execution of the articles, unless a special time is set.

ENDING OF PARTNERSHIPS

Death. — The woman in the novel said, "Death ends all"; and it also ends a partnership unless the articles of agreement are arranged to the contrary.

Withdrawal. — If no time of expiration of partnership is stated any partner can leave the firm when it suits him to do so; and he can always prevent the firm from binding him to future contracts even if a time limit is set. But in both cases he is held liable for unfinished contracts, and if he leaves at such a time or in such a way as to embarrass the firm he may be sued for damages. There is, or should be, reason in all things—even in law.

On the expiration of articles new ones should be made before going further ahead.

Changes. — When changes are made involving the retirement of one partner, limiting liability, or anything of a like nature, public notice should be given so that those with whom the firm deals should understand the new condition of affairs and govern themselves accordingly.

The Bankruptcy of one partner dissolves the firm. A new agreement has to be made among those who are left.

Notice. — When a partnership is dissolved public notice should be given and also sent to all who have had dealings with the firm. One member of the firm should be given authority to settle up all affairs.

Old Firm. — It is often dangerous to enter a firm already established. A careful examination of its affairs should first be made by one competent to do it. A new partner becomes liable for all the debts, contracts, lawsuits, entanglements, liens, and everything else of the old firm.

Equal Shares. — If no special agreement to the contrary is made, all partners must give their whole time to the business of the firm, and all money gained in whatever business way by partners becomes common property. Here law and common sense join.

If one party has more capital in the business than another, or others, the proper arrangement should be made to pay him interest on his extra capital, but after that is attended to, all gain made by each while attending to business that is not of a private nature, becomes partnership property, to be divided in the manner set forth in the articles of agreement, or share and share alike. Gain is shared in a partnership, and so is loss, and there are few businesses which do not occasionally meet the latter.

LANDLORD AND TENANT

Investments. — Many contractors put up houses for rent. This is often a profitable way of investing money, but not unfrequently there are better ways. Few figure up the rate of depreciation on ordinary buildings. According to the government figures, a frame house when rented is supposed to last for 40 years. This means that before figuring profit on the investment, a deduction of 2½ per cent. per annum should be made. Of course, with good care a house should last much longer. The same government figures are 2 per cent. when inhabited by the owner. But even at this rate a $3,000 house costs the owner $5 per month.

Then there are repairs, taxes, vacancies, and insurance to be considered. Some say that there are better investments. But it often happens that a contractor has old material that he can work up to good advantage in his own new houses. He can build cheaper than anyone else. Some of the common laws relating to landlord and tenant are set down here for the use of builders.

Lease. — A lease for a year or less needs no written agreement, although it is better to have one. Printed forms are cheap.

Leases for more than three years must be recorded. A lease for life or a long period must be signed and sealed like a deed or any other legal instrument, and recorded.

When a lease expires and no new arrangement is made, the tenant holds the property for another term of the same length as before, and on the same conditions. In other words, the old lease is considered renewed.

When a tenant turns over his lease to someone else, even with the landlord's consent, he still remains liable for the rent unless his lease is canceled.

Continuation. — Without some special agreement as to time a tenant holds over from year to year. Under the method common in many parts of the country of renting from month to month only, the tenant has to give up possession on one month's notice, unless the statute law decrees otherwise, as in winter, for example.

Who Pays Taxes. — In some leases, such as the Astor ones in New York, the tenant pays all taxes and makes all repairs. Such conditions must be stated in the lease.

Underletting. — In making leases the landlord should be careful about underletting. Unless forbidden, the tenant can sublet to whomsoever he pleases. The tenant by the month cannot do this, but he may have as many roomers as he likes, in default of special agreement. A landlord cannot put out a subtenant unless he has given him the same notice that the tenant himself receives.

There is one danger in cities with renting houses, and especially with subletting. I remember that part of a fine block just finished was rented to a woman of the wrong character by an agent who was a stranger in the city, and was taken in. The owner happened to notice the matter in time, and the lease was canceled. Renting to this wrong kind of tenants not only runs down property in respectable districts, but is contrary to state law.

Married Women. — In most states a married woman is now allowed to lease her property the same as a man. In states where she cannot make a contract she should not be accepted as a tenant.

Guardian. — Care should be exercised in making a lease with a minor. When he comes to his majority the lessee is still held, but the minor may back out. If he receives rent after he is twenty-one, however, he also is "held and firmly bound."

Mortgage. — A lease on mortgaged property, given after the mortgage is filed, terminates if there is a foreclosure.

Tenancy begins from the day possession is taken. Landlords who rent property should have a definite understanding as to when the payment is to be made.

Improvements. — The tenant should not put up buildings with foundations sunk in the ground, or make permanent improvements on the property, for they cannot be removed, and no compensation need be given for them. Whatever is fixed to the land belongs to it.

Insurance Policies are issued for loss of rent during the time that burnt property is being rebuilt.

DEEDS

Forms. — There are plenty of blank forms for deeds, and thus there is no excuse for attempting to write them out. They must be signed, sealed, witnessed, acknowledged, and recorded. If not recorded promptly a new deed might be made out to someone else and recorded first. Then the rascal who sold the property twice has to be found and prosecuted. He may have died since.

But deeds are often unrecorded for long periods, where the party who bought knows that there is no risk, and wishes to keep the transfer secret.

When deeds or other legal papers are handed in for record, the public officer marks down the exact time on the margin, and if another instrument is presented, it is easy to discover which was first.

A Notary usually acknowledges deeds, but other officers can do so, such as judges and clerks of court. Most states have special forms of acknowledgment, which must be used. All state enactments must be complied with.

In some states one witness is sufficient, and a seal is necessary; in others, two witnesses are required. In almost all states corporations must use their seal.

Abstract. — Before taking a deed and paying the money an abstract of the title to the property should be had. This traces the ownership back, in many cases, clear to the original grant by the United States. In others, a terminus is found beyond which all know that things are satisfactory. Happy is that state which has adopted the Torrens system of guaranteeing titles.

This abstract shows whether or not all the taxes are paid, and if there are any liens, judgments, clouds, or troubles of any kind standing against the property.

Guaranty. — Some abstract companies not only make the search, but guarantee the title for an extra charge. But all over the land titles searched and certified by the ablest abstract "sleuths" are disputed. Some day, in some way or another, there will have to be a simplification of the whole disgusting legal mess. No civilization can afford to keep 130,000 lawyers doing what should be useless work, with a large army of court and office help to assist them. Peter the Great said that there was only one lawyer in Russia, and when he got home he meant to hang him. This policy would be too drastic in these United States, but we might put them to a better use than we do now. Turn in whatever direction one will, this "law" sewer seems only to smell the stronger.

Kind of a Deed. — A general warranty deed is best, as it guarantees the purchaser against all claim on the property of whatever nature. This is valuable to the extent that the person who makes it stands ready to fight a claim.

A quit-claim deed merely surrenders all interest the maker has in the property, and guarantees nothing.

Matrimony. — A wife must join with her husband in making a deed. In this land of sorely tangled matrimonial complications, it is sometimes hard to get the lady to toe the mark, or even to find her. Again, there are men who pass themselves off as unmarried when they are. There have been cases of fighting over titles for generations, owing to the dower right that a woman has in her husband's estate.

When a married woman sells property her husband should join in the deed. When a man turns over his property to his wife he should not do it direct, but as if he meant it to land anywhere else than near her. He should first "sell" it to someone outside of his family preferably, and then through him to her, and thus bring it home once more.

Do Not Alter a deed after it is made and executed. Fill in only the blank spaces, and do not interline or erase, unless you make a special acknowledgment of the fact and have it witnessed.

MORTGAGES

A Mortgage never sleeps. It comes first, unless there are liens ahead of it.

Notary. — This instrument should be signed, sealed, etc., just the same as a deed. The one who supplies the money records the instrument.

Release. — When the money is paid according to the terms of the mortgage, it is discharged by sending a release to the court of record. A charge is made for recording the release. Or an entry may be made in the margin of the original record by the owner of the mortgage or his attorney, or representative in the presence of the public official.

Description. — The property mortgaged must be clearly described, and the time when the debt becomes due. A description of the notes is also given. In general, the safest way is to get a lawyer or real estate agent to do the work. A deed is easier made out than a mortgage.

Foreclosure. — If a foreclosure is made, the mortgage is first satisfied, and then the owner gets what is left at public sale, after paying interest, costs, and so on.

A Fire Insurance Policy is usually turned over to the one who supplies the money, or the mortgagee. He comes first in case of fire also. The insurance companies must be notified when a mortgage is placed on property, for their contract is with a person and not with the property of itself. Their policy is different from a lien in this respect. A lien is with the property, but an insurance policy is with the person named in it only, unless it is endorsed over to another with the consent of the company. If a part change of ownership is made, as when a mortgage is given, the company must be notified that another person has acquired an interest in the property.

Notes are usually given for the principal and interest on a mortgage. They should be taken up when the payments are made, and canceled. The mortgage is given to secure them.

Chattel Mortgage. — This kind of an instrument should never be given for more than a year. It should be signed, sealed, witnessed, and recorded, and insurance should be kept up on the goods, which ought to be carefully listed. The obligation still stands against the maker, although the goods are burnt or destroyed. All payments made upon installments should be endorsed upon the instrument.

FIRE INSURANCE

Location of Property. — In a fire insurance policy the property insured to you personally must remain in the location described. If you move it, insurance cannot be collected in case of loss.

See Agent. — In case of anything affecting title to property, as a mortgage, go to the agent and arrange matters. There is no trouble doing so.

Vacancies. — Take only such a policy as permits a vacancy of a reasonable duration without a special permit. Life is too short to run to an agent every time a tenant leaves a house. In many cases he leaves without paying rent, and the house may stand vacant for days before the owner knows about it. Should it burn down then, under some policies, he would get nothing.

Do not accept a policy that cuts down the amount insured about 25 per cent. when the house is vacant. If it burns down then it would cost you just as much to rebuild as if the tenant had been burnt inside of it. There are better policies than that on the market.

When there are more policies than one, have the blanks filled up in such a way that there will be no trouble getting an adjustment. The written matter should correspond.

See that a permit is given for additional insurance on ALL the policies if there are more than one on the property.

In case of loss by fire notify the local agent at once.

We like to stand by our home companies in all lines. Nevertheless, with fire insurance it must be confessed that an old wealthy company is safer than a local new one with limited capital. We remember the state of affairs in San Francisco. A local company is easily wiped out.

It is said that four out of five of the insurance companies in the United States have either failed or retired.

One company sends out the following card:

WHAT PEOPLE WHO INSURE SHOULD KNOW AND DO

A policy of fire insurance can be violated in the following ways:

1. Failure to pay the premium at the proper time.
2. Change of title, or ownership by sale, gift, marriage

settlement, device—any way but by descent—without consent of the company.

3. Mortgaging the property insured, real or personal, when prohibited by conditions of the policy, without consent of the company.

4. Foreclosure proceedings without consent of the company.

5. False statements in applications (when taken) relating to title, incumbrance, and other facts material to the risk.

6. Other insurance without consent of the company.

7. Permitting buildings insured to become vacant or unoccupied for more than ten days without consent of the company.

8. Taking a new partner without consent of the company.

9. Increase of risk by keeping prohibited articles on the premises or by change of occupancy of the premises insured.

10. Removal of personal property to a new location without consent of the company.

11. Erection of an exposure to the property insured without consent of the company.

BANK CHECKS

Checks or Drafts must be presented for payment within a reasonable time. I know of cases where checks of a railroad company were held for several years. The holders had more confidence in the stability of the companies than in the banks; and when the era of illegal "cashier's checks" came on, their foresight was justified.

Endorsement. — When you endorse a check you guarantee its payment, but you can insist that the check be presented at once, or next day at furthest.

The name should be written about three inches from the top to allow for filing, but if another name is already written, put yours below that.

Certified. — When a check is certified the amount is taken out of the owner's account. If you require a larger or smaller certified check do not destroy the first one under any circumstances, but take it to the bank and surrender it for a new one. If you do not return it, the bank is justified in asking for a bond of indemnity in case it should turn up—

and all this regardless of your explanations, telling why and when you destroyed it.

Signatures. — Something is said in Chapter XIV about keeping clear of the forger and check raiser that need not be repeated here. But there is one thing about a forged check that many do not know: if the bank pay a forged check it cannot charge the amount to the depositor whose name has been forged, but it may recover the money from the one who has innocently presented the check, and to whom the money was paid, provided the demand for the return is made immediately. Therefore, it is dangerous to accept forged checks in payment for anything and present them at the bank.

Dating. — Do not date a check ahead or for more than you have in the bank, even if the person you give it to promises not to present it. Average experience shows that he will.

Figures should be made very distinct, although in law they are of less consequence than writing.

Alteration. — Do not alter a check, but make a new one. Paper is cheap. An altered check may make the bank look suspiciously at it.

Spelling. — If your name on a check is spelled wrong, and it is clearly meant for you, write out your signature as the check shows it, and then put your correct one below it.

Some banks insist that even checks payable to yourself should be endorsed on the back.

Overdrawing. — Banks are not permitted to allow customers to overdraw their accounts. After all, it is rather an informal way of borrowing a few dollars. It is best to borrow in the regular manner.

NOTES

Nature of a Note. — An acknowledgment of a debt is not sufficient to make a note or any commercial paper that may be bought and sold. There must be a promise to pay or an order on someone to pay.

Interest. — Notes bear interest only when so stated.

Date. — A note should be correctly dated.

Time. — If the time of payment is not inserted a note is held payable on demand.

Data. — A note should specify the amount of money to be paid, and to whom it is to be paid, or order, and state that it is for value received.

Place. — The place of payment should be stated on the note.

Cancellation. — When a note is paid it should be canceled, or else it may have to be paid twice.

Endorser. — If the maker of a note fails to pay, the one who endorses it is liable.

Protest. — When a note is protested, notice should at once be sent to all who endorse it.

Illegal Note. — A note obtained by fraud or from a drunken person cannot be collected. A note made on Sunday is void.

A Notice to One Person in a firm is sufficient on a partnership note.

Liability. — An endorser is not liable if notice of a note's dishonor is not mailed or served on him inside of twenty-four hours. Mailing, as usual, does not mean delivery from the mails, but putting in the postoffice.

WILLS

Obligation. — All contractors who have any property should make their wills unless they are satisfied with the disposition under state laws. They may "contract out" in the will business.

No Danger. — A will is not necessarily a death warrant, as some seem to imagine. Many a man has made one and survived for years. There are people who have become so used to stories of wills made on deathbeds that the idea of sending for a lawyer to make out theirs always brings with it the other dread of asking the preacher to come also, and do what he can for a case considerably below par.

Technicalities. — Of course we all know that in these days it is almost impossible to get anything to stand the test of the courts. The "e" is put in where it should not be, and the "the" is left out, and there is no legality in it. Still, it is well to say how you wish to have your property disposed of. In most cases wills are undisputed.

Some of the finest lawyers in the United States have made their own wills, or made them for others, and the courts have overthrown them. Even Samuel J. Tilden could not make one to suit the fastidious judges. Judging by these and many other cases of national interest, and some of local interest in most cities, the advice you get in this little treatise would appear to be about as valuable or worthless as if you paid a high price for it to the best lawyer you know.

Plainness. — In the first place use simple language, and precious little of that. Act as if every word were worth a thousand dollars. The trouble with most lawyers here is that they know too much. They are verbose, tautological, "windy," wordy, and full to the chin with legal phrases that were ancient in the time of Cæsar Augustus.

I recently saw an account of a will that disposed of a great deal of property in this fashion, "I leave all my property to my wife, and appoint her executrix without bond."

On February 9, 1910, the shortest will ever filed in Kenton County, Kentucky, ran thus: "I leave everything of which I die possessed to my beloved brother, Justus Goebel." Even the word "beloved" might have been left out, for most people would take that for granted.

The tendency is to use as few words as possible in will making, and thus do away with all chance of misunderstanding.

No particular form of words is required, but the meaning of the will must be clear. If more than one sheet is used, which should seldom be the case with the will of a contractor, every sheet should be numbered, and the will referred to as composed of sheets 1, 2, 3, as the case may be. But if you have a lawyer, and he insists on pouring out language from his never failing reservoir, seek another, or make out the will yourself. You will make less of a botch than Mr. Wordy Wiseman. At the end of this chapter a sample of his work is given for a warning.

Written. — In most states a will must be in writing. Should a contractor fall three or four stories he is apt to regret leaving things in a muddle for lawyers to fight over.

Signatures. — A will must be signed in the presence of the witnesses. In some states two witnesses are required; in others, three. The one who makes a will—the "testator," our legal friends call him—must tell the witnesses that what they are signing is his last will and testament. It is this last word that scares people, but it has no more to do with things of a sacred nature than the other one. Strictly, it applies to personal property only, but the words are interchangeable.

The witnesses must sign in the presence of the testator, and not be mentioned as receiving anything in the will itself.

In some states, witnesses must also sign in the presence of each other. They should write their address on the will, although this is not compulsory. The idea is to be able to find them in case the testator dies.

A Codicil may be added to a will at any time, and changes made in the disposition of the property, but must be done with the same number of witnesses and formalities as the will itself.

Property. — If some particular piece of property is mentioned in a will and it is sold or mortgaged, the one to whom it was going would be short that much. If sold, you can certainly not leave it to anyone. A codicil can be added. When leaving all property to a certain person it is better, for this reason, not to list it.

Marriage. — Upon marriage, a new will should be made, for the wife has a dower right for one-half to one-third of the real estate, according to the statutes of the various states, and a man cannot dispose of it. "Contracting out" is not allowed in this particular case. The lien or mortgage holds till death or divorce do us part.

Children. — The birth of a child will also revoke a will, unless provision is made for this contingency.

New Will. — When a new will is made the old one should be destroyed. There has been no end of trouble on this earth with old wills.

Words to Use. — If the meaning is clear any word will serve, but "devise" is the word for real property, and "bequeath" for personal.

Safekeeping. — In most counties wills are received at the courthouse, and kept free of charge, in what should be a fireproof building. A receipt is furnished, and the old will may be taken out at any time and changed, or a new one made. It is better here than in a safety deposit vault or a safe, because no one but yourself may be allowed to go into the vault, and the owners will not allow even your wife to get in there after your death without an order from the court. If a will is kept in such a place two people should be allowed access to it, in case of death, or some arrangement made to get it when required. Wills are often left in charge of lawyers so that they may be produced when necessary.

It may profit some to read what is told elsewhere in this book about the worthless safes of San Francisco.

If a will is to be made by one's self, blank forms are easily obtained, made out in accordance with the law of the state, and thus better than any special instrument that a layman could make for himself. A New York form should not be used for a California will; for there may be requirements in one state that make the blanks of the other useless.

Expense. — One unpleasant feature of the settlement of small estates is the expense connected with it. It is better to trust all settlement to a wife or husband, if there is no danger of the rights of children being lost. If there are no debts to be paid the best way is to leave such a one in full control without bond, which means another expense and sometimes difficulty. If an executor is appointed costs begin to run up.

Contract Finished. — When we leave this world we leave it for good; and, as a rule, we ought to let the people in it "run" it to suit themselves. Why should a woman be forbidden to marry again without losing an inheritance? Or a husband? Let widow or widower marry again if he or she chooses. That is the best way in most cases. But the difficulty comes with children, if there are any.

There are too many thousands of cases in evidence where a sensible "widow woman" or "widower man,"—if the one, why not the other?—has selected another soul mate of a tolerably worthless character, and practically turned over property meant to protect children, from what is a severe struggle at times, to the selfish mercies of the new partner. Many a woman, when too late, has bitterly regretted being left in full control of property that she sees slipping away from her children.

If it is left in trust it often disappears too, and that is a more expensive way of treating a fund that is too small at the best.

On the other hand, many a woman leaves property in full control of her husband, trusting him with the interests of the children. But one day, after the loss had been dulled, he sees Miss Delilah Pompadour, and the old story begins.

Mr. Bellamy's beautiful earthly paradise is not here yet, but in disgust at tons of legal papers and a general mess where such a state as Illinois has more judges than all England, Scotland, Ireland, and Wales, and notwithstanding we see the rights of children trampled on, we cannot help wishing that we had some simpler and less expensive system than the present one.

Dangers. — Executors, administrators, and guardians also have their troubles. One great principle of their office is to keep the money from the estate, or trust, apart from their own. This too common practice of mixing the funds of banks, estates, etc., with personal accounts has been the ruin of many a good man.

If you are appointed trustee, guardian, or anything of that kind, in general make no move without consulting a lawyer. Unless there is a good reason for taking this particular kind of a contract, try to "side-step" it. When the minors grow old enough they may demand an accounting. If you have taken legal advice the lawyer has charged you, and the bill has had to go against the estate. If it is too much it is clear that you have been feeding an attorney—who is probably, curiously enough, your uncle's son—and if you have gone ahead on your own initiative you have done what you should not have done, and squandered the money of orphans. In any case, it would conduce to good feeling all around if you would explain what took place eleven years previously, and produce the receipts. Otherwise, otherwise——

Before accepting such a trust you should read the following legal definition of GIVING from *Patton's Monthly*:

If a man were to give another an orange, he would merely say, "I give you this orange." But when the transaction is entrusted to the hands of a lawyer to put it in writing, he adopts this form:

I hereby give, grant and convey to you, all and singular, my estate and interest, right, title, claim and advantage of and in the said orange, together with all its rind, skin, juice, pulp and pips, with all right and advantage therein, with full power to bite, cut, suck or otherwise eat the said orange, or give the same away, as fully and effectually as I, the said

A. B. Smith, am now entitled to bite, cut, suck or otherwise eat the said orange, or give the same away, with or without its rind, skin, juice, pulp and pips; anything hereinbefore or hereinafter, in any deed or deeds, instrument or instruments, of whatever kind or nature soever, to the contrary in any wise notwithstanding.

CHAPTER XVIII

INSURANCE AND BONDS

Two Examples. — Once when discussing the subject of fire insurance with a supply man, he said to me that the business that would not pay for insurance had better be left alone. Some time after that I saw his great warehouse, filled with valuable building material, burned to the ground. The correctness of his theory was illustrated in flames.

In "The New Building Estimator" there is a note about contractors who failed to keep up insurance on a schoolhouse, after the contract was completed, but before it was accepted or paid for, naturally. There were only a few days to run, and they felt safe. In ninety-nine cases out of a hundred they would have been. But in this hundredth case they were burned out and put on the shelf. The gamble went against them.

Averages. — There is what is called a Law of Averages. By this law you might escape all your life and never have a fire, for your neighbor might get your share of the average, in addition to his own, but it is not safe to trifle with a risk of that kind. Shakespeare tells us of those who seek a minute's mirth and pay for it by wailing a week; and the contractor who goes without fire insurance on his installed work is often put in the same class. He keeps a dime so close to his eye that he cannot see a few golden eagles beyond.

Builders' Risk. — The Uniform Contract takes care of this insurance question by putting the responsibility upon the owner. If another contract is used the owner can sometimes be induced to take out his permanent insurance on the work as it goes along, with the usual permission to finish. The main idea is to have either the owner or the contractor attend to this vital matter. The fire loss is serious all over the land, and anyone might get caught for his share, and something over.

Accidents. — After fire comes liability for accidents. In some countries the laws are strict on this subject. Both employers and employed have to make provision for annuities.

There is no country where human life is so wickedly trifled with as here. Every year we kill, cripple, or injure about 500,000 people. Our death bill, in one year of peace, is greater than that of the slain and wounded throughout the terrible Russo-Japanese war. At least half of the wicked slaughter is unnecessary. In less than three months about 400 miners were killed in the United States, 1909-1910. Their deaths were the result of the setting aside of state laws, in the worst case, and probably in all. Suppose you read *Everybody's Magazine* for February, 1907.

There are no exact statistics as to the building trades. Of accidents of this kind on buildings *Everybody's* writer says: "In nine cases out of ten they are preventible, and are therefore little less than murder."

In 1906 the Ironworkers' Union, Chicago, lost 156 out of 1,358 on skyscrapers and bridges.

Risk. — As with lightning, no one knows where a fatal accident is going to strike next. With the prospect of a suit for $50,000, and this is now possible in some states, it is best to take out insurance.

The large construction companies and experienced contractors in smaller businesses understand the situation, and take no chances, but a warning is necessary to younger or more careless ones.

An owner takes a risk in giving a contract to a builder who carries no insurance of this kind; and the latter has to watch to whom he gives his subcontracts.

Wrong Idea. — It is not insuring men, properly speaking, although they work it that way in Germany; but insuring the contractor from damage suits and verdicts from injured workers.

I once saw a man go headlong down through several stories. He lay in bed for a week or so, and then, after hearing that there was insurance, came around to the subcontractor for his share. His impression was that he was to be paid for falling, but the Chicago subcontractor smiled and said that it did not work that way. He took the matter to court, but the judge laid the accident to his own carelessness.

Record. — The time and date of an accident should be set down, and all particulars: the insurance company has to be at once notified.

Amount. — The insurance is taken out on the basis of the wages paid in a year. It applies to all buildings under construction, and not merely to one.

Other Risks. — It is not only with the building proper that the risk comes, but in sewer excavation, and such work. Unloading of material also has its dangers. The insurance covers everything.

Assuming Risk. — Some try the system of "contracting out," or making individual agreements with the men to assume the risk themselves. While lawyers disagree, it is not likely that a court would uphold any such arrangement. There are certain things that a man cannot sign away in civilized lands. He cannot sign away his life, for example, on a given day. Who would take it? Neither does it seem that he may sign away the right of his relatives to collect damages for his death or accident to his person through the carelessness of the builder or those working for him. Such rights are not his to sign away. The larger view is that it would be prejudicial to the interests of the community to allow him to do so even if willing.

This matter happened to be discussed a good deal in the British parliament a few years ago. Some laws were laid down that the railroads did not like, and they wanted to be allowed to sign private agreements with their employees; but they did not succeed. All that it would have meant is that the employees would have had to sign or leave the employment, for some other reason than the true one, and this would have nullified the whole intent of the law, and set the companies up above the national legislators.

Mr. McCullough, in his "Business of Contracting," cites instances where married men signed such agreements, and their wives signed with them, a paid up accident policy having been provided as a consideration; but it is again doubtful if such a contract would hold. Just as *ex post facto* laws are not allowed, so, in general, agreements signing away natural rights are worthless.

With relation to this, I notice in the *World-Herald* of Omaha, November 25, 1909, that the supreme court "affirmed a district court decision to the effect that a railroad company cannot relieve itself of liability for its own negligence by making a contract of immunity in advance." Law and justice would seem to be on good terms in this decision.

Cost. — Mr. McCullough gives the cost at from 2 to 12 per cent. of an engineering pay roll, depending upon the danger of the work. In building work the rate usually runs from 3½ per cent. on a small amount of a few thousands to 2½ per cent. where there is a large pay roll. On a pay roll of $5,000 at 3½ the cost would be $175. This would hold good till the sum of $5,000 had been paid out in wages. It is not worth while taking any risk with contracting out when lawyers are not agreed as to the legality of the contracts. It is better to pay the companies the rate demanded and be secure.

Neglect. — The insurance companies properly insist upon a contractor being careful. If an accident is due to his own carelessness or neglect of ordinary precautions, the company can recover damages.

Serious Verdicts. — I wrote an insurance company for a few figures, and got the following ones, which are just from one state. There are about fifty other states and territories to consider.

In some states there was formerly a statutory law limiting the liability for death to $5,000. Now, where this limit is removed, the danger is greater than ever.

In the state of New York, after 1895, a provision of the constitution took from the legislature the power of limiting the amount recoverable. There are now hundreds of cases waiting, or still being fought over, in the lower courts there, but many have been decided under the new law. From the records of the Court of Appeals, Appellate Division, New York, thirty-two cases are cited by one insurance company, with verdicts running from $40,000 to $9,500; thirteen are for $10,000; four from $12,000 to $12,500; six at $15,000; five from $21,000 to $25,000; and two for $40,000.

After Business. — The insurance companies naturally give the verdicts that are most likely to send the contractors on the run for policies, but allowing for all this, the matter ought not to be neglected.

The companies insure only for a limited amount per person injured, and for a limited total amount. If insurance is wanted against such extreme verdicts as for $40,000, then excess liability must be taken out. Contracting is a more dangerous business than some imagine. All the property a contractor has accumulated in the course of a lifetime might vanish in half an hour. This is why some of them grow fonder of their wives every year. She holds the "swag."

Big Business. — The great size of the liability insurance business is shown by the fact that in 1908 the sum of $22,711,547 was paid for premiums; and $11,670,222 for losses.

Construction Bonds. — An indemnity bond has usually to be given to the owner to secure him against liens, etc., and to make the fulfillment of the contract a certainty. Some owners go so far as to ask for a bond to the full amount of the contract, but this is most unreasonable. A bond for one-third, or even one-fourth is enough for a responsible builder. A government bond is usually for half of the contract price.

But even a responsible builder should remember that the erection of a building is purely a business proposition, and not get on his dignity when the owner or his agent, the architect, wishes to see if the money previously paid has been turned over to the dealers and subcontractors in the right proportion before issuing another order. When this is done, a large bond is not necessary.

When the subpayments are made as they should be, every day the owner becomes safer, until at the end he has a large bond for a reserve of often only ten per cent. of the cost. If a full bond is exacted he might have $100,000 of security on this, and, at the finish, 10 per cent. on the building itself, worth $10,000 more, we shall assume. Even this would be in his hands until the last payment. On this assumed building worth $100,000 he would thus, at the end, have security for $110,000 to see him through. There is no sense in a bond that is more than half the contract at most.

And if a bond is really worth anything at all why should there be any reserve? Does the bond not secure payments?

Who Pays. — The owner really has to pay for his own security, for the cost of the bond is added to the estimate, but the trouble comes with the bonding companies. They are more particular with a large than with a small bond. The builder has to tell how much property he has, if it is in his own name or his wife's, how much cash he has, and several other particulars. The contractor who might be able to take a good sized contract is debarred by the size of the bond, and the owner thus restricts the field to builders who charge a higher price for the work. He pays a higher price for the privilege of being extra safe.

Carefulness. — A bond of this kind should be made out to cover a certain job till it is finished, as some of the companies now want to collect an annual premium. From one per cent. to half that amount of the sum for which the bond is made out is charged.

Personal Bonds. — No one should now ask his friends to go on his bond for him. This used to be the fashion, and it was a bad one. There are companies organized for this purpose. It is unfair to expect your friends to risk their fortunes on your business arrangements while they get nothing in return. You could not pay them enough to cover the risk, but the operations of the companies are spread over a large territory, and a loss in one part is made up by gains in many other sections. A personal bondsman can sometimes fight himself out of liability in case of disaster, but there are too many cases where this has not been possible to make the risk desirable to anyone. It is like endorsing notes.

Back Bond. — One method the companies have is to ask for a back bond. They will furnish the main bond, which is larger than any private person would guarantee, but expect the contractor to sign agreements that they will hold the company clear of all damage. This enables the contractor to go ahead, but it is under the old personal bond arrangement. He has to pay the guaranty company, but if they are not satisfied with the risk under a straight bond, they should let it alone. Probably the contractor is taking a larger job than he should.

One disadvantage of having property in your wife's name is when asking for a bond, unless there is enough of your own as well. If a builder will not risk his own property, why should a bonding company risk theirs?

Mortgage. — The first bond I gave was a mortgage upon a cottage. It was thoughtlessly done, for if anything had gone wrong with the contract there might have been trouble with the title for years.

The largest one was for $40,000, or a little less than one-third of the contract.

CHAPTER XIX

HAND AND MACHINE LABOR

Early Days. — When machines were first introduced into the spinning mills and factories the workers rose and smashed them to pieces, and then hunted for the inventors. They fought the machine with brickbats and curses, but it was useless.

It is just about as useless for the building contractor of to-day to try to "buck" the machine in his line. It turns out the finished product almost as cheap as we can buy the raw material for. Robinson Crusoe had to make everything by hand; but why try to play R. C. in the midst of civilization? It costs too much. Wages are too high for that.

High Wages. — In cities as wages get higher machinery must be brought more and more into use. Brick, mortar, lumber, steel—all heavy building material will have to be taken up by steam or electric power in the future. Next to hanging a man, about the worst use you can make of him is to give him a hod full of brick or mortar and tell him to mount three stories with it. A contractor cannot always have machinery of his own, but in large cities he can often rent it.

Gradually as we get into better days, the rough work is being turned over to the electric motor. Even the surfacing of floors is now done in this way, and this one misery done away with.

Craftsmen. — Some of our "craftsmen" friends are taking Mr. Ruskin's advice and trying to get back to the old paths. They can neither mortise nor tenon so well as the machines can, and there is no more virtue in a hole dug in wood by hand than in one dug by machine.

Saw-Pits. — There are a few scattered around. Those who have seen them and the bent shouldered men who used to do the terrible work of sawing planks know that it was a good day when civilization was able to lay aside that R. C. way of doing work. John Stuart Mill sat in a library and penned an often quoted remark to the effect that it is doubtful if all of our inventions have lightened the toil of anyone. If his back had been bent over a saw-pit he would never have written such nonsense. Or if he had ever carried up brick in a hod for a month or two.

Planing-Mills. — As a rule, it does not pay a contractor to run a planing-mill. The expense of machinery for a good mill is heavy, and unless it can be kept continuously going, it is rather a poor investment in these days when the large mills turn out stock work at an astonishingly low price. If a contractor has enough special work to keep the mill going, and plenty of capital, there is a chance of making money.

Gasoline. — In some towns and villages where there is no planing-mill, a profitable investment is a kerosene, alcohol, or power engine of some kind, provided that there is no electric current that can be used at a cheap rate. All over the country farmers are investing in such engines, and are finding that it pays to use them for work formerly done by hand. Country carpenters would find them of great advantage.

Mixing Machines. — It is commonly agreed among architects and engineers that it is better to mix concrete by machine than by hand, although the hand method is cheaper on very small quantities. On large quantities the machine mixing is far cheaper.

Hoisting. — It is also far cheaper to hoist lumber and heavy materials by machine than by hand when above the second floor. The difficulty is to get a hoisting engine. A good many contractors now use an electric motor, and get their power from the local company or the city.

With portable saws, mixing machines, boring machines, floor-smoothing machines, and hoisting power, we live in an age of machinery. We may still use the sickle to cut the lawn, as it were, but the mowing machine beats it.

Waste. — One of the points of attack in all businesses now is the elimination of waste. Doing by hand what is cheaper and better done by machine is wasteful. The man with the machine is going to win in the long run.

Technical books, tables of weights, areas, dimensions, adding machines, and Uniform Contracts—all these are labor-saving inventions to be taken advantage of by those who will. Why should you figure out the area of a circle for yourself when it was done for you before you were born?

Proportion. — The following figures, principally relating to building work, show just about what the situation is. They are reliable and cost a good deal of money to collect, but I did not pay it. Here the time only is given to show the proportion of the two methods. In the 1910 edition of "The New Building Estimator," the quantities are given with the time to show cost of production for estimating purposes. The idea is to set forth the uselessness of "bucking" the machine in this chapter.

DESCRIPTION	HAND		MACHINE		PROPORTION
	Hrs.	Mins.	Hrs.	Mins.	
Making common brick..	20	36	7	30	3 to 1
" paving " ..	33	52	8	43	4 to 1
" sewer pipe	16	12	9	30	2 to 1
" " "	26	10	9	30	3 to 1
" sand and cement pipe	8	44	2	12	4 to 1
" granite balusters (pat'rns only)	41	23	9		4 to 1
" granite balusters turning by lathe	7,488	00	536	00	14 to 1
" granite balusters turning total time	8,303	23	653	26	13 to 1
Carving and tracing granite	228	00	126	20	2 to 1
Cutting marble column 16′ x 2′ diameter	338	35	321	15	
Dressing granite	225	00	15	00	15 to 1
" "	61	00	10	00	6 to 1
Lettering granite	31	30	22	30	
" "	11	15	9	00	

DESCRIPTION	HAND Hrs.	Mins.	MACHINE Hrs.	Mins.	PROPORTION
Polishing granite	90	00	9	00	10 to 1
" "	60	00	9	00	6 to 1
" marble	2	30	2	30	
" "	20	00	6	00	3 to 1
Sawing "	6,000	00	6	30	923 to 1
Cutting sandstone windowsills	79	10	23	24	3 to 1
Stone breaking	650	00	10	00	65 to 1
" drilling	30	00	1	22	22 to 1
" "	89	10	14	50	6 to 1
Granite drilling	504	00	131	00	4 to 1
Loading gravel					11 to 1

WOODWORK

DESCRIPTION	HAND Hrs.	Mins.	MACHINE Hrs.	Mins.	PROPORTION
Making oak bookcases ..	654	00	157	14	4 to 1
" " " ..	480	00	43	12	10 to 1
Cutting same for locks.	6	00	0	11	33 to 1
Making bureaus	443	00	108	00	4 to 1
Sideboards	970	00	182	30	5 to 1
Making outside window blinds	462	30	114	40	4 to 1
Making outside window blinds	695	50	56	40	12 to 1
Making oak brackets ...	196	00	63	30	3 to 1
Making pine brackets ..	27	50	3	25	9 to 1
Making veneered doors .	1,385	00	510	00	2½ to 1
Making four-panel oak doors	702	30	131	00	6 to 1
Making four-panel pine doors	484	00	193	00	2½ to 1
Planing lumber					30 to 1
" "					80 to 1
Making sash	300	00	21	15	15 to 1
" "	400	00	37	20	11 to 1
" "	312	30	30	30	10 to 1
" window screens.	70	50	16	00	4 to 1
" ladders, 30-ft ..	103	15	46	25	2 to 1
" stepladders	58	30	14	10	4 to 1

DESCRIPTION	HAND Hrs.	Mins.	MACHINE Hrs.	Mins.	PROPORTION
Sawing logs	64	00	2	00	32 to 1
" "	96	30	2	45	38 to 1
" " 100,000 ft. B. M...	15,000	00	40	00	375 to 1
Splitting kindling wood.	40	00	3	52	11 to 1

PIPEWORK

Cutting and threading 3″ pipe	100	00	6	40	15 to 1
Tapping and threading pipe	26	40	1	05	25 to 1

BOOK II

THE CONTRACTOR AS A CONSTRUCTOR

CHAPTER I

WEIGHTS, MEASURES, AND THEIR USE

For Whom Intended. — The tables in this chapter are arranged for contractors, and are not so near perfection as some we know of. Decimals are left out where they are not really required; "reciprocals" are never used in contracting, and are therefore not printed here; and other changes are made from the orthodox lists.

Specialists. — It must be remembered that a contractor is not a trained architect, and still less an engineer. But, conversely, it is well to bear in mind, at the same time, that the architect is not a building contractor, and the engineer still less so.

The contractor is sometimes trained to do architectural and engineering work of a plain nature, and architects and engineers occasionally engage in the business of contracting, but in general the spheres are practically distinct, and what is required for the one is useless for the other. What has a builder to do with logarithms or trigonometry or the refinements of the various styles of architecture? The ground comes to him "surveyed, platted, and recorded," and the plans and specifications are delivered with orders to go ahead. He has troubles enough of his own without taking those of other men on his shoulders.

It is all well enough, and desirable enough, if he understands the principles upon which the designs he works from are based, but not really necessary. The architect will look after that end of the common task. The contractor's part is merely to realize the brilliant dream in stone or other "rough materialistic" things of that kind.

WEIGHTS AND MEASURES

LONG MEASURE

Inches						
12=	1 foot					
36=	3 =	1 yard				
72=	6 =	2 =	1 fathom			
198=	16.5=	5.5=	2.75=	1 perch or rod		
7920=	660 =	220 =	110 =	40=	1 furlong	
63360=	5280 =	1760 =	880 =	320=	8=	1 mile

SQUARE MEASURE

Inches					
144=	1 foot				
1296=	9=	1 yard			
39204=	272.25=	30.25=	1 perch		
1568160=	10890 =	1210 =	40=	1 rood	
6272640=	43560 =	4840 =	160=	4=	1 acre

An acre is 69.5701 yards square; or, 208.710321 feet square

A township	is 6 miles square	=	36 sections
" section	" 1 " "	=	640 acres
¼ "	" ½ " "	=	160 "
1-16 "	" ¼ " "	=	40 "

SOLID MEASURE

Cubic inches		
1728 =	1 cubic foot	
46656 =	27 =	1 cubic yard

DRY MEASURE

Pints = 33.6 cubic inches

2 =	1 quart = 67.2 cubic inches				
8 =	4 =	1 gallon = 268.8 cubic inches			
16 =	8 =	2 =	1 peck = 537.6 cubic inches		
64 =	32 =	8 =	4 =	1 bushel	

Note. — The standard U. S. bushel is the *Winchester* bushel, which is in cylinder form 18½ in. diameter and 8 in. deep, and contains 2150 42-100 cubic inches.

The English Imperial bushel	=	2218.192 cubic inches 1.03152 U. S. bushels
The English quarter	=	8 Imperial bushels 8¼ (nearly) U. S. bu. 10.2694 cubic feet

MEASURE OF SURFACE

144	sq. inches	=	1 sq. foot
9	sq. feet	=	1 sq. yard
30¼	sq. yards	=	1 sq. rod
40	sq. rods	=	1 rood
4	roods	=	1 acre
10	sq. chains	=	1 acre
640	acres	=	1 sq. mile

MEASURE OF SOLIDITY

1728	cubic in.	=	1 cubic foot
27	cubic ft.	=	1 cubic yard

LIQUID MEASURE

4	gills	make	1 pint
2	pints	"	1 quart
4	quarts	"	1 gallon
31½	gallons	"	1 barrel

WEIGHTS

One Cubic inch of Cast Iron,	weighs .	0.26 pounds
One Cubic inch of Wrought Iron,	" .	0.28 "
One Cubic inch of Water,	" .	0.036 "
One U. S. Gallon,	" .	8.33 "
One Imperial Gallon,	" .	10.00 "
One U. S. Gallon,	equals .	231.00 cubic inches
One Imperial Gallon,	" .	277.274 " "
One Cubic foot of Water,	" .	7.48 U. S. gallons
One Pound of Steam,	" .	27.222 cubic feet
One Pound of Air,	" .	13.817 " "

RULES FOR OBTAINING APPROXIMATE WEIGHT OF IRON

For Round Bars

Rule.—Multiply the square of the diameter in inches by the length in feet, and that product by 2.6. The product will be the weight in pounds, nearly.

For Square and Flat Bars

Rule.—Multiply the area of the end of the bar in inches by the length in feet, and that by 3.32. The product will be the weight in pounds, nearly.

Wrought iron, usually assumed:

A cubic foot	=	480 lbs.
A square foot, 1 inch thick	=	40 "
A bar 1 inch square, 1 foot long	=	$3\frac{1}{3}$ "
A " " " 1 yard long	=	10 "

To find the weight of Cast Iron Balls when the diameter is given.

Rule. — Multiply the cube of the diameter by .1377.

To find the diameter of Cast Iron Balls when the weight is given.

Rule. — Multiply the cube root of the weight by 1.936.

To find the weight of a Spherical Shell.

From the weight of a ball of the outer diameter subtract the weight of one of the inner diameters.

To convert the weight of

Wrought	Iron	into	Cast Iron	×	0.928
"	"	"	Steel	×	1.014
"	"	"	Zinc	×	0.918
"	"	"	Brass	×	1.082
"	"	"	Copper	×	1.144
"	"	"	Lead	×	1.468

DECIMAL APPROXIMATIONS USEFUL IN CALCULATIONS

Cubic	inches	×	.263	=	lbs. av.	cast iron
"	"	×	.281	=	"	wrought iron
"	"	×	.283	=	"	cast steel
"	"	×	.3225	=	"	copper
"	"	×	.3037	=	"	brass
"	"	×	.26	=	"	zinc
"	"	×	.4103	=	"	lead
"	"	×	.2636	=	"	tin
"	"	×	.4908	=	"	mercury
Cylin.	"	×	.2065	=	"	cast iron
"	"	×	.2168	=	"	wrought iron
"	"	×	.2223	=	"	cast steel
"	"	×	.2533	=	"	copper
"	"	×	.2385	=	"	brass
"	"	×	.2042	=	"	zinc
"	"	×	.3223	=	"	lead
"	"	×	.207	=	"	tin
"	"	×	.3854	=	"	mercury

SPECIFIC GRAVITIES

Cast Iron, average	7.21	Cast Steel, average	7.85
Wrought Iron "	7.78	Bessemer Steel "	7.86

Light iron indicates impurity. The heaviest steel contains least carbon.

Decimal equivalents of 8ths, 16ths, 32s, and 64ths of an inch.

Fractions of an inch.		Decimals of an inch.	Fractions of an inch.		Decimals of an inch.
1-64	=	.015625	33-64	=	.515625
1-32	=	.03125	17-32	=	.53125
3-64	=	.046875	35-64	=	.546875
1-16	=	.0625	9-16	=	.5625
5-64	=	.078125	37-64	=	.578125
3-32	=	.09375	19-32	=	.59375
7-64	=	.109375	39-64	=	.609375
⅛	=	.125	⅝	=	.625
9-64	=	.140625	41-64	=	.640625
5-32	=	.15625	21-32	=	.65625
11-64	=	.171875	43-64	=	.671875
3-16	=	.1875	11-16	=	.6875
13-64	=	.203125	45-64	=	.703125
7-32	=	.21875	23-32	=	.71875
15-64	=	.234375	47-64	=	.734375
¼	=	.25	¾	=	.75
17-64	=	.265625	49-64	=	.765625
9-32	=	.28125	25-32	=	.78125
19-64	=	.296875	51-64	=	.796875
5-16	=	.3125	13-16	=	.8125
21-64	=	.328125	53-64	=	.828125
11-32	=	.34375	27-32	=	.84375
23-64	=	.359375	55-64	=	.859375
⅜	=	.375	⅞	=	.875
25-64	=	.390625	57-64	=	.890625
13-32	=	.40625	29-32	=	.90625
27-64	=	.421895	59-64	=	.921875
7-16	=	.4375	15-16	=	.9375
29-64	=	.453125	61-64	=	.953125
15-32	=	.46875	31-32	=	.96875
31-64	=	.484375	63-64	=	.984375
½	=	.5			

DECIMALS OF A FOOT FOR EACH 1/32 OF AN INCH

Inches	0"	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"
0	0	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
1/32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
3/32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245
1/8	.0104	.0937	.1771	.2604	.3437	.4271	.5104	.5937	.6771	.7604	.8437	.9271
5/32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
7/32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
9/32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
11/32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453
3/8	.0312	.1146	.1979	.2812	.3646	.4479	.5312	.6146	.6979	.7812	.8646	.9479
13/32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
15/32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
17/32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
19/32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
21/32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
23/32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792
25/32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
27/32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870
7/8	.0729	.1562	.2396	.3229	.4062	.4896	.5729	.6562	.7396	.8229	.9062	.9896
29/32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948
31/32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974
1												1.0000

Example.—To use decimals of a foot table. Suppose we want to multiply 3 feet 2½ inches by 8 feet 6¾ inches. In the table we find that 2½ equals .0283, and 6¾, .5625. We therefore multiply 3.0283 by 8.5625 for the exact figure.

DECIMAL EQUIVALENTS OF OUNCES AND POUNDS

Oz.	Lbs.	Oz.	Lbs.	Oz.	Lbs.
¼	= .015625	4	= .25	8½	= .5313
½	= .03125	4½	= .2813	9	= .5625
¾	= .046875	5	= .3125	10	= .625
1	= .0625	5½	= .3438	11	= .6875
1½	= .09375	6	= .375	12	= .75
2	= .125	6½	= .4063	13	= .8125
2½	= .15625	7	= .4375	14	= .875
3	= .1875	7½	= .4688	15	= .9375
3½	= .21875	8	= .5	16	=1.

DECIMAL EQUIVALENTS OF INCHES, FEET, AND YARDS

Frac. of an Inch.	Dec. of an Inch.	Dec. of a Foot.	Ins.	Feet.	Yds.
1-16	= .0625	= .00521	1	= .0833	= .0277
⅛	= .125	= .01041	2	= .1666	= .0555
3-16	= .1875	= .01562	3	= .25	= .0833
¼	= .25	= .02083	4	= .3333	= .1111
5-16	= .3125	= .02604	5	= .4166	= .1389
⅜	= .375	= .03125	6	= .5	= .1666
7-16	= .4375	= .03645	7	= .5833	= .1944
½	= .5	= .04166	8	= .666	= .2222
9-16	= .5625	= .04688	9	= .75	= .25
⅝	= .625	= .05208	10	= .8333	= .2778
11-16	= .6875	= .05729	11	= .9166	= .3055
¾	= .75	= .06250	12	=1.	= .3333
13-16	= .8125	= .06771			
⅞	= .875	= .07291			

USEFUL NUMBERS

Lineal feet,	× .00019	=miles
" yards,	× .0006	= "
Square inches,	× .007	=square feet
" feet,	× .111	= " yards
" yards,	× .0002067	=acres
Acres,	× .4840	=square yards
Cubic inches,	× .00058	=cubic feet
" feet,	× .03704	= " yards
Links,	× .22	=yards
"	× .66	=feet
Feet,	×1.5	=links
Width in chains,	×8.	=acres per mile
Cubic feet,	×7.48	=U. S. gallons
" inches,	× .004329	= " "
U. S. gallons,	× .13367	=cubic feet
" "	×231.	= " inches
Cubic feet,	× .8036	=U. S. bushel
" inches,	× .000466	= " "
U. S. bushel,	× .0495	=cubic yards
" "	×1.2446	= " feet
" "	×2150.42	= " inches

Pounds avoirdupois,	× .009	=cwt. (112)
" "	× .00045	=tons (2240)
Cubic feet of water,	×62.5	=lbs. avoir.
Cubic inches of water,	× .03617	= " "
13.44 U. S. gallons of water,		=1 cwt.
268.8 " " " "		=1 ton
1.8 cubic feet of water,		=1 cwt.
35.88 " " " "		=1 ton
Column of water 12 in. high, 1 inch diameter,		=.341 pounds

MENSURATION

Area of a triangle = base × ½ altitude.

Area of a parallelogram = base × altitude.

Area of a trapezoid = altitude × ½ the sum of parallel sides.

Area of a trapezium = divide into two triangles and find area of the triangles.

Circumference of circle = diameter × 3.1416.

Diameter of circle = circumference × .3183.

Area of circle = diameter² × .7854.

Area of sector of circle = length of arc × ½ the radius.

Area of segment of circle = area of sector of equal radius,—area of triangle, when the segment is less, and + area of triangle, when the segment is greater than the semi-circle.

Area of circular ring = diameters of the two circles × difference of diameter and that product by .7854.

Side of square that shall equal area of circle = diameter × .8862, or circumference × .2821.

Diam. of circle that shall contain area of a given square = side of square × 1.1284.

Area of an eclipse = product of the two diameters × .7854.

Area of parabola = base × ⅔ altitude.

Area of regular polygon = sum of its sides × perpendicular from its center to one of its sides ÷ 2.

Surface of cylinder or prism	=	area of both ends + length × circumference.
Contents of cylinder or prism	=	area of end × length.
Surface of sphere	=	diameter × circumference.
Contents of sphere	=	diameter^3 × .5236.
Convex surface of segment of sphere	=	height of segment × circumference of sphere of which it is a part.
Contents of segment of sphere	=	(height^2 + three times the square of radius of base) × (height × .5236).
Surface of pyramid or cone	=	circumference of base × ½ of the slant height + area of the base.
Contents of pyramid or cone	=	area of base × ⅓ altitude.
Surface of frustum of cone or pyramid	=	sum of circumference at both end × ½ slant height + area of both ends.
Contents of frustum of cone or pyramid	=	multiply areas of two ends together and extract square root. Add to this root the two areas and × ⅓ altitude.
Contents of a wedge	=	area of base × ½ altitude.

Areas of Circles

Size	Area	Size	Area
1/8	0 0123	9	63.617
1/4	0 0491	1/2	70 882
3/8	0.1104	10	78 54
1/2	0.1963	1/2	86.59
5/8	0.3067	11	95 03
3/4	0.4417	1/2	103.86
7/8	0.6013	12	113.09
1	0.7854	1/2	122.71
1/8	0.9940	13	132 73
1/4	1.227	1/2	143 13
3/8	1.484	14	153 93
1/2	1.767	1/2	165.13
5/8	2.073	15	176.71
3/4	2.405	1/2	188.69
7/8	2.761	16	201.06
2	3.141	1/2	213.82
1/4	3.976	17	226.98
1/2	4.908	1/2	240.52
3/4	5.939	18	254.46
3	7 068	1/2	268 80
1/4	8 295	19	283 52
1/2	9.621	1/2	298.64
3/4	11.044	20	314 16
4	12.566	1/2	330.06
1/2	15.904	21	346.36
5	19.635	1/2	363.05
1/2	23.758	22	380.13
6	26.274	1/2	397.60
1/2	33.183	23	415.47
7	38.484	1/2	433.73
1/2	44.178	24	452.39
8	50 265	1/2	471.43
1/2	56.745		

Circumference of Circles

Size	Circumference	Size	Circumference
1/8	.3927	9	28.274
1/4	.7854	1/2	29.845
3/8	1.1781	10	31.416
1/2	1.5708	1/2	32.987
5/8	1.9635	11	34.558
3/4	2.3562	1/2	36.128
7/8	2.7489	12	37 699
1	3 1416	1/2	39.270
1/8	3 5343	13	40.841
1/4	3.9270	1/2	42.412
3/8	4.3197	14	43.982
1/2	4.7124	1/2	45.553
5/8	5.1051	15	47.124
3/4	5.4978	1/2	48.695
7/8	5.8905	16	50.265
2	6.2832	1/2	51.836
1/4	7.0686	17	53.407
1/2	7.8540	1/2	54.978
3/4	8.6394	18	56.549
3	9.4248	1/2	58 119
1/4	10.210	19	59.690
1/2	10.996	1/2	61.261
3/4	11.781	20	62.832
4	12.566	1/2	64.403
1/2	14 137	21	65 973
5	15.708	1/2	67.544
1/2	17.279	22	69.115
6	18 850	1/2	70 686
1/2	20 420	23	72.257
7	21 991	1/2	73.827
1/2	23 562	24	75.398
8	25.133	1/2	76.969
1/2	26.704		

To find diameter of a circle when circumference is given, multiply the given circumference by .31831.

To find the circumference of a circle when diameter is given, multiply the given diameter by 3.1416.

CIRCUMFERENCES AND AREAS OF CIRCLES

Diam	Circum	Area	Diam	Circum	Area
1	3.1416	.7854	64	201.06	3216.99
2	6.2832	3.1416	65	204.20	3318.31
3	9.4248	7.0686	66	207.34	3421.19
4	12.5664	12.5664	67	210.49	3525.65
5	15.7080	19.635	68	213.63	3631.68
6	18.850	28.274	69	216.77	3739.28
7	21.991	38.485	70	219.91	3848.45
8	25.133	50.266	71	223.05	3959.19
9	28.274	63.617	72	226.19	4071.50
10	31.416	78.540	73	229.34	4185.39
11	34.558	95.033	74	232.48	4300.84
12	37.699	113.1	75	235.62	4417.86
13	40.841	132.73	76	238.76	4536.46
14	43.982	153.94	77	241.90	4656.63
15	47.124	176.71	78	245.04	4778.36
16	50.265	201.06	79	248.19	4901.67
17	53.407	226.98	80	251.33	5026.55
18	56.549	254.47	81	254.47	5153.
19	59.690	283.53	82	257.61	5281.02
20	62.832	314.16	83	260.75	5410.61
21	65.973	346.36	84	263.89	5541.77
22	69.115	380.13	85	267.04	5674.50
23	72.257	415.48	86	270.18	5808.80
24	75.398	452.39	87	273.32	5944.68
25	78.540	490.87	88	276.46	6082.12
26	81.681	530.93	89	279.60	6221.14
27	84.823	572.56	90	282.74	6361.73
28	87.965	615.75	91	285.88	6503.88
29	91.106	660.52	92	289.03	6647.61
30	94.248	706.86	93	292.17	6792.91
31	97.389	754.77	94	295.31	6939.78
32	100.53	804.25	95	298.45	7088.22
33	103.67	855.30	96	301.59	7238.23
34	106.81	907.92	97	304.73	7339.81
35	109.96	962.11	98	307.88	7542.96
36	113.10	1017.88	99	311.02	7697.69
37	116.24	1075.21	100	314.16	7853.98
38	119.38	1134.11	101	317.30	8011.85
39	122.52	1194.59	102	320.44	8171.28
40	125.66	1256.64	103	323.58	8332.29
41	128.81	1320.25	104	326.73	8494.87
42	131.95	1385.44	105	329.87	8659.01
43	135.09	1452.20	106	333.01	8824.73
44	138.23	1520.53	107	336.15	8992.02
45	141.37	1590.43	108	339.29	9160.88
46	144.51	1661.90	109	342.43	9331.32
47	147.65	1734.94	110	345.58	9503.32
48	150.80	1809.56	111	348.72	9676.89
49	153.94	1885.74	112	351.86	9852.03
50	157.08	1963.50	113	355.	10028.75
51	160.22	2042.82	114	358.14	10207.03
52	163.36	2123.72	115	361.28	10386.89
53	166.50	2206.18	116	364.42	10568.32
54	169.65	2290.22	117	367.57	10751.32
55	172.79	2375.83	118	370.71	10935.88
56	175.93	2463.01	119	373.85	11122.02
57	179.07	2551.76	120	376.99	11309.73
58	182.21	2642.08	121	380.13	11499.01
59	185.35	2733.97	122	383.27	11689.87
60	188.50	2827.43	123	386.42	11882.29
61	191.64	2922.47	124	389.56	12076.28
62	194.78	3019.07	125	392.70	12271.85
63	197.92	3117.25	126	395.84	12468.98

U. S. GALL IN ROUND TANKS

For One Ft in Depth

Diam of Tanks	No. U. S. Gall	CF and Area in SF	Diam of Tanks	No. U. S. Gall	CF and Area in SF	Diam of Tanks	No. U. S. Gall	CF and Area in SF
1′	5.87	.785	5′ 8″	188.66	25.22	19′	2120.90	283.53
1′ 1″	6.89	.922	5′ 9″	194.25	25.97	19′ 3″	2177.10	291.04
1′ 2″	8.	1.069	5′ 10″	199.92	26.73	19′ 6″	2234.	298.65
1′ 3″	9.18	1.227	5′ 11″	205.67	27.49	19′ 9″	2291.70	306.35
1′ 4″	10.44	1.396	6′	211.51	28.27	20′	2350.10	314.16
1′ 5″	11.79	1.576	6′ 3″	229.50	30.68	20′ 3″	2409.20	322.06
1 6″	13.22	1.767	6′ 6″	248.23	33.18	20′ 6″	2469.10	330.06
1′ 7″	14.73	1.969	6′ 9″	267.69	35.78	20′ 9″	2529.60	338.16
1′ 8″	16.32	2.182	7′	287.88	38.48	21′	2591.	346.36
1 9″	17.99	2.405	7′ 3″	308.81	41.28	21′ 3″	2653.	354.66
1′ 10″	19.75	2.640	7′ 6″	330.48	44.18	21′ 6″	2715.80	363.05
1′ 11″	21.58	2.885	7′ 9″	352.88	47.17	21′ 9″	2779.30	371.54
2′	23.50	3.142	8′	376.01	50.27	22′	2843.60	380.13
2′ 1″	25.50	3.409	8′ 3″	399′88	53.46	22′ 3″	2908.60	388.82
2′ 2″	27.58	3.687	8′ 6″	424.48	56.75	22′ 6″	2974.30	397.61
2′ 3″	29.74	3.976	8′ 9″	449.82	60.13	22′ 9″	3040.80	406.49
2′ 4″	31.99	4.276	9′	475.89	63.62	23′	3108.	415.48
2′ 5″	34.31	4.587	9′ 3″	502.70	67.20	23′ 3″	3175.90	424.56
2′ 6″	36.72	4.909	9′ 6″	530.24	70.88	23′ 6″	3244.60	433.74
2′ 7″	39.21	5.241	9′ 9″	558.51	74.66	23′ 9″	3314.	443.01
2′ 8″	41.78	5.585	10′	587.52	78.54	24′	3384.10	452.39
2′ 9″	44.43	5.940	10′ 3″	617.26	82.52	24′ 3″	3455.	461.86
2′ 10″	47.16	6.305	10′ 6″	640.74	86.59	24′ 6″	3526.60	471.44
2′ 11″	49.98	6.681	10′ 9″	678.95	90.76	24′ 9″	3598.90	481.11
3′	52.88	7.069	11′	710.90	95.03	25′	3672.	490.87
3′ 1″	55.86	7.467	11′ 3″	743.58	99.40	25′ 3″	3745.80	500.74
3′ 2″	58.92	7.876	11′ 6″	776.99	103.87	25′ 6″	3820.30	510.71
3′ 3″	62.06	8.296	11′ 9″	811.14	108.43	25′ 9″	3895.60	520.77
3′ 4″	65.28	8.727	12′	846.03	113.10	26′	3971.60	530.93
3′ 5″	68.58	9.168	12′ 3″	881.65	117.86	26′ 3″	4048.40	541.19
3′ 6″	71.97	9.621	12′ 6″	918.	122.72	26′ 6″	4125.90	551.55
3′ 7″	75.44	10.085	12′ 9″	955.09	127.68	26′ 9″	4204.10	562.
3′ 8″	78.99	10.559	13′	992.91	132.73	27′	4283.	572.66
3′ 9″	82.62	11.045	13′ 3″	1031.50	137.89	27′ 3″	4362.70	583.21
3′ 10″	86.33	11.541	13′ 6″	1070.80	143.14	27′ 6″	4443.10	593.96
3′ 11″	90.13	12.048	13′ 9″	1110.80	148.49	27′ 9″	4524.30	604.81
4′	94.	12.566	14′	1151.50	153.94	28′	4606.20	615.75
4′ 1″	97.96	13.095	14′ 3″	1193.	159.48	28′ 3″	4688.80	626.80
4′ 2″	102.	13.635	14′ 6″	1235.30	165.13	28′ 6″	4772.10	637.94
4′ 3″	106.12	14.186	14′ 9″	1278.20	170.87	28′ 9″	4856.20	649.18
4′ 4″	110.32	14.748	15′	1321.90	176.71	29′	4941.	660.52
4′ 5″	114.61	15.321	15′ 3″	1366.40	182.65	29′ 3″	5026.60	671.96
4′ 6″	118.97	15.90	15′ 6″	1411.50	188.69	29′ 6″	5112.90	683.49
4′ 7″	123.42	16.50	15′ 9″	1457.40	194.83	29′ 9″	5199.90	695.13
4′ 8″	127.95	17.10	16′	1504.10	201.06	30′	5287.70	706.86
4′ 9″	132.56	17.72	16′ 3″	1551.40	207.39	30′ 3″	5376.20	718.69
4′ 10″	137.25	18.35	16′ 6″	1599.50	213.82	30′ 6″	5465.40	730.62
4′ 11″	142.02	18.99	16′ 9″	1648.40	220.35	30′ 9″	5555.40	742.64
5′	146.88	19.63	17′	1697.90	226.98	31′	5646.10	754.77
5′ 1″	151.82	20.29	17′ 3″	1748.20	233.71	31′ 3″	5737.50	766.99
5′ 2″	156.83	20.97	17′ 6″	1799.30	240.53	31′ 6″	5829.70	779.31
5′ 3″	161.93	21.65	17′ 9″	1851.10	247.45	31′ 9″	5922.60	791.73
5′ 4″	167.12	22.34	18′	1903.60	254.47	32′	6016.20	804.25
5′ 5″	172.38	23.04	18′ 3″	1956.80	261.59	32′ 3″	6110.60	816.86
5′ 6″	177.72	23.76	18′ 6″	2010.80	268.80	32′ 6″	6205.70	829.58
5′ 7″	183.15	24.48	18′ 9″	2065.50	276.12	32′ 9″	6301.50	842.39

31½ Gall to 1 Bbl

To find the capacity of tanks greater than the largest given in the table, look in the table for a tank of one-half of the given size and mult its capacity by 4, or one of one-third its size and mult its capacity by 9, etc.

NUMBER OF U. S. GALL IN RECTANGULAR TANKS

For One Ft in Depth

Width of Tank	Length of Tank																				
Ft In	ft 2	ft in 2 6	ft 3	ft in 3 6	ft 4	ft in 4 6	ft 5	ft in 5 6	ft 6	ft in 6 6	ft 7	ft in 7 6	ft 8	ft in 8 6	ft 9	ft in 9 6	ft 10	ft in 10 6	ft 11	ft in 11 6	ft 12
2	29.82	37.40	44.88	52.36	59.84	67.32	74.81	82.29	89.77	97.25	104.73	112.21	119.69	127.17	134.65	142.13	149.61	157.09	164.57	172.05	179.53
2 6		46.75	56.10	65.45	74.80	84.16	93.51	102.86	112.21	121.56	130.91	140.26	149.61	158.96	168.31	177.66	187.01	196.36	205.71	215.06	224.41
3			67.32	78.54	89.77	100.99	112.21	123.43	134.65	145.87	157.09	168.31	179.53	190.75	202.97	213.19	224.41	235.63	245.86	258.07	269.30
3 6				91.64	104.73	117.82	130.91	144.00	157.09	170.18	183.27	196.36	209.45	222.54	235.63	248.73	261.82	274.90	288.00	301.09	314.18
4					119.69	134.65	149.61	164.57	179.53	194.49	209.45	224.41	239.37	254.34	269.30	284.26	299.22	314.18	329.14	344.10	359.06
4 6						151.48	168.31	185.14	201.97	218.80	235.63	252.47	269.30	286.13	302.96	319.79	336.62	353.45	370.28	387.11	403.94
5							187.01	205.71	224.41	243.11	261.82	280.52	299.22	317.92	336.62	355.32	374.03	392.72	411.43	430 13	448.83
5 6								226.28	246.86	267.43	288.00	308.57	329.14	349.71	370.28	390.85	411.43	432.00	452.57	473.14	493.71
6									269.30	291.74	314.18	336.62	359.06	381.50	403.94	426.39	448.83	471.27	493.71	516.15	538.59
6 6										316.05	340.36	364.67	388.98	413.30	437.60	461.92	486.23	510.54	534.85	559.16	583.47
7											366.54	392.72	418.91	445.09	471.27	497.45	523.64	549.81	575.99	602.18	628.36
7 6												420.78	448.83	476.88	504.93	532.98	561.04	589.08	617.14	645.19	673.24
8													478.75	508.67	538.59	568.51	598.44	628.36	658.28	688.20	718.12
8 6														540.46	572.25	604.05	635.84	667.63	699.42	731.21	763.00
9															605.92	639.58	673.25	706.90	740.56	774.23	807.89
9 6																675.11	710.65	746.17	781.71	817.24	852.77
10																	748.05	785.45	822.86	860.26	897.66
10 6																		824.73	864.00	903.26	942.56
11																			905.14	946.27	987.43
11 6																				989.29	1032.3
12																					1077.2

WEIGHT OF FLAT BAR IRON PER LF

Width in In.	Thickness in In.											
	1/16	⅛	3/16	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
1.....	.21	.42	.63	.84	1.05	1.26	1.47	1.68	2.11	2.53	2 95	3.37
1⅛....	.24	.47	.71	.95	1.18	1.42	1.66	1.90	2.37	2.84	3.32	3.79
1¼....	.26	.53	.79	1.05	1.32	1.58	1.84	2.11	2 63	3.16	3.68	4.21
1⅜....	.29	.58	.87	1.16	1.45	1.74	2.03	2 32	2.89	3.47	4.05	4.63
1½....	.32	.63	.95	1.26	1.58	1.90	2.21	2.53	3.16	3.79	4.42	5.05
1⅝....	.34	.68	1.03	1.37	1.71	2.05	2.39	2.74	3.42	4.11	4.79	5.47
1¾....	.37	.74	1.11	1.47	1.84	2.21	2.58	2.95	3.68	4.42	5.16	5.89
1⅞....	.40	.79	1.18	1.58	1.97	2.37	2.76	3.16	3.95	4.74	5.53	6.32
2	.42	.84	1.26	1.68	2.11	2.53	2.95	3.37	4.21	5.05	5.89	6.74
2⅛....	.45	.90	1.34	1.79	2.24	2.68	3.13	3.58	4.47	5.37	6.26	7.16
2¼....	.47	.95	1.42	1.90	2.37	2.84	3.32	3.79	4.74	5.68	6.83	7.58
2⅜....	.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	5.00	6.00	7.00	8.00
2½....	.53	1.05	1.58	2.11	2.63	3.16	3.68	4.21	5.26	6.32	7.37	8.42
2⅝....	.55	1.11	1.66	2.21	2.76	3.32	3.87	4.42	5.53	6.63	7.74	8.84
2¾....	.58	1.16	1.74	2.32	2.89	3.47	4.05	4.63	5.79	6.95	8.10	9.26
3	.63	1.26	1.90	2.5	3.16	3.79	4.42	5.05	6.32	7.58	8.84	10.10
3¼....	.68	1.37	2.05	2.74	3.42	4.11	4.79	5.47	6.84	8.21	9.58	10.95
3½....	.74	1.47	2.21	2.95	3.68	4.42	5.16	5.89	7.37	8.84	10.32	11.79
4	.84	1.68	2.53	3.37	4.21	5.05	5.89	6.74	8.42	10.10	11.79	13.47
4½....	.95	1.90	2.84	3.79	4.74	5.68	6.63	7.58	9.47	11.38	13.26	15.16
5	1.0	2.11	3.16	4.21	5.26	6.32	7.37	8.42	10.53	12.63	14.74	16.84
5½....	1.16	2.32	3.47	4.63	5.79	6.95	8.10	9.26	11.58	13.89	16.21	18.52
6.... .	1.26	2.53	3.79	5.05	6.32	7.58	8.84	10.10	12.63	15.16	17.68	20.21
6½....	1.36	2.73	4.10	5.47	6.84	8.21	9.58	10.94	13.68	16.42	19.16	21.88
7	1.47	2.94	4.42	5.90	7.36	8.84	10.32	11.79	14.74	17.68	20.64	23.58
7½....	1.58	3.16	4.74	6.32	7.90	9.48	11.06	12.64	15.78	18.94	21.11	25.50
8	1.68	3.36	5.05	6.74	8.42	10.10	11.78	13.48	16.84	20.20	23.58	26.34
8½....	1.79	3.58	5.36	7.16	8.94	10.74	12.52	14.32	17.90	21.48	25.06	28.53
9	1.90	3.79	5.68	7.58	9 48	11.36	13.26	15.16	18.95	22.75	26.52	30.32
9½....	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	20.00	24.00	28.00	32.00
10	2.10	4.21	6.32	8.42	10.52	12.64	14.74	16.84	21.05	25.26	29.48	33.68
10½....	2.21	4.41	6.64	8.84	11.05	13.26	15.48	17.68	22.10	26.52	30.95	35.36
11	2.32	4.64	6.95	9.26	11.58	13.90	16.21	18.52	23.16	27.78	32.42	37.04
11½....	2 42	4.84	7.26	9.68	12.10	14.52	16.94	19.36	24.20	29.06	33.90	38.74
12	2.52	5.05	7.58	10.00	12.64	15.16	17.68	20.20	25.26	30.32	35.36	40.40

WEIGHTS AND DIMENSIONS OF ROUND AND SQ BAR IRON PER RUNNING FT IN LBS

Diam	Wt per ft, lbs		Diam	Wt per ft, lbs		Diam	Wt per ft, lbs		Diam	Wt per ft, lbs	
In	Rd	Sq	In	Rd	Sq	In	Rd	Sq	In	Rd	Sq
1/16..	.01	.0131	1 1/16..	2.975	3.80	2⅛...	11 9	15.15	4⅛...	44.85	57.2
⅛...	.0411	.0525	1⅛...	3.338	4.25	2¼...	13 3	17.	4¼...	47.54	60.75
3/16..	.0925	.1182	1 3/16..	3.725	4.73	2⅜...	14.75	18 5	4⅜...	50.33	64.35
¼...	.1651	.2103	1¼...	4.12	5.25	2½...	16.41	20.5	4½...	53.32	68.
5/16..	.2573	.3200	1 5/16..	4.545	5.78	2⅝...	18.1	23 1	4⅝...	56.34	72.
⅜...	.371	.4735	1⅜...	5.	6.35	2¾...	19.85	25.2	4¾...	59.44	75.65
7/16..	.505	.6445	1 7/16..	5.455	6.95	2⅞...	21.5	27 5	4⅞...	62.62	79.80
½...	.657	.84	1½...	5.945	7.55	3 ...	23.7	30.05	5 ...	65.88	83.8
9/16..	.835	1.063	1 9/16..	6.445	8 2	3⅛...	25.55	32.75	5⅛...	69.23	88.25
⅝...	1.031	1.314	1⅝...	6 975	8.85	3¼...	27.81	35.5	5¼...	72.65	92.5
11/16..	1 235	1.59	1 11/16..	7.52	9.57	3⅜...	29.85	38.25	5⅜...	76.18	97.15
¾...	1.475	1.891	1¾...	8.05	10.30	3½...	32.25	41.15	5½...	79 75	101.
13/16..	1.74	2.221	1 13/16..	8.65	11.05	3⅝...	34.45	44.15	5⅝...	83.45	105.8
⅞...	2.015	2.575	1⅞...	9.25	11.83	3¾...	37 1	47.20	5¾...	87.20	110.5
15/16..	2 317	2.95	1 15/16..	9.9	12.62	3⅞...	39.5	50.25	5⅞...	91.50	115.15
1 ..	2.625	3.35	2 ...	10.55	13.4	4 ...	41.95	53.75	6 ...	95.	120.25

For steel, mult tabular number above (for size) by 1·01.

LUMBER RECKONER

Size in In	Length in Feet											
	10	12	14	16	18	20	22	24	26	28	30	32
2 x 4	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16	17⅓	18⅔	20	21⅓
2 x 6	10	12	14	16	18	20	22	24	26	28	30	32
2 x 8	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40	42⅔
2 x10	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40	43⅓	46⅔	50	53⅓
2 x12	20	24	28	32	36	40	44	48	52	56	60	64
2 x14	23⅓	28	32⅔	37⅓	42	46⅔	51⅓	56	60⅔	65⅓	70	74⅔
2 x16	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64	69⅓	74⅔	80	85⅓
2½x12	25	30	35	40	45	50	55	60	65	70	75	80
2½x14	29⅙	35	40⅚	46⅔	52½	58⅓	64⅙	70	75⅚	81⅔	87½	93⅓
2½x16	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80	86⅔	93⅓	100	106⅔
3 x 6	15	18	21	24	27	30	33	36	39	42	45	48
3 x 8	20	24	28	32	36	40	44	48	52	56	60	64
3 x10	25	30	35	40	45	50	55	60	65	70	75	80
3 x12	30	36	42	48	54	60	66	72	78	84	90	96
3 x14	35	42	49	56	63	70	77	84	91	98	105	112
3 x16	40	48	56	64	72	80	88	96	104	112	120	128
4 x 4	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32	34⅔	37⅓	40	42⅔
4 x 6	20	24	28	32	36	40	44	48	52	56	60	64
4 x 8	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64	69⅓	74⅔	80	85⅓
4 x10	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80	86⅔	93⅓	100	106⅔
4 x12	40	48	56	64	72	80	88	96	104	112	120	128
4 x14	46⅔	56	65⅓	74⅔	84	93⅓	102⅔	112	121⅓	130⅔	140	149⅓
6 x 6	30	36	42	48	54	60	66	72	78	84	90	96
6 x 8	40	48	56	64	72	80	88	96	104	112	120	128
6 x10	50	60	70	80	90	100	110	120	130	140	150	160
6 x12	60	72	84	96	108	120	132	144	156	168	180	196
6 x14	70	84	98	112	126	140	154	168	182	196	210	224
6 x16	80	96	112	128	144	160	176	192	208	224	240	256
8 x 8	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128	138⅔	149⅓	160	170⅔
8 x10	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160	173⅓	186⅔	200	213⅓
8 x12	80	96	112	128	144	160	176	192	208	224	240	256
8 x14	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224	242⅔	261⅓	280	298⅔
10 x10	83⅓	100	116⅔	133⅓	150	166⅔	183⅓	200	216⅔	233⅓	250	266⅔
10 x12	100	120	140	160	180	200	220	240	260	280	300	320
10x 14	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280	303⅓	326⅔	350	373⅓
10 x16	133⅓	160	186⅔	213⅓	240	266⅔	293⅓	320	346⅔	373⅓	400	426⅔
12 x12	120	144	168	192	216	240	264	288	312	336	360	384
12 x14	140	168	196	224	252	280	308	336	364	392	420	448
12 x16	160	192	224	256	288	320	352	384	416	448	480	512
14 x14	163⅓	196	228⅔	261⅓	294	326⅔	359⅓	392	424⅔	457⅓	490	522⅔
14 x16	186⅔	224	261⅓	298⅔	336	373⅓	410⅔	448	485⅓	522⅔	560	597⅓

WEIGHTS OF VARIOUS SUBSTANCES PER CF

Names of Substances	Average Wgt, Lbs
Ash, American White, Dry	38
Asphaltum	87
Brass (Copper and Zinc) Cast	504
Brass Rolled	524
Brick, Best Pressed	150
Brick, Common Hard	125
Brick, Soft, Inferior	100
Brick, Fire	137
Brickwork, Pressed Brick	140
Brickwork, Ordinary	112

Names of Substances	Average Wgt, Lbs
Cement, Hydraulic, Ground, Loose, American, Rosendale	56
Cement, Hydraulic, Ground, Loose, American, Louisville	50
Cement, Hydraulic, Ground, Loose, English, Portland	90
Cherry, Dry	42
Chestnut, Dry	41
Concrete	140
Copper, Cast	543
Copper, Rolled	548
Ebony, Dry	76
Elm, Dry	35
Flint	162
Glass, Common Window	157
Gneiss, Common	168
Granite	170
Gravel, about the same as Sand, which see	
Hemlock, Dry	25
Hickory, Dry	53
Ice	50 to 58
Iron, Cast	450
Iron, Wrt. Purest	485
Iron, Wrt, Average	480
Lead	711
Lime, Quick, Ground, Loose, or in Small Lumps	53
Lime, Quick, Ground, Loose, Thoroughly Shaken	75
Lime, Quick, Ground, Loose, Per Struck Bushel	66
Limestones and Marbles	168
Limestones and Marbles, Loose, in Irregular Fragments	96
Mahogany, Spanish, Dry	53
Mahogany, Honduras, Dry	35
Maple, Dry	49
Marbles, see Limestones.	
Masonry, of Granite or Limestone, well dressed	165
Masonry, of Mortar Rubble	154
Masonry, of Dry Rubble (well Scabbled)	138
Masonry, of Sandstone, well dressed	144
Mortar, Hardened	103
Oak, Live, Dry	59
Oak, White, Dry	52
Oak, Other Kinds	32 to 45
Pine, White, Dry	25
Pine, Yellow, Northern	34
Pine, Yellow, Southern	45
Plaster of Paris	74
Quartz, Common, Pure	165
Sand, of Pure Quartz, Dry, Loose	90 to 106
Sand, Well Shaken	99 to 117
Sand, Perfectly Wet	120 to 140
Sandstones, Fit for Building	151
Shales, Red or Black	162
Slate	175
Snow, freshly fallen	5 to 12
Snow, Moistened and Compacted by Rain	15 to 50
Spruce, Dry	25
Steel	490
Sycamore, Dry	37
Tar	62
Tin, Cast	459
Walnut, Black, Dry	38
Water, Pure Rain or Distilled, at 60° Fahrenheit	62½
Water, Sea	64
Zinc or Spelter	437

Green Timbers usually weigh from one-fifth to one-half more than dry.

A Barrel contains 31½ gallons; but for tar and such materials 50 gallons is the standard.

A Builder's Square contains 100 square feet, or a space 10′ x 10′.

A Cord of wood is 4′ x 4′ x 8′ = 128 cubic feet; and measured loose for stone.

A Cord of Stone in Chicago is 100 cubic feet when in the wall.

A Perch depends upon longitude and latitude. It is 16½, 22½, 24¾, and 25, with several back counties yet to be heard from. Never use it. Let both perch and cord die, and use only cubic yards or feet.

The Toise is another chameleon. It belongs to Canada. It is, in Perth, Ont., 36 cubic feet; in Hamilton, 70 cubic feet; in Toronto, 54 cubic feet; in Montreal, 86 cubic feet.

A TABLE OF SQUARES AND SQUARE ROOTS

Abbreviation. — Ordinary tables of this kind have cubes, cube roots, and reciprocals. I have often had occasion in contracting to use square root, but some of the best contractors I know have never even heard of it. They do not use it in their business. Cube root I have never used once since I learned what it meant at school. Judging by this, I conclude that it is not of so very much value in contracting, whatever it may be in some other businesses; and, therefore, cubes, cube roots, and reciprocals are not included in this series of tables.

Use. — Some contractors may ask, Of what value is square root? For one thing, it is useful in taking off lengths of long trusses when they are drawn to 1-16 inch, or less to the foot, and it is risky to scale them in the ordinary way. The drawings are not accurately made, and in many specifications it is forbidden to scale them at all, as the architects do not want to be held responsible for errors. In cases when a change is made in the width of a building when the drawings are nearly finished, it is often done by figures only, and not by remaking the entire set.

Example 1. — How, then, is the length obtained by square root? Let us take a building 160 feet wide over the walls.

From the outside of the wall to the center would be 80 feet. Put the rise at 7 feet, which is enough for a gravel roof.

Turning the feet into inches for a more accurate answer we have 960 and 84. The square of 960 in the proper column of the tables is 921,600; and of 84, is 7,056. Added together the sum is 928,656.

Looking down the column of squares the nearest figure to this is 929,296, which is a trifle over the required size. Directly on the left, in the No. column, we see that the square root of that is 964, or 80 feet, 4 inches. This is the distance from the outside of the wall to the center of the roof on the rake.

Example 2. — The rise in this last case is so small that it would be practically safe for the contractor to take half the width of the building, but it is different with a church truss of the old high style. If the figures are even it is not necessary to turn them into inches. It was done in the last case to show how to get the length when there were odd inches, for the rise was low.

Take a building 60 feet wide and let the rise be 38 feet. What is the distance from the outside edge of the wall to the peak? Half the width is 30 feet. The table gives 900 and 1,444, for in getting the square root the first thing to be done is to multiply the lengths by themselves, or get their squares, and then add the totals together. In this case the sum is 2,344. Looking down the square column the nearest sum to this is 2,304, and the number on the left, the required length, is 48 feet.

For some purposes this might be exact enough, but to get more accurate figures we can take the inches. On the level there are 360, and on the rise, 456. The squares of these found in the table are 129,600 and 207,936, a total of 337,536. The nearest number to this in the table is 337,561, which is practically exact. To the left the length is given in inches— 581, or 48 feet 5 inches.

Why? — The reason for anything is always interesting and useful. Why do the two numbers have to be squared and added? It is on the same principle as 12 on the blade, and 12 on the tongue of a square give 17 across the angle. When 12 is squared it makes 144, and two numbers like this, 288. Looking for the square we find that 289 is the nearest number, so that the 17 which carpenters always use is not strictly accurate, but the difference of a thick pencil and a thin one will equalize matters. All through there is never any chance of getting the exact mathematical sizes on stone and lumber.

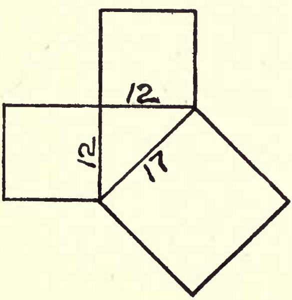
Squaring a Building. — It is on this principle that a building is squared as described in Chapter X, Book I. The square of 8 is 64, and of 6 is 36. These two numbers added together make 100, the square root of which is 10.

Any other set of figures might be taken if desired to get a wider stretch, although 6, 8, and 10 are almost everywhere employed for this purpose. Another set might be 12, 16, and 20, and a steel tape used across the corner, or a long rod. As a still longer check we can take 24, 32, and 40.

Take a square of any kind and lay out two lines at right angles. Mark 12 inches on each from the point or corner where the lines join. Connect these two points by a line which will be 17 inches long. There you have an angle that all carpenters are acquainted with.

Now draw three squares out on the three sides—two at 12 inches, and one at 17. The square root theory proceeds on the basis that the large square has exactly the same area as the two small ones. Now suppose we get the area of the two small ones. We already know that it is 288 square inches. Evidently, then, the large one must have the same area. As each side of a square must be the same length, we have to find the number which, multiplied by itself, will give 288, or, in other words, the square root, which is 17.

Any ordinary arithmetic will show how to extract this square root. For most uses the table will serve.



A TABLE OF SQUARES AND SQUARE ROOTS

No.	Square.	Square Root	No.	Square.	Square Root
1	1	1·000000	41	1681	6·403124
2	4	1·414214	42	1764	6·480741
3	9	1·732051	43	1849	6·557439
4	16	2·000000	44	1936	6·633250
5	25	2·236068	45	2025	6·708204
6	36	2·449490	46	2116	6·782330
7	49	2·645751	47	2209	6·855655
8	64	2·828427	48	2304	6·928203
9	81	3·000000	49	2401	7·000000
10	100	3·162278	50	2500	7·071068
11	121	3·316625	51	2601	7·141428
12	144	3·464102	52	2704	7·211103
13	169	3·605551	53	2809	7·280110
14	196	3·741657	54	2916	7·348469
15	225	3·872983	55	3025	7·416198
16	256	4·000000	56	3136	7·483315
17	289	4·123106	57	3249	7·549834
18	324	4·242641	58	3364	7·615773
19	361	4·358899	59	3481	7·681146
20	400	4·472136	60	3600	7·745967
21	441	4·582576	61	3721	7·810250
22	484	4·690416	62	3844	7·874008
23	529	4·795832	63	3969	7·937254
24	576	4·898979	64	4096	8·000000
25	625	5·000000	65	4225	8·062258
26	676	5·099020	66	4356	8·124038
27	729	5·196152	67	4489	8·185353
28	784	5·291503	68	4624	8·246211
29	841	5·385165	69	4761	8·306624
30	900	5·477226	70	4900	8·366600
31	961	5·567764	71	5041	8·426150
32	1024	5·656854	72	5184	8·485281
33	1089	5·744563	73	5329	8·544004
34	1156	5·830952	74	5476	8·602325
35	1225	5·916080	75	5625	8·660254
36	1296	6·000000	76	5776	8·717798
37	1369	6·082763	77	5929	8·774964
38	1444	6·164414	78	6084	8·831761
39	1521	6·244998	79	6241	8·888194
40	1600	6·324555	80	6400	8·944272

No.	Square.	Square Root	No.	Square.	Square Root
81	6561	9·000000	129	16641	11·357817
82	6724	9·055385	130	16900	11·401754
83	6889	9·110434	131	17161	11·445523
84	7056	9·165151	132	17424	11·489125
85	7225	9·219544	133	17689	11·532563
86	7396	9·273618	134	17956	11·575837
87	7569	9·327379	135	18225	11·618950
88	7744	9·380832	136	18496	11·661904
89	7921	9·433981	137	18769	11·704700
90	8100	9·486833	138	19044	11·747344
91	8281	9·539392	139	19321	11·789826
92	8464	9·591663	140	19600	11·832160
93	8649	9·643651	141	19881	11·874342
94	8836	9·695360	142	20164	11·916375
95	9025	9·746794	143	20449	11·958261
96	9216	9·797959	144	20736	12·000000
97	9409	9·848858	145	21025	12·041595
98	9604	9·899495	146	21316	12·083046
99	9801	9·949874	147	21609	12·124356
100	10000	10·000000	148	21904	12·165525
101	10201	10·049876	149	22201	12·206556
102	10404	10·099505	150	22500	12·247449
103	10609	10·148892	151	22801	12·288206
104	10816	10·198039	152	23104	12·328828
105	11025	10·246951	153	23409	12·369317
106	11236	10·295630	154	23716	12·409674
107	11449	10·344080	155	24025	12·449900
108	11664	10·392305	156	24336	12·489996
109	11881	10·440306	157	24649	12·529964
110	12100	10·488088	158	24964	12·569805
111	12321	10·535654	159	25281	12·609520
112	12544	10·583005	160	25600	12·649111
113	12769	10·630146	161	25921	12·688577
114	12996	10·677078	162	26244	12·727922
115	13225	10·723805	163	26569	12·767145
116	13456	10·770330	164	26896	12·806248
117	13689	10·816654	165	27225	12·845233
118	13924	10·862780	166	27556	12·884099
119	14161	10·908712	167	27889	12·922848
120	14400	10·954451	168	28224	12·961481
121	14641	11·000000	169	28561	13·000000
122	14884	11·045361	170	28900	13·038405
123	15129	11·090536	171	29241	13·076697
124	15376	11·135529	172	29584	13·114877
125	15625	11·180340	173	29929	13·152946
126	15876	11·224972	174	30276	13·190906
127	16129	11·269428	175	30625	13·228757
128	16384	11·313708	176	30976	13·266499

No.	Square.	Square Root	No.	Square.	Square Root
177	31329	13·304135	225	50625	15·000000
178	31684	13·341664	226	51076	15·033296
179	32041	13·379088	227	51529	15·066519
180	32400	13·416408	228	51984	15·099669
181	32761	13·453624	229	52441	15·132746
182	33124	13·490738	230	52900	15·165751
183	33489	13·527749	231	53361	15·198684
184	33856	13·564660	232	53824	15·231546
185	34225	13·601470	233	54289	15·264338
186	34596	13·638182	234	54756	15·297059
187	34969	13·674794	235	55225	15·329710
188	35344	13·711309	236	55696	15·362292
189	35721	13·747727	237	56169	15·394804
190	36100	13·784049	238	56644	15·427249
191	36481	13·820275	239	57121	15·459625
192	36864	13·856406	240	57600	15·491933
193	37249	13·892444	241	58081	15·524175
194	37636	13·928388	242	58564	15·556349
195	38025	13·964240	243	59049	15·588457
196	38416	14·000000	244	59536	15·620499
197	38809	14·035669	245	60025	15·652476
198	39204	14·071247	246	60516	15·684387
199	39601	14·106736	247	61009	15·716234
200	40000	14·142136	248	61504	15·748016
201	40401	14·177447	249	62001	15·779734
202	40804	14·212670	250	62500	15·811388
203	41209	14·247807	251	63001	15·842980
204	41616	14·282857	252	63504	15·874508
205	42025	14·317821	253	64009	15·905974
206	42436	14·352700	254	64516	15·937378
207	42849	14·387495	255	65025	15·968719
208	43264	14·422205	256	65536	16·000000
209	43681	14·456832	257	66049	16·031220
210	44100	14·491377	258	66564	16·062378
211	44521	14·525839	259	67081	16·093477
212	44944	14·560220	260	67600	16·124516
213	45369	14·594520	261	68121	16·155494
214	45796	14·628739	262	68644	16·186414
215	46225	14·662878	263	69169	16·217275
216	46656	14·696939	264	69696	16·248077
217	47089	14·730920	265	70225	16·278821
218	47524	14·764823	266	70756	16·309506
219	47961	14·798649	267	71289	16·340135
220	48400	14·832397	268	71824	16·370706
221	48841	14·866069	269	72361	16·401220
222	49284	14·899664	270	72900	16·431677
223	49729	14·933185	271	73441	16·462078
224	50176	14·966630	272	73984	16·492423

No.	Square.	Square Root	No.	Square.	Square Root
273	74529	16·522712	321	103041	17·916473
274	75076	16·552945	322	103684	17·944358
275	75625	16·583124	323	104329	17·972201
276	76176	16·613248	324	104976	18·000000
277	76729	16·643317	325	105625	18·027756
278	77284	16·673332	326	106276	18·055470
279	77841	16·703293	327	106929	18·083141
280	78400	16·733201	328	107584	18·110770
281	78961	16·763055	329	108241	18·138357
282	79524	16·792856	330	108900	18·165902
283	80089	16·822604	331	109561	18·193405
284	80656	16·852300	332	110224	18·220867
285	81225	16·881943	333	110889	18·248288
286	81796	16·911535	334	111556	18·275667
287	82369	16·941074	335	112225	18·303005
288	82944	16·970563	336	112896	18·330303
289	83521	17·000000	337	113569	18·357560
290	84100	17·029386	338	114244	18·384776
291	84681	17·058722	339	114921	18·411953
292	85264	17·088008	340	115600	18·439089
293	85849	17·117243	341	116281	18·466185
294	86436	17·146428	342	116964	18·493242
295	87025	17·175564	343	117649	18·520259
296	87616	17·204651	344	118336	18·547237
297	88209	17·233688	345	119025	18·574176
298	88804	17·262676	346	119716	18·601075
299	89401	17·291617	347	120409	18·627936
300	90000	17·320508	348	121104	18·654758
301	90601	17·349352	349	121801	18·681542
302	91204	17·378147	350	122500	18·708287
303	91809	17·406895	351	123201	18·734994
304	92416	17·435596	352	123904	18·761663
305	93025	17·464249	353	124609	18·788294
306	93636	17·492856	354	125316	18·814888
307	94249	17·521416	355	126025	18·841444
308	94864	17·549929	356	126736	18·867962
309	95481	17·578396	357	127449	18·894444
310	96100	17·606817	358	128164	18·920888
311	96721	17·635192	359	128881	18·947295
312	97344	17·663522	360	129600	18·973666
313	97969	17·691806	361	130321	19·000000
314	98596	17·720045	362	131044	19·026298
315	99225	17·748239	363	131769	19·052559
316	99856	17·776389	364	132496	19·078784
317	100489	17·804494	365	133225	19·104973
318	101124	17·832555	366	133956	19·131127
319	101761	17·860571	367	134689	19·157244
320	102400	17·888544	368	135424	19·183326

No.	Square.	Square Root	No.	Square.	Square Root
369	136161	19·209373	417	173889	20·420578
370	136900	19·235384	418	174724	20·445048
371	137641	19·261360	419	175561	20·469490
372	138384	19·287302	420	176400	20·493902
373	139129	19·313208	421	177241	20·518285
374	139876	19·339080	422	178084	20·542639
375	140625	19·364917	423	178929	20·566964
376	141376	19·390719	424	179776	20·591260
377	142129	19·416488	425	180625	20·615528
378	142884	19·442222	426	181476	20·639767
379	143641	19·467922	427	182329	20·663978
380	144400	19·493589	428	183184	20·688161
381	145161	19·519221	429	184041	20·712315
382	145924	19·544820	430	184900	20·736441
383	146689	19·570386	431	185761	20·760540
384	147456	19·595918	432	186624	20·784610
385	148225	19·621417	433	187489	20·808652
386	148996	19·646883	434	188356	20·832667
387	149769	19·672316	435	189225	20·856654
388	150544	19·697716	436	190096	20·880613
389	151321	19·723083	437	190969	20·904545
390	152100	19·748418	438	191844	20·928450
391	152881	19·773720	439	192721	20·952327
392	153664	19·798990	440	193600	20·976177
393	154449	19·824228	441	194481	21·000000
394	155236	19·849433	442	195364	21·023796
395	156025	19·874607	443	196249	21·047565
396	156816	19·899749	444	197136	21·071308
397	157609	19·924859	445	198025	21·095023
398	158404	19·949937	446	198916	21·118712
399	159201	19·974984	447	199809	21·142375
400	160000	20·000000	448	200704	21·166011
401	160801	20·024984	449	201601	21·189620
402	161604	20·049938	450	202500	21·213203
403	162409	20·074860	451	203401	21·236761
404	163216	20·099751	452	204304	21·260292
405	164025	20·124612	453	205209	21·283797
406	164836	20·149442	454	206116	21·307276
407	165649	20·174241	455	207025	21·330729
408	166464	20·199010	456	207936	21·354157
409	167281	20·223748	457	208849	21·377558
410	168100	20·248457	458	209764	21·400935
411	168921	20·273135	459	210681	21·424285
412	169744	20·297783	460	211600	21·447611
413	170569	20·322401	461	212521	21·470911
414	171396	20·346990	462	213444	21·494185
415	172225	20·371549	463	214369	21·517435
416	173056	20·396078	464	215296	21·540659

No.	Square.	Square Root	No.	Square.	Square Root
465	216225	21·563859	513	263169	22·649503
466	217156	21·587033	514	264196	22·671568
467	218089	21·610183	515	265225	22·693611
468	219024	21·633308	516	266256	22·715633
469	219961	21·656408	517	267289	22·737634
470	220900	21·679483	518	268324	22·759613
471	221841	21·702534	519	269361	22·781572
472	222784	21·725561	520	270400	22·803509
473	223729	21·748563	521	271441	22·825424
474	224676	21·771541	522	272484	22·847319
475	225625	21·794495	523	273529	22·869193
476	226576	21·817424	524	274576	22·891046
477	227529	21·840330	525	275625	22·912879
478	228484	21·863211	526	276676	22·934690
479	229441	21·886069	527	277729	22·956481
480	230400	21·908902	528	278784	22·978251
481	231361	21·931712	529	279841	23·000000
482	232324	21·954498	530	280900	23·021729
483	233289	21·977261	531	281961	23·043437
484	234256	22·000000	532	283024	23·065125
485	235225	22·022716	533	284089	23·086793
486	236196	22·045408	534	285156	23·108440
487	237169	22·068077	535	286225	23·130067
488	238144	22·090722	536	287296	23·151674
489	239121	22·113344	537	288369	23·173261
490	240100	22·135944	538	289444	23·194827
491	241081	22·158520	539	290521	23·216374
492	242064	22·181073	540	291600	23·237900
493	243049	22·203603	541	292681	23·259407
494	244036	22·226111	542	293764	23·280894
495	245025	22·248596	543	294849	23·302360
496	246016	22·271058	544	295936	23·323808
497	247009	22·293497	545	297025	23·345235
498	248004	22·315914	546	298116	23·366643
499	249001	22·338308	547	299209	23·288031
500	250000	22·360680	548	300304	23·409400
501	251001	22·383029	549	301401	23·430749
502	252004	22·405357	550	302500	23·452079
503	253009	22·427662	551	303601	23·473389
504	254016	22·449944	552	304704	23·494680
505	255025	22·472205	553	305809	23·515952
506	256036	22·494444	554	306916	23·537205
507	257049	22·516661	555	308025	23·558438
508	258064	22·538855	556	309136	23·579652
509	259081	22·561028	557	310249	23·600847
510	260100	22·583180	558	311364	23·622024
511	261121	22·605309	559	312481	23·643181
512	262144	22·627417	560	313600	23·664319

No.	Square.	Square Root	No.	Square.	Square Root
561	314721	23·685439	609	370881	24·677925
562	315844	23·706539	610	372100	24·698178
563	316969	23·727621	611	373321	24·718414
564	318096	23·748684	612	374544	24·738634
565	319225	23·769729	613	375769	24·758837
566	320356	23·790755	614	376996	24·779023
567	321489	23·811762	615	378225	24·799194
568	322624	23·832751	616	379456	24·819347
569	323761	23·853721	617	380689	24·839485
570	324900	23·874673	618	381924	24·859606
571	326041	23·895606	619	383161	24·879711
572	327184	23·916522	620	384400	24·899799
573	328329	23·937418	621	385641	24·919872
574	329476	23·958297	622	386884	24·939928
575	330625	23·979158	623	388129	24·959968
576	331776	24·000000	624	389376	24·979992
577	332929	24·020824	625	390625	25·000000
578	334084	24·041631	626	391876	25·019992
579	335241	24·062419	627	393129	25·039968
580	336400	24·083189	628	394384	25·059928
581	337561	24·103942	629	395641	25·079872
582	338724	24·124676	630	396900	25·099801
583	339889	24·145393	631	398161	25·119713
584	341056	24·166092	632	399424	25·139610
585	342225	24·186773	633	400689	25·159491
586	343396	24·207437	634	401956	25·179357
587	344569	24·228083	635	403225	25·199206
588	345744	24·248711	636	404496	25·219040
589	346921	24·269322	637	405769	25·238859
590	348100	24·289916	638	407044	25·258662
591	349281	24·310492	639	408321	25·278449
592	350464	24·331050	640	409600	25·298221
593	351649	24·351591	641	410881	25·317978
594	352836	24·372115	642	412164	25·337719
595	354025	24·392622	643	413449	25·357445
596	355216	24·413111	644	414736	25·377155
597	356409	24·433583	645	416025	25·396850
598	357604	24·454039	646	417316	25·416530
599	358801	24·474477	647	418609	25·436195
600	360000	24·494897	648	419904	25·455844
601	361201	24·515301	649	421201	25·475478
602	362404	24·535688	650	422500	25·495098
603	363609	24·556058	651	423801	25·514702
604	364816	24·576412	652	425104	25·534291
605	366025	24·596748	653	426409	25·553865
606	367236	24·617067	654	427716	25·573424
607	368449	24·637370	655	429025	25·592968
608	369664	24·657656	656	430336	25·612497

No.	Square.	Square Root	No.	Square.	Square Root
657	431649	25·632011	705	497025	26·551836
658	432964	25·651511	706	498436	26·570661
659	434281	25·670995	707	499849	26·589472
660	435600	25·690465	708	501264	26·608269
661	436921	25·709920	709	502681	26·627054
662	438244	25·729361	710	504100	26·645825
663	439569	25·748786	711	505521	26·664583
664	440896	25·768198	712	506944	26·683328
665	442225	25·787594	713	508369	26·702060
666	443556	25·806976	714	509796	26·720778
667	444889	25·826343	715	511225	26·739484
668	446224	25·845696	716	512656	26·758176
669	447561	25·865034	717	514089	26·776856
670	448900	25·884358	718	515524	26·795522
671	450241	25·903668	719	516961	26·814175
672	451584	25·922963	720	518400	26·832816
673	452929	25·942244	721	519841	26·851443
674	454276	25·916510	722	521284	26·870058
675	455625	25·980762	723	522729	26·888659
676	456976	26·000000	724	524176	26·907248
677	458329	26·019224	725	525625	26·925824
678	459684	26·038433	726	527076	26·944387
679	461041	26·057628	727	528529	26·962938
680	462400	26·076810	728	529984	26·981475
681	463761	26·095977	729	531441	27·000000
682	465124	26·115130	730	532900	27·018512
683	466489	26·134269	731	534361	27·037012
684	467856	26·153394	732	535824	27·055499
685	469225	26·172505	733	537289	27·073973
686	470596	26·191602	734	538756	27·092434
687	471969	26·210685	735	540225	27·110883
688	473344	26·229754	736	541696	27·129320
689	474721	26·248810	737	543169	27·147744
690	476100	26·267851	738	544644	27·166155
691	477481	26·286879	739	546121	27·184554
692	478864	26·305803	740	547600	27·202941
693	480249	26·324893	741	549081	27·221315
694	481636	26·343880	742	550564	27·239677
695	483025	26·362853	743	552049	27·258026
696	484416	26·381812	744	553536	27·276363
697	485809	26·400758	745	555025	27·294688
698	487204	26·419690	746	556516	27·313001
699	488601	26·438608	747	558009	27·331301
700	490000	26·457513	748	559504	27·349589
701	491401	26·476405	749	561001	27·367864
702	492804	26·495283	750	562500	27·386128
703	494209	26·514147	751	564001	27·404379
704	495616	26·532998	752	565504	27·422618

No.	Square.	Square Root	No.	Square.	Square Root
753	567009	27·440846	801	641601	28·301943
754	568516	27·459060	802	643204	28·319605
755	570025	27·477263	803	644809	28·337255
756	571536	27·495454	804	646416	28·354894
757	573049	27·513633	805	648025	28·372522
758	574564	27·531800	806	649636	28·390139
759	576081	27·549955	807	651249	28·407745
760	577600	27·568098	808	652864	28·425341
761	579121	27·586228	809	654481	28·442925
762	580644	27·604348	810	656100	28·460499
763	582169	27·622455	811	657721	28·478062
764	583696	27·640550	812	659344	28·495614
765	585225	27·658633	813	660969	28·513155
766	586756	27·676705	814	662596	28·530685
767	588289	27·694765	815	664225	28·548205
768	589824	27·712813	816	665856	28·565714
769	591361	27·730849	817	667489	28·583212
770	592900	27·748874	818	669124	28·600699
771	594441	27·766887	819	670761	28·618176
772	595984	27·784888	820	672400	28·635642
773	597529	27·802878	821	674041	28·653098
774	599076	27·820856	822	675684	28·670542
775	600625	27·838822	823	677329	28·687977
776	602176	27·856777	824	678976	28·705400
777	603729	27·874720	825	680625	28·722813
778	605284	27·892651	826	682276	28·740216
779	606841	27·910572	827	683929	28·757608
780	608400	27·928480	828	685584	28·774989
781	609961	27·946377	829	687241	28·792360
782	611524	27·964263	830	688900	28·809721
783	613089	27·982137	831	690561	28·827071
784	614656	28·000000	832	692224	28·844410
785	616225	28·017852	833	693889	28·861739
786	617796	28·035692	834	695556	28·879058
787	619369	28·053520	835	697225	28·896367
788	620944	28·071338	836	698896	28·913665
789	622521	28·089144	837	700569	28·930952
790	624100	28·106939	838	702244	28·948230
791	625681	28·124722	839	703921	28·965497
792	627264	28·142495	840	705600	28·982754
793	628849	28·160256	841	707281	29·000000
794	630436	28·178006	842	708964	29·017236
795	632025	28·195744	843	710649	29·034462
796	633616	28·213472	844	712336	29·051678
797	635209	28·231188	845	714025	29·068884
798	636804	28·248894	846	715716	29·086079
799	638401	28·266588	847	717409	29·103264
800	640000	28·284271	848	719104	29·120440

No.	Square.	Square Root	No.	Square.	Square Root
849	720801	29·137605	897	804609	29·949958
850	722500	29·154760	898	806404	29·966648
851	724201	29·171904	899	808201	29·983329
852	725904	29·189039	900	810000	30·000000
853	727609	29·206164	901	811801	30·016662
854	729316	29·223278	902	813604	30·033315
855	731025	29·240383	903	815409	30·049958
856	732736	29·257478	904	817216	30·066593
857	734449	29·274562	905	819025	30·083218
858	736164	29·291637	906	820836	30·099834
859	737881	29·308702	907	822649	30·116441
860	739600	29·325757	908	824464	30·133038
861	741321	29·342802	909	826281	30·149627
862	743044	29·359837	910	828100	30·163206
863	744769	29·376862	911	829921	30·182777
864	746496	29·393877	912	831744	30·199338
865	748225	29·410882	913	833569	30·215890
866	749956	29·427878	914	835396	30·232433
867	751689	29·444864	915	837225	30·248967
868	753424	29·461840	916	839056	30·265492
869	755161	29·478806	917	840889	30·282008
870	756900	29·495762	918	842724	30·298515
871	758641	29·512709	919	844561	30·315013
872	760384	29·529646	920	846400	30·331502
873	762129	29·546573	921	848241	30·347982
874	763876	29·563491	922	850084	30·364453
875	765625	29·580399	923	851929	30·380915
876	767376	29·597297	924	853776	30·397368
877	769129	29·614186	925	855625	30·413813
878	770884	29·631065	926	857476	30·430248
879	772641	29·647934	927	859329	30·446675
880	774400	29·664794	928	861184	30·463092
881	776161	29·681644	929	863041	30·479501
882	777924	29·698485	930	864900	30·495901
883	779689	29·715316	931	866761	30·512293
884	781456	29·732138	932	868624	30·528675
885	783225	29·748950	933	870489	30·545049
886	784996	29·765752	934	872356	30·561414
887	786769	29·782545	935	874225	30·577770
888	788544	29·799329	936	876096	30·594117
889	790321	29·816103	937	877969	30·610456
890	792100	29·832868	938	879844	30·626786
891	793881	29·849623	939	881721	30·643107
892	795664	29·866369	940	883600	30·659419
893	797449	29·883106	941	885481	30·675723
894	799236	29·899833	942	887364	30·692019
895	801025	29·916551	943	889249	30·708305
896	802816	29·933259	944	891136	30·724583

No.	Square.	Square Root	No.	Square.	Square Root
945	893025	30·740852	973	946729	31·192948
946	894916	30·757113	974	948676	31·208973
947	896809	30·773365	975	950625	31·224990
948	898704	30·789609	976	952576	31·240999
949	900601	30·805844	977	954529	31·256999
950	902500	30·822070	978	956484	31·272992
951	904401	30·838288	979	958441	31·288976
952	906304	30·854497	980	960400	31·304952
953	908209	30·870698	981	962361	31·320920
954	910116	30·886890	982	964324	31·336879
955	912025	30·903074	983	966289	31·352831
956	913936	30·919250	984	968256	31·368774
957	915849	30·935417	985	970225	31·384710
958	917764	30·951575	986	972196	31·400637
959	919681	30·967725	987	974169	31·416556
960	921600	30·983867	988	976144	31·432467
961	923521	31·000000	989	978121	31·448370
962	925444	31·016125	990	980100	31·464265
963	927369	31·032241	991	982081	31·480153
964	929296	31·048349	992	984064	31·496032
965	931225	31·064449	993	986049	31·511903
966	933156	31·080541	994	988036	31·527766
967	935089	31·096624	995	990025	31·543621
968	937024	31·112698	996	992016	31·559468
969	938961	31·128765	997	994009	31·575307
970	940900	31·144823	998	996004	31·591138
971	942841	31·160873	999	998001	31·606961
972	944784	31·176915			

DECIMALS

Here it might be said that decimals are so useful for calculations that it is surprising that anyone should be content to go through life without understanding them. The tables in catalogs and handbooks cannot be properly used without them. For ordinary purposes they are easy. The refinements of the system are not really necessary for contract work. Recurring decimals need not "recur" beyond two or three figures. An ordinary arithmetic will show how to use the system, and there is no need for those who do not want intellectual exercise going beyond the easy part.

Ladder. — Suppose you are standing on the first floor of a building, and there is a ladder going up and another going down to the basement. The first floor is regarded as the standard or dividing line. So with the decimal notation. We go up or down, increasing or decreasing, or rather we keep on the level and go to the left from the point to increase, and to the right from the point to decrease. We multiply as if there were no point, and simply put the point in at the right place afterwards.

Example. — This example is for the encouragement of those who have hitherto thought that there is something mysterious about the dot. Suppose you find an I-beam listed at 14.75 pounds to the foot, and 19 feet are required, what is the weight? We go ahead as in plain multiplication.

```
 14.75
    19
 -----
 13275
 1475
 -----
280.25
```

This means that there are 280 pounds and $\frac{25}{100}$ of a pound. This is only a quarter of a pound, and need not be regarded.

Method. — It is thus seen that the process is the same as ordinary multiplication. So with addition and subtraction. If instead of 19 we had had 1.9, only one-tenth as much, there would have been three points cut off in the answer, which would thus have been 28.025. Surely that is simple enough for anybody.

Another Example. — Add 213.05 and 1.23.

```
213.05
  1.23
------
214.28
```

Subtract 1.23 from 213.05

```
213.05
  1.23
------
211.82
```

The theory is just the dollar and cent one used for something else than money. The dot is the dividing point between the whole numbers and the fractions, just as it is between the dollars and cents, or the fractions of a dollar.

Take $1,111.11, for example, and we know how much this is. Now call it 1,111.11 feet or pounds, miles, or pints, or anything else, and we have the whole decimal trouble explained.

Divide $1,111.11 by 8, suppose, and we get $138.88. The exact answer would be $138.88875, but no one wants to trouble with mills and further refinements for daily use, and the stop is made at the cents, or two figures to the right of the point. So with decimals used for feet, inches, pounds, pints, quarts, or anything else. For ordinary use we can stop at two figures to the right of the dot, and get close enough to what we want to "call it square."

The foregoing figures will give a hint to anyone who wants to go further.

TABLES OF AREAS

Polygons or Many-sided Figures

Rule. — Multiply the square of the side by the multiplier corresponding to the figure in the following table: the product will be the area.

NAMES	NO. OF SIDES	PERPENDICULARS	MULTIPLIER
Equilateral triangle	3	0.289	0.433
Square	4	0.500	1.000
Pentagon	5	0.688	1.720
Hexagon	6	0.866	2.598
Heptagon	7	1.038	3.634
Octagon	8	1.207	4.828
Nonagon	9	1.373	6.181
Decagon	10	1.539	7.694
Undecagon,	11	1.703	9.365
Dodecagon	12	1.866	11.196

Method of Measurement. — Contractors have sometimes to figure the areas of polygons, especially of octagons. The simplest method, if the table is not at hand, is to make a triangle of each side, multiply it by the height, and take the half. Practical builders know well enough that there is so much waste in floors and work made on this shape that the exact area is not a matter of so much consequence as the time required to cover it.

Example. — For an illustration of the use of the table let us assume that there is a room or a dancing pavilion that measures 12 feet on the side. For the areas of flooring, plaster, and paint, the square of 12, or 144, would be multiplied by 4.83—for there is no use going beyond two decimals. This would make an exact area of 695.52 square feet, or 700 as a contractor would allow it. This makes no allowance for waste in lumber on the octagon.

Towers. — For taking the surface or solidity of towers the following table may be used. They may be estimated by the usual triangular rule of multiplying the base of each side by the slope and dividing by two, and this method is the one generally employed.

TABLE OF THE SURFACES AND SOLIDITIES OF REGULAR BODIES

Rule 1. To Find the Surface. — Multiply the square of the linear side by the proper number in the table under *Surface:* the product will be the area.

Rule 2. To Find the Solidity. — Multiply the cube of the linear side by the proper number under *Solidity:* the product will be the solid content.

NO. OF FACES	NAME	SURFACE WHEN THE SIDE IS 1	SOLIDITY WHEN THE SIDE IS 1
4	Tetrahedron . . .	1.73	0.118
6	Hexahedron . . .	6.00	1.000
8	Octahedron . . .	3.46	0.471
12	Dodecahedron . . .	20.64	7.663

AREAS OF SEGMENTS OF CIRCLES

The common method is to divide the segment into a sufficient number of triangles and multiply the base by half the height. This is close enough for lumber.

A rule, at least a century old, to get an approximate area runs as follows:

To the chord add $1\frac{1}{3}$ of the chord of half the segment, and multiply the sum by $\frac{2}{5}$ of the height.

Example. — Suppose we have a segment of a circle with a chord 30 feet long and a height of five feet. The chord of half the segment is 15 feet, and $1\frac{1}{3}$ of this is 20. Adding 20 to 30 equals 50, which, multiplied by 2, gives the area.

Someone may ask, What is a segment and a chord? The segment is the bow used for arrows, and the chord is the string that connects the two ends.

DUODECIMAL MULTIPLICATION

This system is divided into twelfths instead of tenths as our ordinary notation is. It is used to compute the contents of stones, etc. It is a little more accurate than the decimal system. But it is not so popular as it used to be. Many now turn the inches to decimals of a foot and go on in the way already explained.

The inch is supposed to be divided into 12 parts, and each part into 12 seconds, etc.

Rule. — Multiply each denomination of the multiplicand by the feet of the multiplier, and place the product under that denomination of the multiplicand from which it arises, carrying at 12. Then multiply by the inches of the multiplier, and set each product a denomination farther towards the right hand. Next multiply by the parts, if any, and set the products a place still farther to the right. Then add the products.

1. Multiply 9 f. 4 in. by 3 f. 8 in.

3	8		
28	0		
6	2	8	
34	2	8	product.

2. Multiply	98 3 by 5 6	.....Ans. 540 4 6
3.	148 3 by 8 9	.... 1297 2 3
4.	87 6 8 by 11 10	.... 1036 0 10 8
5.	63 4 6 by 8 9 6	.... 557 2 0 9
6.	55 8 7 by 72 6 3	.... 4040 6 2 7 9

The feet in the product are square feet, 9 of which make a square yard. The inches in the product are 12th parts of a square foot, or each of them is 12 square inches, and the parts are square inches. The lower denominations are commonly expressed in fractions of a square inch: thus, 8 seconds are $\frac{2}{3}$ of a square inch, 9 seconds are $\frac{3}{4}$, and 7 seconds 6 thirds are $\frac{5}{8}$.

Example. — Suppose a stone 14 feet 8 inches x 2 feet 5 inches x 1 foot 4 inches, what is the cubical contents?

14	8		
2	5		
29	4		
6	1	4	
35	5	4	
1	4		
35	5	4	
11	9	9	4
47	3	1	4

Throwing aside the smaller figures as of no practical account the stone has $47\frac{3}{12}$ cubic feet. By the decimal system it has 47.21.

SPECIAL WEIGHTS

2 x 6. — This size of timber, set at 12-inch centers and ripped in two, would cover an entire floor with a lining of ordinary boarding, supposing the size to be full. In yellow pine each square foot would therefore weigh 3 pounds.

2 x 8. — This joist would weigh $1\frac{1}{3}$ as much as a 2 x 6, or 4 pounds when set at 12-inch centers on a floor.

2 x 10. — This size of joist, set at 12 inches, weighs 5 pounds per square foot of floor.

2 x 12. — This size weighs 6 pounds for every square foot of floor on a 12-inch center.

For 16-inch centers the weights are cut down one-fourth.

FLOORS

In general, for floor loads all lumber may be taken, in board measure, or one inch thick, at from $2\frac{1}{2}$ to 3 pounds per square foot. Oak and maple, if of full thickness, run to 3½ or so. The weights of the various kinds of lumber are found in the "Estimator."

Wood Partitions. — A 2″ x 4″ partition, 16-inch centers, plastered both sides, weighs 22 pounds to the square foot.

A 2 x 6, as above, 24 pounds.

Solid Partitions. — If these are estimated for weight use a basis of 120 pounds per cubic foot for plaster, and about 96 pounds for cinder concrete. One manufacturer gives only 60 pounds for cinder concrete, but this is too light. A partition, therefore, 2 inches thick, which is common, would average 20 pounds to the square foot. But the steel studs should be added if they are of heavy design.

Partitions 4 inches thick, of 2 inches cinder concrete, and 2 inches plaster, run about 32 pounds. Some would allow a little more.

Hollow Tile Partitions. — Each maker has different styles, thicknesses, and consequently weights of blocks. The following weights are average only. We should remember, however, that the government authorities at the San Francisco fire wreck came to the conclusion that no partition should be used less than 6 inches thick.

WEIGHT OF HOLLOW TILE PARTITIONS

	2-inch	3-inch	4-inch	5-inch	6-inch	8-inch
Semi-porous	12	15	16	18	24	27
Porous	14	17	18	20	26	32

These weights do not include the thin coat of plaster, which would be about 7 pounds on each side.

HOLLOW TILE FIRE-PROOF FLOORS

The weight of steel beams, plastered ceiling, concrete or flooring on top is not included. Average weights only are given. The heavier ones are standard.

	SIDE CONSTRUCTION		END CONSTRUCTION	
Depth inches	lbs. to sq. ft.		lbs. to sq. ft.	
6	24 to	27	20 to	25
7	26	28	22	26
8	27	32	24	30
9	29	36	26	34
10	33	38	28	36
12	37	44	30	40
15			37	50

Roof Blocks, 20 to 22 pounds.

Ceiling Blocks, 12 to 20 pounds.

Wall Furring, 9 to 10 pounds.

The Herculean Arch, Maurer's, weighs, for hollow tile alone, 8-inch, 33 pounds; 10-inch, 42; 12-inch, 51.

Concrete Floors. — The weight of these is easily enough obtained at 140 pounds to the cubic foot for stone or gravel concrete, and 90 to 96 pounds for cinder.

Plaster. — On some terra cotta ceilings the plaster does not weigh more than 5 or 6 pounds to the square foot; on others it may run to 10. For ordinary wood lath and plaster 9 pounds is about right. This is for one side only. For metal lath, allow 10 pounds.

Ceilings. — Made of wood they weigh from 2 to 2½ pounds per square foot; of corrugated iron, 1 pound; of stamped galvanized iron, 2 pounds.

Terra Cotta. — When solid allow 120 pounds per cubic foot. In shapes, from 60 to 90.

Roofs. — Instead of figuring out the weights in detail, allow from 40 to 50 pounds per square foot on roofs of flat pitch, to include everything. Wind pressure is not regarded on small buildings.

If desired, the weights can be easily obtained from the foregoing lists. Lumber weighs the same on a roof as on a floor.

Gravel alone, 4 to 4½ pounds per square foot.

Composition Roofs complete, 5½ to 6½ pounds per square foot.

Patent roofs from 30 to 100 pounds to the square.

Shingles not quite 3 pounds to the square foot.

Shingle tile, 9 to 10 pounds to square foot.

Average Tile, 7½ to 8½ pounds to the square foot.

Heavy Tile, 18 pounds to square foot.

Slate, 6 to 9 pounds to square foot.

The cost of labor per square on all these roofs is given in the "Estimator."

WEIGHT OF VARIOUS BUILDING MATERIALS PER CUBIC FOOT

	Pounds		Pounds
Brickwork, pressed	150	Steel	490
" fire	137	Lead	711
" ordinary	112 to 120	Rubble	154
" soft, salmon	100	Ordinary earth	80 to 90
Sandstone	151 to 170	Clay	100
Concrete, stone	140 to 150	Sand, dry or wet	95 to 140
" cinder	95	Gravel	110
" broken brick	125	Slate	175
Granite	165 to 170	White marble	165 to 170
Iron, cast	450		
" wrought	480 to 485		

The following table is from one of Mr. Richey's handbooks, listed in another chapter:

APPROXIMATE WEIGHT OF VARIOUS ROOF COVERINGS

Material	Weight in Pounds per Square of Roof
Yellow pine (Northern) sheathing 1 inch thick	300
" " (Southern)	400
Spruce	200
Chestnut or maple	400
Ash or oak	500
Shingles, pine	200
Slate ¼ inch thick	900
Sheet iron $\frac{1}{16}$ inch thick	300
" " $\frac{1}{16}$ inch " and laths	500
Iron, corrugated	100 to 375
" galvanized, flat	100 to 350
Tin	70 to 125
Felt and asphalt	100
" " gravel	800 to 1000

Skylights, glass, $\frac{3}{16}$ inch to ½ inch thick	250 to 700
Sheet lead	500 to 800
Copper	80 to 125
Zinc	100 to 200
Tiles, flat	1500 to 2000
" " with mortar	2000 to 3000
" pan	1000

The Northwestern Expanded Metal Company gives the following table of weights to go with its slabs of reinforced concrete.

MATERIALS USED FOR FLOORS AND ROOFS—WEIGHTS PER SQ. FT.

When slabs are covered with any of the following materials the weight is considered as forming part of the superimposed safe load.

Floors

Materials	Weight in lbs. per sq. ft.
⅞″, single thickness flooring, wood	3.00
2″ x 4″ spruce sleepers 16″ ctrs. and 2″ dry cinder concrete filling	8.50
Asbestone flooring ½″ thick	3.50
Rubber tiling	1.00 to 3.00
Tiling	3.00 to 8.00

Ceilings

¾″ wood ceiling	2.50
Corrugated iron	1.00
Stamped steel	2.00
Metal lath and plaster	10.00
6″ hollow tile	23.00
8″ " "	28.00
Plastering	5.00

Roofs

Common shingles	2.50
18″ shingles	3.00
Slate, $\frac{3}{16}$″ thick	7.25
" ¼″ "	9.60
Plain tile or clay shingle	11.00 to 14.00

Ludowici tile	8.00
Copper sheets	1.50
Tin, including one thickness of felt	1.00
Five-ply felt and gravel	6.00
Four " " " "	5.50
Three " ready roofing	1.00
Skylights with galvanized iron frame	5.00
Sheathing, 1″ thick, Pine or Hemlock	3.00
" " " Yellow Pine	4.00
2″ book tile	12.00
3″ " "	20.00
2½ solid tile	16.00

WAGON LOADS

"A team goes about three miles an hour with a loaded wagon, and four with an empty."

The average load all over the country with a double team is 4,000 pounds. On a paved street a heavier load can be estimated on. For sand, stone, earth, and such material a load is usually about one cubic yard. On good roads side-boards are put on the wagons, and about a yard and a half hauled.

Sewer Pipe.—A load is usually about 2,000 lbs. of standard pipe and 2,200 of double strength. The lengths are 2, 2-6, and 3 feet. The following table is from "The Business of Contracting," by McCullough.

A LOAD OF SEWER PIPE

Size inches	Number pieces	Size inches	Number pieces
5	80	16	14
6	63	18	12
8	44	20	9
9	36	21 and 22	8
10	29	24	7
12	23	27	5
14	19	30	4
15	16	33 and 36	3

Load of cement, 10 barrels; load of brick, 1000; load of lumber, 4,000 to 5,000 pounds.

There are 7½ barrels to the cubic yard.

CHAPTER II

FOUNDATIONS

Risk. — The risky part of a building is the foundation. If that sinks nothing is safe. A few plain instructions are given in this chapter for the use of the contractor-constructor.

Limit. — It is not wise for the ordinary builder to attempt to design a sky-scraper, a pyramid, or a reinforced concrete building without help from the experts. It is best to leave some work to the regulars. When even they fail on reinforced structures, quicksand soils, and have to stand back and look at the wreckage, it is better that the builder-architect should be modest.

Special Foundations. — Tanks and such installations often require foundations running clear down to the basement footings. The weight is thus kept off the main walls.

The Underwriters' Code calls for iron or steel beams for tanks carrying more than 500 gallons. They must rest on masonry or steel supports, and must not be placed near a stair unless it is enclosed with brick walls strong enough to support the weight. If a wood cover is used on the tank it must be protected with tin.

BEARING POWER OF SOILS IN TONS OF 2,000 POUNDS TO SQ. FT.

Quicksand and marshy soil	½ to 1
Good dry sand in natural bed	2 to 3
Good dry sand well packed	4 to 5
Gravel and coarse sand well packed	8 to 9
Dry clay 15 feet or more thick	4 to 5
Soft wet clay	1
Clay and sand	1½
Best solid natural earth	3½ to 4
Rock broken or partly disintegrated	5 to 25
Solid bed rock	100

The Chicago building ordinance, 1905, allows for clay at least 15 feet thick, 3,500 pounds to square foot; dry sand, 4,000; mixed clay and sand, 3,000.

Almost all the great Chicago buildings have settled. The main thing is to have an equal settlement.

The Building Code recommended by the National Board of Fire Underwriters has the following allowances in tons per square foot:

Soft clay	1
Ordinary clay and sand together, in layers wet and springy	2
Loam, clay, or fine sand, firm and dry	3
Very firm coarse sand, stiff gravel, or hard clay	4

The following table, published by the Ransome Company, forms an interesting and useful comparison:

BEARING POWER OF SOILS

Kind of Material	Bearing Power in Tons per sq. ft.	
	Min.	Max.
Rock—the hardest—in thick layers of native bed	200	..
Rock equal to best ashlar masonry	25	30
Rock equal to best brick masonry	15	20
Rock equal to poor brick masonry	5	10
Clay on thick beds, always dry	4	6
Clay on thick beds, moderately dry	2	4
Clay, soft	1	2
Gravel and coarse sand, well compacted	8	10
Sand, compacted and well cemented	4	6
Sand, clean, dry	2	4
Quicksand, alluvial soils, etc.	0.5	1

COMPUTING OF LOADS

For buildings of more than three stories the Underwriters recommend the following manner of "weighing" the total building.

For warehouses and factories full dead and live load.

In stores and light manufacturing buildings, churches, schoolhouses, and places of assembly, full dead load and 75 per cent. of live load.

In office buildings, hotels, dwellings, apartment and tenement houses, full dead load and 60 per cent. of live load.

The foundations should be loaded uniformly.

TESTING THE SOIL

Variations. — Some cities specify a load of not more than 40 pounds to the square foot, and others allow 70. When there is such a difference among the experts we need not be so very nice in our calculations for an ordinary dwelling.

Weight. — When figured out in detail an ordinary frame house, including the weight of joists, floors, and plaster, at 70 pounds to the square foot, the pressure is only about 1½ tons to the square foot of soil, allowing the usual offsets for brick or masonry.

As good soils carry more than twice as much, there is no danger of settlement, so far as the bearing is concerned. The earth will hold if the mortar will.

This is for 70 pounds; if only 40 are allowed the security is even greater, so far as figures go.

Brick Weights. — A change to brick walls makes a weight of only 1¾ tons. For ordinary dwellings, or two-story and basement houses, then, the usual footings are ample without testing on reasonable soil. Tradesmen have found out this long ago. The footings would have been increased had they been too narrow.

Manner of Testing. — The test should be made at the required depth, and not on the surface. Take a timber 12″ x 12″ or a smaller one with a plank of that area nailed on the bottom. Stand it on end and build a platform large enough to hold the material to be used for weight. This will give a testing surface of 1 square foot when set upright. Pig iron is best for a load, but may not be obtainable; stone or brick are good; coal may be made to serve; sacks of cement or grain will do.

Level. — Take the exact level before testing; this may be done with an ordinary level and straight-edge, for contractors do not generally have a builder's level. They cost about $40.

Watch at what weight the timber settles, and allow not more than half for the permanent load. If the settlement is made at 3 tons, the unit should be 1,500 pounds. The ground below the 12″ x 12″ should be cleared off before testing. The platform may be held in place by guy ropes.

WEIGHT OF A FRAME HOUSE

With ordinary soils it is thus never necessary to figure out the weight of a dwelling. In case it has to be done for a very soft soil, the method is easy. Get the area of each floor over the walls in square feet and multiply it by not more than 70 pounds; add the area of only that part of the attic floor used, and not in the angle below the rafters, and allow 40 pounds for that per square foot; put the roof at 10 pounds per square foot of surface; add the side brick foundation walls at 80 pounds to the square foot; then the outside walls above at 20 pounds; and finally the inside partitions at 20 pounds also.

Taken in this way, there is a weight of 140 tons on a house 26′ x 32′. But the central girder would take off about 20 tons, thus leaving 120 tons, or 60 tons on each side wall, on a distance of 32 feet.

The end walls have nothing but their own weight to carry, and theoretically the footing for them should be narrower, but it is usually made of the same width.

We now see how to take the weight of another building, and go into it more in detail. The method can then be applied to any structure.

WEIGHT OF A PLAIN BUSINESS BUILDING

Example. — Let us take a business building 40′ x 100′ as an illustration. Assume that it is three stories and basement high, with basement 9 feet in the clear, first story 12, second and third stories 11. The thickness of the walls would be 17, 17, 13, 13-inch. A row of cast iron columns would go through the center of the building.

The openings would be of the usual type, and would not be deducted in calculating the weights. Where the bearing power of the soil may be miscalculated 20 to 30 per cent., there is no use in being finical about the difference in weight between brickwork and glass or doors. In large machine shops, foundries, and other manufacturing buildings where the openings take up from one-third to one-half the area of the walls, the difference has to be taken into account.

We shall assume that the soil will support three tons to the square foot and that the floor load is set at 125 pounds. This will include the weight of the material in the floor itself—joists, plaster, etc.

Summary. — We have then the weights as follows:

Basement concrete footings below floor line, 100′ x 12″ x 32″=267 cubic feet at 145 pounds	38,715
Basement brick walls to top of first story floor joists, 100′ x 10′6″ x 17″=1,050 square feet at 160 pounds	168,000
First story walls to top of second floor joists, 100′ x 13′6″ x 17″, 1,350 square feet at 160 pounds	216,000
Second story walls to top of third floor joists, 100′ x 12′6″ x 13″, 1,250 square feet at 120 pounds	150,000
Third story walls to top of ceiling joists, 100′ x 11′9″ x 13″, 1,175 square feet at 120 pounds...........	141,000
Average from top of ceiling joists to top of parapet wall, 100′ x 4′ x 9″=400 square feet at 80 pounds..	32,000
Floor load on first, second, and third stories, 100′ x 9′6″ x 125 pounds x 3	356,250
Live load, 15 per cent. of the floor load	53,435
Roof load, 1,000 square feet at 50 pounds	50,000
	1,205,400

Remarks. — To get at the weight of the concrete, the ordinary extension of two-thirds of the height was allowed on a 12-inch base. That is, it was assumed that a 12-inch base course of concrete was thick enough, and since a 17-inch brick wall went on top of this, the extension required would be two-thirds of the 12 inches, or 8 inches. The 8-inch extension on each side added to the 17-inch wall, or as some call it, the 16-inch brick wall, gave the 32-inch width for a trial base in order to get about the weight.

We must now see if this is wide enough to support the foundation at three tons to the square foot.

Lineal Foot Weight. — Dividing the total weight of 1,205,400 pounds by 100 feet, the total length of the side wall, we have 12,054 pounds to the running foot. This is practically a weight of six tons, so that if the foundation was only 2 feet wide it would be strong enough. We could, therefore, reduce the width of the base so far as strength goes by, say, 4 inches to be entirely safe, leaving it 2 feet 4 inches wide, and proportioning the footings of the interior columns on the same basis per square foot.

But if 2 feet only is required to carry the load, and we make the base 2 feet 4 inches, it is clear that the load is less. How much is it? We have to divide 12,054 pounds by $2\frac{1}{3}$ feet. By the vulgar fraction route the answer is 5,166 pounds.

Here is a chance to make use of the decimal notation alluded to in another chapter. Looking in the table of decimal equivalents of inches expressed in feet, we find that 4 inches is a recurring decimal and would go on a mile long at .333333333. As with dollars and cents, we do not need to go beyond the cents, or two points. We have then to divide a weight of 12,054 pounds per lineal foot by 2.33 feet of a width.

```
2.33)12,05400(5173
     11,65
     -----
        404
        233
        ----
        1710
        1631
        ----
          790
          699
         ----
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There is a difference of a few pounds in the two methods. It will be noticed that two ciphers are added to the 12,054 pounds before the division begins. This is because there are two figures to the right of the dot in 2.33. Matters are thus equalized, and we proceed as if there were no dot at all. No more attention is paid to it. In this western country there used to be an Indian called Young-Man-Afraid-of-His-Horse. When we see anyone balking at a simple decimal we have to think of this Indian.

But 5,173 pounds is too cumbersome to work with. We can therefore reduce it to tons by dividing by 2,000 pounds. Work this with the decimal system and you will find the answer to be 2.586 tons. This is really 2 tons, and 586-1000 of a ton. We might as well call it 600-1000 of a ton, as it is almost that. Cutting off the useless ciphers we have $\frac{6}{10}$ of a ton, or in decimals 0.6. The figure required would thus be 2.6 tons to the square foot. We have to arrange the foundations of the interior columns, rear and front walls on this basis, so that all the building will bear equally on the soil, and if settlement occurs it will go down in a body.

Practice. — It may be said that we could reduce the foundations to 2 feet wide and still be safe, but that would make only a 4-inch extension of the footing beyond the face of the brick, and no matter how much of a theorist an architect may be, he likes to see the footing course run out more than that. Besides, the building laws of cities compel a wider extension. It is better to be safe than sorry. The extension has to be at least 6 inches on each side for most cities. Under a 16-inch wall this would give a base of 2 feet 4 inches, which is what we are figuring on. If the soil carried only two tons instead of three it would have to be wider.

Brick Footings. — It is thus seen that the usual brick footings are ample bearing for ordinary buildings. A 9-inch wall has a 21-inch base; a 13-inch, a 25-inch; a 17-inch, a 29-inch; a 21-inch, a 33-inch; a 25-inch, a 37-inch.

The Offsets should really be made about 1½ inches for a single course, and 3 inches for a double. The first brick course should not be set back more than half the thickness of the concrete base upon which it rests.

The Rear Walls. — Instead of taking the whole width of the building for this weight we might just take one lineal foot, and thus use fewer figures.

Concrete, 2.33 cubic feet at 145 pounds	338
Brick to top of second story joists, 24′ x 1′ x 17″ x 160 pounds	3840
Brickwork from top of second story joists to top of roof joists, 25′ x 1′ x 13″ x 120 pounds	3000
	7178

There is no floor or roof load to be considered on the rear wall, unless where the central girder comes. This calculation is only for the regular wall with a footing supposed to be continuous, and not for concentrated piers.

Supposing the rear footing were to be made 2 feet wide, the weight to each square foot would be only 3,600 pounds, or 1.8 tons.

Theory. — We might leave the side walls 2 feet 8 inches, as originally figured for weight, and cut the rear ones to 2 feet if the building laws would allow us. This would make the weight on the side 2.35 tons, and on the rear, 1.8. The sides would have to be increased even more to equalize the pressure.

Practice. — As a matter of fact most architects leave the rear wall the same as the side ones, although the floor weight does not come on it at all. The building laws compel the same thickness for brick, regardless of rear or side, bearing of floor or not. The floor load is always figured much higher than it ever weighs, for few floors are loaded all over at one time, and this makes a factor of safety that takes care of part of the difference of rear and front walls as compared with those on the sides.

Piers. — In the center of the rear wall the girder supporting the floor has to have a bearing. A specially wide foundation is therefore necessary, and the method of figuring out this is the same as for any pier in front, side, or interior. If there is a continuous wall where the girder comes, of course the footings are simply extended. Here we shall assume that there is an isolated pier, and that the design of the building gives it a width, running the long way of the wall, of 6 feet.

PIER WEIGHT

Concrete (assumed at 8′ x 3′ x 2′) x 145 pounds	6,960
Brickwork to top of second story joists, 6′ x 24′ x 160 lbs.	23,040
" from top of second story joists to top of roof joists, 6′ x 25′ x 120 pounds	18,000
Floor load, 7′ x 20′ x 3 x 125 pounds	7,500
Live load, 15 per cent. of the floor load	1,125
Roof load, 7′ x 20′ x 50 pounds	7,000
	63,625

This total load goes on a base we have supposed to be, in order to get about the weight, 3′ x 8′, or 24 square feet. That is a weight of 2,651 pounds to square foot. But the rear wall has 3,600 pounds, and therefore our assumed base is too large. Dividing 63,625 by 3,600 we find that we require only 17.67, or say 18 square feet. As this pier carries a good deal of the load we should increase the area about 10 per cent. to be safe. Suppose we allow 20 square feet for a base. The brickwork above is 17″ x 6′. The footing resting on the ground would be practically 2′9″ x 7′4″, tapered up from a square concrete base to suit the brick above.

The pressure on this pier and on the rear wall would be about equal, with the advantage in favor of the girder pier.

There is a certain amount of weight coming on both sides of the pier, with windows and brick above and below them, but as each plan has its own different features of this kind these weights are not figured here, although they must be added to the total of an actual plan.

Interior Piers. — In getting the floor load for the girder pier a distance of 14 feet from center to center of columns and wall bearing was assumed, and thus the allowance was 7 feet back. The 20 feet was 10 feet on each side of the center, or reaching half way to the walls, where it met the other load supported by them.

At 14-foot centers each of the interior columns has thus a floor space of 14′ x 20′ to take care of, and to get the size of the base required we proceed as follows, after supposing that the concrete base will be about 4′ x 5′ x 2′.

Concrete, 4′ x 5′ x 2′ x 145 pounds	5,800
Floor load, 14′ x 20′ x 3 x 125 pounds	105,000
Live load, 15 per cent.	15,750
Roof load, 14′ x 20′ x 50 pounds	14,000
Weight of cast iron columns from basement to roof, about	3,500
	144,050

This is a weight of 72 tons. At 2.4 tons to the square foot, the same as the side walls, we require 30 square feet. But it is clear that the weight of concrete allowed is too small. With the extra size of base and the tapering required we may allow 6 tons more to be safe. This gives a total of 78 tons to be provided for. Dividing this by 2.4 we see that the base has to have 32.5 or 32½ square feet.

But now comes another trouble: I have seen the floors of buildings going up and down like the waves of a lake through settlement of piers, and that in buildings designed by good architects. A pier is so much more concentrated than a long wall that we must be more careful with the loading. We shall therefore increase the base to 6′ x 6′, or 36 square feet.

First of all, a base of this size would be put down about 16 inches thick; the next layer would be set back about two-thirds of the thickness, say, 10 inches, making it 5′2″ x 5′2″ and 16 inches thick also; the third layer would be 4′4″ x 4′4″ and 12 inches thick; and the top layer might be 3′6″ x 3′6″ x 9″, ready for the base plate.

It should be noted here, however, that some architects set back only half the thickness of the base below, instead of two-thirds as above. The main thing is to get the base of the right size, and after allowing at least 12 inches thick a set-back of 8 inches to 6 inches can be made and the pier tapered instead of being put up layers as figured above. Concrete piers of this kind usually are tapered.

Front Piers. — These should be figured out in the same way. With a store front, for example, most of the load comes on the center pier. Any special weights of this kind must be taken into account.

Unit. — In all these calculations 125 pounds is supposed to include the floor itself. This is the weight usually given for light manufacturing and light storage buildings, but in addition, the weight of joists, flooring, and plaster has to be put in the total.

Yet the average floor load of 210 office buildings in Boston was found to be only 17 pounds to the square foot, and the heaviest was 34 pounds. This was the live or movable load, and did not include the floor itself. We thus see that there is a safe margin with all the loads allowed in a code of the average kind.

Any weight may be figured up the same as the 125 pound one in the foregoing building.

Equal Pressure. — The danger comes with heavy chimneys, vaults, water tanks, and such special installations. We have all seen chimneys settle and crack the plaster through one story after another. The main thing is to have an equal settlement. Sometimes piers in the interior are made to carry a heavier load than the outside walls, so that if the building settles the weight will press inward and keep it together, instead of outward and pull it apart, as would be the case if the outside walls settled and the inside piers did not.

So with a block of a couple of flats, for example, or a business building, like the one we have just considered, if there were a center wall instead of a row of columns. It must be remembered that the floor load comes from both sides on such a wall, and that it has therefore twice as much to take care of. The footings have to be arranged to suit. If anything, they should be given a heavier load than the outside walls.

Dead and Live Loads. — For our purpose a dead load may be defined as the weight of the permanent, unchanging structure, and a live load as the weight of the movables coming upon it. A brick wall is thus a dead load, and furniture, a movable safe, a machine, or a person, a live load.

Theory. — Many engineers say that dead loads only should be considered in proportioning footings. For an ordinary building this is probably right. After settlement takes place there is not much probability that the live loads will disturb the structure in any way. "To get the best results in the way of equal settlement, the foundations should be proportioned to the dead load only," say two engineers.

Concentrating Loads. — But in such a case as railroad shops, where a 120-ton crane lifts an engine, sometimes close to one end, and most of the live load is thrown on a single column, an allowance has to be made to receive it. But this is out of the ordinary line of construction dealt with here.

Method. — For buildings such as storage warehouses, where heavy loads are carried, "to allow for the live load the unit bearing load should be reduced."

Take, for example, a soil carrying 4 tons per square foot as a maximum, or heaviest load. Suppose one column receives a dead load of 260 tons and a live load of 140; and another, 140 and 80. For the first column we require 100 square feet on a 4-ton basis. But assuming that the dead load only is considered there are 260 tons to be divided by 100, thus giving only 2.6 tons to the square foot.

Setting aside the 80 tons of live load in the second column we have the other load of 140 left. Dividing this by 2.6 gives the number of 54 square feet required for the base.

In other words, the column or pier receiving the heaviest load is taken as the standard, and the size of the footing based upon this load at 4 tons, or whatever it may be to suit the soil. Then the total dead load is divided by the number of square feet obtained in order to get the unit figure for the entire building, regardless of live loads.

One Ordinance. — The New York ordinance requires that for stores and light manufacturing buildings, schoolhouses, churches, etc., the full dead load and 75 per cent. of the live load shall be taken. For office buildings, tenements, hotels, etc., the dead load and 60 per cent. of the live load is taken. The unit pressure is obtained as above by selecting the heaviest pier or column, getting the area required for both dead and live, then dividing the dead by the square feet in the base, and proportioning all footings on this figure.

Average. — For ordinary dwellings 70 pounds includes everything. Wind pressure is not considered under the ordinance of New York for any building less than 100 feet high; and it need not be, unless the building is of an extremely narrow type.

For warehouses and stores, etc., Kidder allows 50 per cent. of live load; but for office buildings and hotels he adds 15 pounds per square foot to the dead load.

PILE FOUNDATIONS

"Doing Time." — For six or seven years I worked on plans for railroad shops, mostly all set on piles. According to the fashion of such work we usually made several sets of drawings to suit various temperaments and requirements, until the desired type was finally decided on. I thus had a chance of spacing more piles than the average architect runs across in a lifetime. As a rule, railroad engineers have more to do with piling than architects.

Load. — As a rough and ready "formula" we held to a minimum distance of 2 feet 6 inches, and a maximum of 4 feet on centers. The load was usually 17 tons, but seldom more than 20. The soil was so soft that it had little side resistance. In good soil, with piles driven to rock, 30 tons might have been used. Loads of more than this would be carried, but for ordinary buildings the piles would have to be spaced too far apart to get on enough of the superstructure to make up the load.

No grillage was used, but a heavy mass of concrete was required on top as the distance from base to grade ran from 8 feet to 12 feet. The piles were driven to rock.

In special cases the center distance was changed. No concrete piles were used.

Theories. — It would be easy to collect a small volume of pile theories, but the man for whom this book is written, the Average Contractor, does not require theories.

Spacing. — In that excellent publication, " The Underwriters' Model Code," for example, the rule is laid down that wood piles shall not be spaced more than 36 inches on centers, nor less than 20 inches. The diameter is given as 5 inches and 10 inches for short piles, and 12 inches for long ones, at the heavy end. The greatest load is 20 tons.

It may be possible to drive a pile at 20-inch centers in some soils, but in others it could not be done. Assuming a 10-inch head that would leave only 10 inches between the piles.

In New York 2 feet 6 inches is the maximum distance, and the load is 20 tons. Boston allows 3 feet, at most, between centers.

Water. — The tops of wood piles have to be cut off below the water line. Wood under water lasts for centuries. If not kept below water it rots.

Concrete Piles. — These are much used now, and especially in places where the water is low. They can come up clear to grade. A load of 25 tons per square foot is allowed, plus 3 tons more per square inch of the longitudinal steel reinforcement. Take as an illustration a pile 10 inches in diameter. Looking in the table of areas of circles we find that this pile would have a surface of 78.54 square inches. A square foot has 144. Reducing the load in proportion to the area we get close to 14 tons. But an allowance of 3 tons is made for each square inch of steel showing in the end or section. This has to be added, and would vary according to the load to be carried.

Capping. — Boston specifies a granite capping for piles; Chicago a wood grillage; but it would seem that concrete accommodates itself better to the requirements than any of these two. It goes down about 12 inches over the piles and surrounds them with about 10 or 12 inches in such a way that side motion becomes impossible. Then the older it gets, up to at least three years, the harder it grows. If grillage is used it should be hardwood, not less than 6 inches thick.

Light Load. — In many cases, such as the gables of manufacturing buildings, more piles have to be put in than the weight of the wall really requires. Take, for illustration, a section of a 17-inch gable, 20 feet long and 40 feet high. Even disregarding the large openings which usually come in such buildings, the weight would be only 128,000 pounds for brick; and taking the concrete at 6 feet deep, and the foundation continuous, say, 5 feet wide by 20 feet long by 2 feet high for base; and an average of 3 feet wide by 20 feet long by 4 feet high for the upper part. This is a total for concrete of 440 cubic feet at 145 pounds equals 63,800.

Brick and concrete would therefore weigh less than 96 tons. At 16 tons to the pile, six only would be required so far as strength goes. But the piles have to be set in at least two rows, and cannot be more than 4-foot centers—some cities, as already seen, allow only 3 feet. This would make it necessary to use 10 piles, and under the Boston law, 15.

Staggering. — Piles are arranged in staggered rows. That is, if there are two rows the piles are not set opposite each other, but the pile in the one row is set opposite the center of the space in the other.

Post Foundations. — The first cottage I built was set on a post foundation. Many buildings are, especially in railroad work. Cuttings of pile heads are used for supports, or ordinary timbers.

The posts are usually set about 8 feet apart, and a 6″ x 8″ or a larger sill laid on top. As we have seen, the load on the side walls of the average two story frame house is never more than 1½ tons to the square foot, while a base 2′ x 2′ on good soil carries about 12, which is good for a continuous foundation, 8 feet long, at 1½ tons. A 3′ x 3′ base does not cost much more than a 2′ x 2′ one, and gives over twice the bearing surface.

A layer of plank is put down and a cross plank spiked on top. The post is then set and braced into position.

GENERAL NOTES ON FOUNDATIONS

Frost. — For a good building be sure to go below the frost line. In the middle west this is about 4 feet below the surface. But thousands of cottages are set only about a foot in the ground.

Dry Sand or gravel makes the best foundation, short of rock. Sometimes to improve a poor soil holes are bored and dry sand rammed into them. This not only gives good soil in the place of poor in the holes themselves, but compacts the surrounding soil.

Trenches are also dug and rammed full of dry sand and gravel. If the sides are confined so that the material can be packed in, this makes a good foundation, unless the soil below is too poor.

Side Pressure. — Sometimes, again, ordinary wood piles are driven in, and the soil compacted in this way. The danger comes from dry rot, if the piles are above water.

Wet Soils are improved by drainage.

Direct Pressure. — Keep the center line of the footings below the center line of the wall above. In other words, do not extend the footing over on one side more than on the other.

Stepping. — Keep all the foundation walls at the same level if possible, but if not, step up in stair fashion, and do not lay on the angle. Any bricklayer understands this system.

Concrete Layers. — Tamp the concrete in layers of 6 inches or 8 inches thick. On soft soils see that the footings are spread wide enough. But after the size is set, it may be found that it is cheaper to use piles.

Offsets. — As already noted the offsets on concrete should not be more than two-thirds of the height of the base, and some allow only half. For good heavy dimension stone three-fourths of the height may be used.

Made Ground. — Do not build a structure of any weight on filled ground without taking extra precautions. Architects have had their reputations hurt in this field trying to save money for the owners. Concrete piles can be used for a heavy structure. Plank is often made to serve for an ordinary cottage. A better material now is expanded metal and concrete. This will make a continuous foundation if anything will, and it will be a strong one if properly built and allowed to harden before the weight is piled on.

Paint. — If iron is used below the water level it should be well painted or coated with asphaltum.

Concrete. — This seems to be the best kind of a material for the footing course. Bricklayers stand firmly by hard brick laid in good Portland cement mortar, and properly wetted and laid they make a foundation that lasts for centuries; but, generally speaking, concrete would seem to be superior. It does not require skilled labor, and hardens for several years until it is practically a solid stone lying on the earth. It is much superior to rubble of the ordinary kind.

Thickness. — The base should be made 12 inches thick, although 8 inches is enough for cottages and light structures.

Cements. — The natural cements are seldom used now. Portland is cheap enough. The bearing load of concrete with Portland is set at 15 tons per square foot; with natural cement, at only 8. This shows the difference in values. The crushing strength is 15 tons per square foot for concrete a month old; 60 tons for 6 months old; and 96 tons for one year old.

Foundation Proportions. — As to quality of concrete, a mixture of 1, 2, 5 is recommended by the Underwriters; but 1, 3, 6 is often used and is all right for ordinary work. This means 1 cement, 3 sand, and 6 broken stone. The measurement should be made on the basis of a packed barrel.

Rubble has been used for foundations for centuries, and it is now somewhat too late to say anything against it. But the rubble that was laid in Europe had much wider foundations than ours to begin with, and was also laid in better mortar, as a rule, and with closer joints. Allusion is made elsewhere to the walls of a cottage with an 8-foot ceiling being 30 inches thick. I have crawled through old castle walls from 8 feet to 10 feet in thickness. Why compare our nicely proportioned work with that kind? Concrete is better than the ordinary rubble we build.

Thickness. — All good codes specify a thickness of 4 inches more for rubble than for brick.

Water Supply. — In country districts, and sometimes in cities, a private supply has to be put in. The size of the pipe has to be regulated by the demand in houses, stables, and other consuming points.

In some cities 50 gallons is the amount used per day per family; in others, 200. When meters are used the demand is considerably reduced; probably 80 gallons for a family of five is sufficient; 100 is liberal.

The amount of water delivered is regulated by the pressure and the size of the pipe. With the same pipe several times as much water may be delivered by changing the pressure.

The following table is made out for a 10-foot fall and a pipe 500 feet long. All that it is meant for is merely an approximate figure. Here it should be remembered that circles, or ends of pipe, are to each other as the square of their diameter. A 1-inch pipe and a 1½ have bores in the proportion of 64 and 144, for the one measures 8 eighths and the other 12. This means that for a little extra expense a pipe can be had with twice the capacity.

The table is made out for a 24-hour supply.

⅜-inch bore	576 gals.	¾-inch bore	3,200 gals.
½ " "	1,150 "	1 " "	6,624 "
⅝ " "	2,040 "	1¼ " "	10,000 "

SEWERS

Taking an average all over a city an allowance of 100 gallons of discharge in 12 hours is a very large factor to use. The 12-hour basis really means 24, but we sleep one-third of the time, and the factories run only 8 to 10 hours.

Size of pipe	Cu. ft. per second	Gals. per hour	Size of pipe	Cu. ft. per second	Gals. per hour
4-inch	0.05	1350	15-inch	1.9	51300
6 "	0.15	4050	18 "	3.1	83700
8 "	0.33	9000	20 "	4.1	110700
10 "	0.60	16200	24 "	6.8	185600
12 "	1.00	27000			

CARRYING CAPACITY OF SEWER PIPE

When the area to be drained, and the fall of the sewer per hundred feet is known, the size of the pipe required can be easily ascertained by referring to the following table, which shows the number of gallons discharged per minute by specified sizes and grades. In main sewers this flow of course is greatly increased by the added pressure of connecting laterals:

CARRYING CAPACITY—GALLONS PER MINUTE

Size of Pipe	1 in. fall per 100 ft.	2 in. fall per 100 ft.	3 in. fall per 100 ft.	6 in. fall per 100 ft.	9 in. fall per 100 ft.	1 foot fall per 100 ft.	2 feet fall per 100 ft.	3 feet fall per 100 ft.
3 in.	9	12	15	22	27	31	44	54
4 "	20	28	35	50	62	71	101	124
6 "	63	89	111	156	194	224	317	389
8 "	140	198	246	348	432	499	706	864
9 "	196	277	339	480	595	687	971	1180
10 "	261	369	457	648	803	928	1310	1610
12 "	432	612	758	1070	1330	1530	2170	2660
15 "	800	1130	1400	1980	2450	2830	4010	4910
18 "	1320	1860	2310	3260	4040	4660	6590	8080
20 "	1720	2500	3060	4330	5305	6130	8660	10610
24 "	2910	4110	5035	7191	8810	10270	14520	17790
27 "	4020	5680	6960	9840	12050	13920	19680	24110
30 "	5380	7618	9320	13180	16140	18640	26350	32280
33 "	6950	9840	12050	17040	20865	24090	34070	41730
36 "	8800	12450	15210	21565	26410	30500	43130	52820

Sewer pipe have very much greater carrying capacity than brick sewers of same dimensions.

Statistics show the maximum rainfall to be about one inch per hour, except during very heavy and uncommon storms.

One inch rainfall per hour gives 22,633 gallons per hour for each acre, or 377 gallons per minute per acre.

Experience shows that owing to various obstructions, not over 50 or 75 per cent. of the rain falling will reach the drain within the same hour. Due allowance should be made for this fact in determining the size of pipe required, as severe storms are generally of short duration.

CHAPTER III

THE SUPERSTRUCTURE (1)

WALLS AND MASONRY

Thickness. — The following table of thickness of walls as specified in the city of Omaha is given as a guide to average practice. Those who have gone over building codes know that they are practically alike in their main features.

BUSINESS, MANUFACTURING, AND PUBLIC BUILDINGS

Outside, Party and Division Walls	Basement	1st Story	2nd Story	3rd Story	4th Story	5th Story	6th Story	7th Story	8th Story	9th Story	10th Story	11th Story	12th Story
1 Story	16	12											
2 "	16	12	12										
3 "	16	16	12	12									
4 "	20	16	16	12	12								
5 "	24	20	16	16	12	12							
6 "	24	20	20	16	16	16	12						
7 "	24	20	20	20	16	16	16	12					
8 "	28	24	20	20	20	16	16	16	12				
9 "	28	24	24	20	20	20	16	16	16	12			
10 "	28	24	24	24	20	20	20	16	16	16	12		
11 "	32	28	24	24	24	20	20	20	16	16	16	12	
12 "	32	28	28	24	24	24	20	20	20	16	16	16	12

All brick or stone buildings having the first story, or basement and first story, designed for business purposes and the upper stories for dwellings, shall have all walls of a thickness not less than the number of inches shown in the following table, to-wit:

Brick Walls and Dwellings	Basement	1st Story	2nd Story	3rd Story	4th Story	5th Story	6th Story	7th Story	8th Story	9th Story	10th Story	11th Story	12th Story
2 Story	16	12	8										
3 "	16	12	12	12									
4 "	20	16	12	12	12								
5 "	20	16	16	12	12	12							
6 "	20	20	16	16	12	12	12						
7 "	24	20	20	16	16	12	12	12					
8 "	24	24	20	20	16	16	12	12	12				
9 "	24	24	20	20	20	16	16	12	12	12			
10 "	28	24	24	20	20	20	16	16	12	12	12		
11 "	28	24	24	24	20	20	16	16	16	12	12	12	
12 "	32	28	24	24	24	20	20	16	16	16	12	12	12

The above table shall apply to all walls of 60 feet and under in length; walls exceeding 60 feet in length shall not be allowed to have more than 2 upper stories 12 inches thick, and no 8-inch wall will be permitted on a building more than 60 feet in length. And brick or stone dwelling houses shall have walls of a thickness not less than the number of inches shown in the following table, to-wit:

DWELLINGS

Brick Walls for Dwellings	Basement	1st Story	2nd Story	3rd Story	4th Story	5th Story	6th Story	7th Story	8th Story	9th Story	10th Story	11th Story	12th Story
1 Story	12	8											
2 "	16	12	8										
3 "	16	12	12	12									
4 "	16	16	12	12	12								
5 "	20	16	16	12	12	12							
6 "	20	16	16	16	12	12	12						
7 "	24	20	16	16	16	12	12	12					
8 "	24	20	20	16	16	16	12	12	12				
9 "	24	20	20	20	16	16	16	12	12	12			
10 "	28	24	20	20	20	16	16	16	12	12	12		
11 "	28	24	24	20	20	20	20	16	16	12	12	12	
12 "	32	28	24	24	20	20	20	20	16	16	12	12	12

The above table shall apply to all walls 44 feet and under in length; when over 44 feet in length such walls shall not be allowed to have more than two upper stories 12 inches thick, and no 8-inch wall will be permitted on a building more than 44 feet in length.

Every party wall must be built through and at least 18 inches above the roof boarding, not less than 12 inches thick.

Variation in Size. — But while walls for dwellings are specified as 16 inches in the basement, and 12 and 8 inches above, they are usually built of 12 inches for the two first stories and 8 inches on the second. Here it should be observed that some cities specify their walls in odd and others in even inches—9, 13, 17, 21, 25; and 8, 12, 16, 20, 24. The real thickness is often midway between.

The Underwriters for rubble and concrete call for 8 inches thicker in the basement than on the first story, but only 4 inches difference if of brick. This is for 12 feet below the curb level, and would take in most buildings; if deeper, each 10 feet, or fraction, must have 4 inches more. This would seem to flatter brick more than concrete.

No wall, even for a dwelling, is allowed in this code under 12 inches.

Distance of Walls. — This Underwriters' code, and most others, are based on a width of not more than 25 feet between bearings. If the span is more the wall should be increased 4 inches or else have strong buttresses. Not less than 4 inches of masonry is put between the ends of timbers in center walls to block fire. One division wall, at least, must be put in every 50 feet.

Length. — When a building is more than 105 feet long this model code would make the walls 4 inches thicker. Western codes allow from 120 to 132 feet.

HEIGHT OF STORIES

Many codes limit the height of stories with the thicknesses as already given. The Underwriters give the following limits:

First story, 16 feet in clear
Second story, 14 feet in clear
Third story, 12 feet in clear
Fourth and upper stories, 11 feet in clear

When these heights have to be exceeded an extra 4 inches must be added. These walls and all others should come to the top of the joists of each story full thickness.

Parapets. — The difference between an ideal code and an ordinary one is seen in the provision for fire walls above the roof. A good many codes call for 18 inches above the boarding, but the Underwriters give 24 inches for ordinary buildings, and 36 inches for business ones.

Sameness. — Several years ago I had occasion to go over the codes of about a dozen of the leading cities, and it often seemed that the one was practically copied from the other. The Underwriters' goes further in the right direction than any of them, although it is sometimes too far advanced for light pocketbooks.

Ashlar. — In calculating thickness an ashlar course of 4 inches is not included; but above that thickness is taken as a part of the wall when well bonded and tied into it.

Bonding. — It is usual to run headers every sixth or seventh course in ordinary brickwork. These headers should run clear through to the face of the wall even on a pressed brick front. The big fires showed that.

Anchors. — All masonry buildings should be carefully anchored. Joists and walls are thus tied together. The size of the iron for ordinary work is $1\frac{1}{2} \times \frac{5}{16}$. The regular anchor is made in T shape. When the joists meet, as over a girder, they are fastened with strap anchors.

The end anchors should stretch back and take in three joists. The girders must be heavily anchored at the wall with T anchors; and with strap ones at the joints. Many buildings fell in San Francisco, at the fire, through bad anchorage. In Scotland I never saw a wall anchored. They are made thick enough, of good stone, good mortar, and good workmanship to stand without being tied up.

Party Walls. — As will be noticed in the tables, 9-inch walls are allowed on the top stories of dwellings; but party walls should be at least 13 inches in a block of flats or houses of any kind, as much for deadening sound as for fire protection.

Thin Walls. — These are becoming more popular than ever, in spite of the fact that the fire insurance men do not like them. They are used on top stories, and with the right kind of tile are nearly 10 inches thick. The inside course is of hollow tile. This is often protected with a damp-proof mixture, and the plaster applied directly to the wall. In frosty, rainy climates the damp sometimes comes through. Furring is the old remedy, and it is a safe one. The danger is that when the carpenters plug a 9-inch wall they will drive the bricks loose on the outside.

Mortar. — Do not use bad mortar, and this is often equivalent to saying lime mortar. Never forget the St. Louis cyclone and the fires at Baltimore and San Francisco. Poor mortar lay at the root of a great deal of the trouble. It pays to put some Portland cement among the lime, if that is used.

A mortar of one-fourth Portland cement and three-fourths lime makes an excellent wall. The U. S. engineers give 1 of lime paste and 2 of sand as the best for lime alone, but few contractors like to use such a rich mixture. One to 3 is about right for natural cement, which is not so much used now. One to 2 should be used for the best work.

For Portland 1 to 3 for the best masonry, and 1 to 4 for ordinary construction. For rubble 1 to 4 is used.

The Underwriters give 1 to 4 for lime, but much depends upon the brand used. There are limes that are hardly worth taking as a gift. For cement, 1 to 3; for cement and lime mortar, 1 of slaked lime paste, 1 of cement, and not more than 3 parts of sand to each.

Shoring. — Bricklayers should know enough to shore their walls, but they often forget and trouble comes. When writing this I saw a building a few weeks old, with steel channels bolted along the outside of the brick wall, and wood shoring behind that, to keep it from going into a mass of ruins. The shoring was done, but it was too late.

Disaster. — I once saw a brick gable 150 feet wide, 40 feet high, and 17 inches thick that seemed strong enough but was blown down on a stormy afternoon, and all the window frames and coping tile with it. This kind of work costs money.

SAFE LOADS PER SQUARE FOOT

The Underwriters give the following allowances for masonry:

BRICKWORK		RUBBLE	
In lime mortar....	8 tons	In lime mortar.....	5 tons
In lime and cement	11½ "	In lime and cement mortar	7 "
In Portland cement	15 "	In natural cement mortar	8 "
		In Portland cement mortar	10 "

CONCRETE

In natural cement	8 tons
In Portland cement mortar	15 "

The 1905 Chicago code has the following provisions:

BRICKWORK

In lime mortar	6½ tons
In natural cement	9 "
In Portland cement	12½ "

DIMENSION STONE

In Portland cement	10 tons
In Portland cement dressed and level on solid beds	12½ "

CONCRETE

In Portland cement, not reinforced	12½ tons

BOSTON CODE

Granite, cut	60 tons
Marble and limestone, cut	40 "
Sandstone, hard, cut	30 "
Hardest brick in 1 to 2 cement mortar	15 "
Hardest brick in 1 cement, 1 lime, 4 sand	12 tons
Hardest brick in lime mortar alone	8 "

For light hard brick use only two-thirds of the above loads.

Piers. — For brick piers whose heights run from 6 to 12 times their least dimension the above Boston loads are reduced to 13, 10, and 7.

Piers are often spoiled, both for strength and looks, by being built too small. The difference in cost is nothing to speak of between a 13″ x 13″, or even a 17″ x 17″, as compared with a 9″ x 9″ under a heavy porch, yet the light one is used, and often goes to pieces.

In store fronts too, we see the same bad policy carried out. The idea is to give as much glass surface as possible, but it is not worth spoiling the building for this. For such a pier a load of 4 tons to the square foot is enough in the best lime mortar or natural cement, and 8 to 10 in the strongest Portland. If anywhere, good mortar should be put in piers.

Example. — Suppose a store front of 44-foot span with I-beams supported in the center on a brick pier. Let us assume that there are two stories above the I-beams, the first with a 13-inch wall, and the other with a 9-inch. Measuring back 16 feet from the inside of the front wall a column is placed to support the floors above, and other columns are set at the same centers clear back to the rear of the building.

Floor Load. — For the store floor allow a load of 150 pounds to the square foot and 70 pounds for the two upper ones, this to include the weight of the floor itself and the live load also.

The two upper stories to have a height of 10 feet in the clear. No partitions or ceiling joists to be considered, so as to make fewer figures. Each building has to be analyzed. The method only is given here.

Pier. — What size of a brick pier is required in the center to support the load? There are two bearings required. One below the level of the store floor and another up under the I-beams.

The walls may be taken solid without deduction for windows, and thus the weight will be large enough. The top of the I-beam is usually placed about level with the top of the joists, or a little below. We can figure the brickwork as starting 6 inches below the top of the floor to be safe.

The pier, it can be readily seen, will carry half the weight of the front wall clear to the roof, and the other two quarters of the weight will be transmitted to the outside walls.

WEIGHTS

	Pounds
Front wall, 22′ long x 11′6″ from top of I-beam to top of third story floor joists. 13″=120 lbs. to sq. ft...	30,360
Front wall, 22′ x 15′ x 9″, from top of third story joists to top of parapet above roof at 80 lbs. to sq. ft......	26,400
Store floor, 8′ back x 22′ x 150 lbs..................	26,400
Upper floors, 8′ x 22′ x 2 x 70 lbs.....................	24,640
Roof, 8′ x 22′ x 50 lbs..............................	8,800
	116,600

Beam Capacity. — Thus far, we have a trifle over 58 tons. The tables of beam capacities include the weight of the beam itself, as a rule, and it need not be included here.

The corners of the outside walls are usually carried in on the inside to receive the end of the beam, and when we consider these corners, and the pier in the middle, it is safe to say that the clear span will not be 21 feet. We can therefore take this distance in the table, given elsewhere in this book.

A 12-inch 40-pound beam carries 11.9 tons; twice this is 23.8 for the double beam required under the 13-inch wall; and across the entire front, 47.6. This apparently is too light a beam; but the full weight is never piled on any floor at one time. From 80 to 85 per cent. is usually allowed. Instead of 50 pounds we used to allow only 40 for roofs with spans of 150 and 175 feet. This included heavy steel trusses, wind pressure, and everything else. Judging from this, 50 pounds is too much, although it is often used.

Allowing 85 per cent. we get 49 tons; and the two 12-inch, 40-pound beams will thus carry the load because of the window openings that reduce the total weight. If, as is now common, hollow tile are used on the inside of the walls, the total is still further reduced, for the figures are made out for ordinary brickwork.

Some might prefer to use two 15-inch, 41-pound beams to guard against deflection or bending. These carry 14.4 tons each, or a total of 57.6 tons. Deep beams should always be used in preference to shallow ones.

The method of figuring out the load for the other beams running from front to rear is explained elsewhere.

The top pier comes up directly under the I-beams, and the question is, How much surface must it have for a safe bearing?

Size. — This total does not include the store floor. The load is thus reduced to 45 tons. If the pier is laid up in the best brick and Portland cement mortar we require a bearing area of a little less than 4 square feet, or 2′ x 2′. This size would provide for the beams running in the other direction also, or at right angles from the store front, for our front wall and upper floor load combined would not exceed 50 tons. When we consider that the actual floor loads in a large wholesale warehouse were found to be only 50 pounds, not including the weight of the floor itself, we can see that the 70 pounds allowed for dwellings above the store we are considering is too high.

Lower Pier. — The one below the level of the store front has to be considered. There are 58 tons and the weight of the

2′ x 2′ pier. Adding 3 tons for this makes a total of 61, allowing the full load. This would require a base of 5 square feet. If any sidewalk weights came upon this pier they would have to be added.

Down in the basement architects are inclined to be safe rather than take chances. Taking 85 per cent. of the total load we get about 52 tons. Using the best Portland cement work and the Boston allowance of 15 to the square foot we really require only 3½ square feet here, and thus a pier 2′ x 2′ would be ample. But the difference between a pier with 5 square feet and another with 4 is only a few dollars.

Base. — The base on the soil has to be arranged to suit its bearing power. If 3 tons are taken that means 20 square feet; if 2 tons, 30.

Mortar. — In all of the above, Portland cement is taken; if lime is used and 8 tons is the limit, that means a larger pier.

Piers for Columns running from front to rear are figured out in the next chapter.

Bearing Plates should be used on top of piers or cap stones.

Height. — In the above discussion the piers are assumed to be of the ordinary height. When they exceed in height seven times their smallest dimension, 4 inches should be added for every 6 feet or part of 6 feet. Thus a store front pier about 12 feet high at 25″ x 21″ should be made 25″ x 25″ for anything over that height.

According to the Underwriters, isolated brick piers should not exceed in height 10 times their least dimension.

Stone Piers of good squared material should not exceed 10 times their least dimension in height.

Rubble. — This material makes a poor pier unless the size can be made large enough, as in a basement.

Bonds. — A well built pier does not require bond stones, but a sheet of expanded metal is an excellent binder. The Chicago ordinance calls for a plate of wrought iron or steel not less than ¼-inch thick, but expanded metal is better. For a fine joint, as in pressed brick, expanded metal lath can be used.

The New York code requires bond stones. The Underwriters' code calls for a bond of cast iron or steel every 30 inches if the pier has less than 9 square feet of a base and when there is a span of more than 10 feet.

Cap Stones. — The Underwriters' code allows cap stones on the front of the building to correspond with the bond stones or other trimmings, but they must cover the entire area of the pier and be not less than 5 inches thick.

The Doubled I-Beams over store fronts have to be bolted together with separators between, and bearing plates provided under the ends.

RETAINING WALLS

Material. — Taking everything into consideration, probably a concrete made of good Portland cement is the best material to use for retaining walls. It may be put in place by unskilled labor, and this is occasionally a great advantage.

Proportions. — The danger in some sections of the country is in using a mixture that will let water go through. An ordinary concrete of 1, 3, 6 will not hold water, nor will 1, 3, 5. The poorest that can be used is 1, 2½, 5; and for the best work with a wet soil behind, the mixture should be 1, 2, 4. No stone or gravel should be more than ¾-inch diameter.

Wet Soils should be drained. Not long before this writing I saw a retaining wall washed out by water getting in behind it.

Frost. — In the middle west we keep 4 feet below the surface for a frost line. Retaining walls, especially, should go below frost in a rainy climate, for if the frost heave them and a crack develops, the road is open for a wreck.

The Section of wall chosen seems to depend upon the taste, as all kinds are used. Sometimes it is desirable to keep the face of the wall plumb, and again, in other cases, battered ones are better. The batter or slope of the face side may be used up to 1½ inches to the foot of height. Thus a wall 4 feet high above the grade would be 6 inches out of plumb.

Stepped. — A wall may run up the back on a straight slope or be stepped from one thickness to another. The stepping helps to retain the earth and keeps it from "wedging" down and forcing out the masonry. It is the difference between a straight slope and a stair.

In case the stepped-up wall is chosen the plank forms have to be made in sections instead of in a single slope. Thus the first base might be 2 feet 2 inches, carried up a foot; the next, 1 foot 11 inches, carried up another foot; the one above, 1 foot 8 inches, and so on.

Plastering cement work on the face does not seem to be much of a success. It should stick, but it often cracks and falls off. The time to plaster is when the main body of the concrete is still green, and the forms cannot be removed then. There is not so good a chance on a dry surface. The best way is to plaster the inside of the boards just a little ahead of the time when the concrete is poured in, and by working a thin blade of some kind in between the mortar and the wood, any places that are not closely filled may be made right. This course will usually give a good enough surface for ordinary work.

Plaster does not stick on the top of the wall either. After a time it cracks and falls off. Smooth the mass with a trowel on top or a wood float. The main idea all through is to get the mass and the surface bound together, and not plaster the one on the face of the other. When the boards are plastered as suggested a rich mixture of not more than 1 to 1½ should be used, and this will keep out the water. In arid or semi-arid regions, such precautions do not need to be taken.

The Underwriters give their retaining wall rule as follows: The thickness of a retaining wall at its base shall be in no case less than one-fourth of its height.

A retaining wall is usually thinner at the top than the bottom, although they make no allowance for this.

There are many different theories of retaining walls. The following table will give a fair average idea of what the dimensions should be. A depth of 4 feet below the surface is figured.

RETAINING WALL TABLE

Height above ground	Total height	Thickness at base	Thickness at surface	Thickness at top
2′	6′	2′ 2″	1′ 6″	10″
3	7	2 5	1 7	10
4	8	2 9	1 11	12
5	9	3 2	2 1	12
6	10	3 6	2 5	15
7	11	3 10	2 8	18
8	12	4 2	2 10	18

STONE LINTELS

Size. — The longest stone lintel in any contract I ever had was about 16 feet, and the section was perhaps 24″ x 20″. Naturally, it had to be supported by an unseen steel beam. This means that beyond a certain limit it is not safe to trust to stone alone.

Concrete. — In a new building I know of, three or four stories high, all the cement stone lintels are cracked in the center. This means, also, that for narrow openings it is not wise to use the new kind of stone without reinforcement. Long beams of reinforced concrete are made for all widths of buildings, and there is no reason why such a lintel over a narrow window should crack.

Several kinds of reinforcement may be used for lintels. There are rods, bars, barbed wire, or a sheet of expanded metal kept back from the edge so that it will not show. The reinforcement of this kind should be put at the bottom of the lintel with just about enough mortar below it to cover the steel.

Supposing the lintel to be 10 inches deep, for example, the reinforcement would be placed about an inch from the bottom. The metal acts like a rope, if such an illustration may be used. To hold the mass the rope must be put as low as possible. It would do no good if put on top.

Safe Load. — Generally this is never figured out. Everybody uses the sizes that have been used since before Shakespeare's day, to go no further back. Two standard sizes are 4″ x 10″ and 8″ x 12″. The thin one is put where there is only the usual brick reveal.

Every bricklayer knows that the load relieves itself after a few feet of brickwork are laid above the stone. An arch is formed of itself like an inverted V.

For special work we can multiply the width of the stone by the square of its depth. Then divide by the span in inches; and for sandstone multiply by 0.08; limestone, 0.10; granite, 0.12. Suppose we have an 8 x 12 x 60-inch span in the clear. The figures would be 8 x 12 x 12, divided by 60, and multiplied by 0.08 for sandstone. The load would be 1.536 tons or 3,072 pounds. For a concentrated load allow half.

BRICK CHIMNEY STACKS

Diameter. — At the base the outside measurement should not be less than one-tenth of the total height of the chimney. For a square one, the side is made one-tenth also. Round chimneys are generally considered better than square ones.

In building some railroad shops we had several large chimneys—one at 175 feet, and the other at 200 feet. They were built of radial brick of the same kind as those used for the highest chimney in the world at Butte, Montana. Above the foundation this chimney is 506 feet in height; the inside diameter is 64 feet at bottom and 50 feet at top. The walls are 66 inches at bottom and 18 inches at top. The foundation walls are 28 feet thick. The foundation cost $50,000, and the chimney proper about $200,000. The foundation was tested to a weight of 104 tons to the square foot. The chimney was lined, after it was built, with a 4-inch lining of heat resisting and acid proof bricks. Smelter work is hard on the inside of chimneys.

The radial brick chimneys are usually unlined. The shop ones referred to had no lining. With ordinary brick it is customary to line with fire brick up to 25 or 30 feet.

Thickness. — Molesworth's rule for the thickness of high chimneys is well known. It is 9 inches from the top to 25 feet down; from that, 13 inches to 50 feet down; and 17 inches from that to 75 feet down. For each 25 feet coming down increase 4 inches.

This is for the ordinary chimney. Those with a diameter of 4 feet 6 inches at top should not be less than 13 inches there, and be 4 inches thicker all the way down than the standard sized ones.

Batter. — The regular batter is 0.3 inches to the foot, or nearly five-sixteenths.

Cores on the inside do not seem to be so much used now as formerly.

Lightning Rods are more popular than they were some years ago. One of the chimneys on the railroad shops was struck by lightning. On the big one at Butte 16 rods of round copper, 1 inch diameter, are installed.

The tendency now is to use smaller and lower chimneys and more of them in ordinary plants. Forced draft is resorted to rather than great height.

HEIGHT AND DIAMETER OF ORDINARY BOILER CHIMNEYS

Horse power of boiler	Height of chimney	Inside diam. at top	H. P. of boiler	Height of chimney	Inside diam. at top
10	60′	14″	70	120′	30″
12	75	14	90	120	34
16	90	16	120	135	38
20	100	17	160	150	43
30	105	21	200	165	47
50	120	26	250	180	42
60	120	27	380	200	57

Self-supporting Steel Chimneys. — In the shops alluded to these were first figured on, but radial bricks were chosen. They are anchored down to a deep foundation with rods of large diameter. Construction of this kind, as well as that for reinforced chimneys, belongs rather to the specialist than to the ordinary contractor. The distressing number of such chimneys that have fallen in the dust shows that even the experts have still something to learn.

In 1909 I watched a large one being taken down after a too brief service. Someone had blundered.

It is said that the fire takes the life out of the concrete. One of the hollow tile companies makes a specialty of covering concrete fire-proofing with tile. Even if the tile is destroyed the concrete is saved, and a new covering or lining can be put in at a reasonable cost.

CHAPTER IV

THE SUPERSTRUCTURE (2)

FLOOR LOADS

Average Code. — The requirements in the following table are about the standards, and safe enough for any construction.

TABLE OF FLOOR LOADS

All floors shall be constructed to bear a safe weight per superficial foot, exclusive of materials, as follows:

For armories, drill halls, storage warehouses	250 lbs.
Retail stores	150 "
Public buildings	125 "
Large halls, corridors, rotundas, etc., of hotels	125 "
All other rooms in hotels	75 "
Office buildings	75 "
Dwelling houses	50 "

The ideal code of the Underwriters gives the weights allowed, but this does not include the materials in the floor, which must be added:

Dwellings	60 lbs.
Office buildings, first floor	150 "
" " above first floor	75 "
Schools	75 "
Stables and carriage houses	75 "
Public assembly buildings	90 "
Stores, light manufacturing and light storage	150 "
Flat roofs	50 "
Pitched roofs measured on the level	30 "
Sidewalks, live load	300 "

Live Load. — This code when dealing with buildings of more than five stories allows the following reduction: For the roof and top floor the full live load must be figured. For each succeeding lower floor it may be reduced 50 per cent., until 50 per cent. of the live load is reached, and this load shall then be used clear down on the remaining floors. This is to establish the weight on columns. The floor loads are to be distributed, and not concentrated.

It is usually just as easy to load floors close to the bearing of wall or column as to pile up the weight in the center on the weakest part of the floor; but there are many wholesalers and merchants who never seem to get this idea in their minds.

Limit. — It will be noticed in the Underwriters' code that the heaviest load for the building proper is 150 pounds. Boston, Omaha, and some other cities give 250. In many of the new reinforced concrete warehouses the allowance is more than twice as much. In the old style of warehouses the ceilings were purposely kept low in order to prevent overloading.

Choice. — Here, then, are two good standards to go by— first, the one used by average cities, and, second, the ideal one recommended by the fire insurance companies of the United States.

Wide Spans. — In schoolrooms there is usually a width of 26 or 28 feet, and contractors who have laid the 3 x 14 or 3 x 16 joists know that they are strong enough to carry several times the load that ever comes upon them. But those who have had to hoist and lay them by ropes and main strength up on the second story have often wished that the architects could substitute something lighter.

This length has always been necessary on account of the number of scholars. Each room is supposed to hold from 45 to 50. But now the limit is lowering to 40; and one private school in New York allows only 15. The day of the large schoolroom is passing.

Example. — Suppose now that we take a building as before, 40′ x 100′, to get the size of the timbers. The span between wall and columns, and between columns, was set at 16 feet, but let us take 14 here, and this will keep us from having the idea that there is any fixed distance. It might be made 12 feet if we wanted to.

The joists are 20 feet long, and the weight is to be 125 pounds to the square foot, including that of the floor itself. The joist is shorter, of course, but the bearing is also included, as we do not figure down to a fraction where there are so many factors that we cannot exactly determine, like the resistance of the soil to pressure, and so on.

Weight. — From column to column, then, is 14 feet; and from the column half way to the walls on each side is 10 feet. Measuring half way between bearings, both ways, we have a space of 14 feet running the long way of the building, and 20 feet the cross way. As the column stands exactly in the center, it supports all this area.

But measuring from center to center of columns we have the same 14 feet, and thus we see that the girder which connects them supports all this space of 14′ x 20′ x 125 lbs. = 35,000. This is only for one floor.

We require a girder of steel or wood between the columns that will support 35,000.

Trial Test. — A long-leafed Y. P. girder of not more than 14 inches deep may be tried first. Looking at the table given on page 237 we see that a 3 x 14 on a 14-foot span will support 2.91 tons. The third of this is 0.97, or close enough to a ton to call it so, for a 1 x 14. As our weight is 17½ tons we therefore require a girder 17½ inches wide, and this is out of the question.

Referring again to the table we find that a 3 x 16 Y. P. joist carries 3.80 tons. One-third of this is 1.27. Dividing 17½ tons by this shows that the width at 16 deep would be 14 inches. Timbers come less than the full size; and a 14 x 16 would measure only 13½ x 15½ at most. Considering that 85 per cent. of the load is enough to figure on, the size would be large enough. Two good, sound, dry 6″ x 16″ timbers bolted together would hold the load.

Flitch Plates. — This style of girder is not so common as formerly. It is made by putting a plate of steel between two girders and bolting them together. When the fire comes the steel is protected from buckling. Sometimes a triple beam is used with two of these plates. The bolts are usually about ¾-inch diameter, spaced from 20 inches to 24 inches. Directly above the bearing on each end two bolts are put in. The other bolts are put not more than 3 inches from the edge, and staggered. If an iron plate is used the wood should be about 11 times as thick; if a steel one, 15 times.

In the following tables for Flitch plate girders it should be remembered that the timbers come a little less than the full size. The tables are made out to suit the market size.

TABLE FOR FLITCH PLATE GIRDERS

Safe load in pounds uniformly distributed, supported at both ends.

For concentrated load in center allow one-half the load given in tables.

Span in Feet.	SIZE OF GIRDER					
	Beams 2-3x8 Plate ½x7½	Beams 2-3x10 Plate ½x9½	Beams 2-3x12 Plate ½x11½	Beams 2-3x14 Plate ½x13½	Beams 2-3x16 Plate ½x15½	Beams 2-3x18 Plate ½x17½
10	11,185	17,946	26,297	36,240	47,773	60,897
12	9,321	14,955	21,915	30,200	39,811	50,748
14	7,989	12,819	18,784	25,886	34,124	43,498
16	6,991	11,216	16,436	22,650	29,859	38,061
18	6,214	9,970	14,609	20,133	26,540	33,832
20	5,592	8,973	13,148	18,120	23,887	30,449
22	5,084	8,157	11,953	16,476	21,715	27,680
24	4,660	7,478	10,958	15,100	19,906	25,374
26	4,302	6,902	10,114	13,938	18,374	23,422
28	3,995	6,409	9,392	12,943	17,062	21,749
30	3,728	5,982	8,766	12,080	15,924	20,299
32	3,496	5,608	8,218	11,325	14,929	19,031

Span in feet	SIZE OF GIRDER					
	Beams 2-4x8 Plate 11-16x7½	Beams 2-4x10 Plate 11-16x9½	Beams 2-4x12 Plate 11-16x11½	Beams 2-4x14 Plate 11-16x13½	Beams 2-4x16 Plate 11-16x15½	Beams 2-4x18 Plate 11-16x17½
10	15,184	24,554	35,985	49,603	65,388	83,350
12	12,653	20,462	29,988	41,336	54,490	69,459
14	10,845	17,539	25,704	35,431	46,706	59,536
16	9,490	15,346	22,491	31,002	40,861	52,094
18	8,436	13,641	19,992	27,557	36,327	46,306
20	7,592	12,277	17,992	24,802	32,694	41,675
22	6,902	11,161	16,357	22,547	29,722	37,886
24	6,326	10,231	14,994	20,668	27,245	34,729
26	5,840	9,444	13,841	19,078	25,149	32,057
28	5,423	8,769	12,852	17,715	23,353	29,768
30	5,061	8,185	11,995	16,534	21,796	27,783
32	4,745	7,673	11,246	15,501	20,431	26,047

Span in feet.	SIZE OF GIRDER							
	Beams 2-6x10 Plate 1x9½	Beams 2-6x12 Plate 1x11½	Beams 2-6x14 Plate 1x13½	Beams 2-6x16 Plate 1x15½	Beams 2-6x18 Plate 1x17½	Beams 2-8x14 Plate 1⅜x13½	Beams 2-8x16 Plate 1⅜x15½	Beams 2-8x18 Plate 1⅜x17½
10	35,892	52,595	72,480	95,547	121,795	100,093	130,776	166,702
12	29,910	43,829	60,400	79,623	101,496	83,411	108,980	138,919
14	25,637	37,568	51,772	68,248	86,997	71,495	93,411	119,073
16	22,432	32,872	45,301	59,717	76,122	62,559	81,735	104,189
18	19,940	29,219	40,267	53,082	67,664	55,607	72,653	92,612
20	17,946	26,298	36,240	47,774	60,898	50,047	65,388	83,351
22	16,314	23,907	32,946	43,431	55,361	45,497	59,444	75,774
24	14,955	21,915	30,200	39,812	50,748	41,706	54,490	69,459
26	13,805	20,229	27,877	36,749	46,884	38,500	50,298	64,116
28	12,819	18,784	25,886	34,124	43,498	35,748	46,706	59,037
30	11,964	17,532	24,160	31,849	40,598	33,364	43,592	55,567
32	11,216	16,436	22,650	29,859	38,061	31,279	40,867	52,095

Steel. — Supposing that a steel beam were chosen, we refer to the table and find out that a 12″ x 40-lb. beam will support nearly 18 tons, and this is over our limit. Some would prefer two 10″ x 25-lb. beams bolted together, especially in cases where the ceiling heights were low, and it was not considered desirable to frame the joists down to the level.

Bearing. — Girders should have at least 6 inches bearing on the walls, but 4 inches is enough for joists.

Joists. — We next come to the size of the joists required on a span of 20 feet, with a load of 125 pounds to the square foot.

In stores, all over the country, 2″ x 14″ are used at 12-inch centers on a 22-foot span. Our span is 2 feet less, and 16-inch centers might be assumed.

A 3 x 14, according to the table, carries 2.91 tons; and a 1-inch full size by 14 would thus take care of a ton. A joist 1¾, the market size, on this basis would support 3,500 pounds of clear span without a girder in the center, which stores usually have.

On a space, really 19 feet after deducting the wall, which is not often done, by 16 inches there are 25.3 square feet at 125 pounds = 3,162. A 2 x 14 set 16-inch centers is therefore ample, as the full load never goes on.

How would a 2 x 12 work? On a 14-foot span it carries 1.43 tons, full size. Allowing only 1¾ thick, and disregarding the deficiency in depth, the load would be 1.25 tons, or 2,500 pounds. At 125 pounds a 19-foot span, a foot wide, will support 2,375 pounds. A 2 x 12 would be large enough set at 12-inch centers.

Girder. — By putting in the right kind of a girder, and wide enough bases below the posts, we can cut the span in half, and space the 2 x 12″ joists at 16 inches. Even 2 x 10's would be strong enough, but such light sizes are not used on good construction. The trouble with a store floor is that a car-load of nails is apt to be put down on the weakest part of the area. We have to make it "fool-proof" for this reason.

But all this is what some of our colored friends would call "powerful good construction." I once stood in a Wyoming town and watched a Chinese mason building above a store front with cement blocks set on 2 x 8's, and they were already bending. The endeavor all through this book is to strike a reasonable medium between him and the white man referred to elsewhere who ordered a 6-inch column of 2-inch metal for the same job.

Wet or Dry. — Something was said about the owner and his haste in getting possession of the new building. Perhaps if he would read this part he would find out something about the difference between wet and dry lumber. The contractor who takes time on a building is really serving the owner—as was set forth.

Dry Lumber, it has been found by experiment, is fifty per cent. stronger than green just from the woods—where most of ours is from in these days. The tables of strength make allowance for this. They are figured to use only about one-fourth of the breaking load. As the timbers become dry they increase in strength, but they shrink, and often spoil plaster and finish in the process. The largest timbers may take several years to dry thoroughly.

The United States experiments give the bending strength of long-leaf yellow pine with moisture as follows:

Per cent. of moisture	Strength	Per cent. of moisture	Strength
33	7660	15	10900
20	8900	10	14000

Plaster Cracking. — The danger from cracking of the ceilings is not so great as some theoretical tables would have us believe. Many schoolrooms stretch 26 feet, and their ceilings stand; but the tables tell us that a joist of even 16 inches deep is restricted to a span of 18 feet. There is too much theory there.

Joists. — Let us for variety allow 100 pounds to the square foot for the third floor. The girder would support only 28,000 in place of 35,000. If we allow 85 per cent., the total weight is 12 tons. A 1 x 14 carries a ton on the span of 14 feet, and a 12 x 14, or two 6 x 14's, would easily carry the load.

The clear span of 19 feet, a foot wide, has a load of 1,900 pounds. A joist 2 x 12 supports 1.43 tons or 2,860 pounds. This will take care of more surface than on 12-inch centers. Will it hold up the weight that goes on the next standard span of 16 inches? One-third more surface gives a total of 2,533 pounds. But the joist is sure to be not more than 1¾ inches thick. This reduces the load it will carry to 2,500 pounds, which is just what is required.

Another way of arriving at the joists is to take in the whole floor. Let us take a floor 20 x 100′ x 100 pounds to square foot, this to include everything. The total load is 200,000 pounds, and 85 per cent. of that is 170,000. An 1¾ x 12″ joist, as we have seen, supports 2,500. Dividing 170,000 by this figure we see that 68 joists carry the load. In 100 feet there are 1,200 inches. We have 67 spaces for 68 joists. Dividing 1,200 inches by 67 we find that the joists should be spaced at 18 inches. But our lumber and lath are cut to suit 16 inches, and this size is chosen. It gives more strength than what is required.

No Partitions. — All through, it will be noticed that no partitions or special weights of that kind are included. These must be added if there are any. Above a wide store floor provision would have to be made for them, and that would mean stronger joists or closer centers. But on the higher floors the partitions might support the joists midway, and allow lighter ones. The whole extra weight would be transferred down to the ones above the store when it came near the center of the span.

Ceiling and Roof Joists. — These should be tied together to make a kind of a truss, and do not need to be figured independently. A 2 x 6 ceiling joist and a 2 x 10 roof joist, or even a 2 x 8, can be so trussed as to make a splendid roof. Sometimes—or rather quite often—2 x 4 ceiling joists and 2 x 6 roof joists are made to serve. If plenty of 1 x 4 or 1 x 6 bracing is nailed on, a strong job can be made. This applies to a flat roof.

Doubling. — Under all partitions, at stairs, wide chimneys, and such places, the joists must be doubled. If a special weight comes upon a timber it stands to reason that a special strength must be supplied to carry it.

Concentrated Load. — If all the load comes midway on the girder or joist, allow double thickness. In other words, only half the load should be carried.

At a distance of ¼ of the full span allow about 70 per cent. of the safe distributed load. At ⅛ of the span, allow $1\frac{1}{7}$ of the full load. Thus, supposing a beam 12 feet long between supports carried a distributed load of 4,400 pounds, it would have only 2,200 if all the load was put in the center; at 3 feet from one end, 3,080; at 1 foot 6 inches from the end, a little over 5,000.

Built-up Beam. — In general, a beam of this kind is stronger than a solid one. A solid beam might have, or might develop, some imperfections that affected the strength; but the different members of a built-up beam distribute the defect. One plank in five might be bad, but the others would stand the strain. But the planks must be well bolted or spiked together. The joints should be broken. It does not seem to matter where they come, so that they are well distributed. We used to make such beams continuous, and not join them over columns or posts. Just as it does not matter where reinforced concrete is joined, above the girder or in the center of the span, so the built-up beam is strong enough made either way—jointed above the post or continuous.

Experience. — There are certain standard sizes used from the one end of the land to the other, and we do not have to stop to figure them. We know that 2 x 10 joists are large enough for the ordinary dwelling, for they have been used ten thousand times over for this purpose; we also know that a 2 x 14 may be used for store floors on a 22-foot span, 16-inch centers without a girder, although 12-inch centers are often used; and that with a girder, 2 x 12's set at 16 inches will carry the load, for we have often seen 2 x 10's doing it; and 2 x 14's have been put over 26-foot spans of schoolrooms so many times at 16-inch centers that we feel sure we are safe enough when 3 x 14's are specified; and smile when we have to put on 3 x 16's.

Then all good carpenters know that doubling or cross strengthening is required below partitions; that all around a stair well there have to be two joists; that the same is true at wide chimneys; and that special weights have to be specially provided for. Good common sense goes a long way in building. We do not have to refer to tables of strength every time a difficulty arises. As noted in the educational chapter, there are two ways of learning—by book and by experience. Knowledge is knowledge and nothing more or less, no matter by which route we obtain it.

Warehouse Floors. — These are sometimes laid with a fall to the outside walls sufficient to drain off water in case of fire, and scuppers are placed in the walls of each floor to allow it to run to the ground. The floor is put just a little out of level, say ⅛-inch to the foot. In fires it is often said that more damage is done by water than by flames.

Theory and Practice. — I have seen long floors with joists, or rather girders, they should be called, heavy enough to astonish the carpenters who are accustomed to almost anything. They were 8 x 16's, 24-inch centers, on a 22-foot span. One floor was for a machine shop, and the other for light storage.

Now, theory may say that such an arrangement is correct, but the experienced men who laid the timbers kept up a running fire of banter. Why? Well, they saw that a railroad engine could have been run over the floor. The space between the timbers was only 16½ inches at most.

Load. — The material was Oregon fir. On a 22-foot span Kidder gives a load of 2,094 pounds for each inch, 16 inches deep. Cutting off the 94 pounds for deficiency in size, and multiplying by 7½ we have a total load of 15,000 pounds on 44 square feet, or 341 pounds to the square foot. Where there is to be concentrated load, as with machines, that is not too much, but for light storage it is twice what it should be. The trouble seems to be with the tables.

The table in the Carnegie handbook allows 970 pounds per inch for 16-inch deep on a 22-foot span for spruce. Turning the 970 spruce into 1,250 for Oregon fir, and cutting off the 50 for deficiency in sizes, we find that the 7½ inches supports only 9,000 pounds. It is too safe. The carpenters smile even if the professors frown.

Extra Precautions. — This is also the trouble with that excellent book, the Underwriters' code. It is often too safe.

The method given for calculating the uniformly distributed load on floor beams is to multiply the area in square inches by the depth in inches, and divide the product by the span of the beam in feet. This figure is then multiplied by

70 for hemlock
90 for spruce and white pine
120 for oak
140 for yellow pine.

In round numbers, spruce in Kidder is 1,630, while Oregon fir is 2,100 on a 22-foot span. Increasing the Underwriters' factor of 90 for spruce in the same proportion we get 116.

The sectional area of an 8 x 16 is 128. Multiplying this by the depth of 16 inches = 2,048. Dividing by the length of 22 we have 93.1. Multiplying this by 116 we get the permissible load of 10,800 pounds.

Kidder thus gives us..	15,000
Carnegie's Handbook....	9,000
Underwriters	10,800

No deduction is made on the latter for deficiency in size which would bring it down lower than 10,000.

The Underwriters give a simple way of figuring up the strength instead of the lineal foot of formulas that the average professor needs to express the simplest idea.

Y. P. Only. — In the West, at least, we may as well disregard the other factors, and deal only with yellow pine. The Underwriters' figure should be increased from 140 to 160, which would still be below other standard tables, but would make allowance for deficiency in size.

Rule. — For Y. P. multiply the area of the section in square inches by the depth in inches, and divide this product by the clear span of the beam in feet. Then multiply the result by 160 for the load in pounds.

Example. — A 4 x 12 x 16′ in clear would thus be: 4 x 12 = 48 x 12 = 576, which divided by 16 = 36 x 160 = distributed load of 5,760 pounds.

MILL CONSTRUCTION

What It Is. — The Chicago code defines "mill construction" as applying to all buildings in which all the girders and joists supporting floors and roof have a sectional area of not less than 72 square inches, and above the joists of which there is laid a timber floor not less than 3¾ inches thick. Wooden posts must not be less than 100 square inches in sectional area, which means 10 x 10 for a square post.

Partitions and elevators have to be enclosed in non-combustible material, but the posts, girders, and joists are left unprotected. No wood furring, wood lath, or stud partitions are to be used in this kind of a building.

Slow Burning Construction, on the contrary, is protected from fire as with metal lath and heavy coats of plaster. But the posts if of oak with more than 100 square inches of area need not be covered. The stairs must be of non-combustible material. When a girder cannot be easily found in one piece, two may be used side by side and bolted together, but this is not considered so desirable.

The Underwriters' code defines mill construction as that in which no structural material is less than 8 inches either way. The floor plank must not be less than 3 inches, either splined, or tongued and grooved. A spline is what a carpenter calls a slip tongue or feather. On top a regular ⅞-inch floor would be placed also tongued, running the cross way or diagonally. Two thicknesses of waterproof material of some kind would be put between the floors, and flashed 3 inches up the posts or walls.

Wood Posts would not be less than 100 square inches, nor less than 10 each way, except in the top story, which might be 8″ x 8″. They would all have cast iron caps to serve as a base for the post above.

Square Edged. — While tongued and grooved top flooring is an excellent material in every way, it seems that the square-edged kind is better adapted for mills and manufacturing buildings, not on account of safety from fire which might the easier penetrate the joints from below, but on account of wearing qualities.

Fire Resistance. — The idea in mill construction is to make the timbers so large that the fire, even if it gains headway, can yet be checked before it burns through them, and the structure can then be easily put in shape again. Where there are many joists sticking down from the ceiling the fire has a good chance to catch, but where four or five joists are combined into one timber at four or five times the distance apart, the danger is much lessened. The floor necessarily being heavier on such spans is also harder to burn through. It takes a fire a considerable time to eat through a 12 x 12 wood post, or an 8 x 16 girder. Then another advantage is that the wood does not expand and buckle as iron and steel do. In the San Francisco fire, in many buildings, and especially in the Fair-mount Hotel, the unprotected cast iron columns failed as the result of unequal expansion caused by the lugs. One expert of the government said, "Cast iron columns in some buildings endured the fire fairly well, but undoubtedly would have been broken or shattered if cold water had been thrown upon them in the midst of the great heat. They should no longer be used."

Stairways, Hatchways, and so forth should be enclosed with masonry. Every opening is blocked in some way to prevent the fire from spreading, sometimes with tinned doors hung so as to cover the opening when the fusible link melts.

No varnish or painting is allowed, as fire spreads quickly over it, and some of the manufacturers object to covering the surfaces on account of danger from dry rot. But sometimes the whole interior surface is covered with cold water paint, either put on by brush or a hose and nozzle.

No wood is used beyond what is absolutely necessary. We have all seen buildings of this construction correct in everything, yet filled in the inside with ceiling partitions, stair rails, etc., that undo the care expended on the main body of the work.

Scuppers are put in the walls to take care of the water in case of fire or other cause of flood. In two cases that I know of, the automatic sprinklers began to work through the night, and flooded a drygoods store with water. Scuppers would have saved some of the loss.

Distance. — The floor beams in mill construction are seldom placed closer than 4-foot centers, and usually about 6-foot or 8-foot, according to the load. The following table gives the thickness of flooring to use.

LOADING OF Y. P. MILL FLOORS

Safe loads per square foot in pounds uniformly distributed.

The upper load is for strength.

The lower load is for stiffness and allows a deflection of one-thirtieth of an inch per foot of span.

The weight of the floor itself is included.

Thickness of Floor	Span in Feet	Load per Square Foot
1⅝	4	317 167
	5	202 85
	6	140 50
2⅝	4	827 705
	5	529 361
	6	367 209
	7	269 131
	8	206 88
3⅝	5	1,009 951
	6	700 550
	7	515 346
	8	394 232
	9	311 163

SAFE LOADS, IN TONS, UNIFORMLY DISTRIBUTED, FOR WOOD BEAMS

Size of Timber	Kind of Timber	Distance Between Supports, in Feet														
		6	8	10	11	12	14	15	16	17	18	19	21	23	25	26
2x6	Spruce	0.50	0.37	0.30	0.27	0.25	0.21	0.20	0.19	0.18	0.17	For White Pine, use loads given for Spruce				
	W. Oak	0.67	0.50	0.40	0.36	0.33	0.29	0.27	0.25	0.24	0.22					
	Y. Pine	0.84	0.63	0.50	0.46	0.42	0.36	0.33	0.31	0.29	0.28					
2x8	Spruce	0.89	0.67	0.53	0.48	0.44	0.38	0.36	0.33	0.31	0.30	0.28	0.25	0.23	0.21	
	W. Oak	1.19	0.89	0.71	0.65	0.59	0.51	0.47	0.44	0.42	0.40	0.37	0.34	0.31	0.28	
	Y. Pine	1.49	1.11	0.89	0.81	0.74	0.63	0.59	0.56	0.52	0.49	0.47	0.42	0.39	0.36	
2x10	Spruce	1.39	1.04	0.83	0.76	0.69	0.60	0.56	0.52	0.49	0.46	0.44	0.40	0.36	0.33	0.32
	W. Oak	1.85	1.39	1.11	1.01	0.93	0.79	0.74	0.69	0.65	0.62	0.58	0.53	0.48	0.44	0.43
	Y. Pine	2.33	1.74	1.39	1.27	1.16	0.99	0.93	0.87	0.82	0.77	0.73	0.66	0.60	0.56	0.53
2x12	Spruce	2.00	1.50	1.20	1.09	1.00	0.86	0.80	0.75	0.71	0.67	0.63	0.57	0.52	0.48	0.46
	W. Oak	2.67	2.00	1.60	1.45	1.33	1.14	1.07	1.00	0.94	0.89	0.84	0.76	0.70	0.64	0.62
	Y. Pine	3.35	2.50	2.00	1.82	1.66	1.43	1.33	1.25	1.18	1.11	1.05	0.95	0.87	0.80	0.77
3x6	Spruce	0.75	0.56	0.45	0.41	0.37	0.32	0.30	0.28	0.26	0.25	0.24	0.21	0.20		
	W. Oak	1.00	0.75	0.60	0.55	0.50	0.43	0.40	0.37	0.35	0.33	0.32	0.29	0.26		
	Y. Pine	1.26	0.94	0.75	0.68	0.62	0.53	0.50	0.47	0.44	0.42	0.39	0.36	0.33		
3x8	Spruce	1.33	1.00	0.80	0.73	0.67	0.57	0.53	0.50	0.47	0.44	0.42	0.38	0.35	0.32	0.31
	W. Oak	1.78	1.33	1.07	0.97	0.89	0.76	0.71	0.67	0.63	0.59	0.56	0.51	0.46	0.43	0.41
	Y. Pine	2.23	1.67	1.33	1.22	1.11	0.95	0.89	0.83	0.78	0.74	0.70	0.64	0.58	0.53	0.51
3x10	Spruce	2.08	1.56	1.25	1.14	1.04	0.89	0.83	0.78	0.74	0.70	0.66	0.60	0.55	0.50	0.48
	W. Oak	2.78	2.08	1.67	1.52	1.39	1.19	1.11	1.04	0.98	0.93	0.88	0.79	0.72	0.67	0.64
	Y. Pine	3.49	2.61	2.08	1.90	1.73	1.49	1.39	1.30	1.22	1.16	1.10	0.99	0.91	0.83	0.80
3x12	Spruce	3.00	2.25	1.80	1.64	1.50	1.29	1.20	1.13	1.06	1.00	0.95	0.86	0.79	0.72	0.69
	W. Oak	4.00	3.00	2.40	2.18	2.00	1.71	1.60	1.50	1.41	1.33	1.26	1.14	1.04	0.96	0.92
	Y. Pine	5.02	3.76	3.00	2.73	2.50	2.14	2.00	1.88	1.76	1.67	1.58	1.43	1.30	1.20	1.16
3x14	Spruce	4.08	3.06	2.45	2.23	2.04	1.75	1.63	1.53	1.44	1.36	1.22	1.17	1.07	0.98	0.94
	W. Oak	5.45	4.08	3.27	2.97	2.72	2.37	2.18	2.04	1.92	1.82	1.72	1.56	1.42	1.31	1.25
	Y. Pine	6.84	5.11	4.08	3.72	3.40	2.91	2.72	2.56	2.40	2.27	2.15	1.95	1.78	1.63	1.57
3x16	Spruce	5.33	4.00	3.20	2.91	2.67	2.29	2.13	2.00	1.88	1.78	1.68	1.52	1.40	1.28	1.23
	W. Oak	7.11	5.33	4.27	3.88	3.56	3.05	2.84	2.67	2.51	2.37	2.25	2.03	1.86	1.71	1.64
	Y. Pine	8.93	6.68	5.33	4.86	4.44	3.80	3.56	3.34	3.13	2.97	2.80	2.54	2.32	2.13	2.05
4x10	Spruce	2.78	2.08	1.67	1.52	1.39	1.19	1.11	1.04	0.98	0.93	0.88	0.79	0.72	0.67	0.64
	W. Oak	3.70	2.78	2.22	2.02	1.85	1.59	1.48	1.39	1.31	1.23	1.17	1.06	0.97	0.89	0.85
	Y. Pine	4.65	3.48	2.78	2.53	2.31	1.98	1.85	1.74	1.63	1.54	1.46	1.32	1.21	1.11	1.07
4x12	Spruce	4.00	3.00	2.40	2.18	2.00	1.71	1.60	1.50	1.41	1.33	1.26	1.14	1.05	0.96	0.92
	W. Oak	5.33	4.00	3.20	2.91	2.67	2.29	2.13	2.00	1.88	1.78	1.68	1.52	1.39	1.28	1.23
	Y. Pine	6.70	5.01	4.00	3.65	3.33	2.85	2.67	2.50	2.35	2.19	2.10	1.91	1.74	1.60	1.54
4x14	Spruce	5.44	4.08	3.27	2.97	2.72	2.33	2.18	2.04	1.92	1.82	1.72	1.56	1.42	1.31	1.25
	W. Oak	7.26	5.44	4.36	3.96	3.63	3.11	2.90	2.72	2.56	2.42	2.29	2.07	1.90	1.74	1.68
	Y. Pine	9.12	6.82	5.44	4.96	4.53	3.88	3.63	3.41	3.20	3.03	2.86	2.60	2.37	2.18	2.10
4x16	Spruce	7.11	5.33	4.27	3.88	3.56	3.05	2.84	2.67	2.51	2.37	2.25	2.03	1.86	1.71	1.64
	W. Oak	9.48	7.11	5.69	5.17	4.74	4.06	3.79	3.56	3.35	3.16	3.00	2.71	2.47	2.28	2.19
	Y. Pine	11.91	8.90	7.11	6.48	5.92	5.07	4.74	4.45	4.18	3.95	3.74	3.39	3.10	2.84	2.74
4x18	Spruce	9.00	6.75	5.40	4.91	4.50	3.86	3.60	3.38	3.18	3.00	2.84	2.57	2.35	2.16	2.08
	W. Oak	12.00	9.00	7.20	6.55	6.00	5.14	4.80	4.50	4.24	4.00	3.79	3.43	3.13	2.88	2.77
	Y. Pine	15.10	11.30	9.00	8.20	7.49	6.42	6.00	5.63	5.29	5.00	4.73	4.29	3.92	3.60	3.47

Cost. — In the "Estimator" there is a cost table of mill construction work with sizes running from 6 x 12 to 8 x 16, and from 2-foot up to 8-foot centers. In some warehouses with heavy loads joists are put in with closer centers than for mill construction, and the table of cost is made out to suit.

Partitions. — If they must be put in mill construction they should be made of solid plaster on expanded metal, or of plank two or three inches thick.

Hangers. — In much of this heavy work hangers are used entirely, and the timbers never allowed to rest directly upon the wall or girder.

Ground Floors. — For floors suitable for this kind of mill and warehouse construction we used the following mixture on several railroad shops: 8 barrels of cinders to 1 of coal tar, laid 6 inches thick, with 3″ x 4″ bedded in the mixture at 16-inch centers, and covered with 3-inch flooring. This was coal tar, and not water gas tar, which is a good deal cheaper.

It is claimed by some that asphalt is a better material to use for such floors than coal tar, cinders, and wood. The tar evaporates, and the substance or life goes out of it. But asphalt cannot be used where oil is dropping on it all the while.

Roofs. — Some of the insurance men want plank roofs about 3 inches thick. This is for the same reason that thick timbers are used in mill construction. The slope recommended is ½-inch to the foot, and this is enough for gravel and such roofs.

Slope of Roofs. — For flat seam tin, not less than ½-inch; for standing seam, not less than 2 inches; for gravel, not more than 1 inch, although 1½ inches may be used if required. I have seen several large roofs with 2 inches, and the gravel washes off and fills the sewers where they are connected to the downspouts.

Wood shingles should not have less than 8 inches in 12 inches, or ⅛ pitch, but sometimes only 6 inches to 12, or ¼ pitch is made. This is too low in a rainy climate. When rooms are to be used in the attic, half pitch is best. On a 22-foot span this would be 11 feet.

CHAPTER V

LOADS UPON POSTS, COLUMNS, LINTELS, RODS, AND ROPES

Bridges. — When serving my apprenticeship the foreman came to my bench one winter morning and said, "Do you know that the Tay Bridge has fallen?" That seemed to be impossible, yet it had gone into the river with a trainload of passengers. It was a case of bad wind bracing, bad material, and unsafe loading.

In 1907 the splendid Quebec Bridge went smash into the St. Lawrence. About 100 workmen went with it to their death. The report of the crash was heard for a distance of six miles.

As we think of such terrible disasters, and of many collapsed buildings, both of steel and reinforced concrete construction, we are reminded of Mr. Edison's saying that we know just about one-billionth part of one per cent. about anything. Even the theories about poured cement houses do not work out as they should.

Proverbs. — There are two old sayings worth noting. One is that all extremes are wrong; and the other that safety lies in the middle.

Thick Metal. — One day in an architectural office we were interested at the story a draftsman told. It seems that while he was working in a foundry, a man from the wildest part of the West sent in an order for a 6-inch column with 2-inch metal, to hold up a light store front that did not extend more than one story above the I-beams, if even so much as that. I think it was only for a cornice. The foundryman laughed, but had conscience enough not to cast it. The freight would have been too high.

The following tables are meant to keep any man from making out such an order. The contractor-architect is not equipped with the learning of the schools, and the tables will help him out of the worst difficulties of the structural part.

Averages. — The method employed, in general, in arriving at the safe load for wooden posts was very simple. The highest table and the lowest of unimpeachable authorities were taken, shaken together, and divided by two. For those who think that this is not exactly a scientific method it may be well to respectfully call their attention to the two bridges just spoken of, to the Darlington steel frame hotel in New York City, to the reinforced concrete building in Long Beach, Calif., both of which fell; and to so many others from the Atlantic to the Pacific that it would take up too much space even to list them here. Evidently, whether we call them "artchitects," or architects, they have still a good deal to learn, and need not pretend to too much accuracy.

Decimals. — Tons are given in even figures. Why potter with decimals when the best authorities sometimes differ as much as 50 per cent. in their loads?

Posts when dressed are usually ½-inch less than the marked size, but this may be safely neglected when one standard table is made out for much more of a load than is allowed here.

SAFE LOADS, IN TONS, OF 2,000 POUNDS FOR SQUARE WOOD POSTS

SPRUCE OR WHITE PINE

Length	Size					
ft.	6 x 6	8 x 8	10 x 10	12 x 12	14 x 14	16 x 16
8	10	19	31	47	62	—
10	9	18	29	45	60	—
12	8	17	27	43	58	76
14	7	16	26	41	56	74
16	6	15	25	39	54	72
18	—	14	24	37	52	70
20	—	12	23	36	50	68
22	—	—	22	35	49	66
24	—	—	21	34	47	64

Yellow Pine Square Posts

8	13	24	39	58	80	100
10	12	23	38	54	78	100
12	11	22	37	52	75	100

Yellow Pine Square Posts

14	10	21	36	50	73	96
16	9	20	35	48	71	92
18	—	19	34	46	69	88
20	—	18	33	44	67	84
22	—	—	31	42	65	81
24	—	—	—	40	63	78

For **Oak** and **Norway Pine** allow from 15 to 20 per cent. less weight than on the above Y. P. list.

Yellow Pine Rectangular Posts

Safe loads in pounds per square inch for various values of L/D.

$L =$ Length of post in inches.

$D =$ Least side in inches.

$\frac{L}{D}$		$\frac{L}{D}$		$\frac{L}{D}$		$\frac{L}{D}$	
1	998	11	877	21	697	32	535
2	994	12	859	22	680	34	511
3	988	13	841	23	664	36	489
4	979	14	823	24	648	38	468
5	969	15	804	25	632	40	448
6	956	16	786	26	617	42	429
7	942	17	768	27	602	44	412
8	927	18	749	28	588	46	396
9	912	19	732	29	574	48	381
10	895	20	714	30	561	50	367

Method of using above table: The weight is given in pounds, and not in tons, as the others are; and for a square inch alone, and not for the whole post. Get the length of the post in inches, and divide this by the least thickness. Thus, a 10 x 14 would give 10, and an 8 x 12 would give 8 for a divisor. Look down the lines $L/_D$ and find a number the same as the result. Opposite this will be found the permissible load per square inch.

Example. — What load may be put on a wood post, unbraced between head and foot, if 10″ x 14″ x 16′ long? There are 192 inches in 16 feet. Dividing this by 10, as the smallest side, we get 19.2. Looking down the column for the nearest number of 19 we find the weight of 732 pounds per square inch. Supposing the post to be full size we multiply 140 square inches by 732, and get the total load of 102,480 pounds, or 51 tons.

Boring. — A wood post should be bored from end to end, and have a small hole bored in at top and bottom to connect with the long one. This is to allow air to pass through and prevent dry rot. About the time of this writing there was a wall-paper factory burned in West 34th Street, New York. It was of mill construction, and the posts were of ample size. It was only 18 years old, yet dry rot had eaten the strength out of the 14- and 15-inch oak posts. There must be a 1½-inch hole from end to end, and a ½-inch connecting cross one to let air through. This saves checking as well as dry rot.

Fire. — Perhaps the day of the wood post is passing. Probably we shall go back to the old style of brick piers clear from foundation to roof, or reinforced concrete, instead of steel, iron, or wood supports. One engineer has preached against the interior steel columns for years.

If it is said that a brick pier 2′ x 2′ looks too clumsy in the center of a floor, we might reply that it is far more in keeping with the architecture of a heavy factory or warehouse than on the front of a porch, and now we see piers of this size all over the country supporting light porch cornices.

SAFE LOADS, IN TONS, FOR HOLLOW ROUND CAST COLUMNS

Diam in In.	Thickness in Inches	Unsupported Length, in Feet									
		6	8	10	12	14	16	18	20	22	24
6	¾	50	43	37	32	27					
	⅞	57	50	42	36	31					
7	¾	62	56	49	43	38	33				
	⅞	71	64	57	49	43	38				
8	¾	75	69	62	56	50	44	39			
	⅞	86	79	71	64	57	50	44			
	1	97	89	81	72	63	56	50			
9	⅞	101	94	86	78	70	63	57			
	1	113	105	97	88	79	71	64			
	1⅛	126	117	107	97	88	79	71			
10	⅞	116	109	101	93	85	78	71	64		
	1	130	122	114	105	96	88	80	72		
	1⅛	145	136	126	117	107	97	88	80		
	1¼	158	149	139	128	117	107	97	88		
11	1	147	139	131	122	113	104	96	88	80	
	1⅛	163	155	146	136	126	116	106	97	89	
	1¼	179	170	160	149	138	127	117	107	98	
	1⅜	195	185	174	162	150	138	127	117	106	
12	1⅛	181	174	165	155	145	135	125	115	106	98
	1¼	199	191	181	170	159	148	137	127	117	108
	1⅜	217	207	197	185	173	161	149	138	127	117
	1½	234	224	212	200	187	173	161	149	137	126
13	1⅛	200	192	184	174	164	154	144	134	125	116
	1¼	219	211	202	191	180	169	158	147	137	127
	1⅜	239	230	220	208	196	184	172	160	149	138
	1½	258	248	237	225	212	199	186	173	161	149
14	1¼		232	223	213	202	191	180	168	157	147
	1⅜		253	243	232	220	207	195	183	171	160
	1½		273	263	251	238	224	211	198	185	173
	1⅝		293	282	269	255	241	227	212	198	185
15	1⅜			266	255	243	231	219	206	194	182
	1½			287	276	263	250	236	223	210	197
	1⅝			309	296	283	268	254	239	225	211
	1¾			329	316	301	286	271	255	240	225
16	1½				301	288	275	262	248	235	222
	1⅝				323	310	296	282	267	253	239
	1¾				345	331	316	300	285	270	254

SAFE LOADS, IN TONS, FOR HOLLOW SQUARE CAST COLUMNS

Side in In.	Thick-ness in Inches	Unsupported Length, in Feet									
		6	8	10	12	14	16	18	20	22	24
6	¾	67	60	53	46	40					
	⅞	76	68	60	52	45					
7	¾	83	76	69	61	54	49				
	⅞	94	87	79	70	62	55				
8	¾	99	92	85	78	70	63	57			
	⅞	113	106	98	89	80	72	65			
	1	127	119	110	100	90	81	73			
9	⅞	131	124	116	107	99	91	82			
	1	148	140	131	121	112	103	94			
	1⅛	164	155	145	134	123	113	103			
10	⅞	150	143	135	126	118	109	100	92		
	1	169	161	153	143	133	123	114	105		
	1⅛	187	179	169	158	147	136	126	116		
	1¼	206	196	186	174	162	150	138	127		
11	1	190	183	174	165	155	144	135	125	116	
	1⅛	211	203	193	183	172	160	150	139	129	
	1¼	232	223	212	201	189	177	166	154	142	
	1⅜	251	242	230	218	205	191	179	167	157	
12	1⅛	234	226	217	207	196	185	174	163	153	143
	1¼	258	249	239	228	216	204	192	179	167	156
	1⅜	279	270	260	247	235	221	208	195	182	169
	1½	301	292	280	267	253	239	225	210	197	184
13	1⅛	257	250	241	231	221	210	199	187	176	165
	1¼	283	275	266	255	243	232	219	206	194	182
	1⅜	308	299	289	277	265	250	237	224	211	198
	1½	332	323	312	299	286	271	257	242	228	214
14	1¼		301	292	282	271	259	247	234	221	209
	1⅜		328	318	306	294	281	268	254	240	227
	1½		354	343	331	318	304	290	275	260	245
	1⅝		380	368	355	341	326	311	295	279	263
15	1⅜			347	336	324	311	298	284	270	256
	1½			375	363	350	336	322	307	292	277
	1⅝			402	390	376	361	345	329	313	297
	1¾			430	416	401	385	368	351	334	318
16	1½				395	383	369	354	339	324	310
	1⅝				424	411	396	380	364	348	332
	1¾				453	439	423	407	389	371	354

WEIGHT OF SQUARE CAST IRON COLS IN LBS PER LF

(Birkmire)

a □ b 2a+2b	Thickness of Metal in In								
	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
*12	18.6	21.1	23.3	25.0	26.4	27.3	28.1		
14	22.5	25.8	28.7	31.3	33.4	35.1	37.5		
16	26.4	30.5	34.2	37.5	40.4	43.0	46.9	49.2	50.0
18	30.3	35.2	39.7	43.8	47.4	50.8	56.3	60.2	62.5
20	34.2	39.8	45.1	50.0	54.5	58.6	65.6	71.1	75.0
22	38.1	44.5	50.6	56.3	61.5	66.4	75.0	82.0	87.5
24	42.0	49.2	56.1	62.5	68.5	74.2	84.4	93.0	100.0
26	45.9	53.9	61.5	68.8	75.6	82.0	93.8	103.9	112.5
28	49.8	58.6	67.0	75.0	82.6	89.8	103.1	114.8	125.0
30	53.7	63.3	72.5	81.3	89.6	97.7	112.5	125.8	137.5
32	57.6	68.0	77.9	87.5	96.7	105.5	121.9	136.7	150.0
34	61.5	72.7	83.4	93.8	103.7	113.3	131.3	147.7	162.5
36	65.4	77.3	88.9	100.0	110.7	121.1	140.6	158.6	175.0
38	69.3	82.0	94.3	106.3	117.8	128.9	150.0	169.5	187.5
40	73.2	86.7	99.8	112.5	124.8	136.7	159.4	180.5	200.0
42	77.1	91.4	105.3	118.8	131.8	144.5	168.8	191.4	212.5
44	81.0	96.1	110.8	125.0	138.8	152.3	178.1	202.3	225.0
46	84.9	100.8	116.2	131.3	145.9	160.2	187.5	213.3	237.5
48	88.8	105.5	121.7	137.5	152.9	168.0	196.9	224.2	250.0
50	92.8	110.2	127.2	143.8	159.9	175.8	206.3	235.2	262.5
52	96.7	114.8	132.6	150.0	167.0	183.6	215.6	246.1	275.0
54	100.6	118.5	138.1	156.3	174.0	191.4	225.0	257.0	287.5
56	104.5	124.2	143.6	162.5	181.0	199.2	234.4	268.0	300.0
58	108.4	128.9	149.0	166.8	188.1	207.0	243.8	278.9	312.5
60	112.3	133.6	154.5	175.0	195.1	214.9	253.2	289.8	325.0
62	116.2	138.3	160.0	181.3	202.1	222.7	262.5	300.8	337.5
64	120.1	143.0	165.4	187.5	209.2	230.5	271.9	311.7	350.0
66	124.0	147.7	170.9	193.8	216.2	238.3	281.3	322.7	362.5
68	127.9	152.3	176.4	200.0	223.2	246.1	290.6	333.6	375.0
70	131.8	157.0	181.8	206.3	230.3	253.9	300.0	344.5	387.5
72	135.7	161.7	187.3	212.5	237.3	261.7	309.4	355.5	400.0
74	139.6	166.4	192.8	218.8	244.3	269.5	318.8	366.4	412.5
76	143.5	171.1	198.3	225.0	251.3	277.3	328.1	377.3	425.0
78	147.4	175.8	203.7	231.3	258.4	285.2	337.5	388.3	437.5
80	151.3	180.5	207.2	237.5	265.4	293.0	346.9	399.2	450.0

* A and b = either side (outside measurement). 2a + 2b = number. Allowance has been made in above table for corners counted twice.

EXAMPLE:—What is the weight per lf of a 12″x16″x1″ thick col?

ANS:—$2a + 2b = 24 + 32 = 56$. Opposite this number, under 1 inch thick metal, we find 162.5, which is weight per lf in lbs for a col of this size.

WEIGHT OF ROUND CAST IRON COLUMNS

Diam	Thickness	Weight	Diam	Thickness	Weight	Diam	Thickness	Weight
6	½	26.95	8	1¼	82.71	11	1	98.03
6	¾	38.59	9	¾	60.65	11	1¼	119.46
6	⅞	43.96	9	1	78.40	11	1½	139.68
6	1	49.01	9	1¼	94.94	11	1¾	158.68
6	1⅛	53.76	9	1½	110.26	11	2	176.44
7	¾	45.96	9	1¾	124.36	12	1	107.51
7	1	58.90	10	1	88.23	12	1¼	131.41
7	1⅛	64.77	10	1¼	107.23	12	1½	154.10
8	¾	53.29	10	1½	124.99	12	1¾	175.53
8	1	68.64	10	1¾	141.65	12	2	195.75

RECTANGULAR COLUMNS

If a square column is not suitable it is easy to figure out one of a rectangular shape from the square column table.

Take a column, for illustration, 10″ x 10″, 1⅛″ metal x 10′ long. It is listed to carry 169 tons. Two sides at 10 inches = 20 inches, and two at 7¾ inches make 15½ inches, a total length if spread out of 35½″ x 1⅛″ thick. For the same weight of 169 tons we require the same area of metal put into the particular size we want to suit a store front or some other part of a building where a square column would not do.

Example. — Suppose it has to be only 7 inches wide on the front, what would be the other size? Twice 7 are 14 for the front and back. Taken from 35½ this leaves 21½ inches. The half of this is 10¾ inches, which added to the thickness of front and back, each 1⅛ inches thick, makes 13 inches. The column would therefore be 7″ x 13″.

Example. — Another method is to get the area of the metal on the end, and make the new column thicker or thinner as may be required to fill out the new depth. Take as before a square column 35½″ x 1⅛″. In decimals this is 35.5 and 1.125. Multiplying these we get 39.9375, or 40 square inches required. Suppose the column has to be 7 inches, but cannot be more than 11 deep instead of 13, how thick has the metal to be?

The area has to be 40 square inches, the outside size 7″ x 11″ = 77 square inches, and the difference of 37 square inches must be the opening in the end.

As a rough and ready way to get at it we may assume the metal to be 1 inch thick. Around the outside of the column is 36 inches, but owing to the overlapping of the corners we should have only 34 square inches of section. We can work it by simple proportion thus: If 34 square inches require 1-inch metal, what thickness will 40 require? In the proportion of 34 to 40. Dividing 40 by 34 we get 1.18 inches thick. Multiplying the .18 by 16 to get it to 16ths of an inch we get 2.88, or practically $\frac{3}{16}$. The metal would be made $1\frac{3}{16}$ inches.

We can now reverse the process and test this. The decimal of $\frac{3}{16}$ inch is .1875. We have front and back, making together 14 inches; and two sides $9\frac{3}{16}$ inches each, a total of $33\frac{10}{16}$, or $33\frac{5}{8}$. The decimal for $\frac{5}{8}$ is .625. We therefore have a section of metal 33.625 inches long by a thickness of $1\frac{3}{16}$ or 1.1875. When multiplied these make 39.93 square inches, or closer to 40 than a foundryman will make it.

SAFE LOADS, IN TONS OF 2,000 POUNDS, FOR HOLLOW RECTANGULAR CAST IRON COLUMNS

Length in Feet	6x8 INCHES						6x10 INCHES						6x12 INCHES					
	Thickness of Metal in Inches																	
	¾	⅞	1	1⅛	1¼	1⅜	¾	⅞	1	1⅛	1¼	1⅜	¾	⅞	1	1⅛	1¼	1⅜
7	73	83	92	100	108	115	86	98	109	119	129	137	98	112	125	137	149	160
8	69	78	86	94	101	107	81	92	102	111	120	128	93	105	117	129	139	148
9	64	72	80	87	93	99	75	85	95	103	111	119	87	99	110	120	129	138
10	60	67	74	80	86	91	70	80	88	96	103	110	81	92	102	111	120	128
11	55	62	69	74	80	84	66	74	82	89	95	101	76	86	95	103	111	118
12	51	58	63	69	74	77	61	69	76	82	88	93	70	80	88	96	103	109
13	48	53	59	63	67	71	57	64	70	76	81	86	66	74	82	89	95	101
14	44	49	54	58	62	66	53	59	65	70	75	79	61	69	76	82	88	93
15	41	46	50	54	57	60	49	55	61	65	69	73	57	64	70	76	81	86
16	38	42	46	50	53	55	45	51	56	60	64	67	53	59	65	71	75	80
17	35	39	43	46	49	52	42	47	52	56	59	63	49	55	61	65	70	73
18	32	37	40	43	45	48	39	44	48	52	55	58	46	51	56	61	65	68
19	31	34	37	40	42	44	37	41	45	48	51	54	43	48	52	57	61	63
20	28	32	34	37	39	41	35	38	42	45	48	50	40	45	49	53	56	59

Length in Feet	8x10 INCHES								8x12 INCHES							
	Thickness of Metal in Inches								Thickness of Metal in Inches							
	¾	⅞	1	1⅛	1¼	1⅜	1½	1¾	¾	⅞	1	1⅛	1¼	1⅜	1½	1¾
7	107	123	138	152	166	178	191	213	121	139	156	172	188	203	217	244
8	103	118	132	146	158	171	182	203	117	134	150	166	180	195	208	233
9	99	113	126	139	151	163	173	193	112	128	144	158	172	186	198	222
10	95	108	121	133	144	155	165	183	107	122	137	151	164	177	189	210
11	90	103	115	126	136	146	156	173	102	117	131	144	156	168	179	199
12	86	98	109	119	129	139	147	163	97	111	124	136	148	159	169	188
13	81	93	103	113	122	131	139	153	93	106	118	129	140	150	160	177
14	77	88	98	107	115	123	131	144	88	100	112	122	133	142	151	167
15	73	83	92	101	109	116	123	135	83	95	106	116	125	134	142	157
16	69	78	87	95	103	110	116	127	79	90	100	109	118	127	134	148
17	65	74	82	90	97	103	109	120	75	85	95	103	112	119	126	139
18	62	70	78	85	91	97	103	112	71	80	89	98	105	113	119	131
19	59	66	73	80	86	92	97	106	67	76	85	92	100	106	112	123
20	55	63	69	76	81	86	91	99	64	72	80	87	94	100	106	116

Length in Feet	8x14 INCHES								8x16 INCHES							
	Thickness of Metal in Inches								Thickness of Metal in Inches							
	¾	⅞	1	1⅛	1¼	1½	1¾	2	¾	⅞	1	1⅛	1¼	1½	1¾	2
7	135	155	174	193	211	244	275	303	148	171	192	213	233	271	306	338
8	130	149	168	185	202	234	263	289	143	165	185	205	224	260	293	323
9	125	143	161	177	193	223	251	275	138	158	178	196	214	248	279	307
10	120	137	154	169	185	213	238	261	132	151	170	188	205	236	265	291
11	114	131	146	161	176	202	225	246	126	145	162	179	195	225	252	276
12	109	124	139	153	167	191	213	232	121	138	154	170	185	213	238	260
13	104	118	132	146	158	181	201	219	115	131	147	162	176	202	225	245
14	99	112	126	138	150	171	190	206	109	125	139	153	167	191	212	231
15	94	107	119	131	142	161	179	194	104	118	132	145	158	180	200	218
16	89	101	113	124	134	152	168	182	99	112	125	138	149	170	189	205
17	84	96	107	117	126	144	159	171	94	107	119	130	141	161	178	193
18	80	91	101	111	119	136	149	161	89	101	113	123	133	152	168	181
19	76	86	96	105	113	128	141	151	84	96	107	117	126	143	158	171
20	72	81	90	99	107	121	133	143	80	91	101	110	119	135	149	161

Length in Feet	10x12 INCHES								10x14 INCHES							
	Thickness of Metal in Inches								Thickness of Metal in Inches							
	1	1¼	1½	1¾	2	2¼	2½	2¾	1	1¼	1½	1¾	2	2¼	2½	2¾
7	182	221	257	291	322	350	376	400	201	244	285	323	359	392	422	450
8	177	215	250	282	312	339	363	386	196	238	277	314	348	379	408	435
9	172	208	242	273	301	327	350	371	190	231	269	304	336	366	394	418
10	166	203	233	263	290	314	336	356	184	223	260	293	324	353	378	402
11	161	194	225	253	278	301	322	340	178	216	250	282	312	339	363	385
12	155	187	216	243	267	288	308	325	172	208	241	271	299	325	347	368
13	149	180	207	233	255	276	294	310	166	200	232	260	287	311	332	351
14	143	172	199	223	244	263	280	295	159	192	222	250	274	297	317	334
15	138	165	190	213	233	251	267	280	153	184	213	239	262	283	302	318
16	132	158	182	203	222	239	254	266	147	177	204	228	250	270	287	303
17	126	151	174	194	212	227	241	253	141	169	195	218	239	257	273	288
18	121	145	166	185	202	216	229	240	135	162	186	208	228	245	260	273
19	116	138	158	176	192	206	218	228	129	155	178	199	217	233	247	260
20	111	132	151	168	183	196	207	216	124	148	170	189	207	222	235	246
21	106	126	144	160	174	186	196	205	119	142	162	181	197	211	223	234
22	101	121	138	153	166	177	187	195	113	135	155	172	188	201	213	222
23	97	115	131	145	158	168	177	185	109	129	148	164	179	191	202	211
24	93	110	125	139	150	160	169	176	104	124	141	157	170	182	192	201
25	89	105	120	132	143	152	160	167	99	118	135	150	161	174	183	191

Length in Feet	10x16 INCHES								10x18 INCHES							
	Thickness of Metal in Inches								Thickness of Metal in Inches							
	1	1¼	1½	1¾	2	2¼	2½	2¾	1	1¼	1½	1¾	2	2¼	2½	2¾
7	220	268	313	356	396	433	417	438	238	291	341	388	433	475	514	457
8	214	261	305	346	384	420	392	410	233	284	332	378	420	460	498	423
9	208	253	295	335	372	406	367	382	226	276	322	366	407	445	480	391
10	202	245	285	323	358	391	343	355	220	267	312	354	393	429	463	359
11	195	237	276	312	345	376	320	330	213	258	301	341	378	413	444	330
12	189	229	266	300	332	360	297	306	206	250	291	329	364	396	426	303
13	182	220	256	288	318	345	277	283	198	240	280	315	349	380	408	280
14	175	212	245	276	304	330	257	262	191	231	269	303	335	363	390	256
15	169	203	235	265	291	315	239	243	184	222	258	290	320	347	372	236
16	162	195	226	253	278	301	223	225	177	213	247	278	306	332	355	217
17	155	187	216	242	266	287	207	209	170	205	237	266	293	316	338	201
18	149	179	207	231	254	273	193	194	163	196	227	254	279	302	322	185
19	143	172	198	221	242	260	180	181	156	188	217	243	267	288	306	172
20	137	164	189	211	231	248	168	168	150	180	207	232	254	274	292	159
21	131	157	180	201	220	236	157	157	144	172	198	222	243	261	278	148
22	126	150	172	192	210	225	147	147	138	165	190	212	232	249	264	138
23	120	144	165	183	200	214	138	137	132	158	181	202	221	237	252	128
24	115	137	157	175	191	204	129	129	126	151	173	193	211	226	240	120
25	110	132	150	167	182	195	122	121	121	145	166	185	202	216	228	112

Length in Feet	12x14 INCHES								12x16 INCHES							
	Thickness of Metal in Inches								Thickness of Metal in Inches							
	1	1¼	1½	1¾	2	2¼	2½	2¾	1	1¼	1½	1¾	2	2¼	2½	2¾
7	225	275	322	366	408	447	484	518	244	299	350	400	446	490	532	570
8	221	269	315	358	399	437	472	506	240	293	344	391	437	479	520	557
9	216	263	308	350	390	426	461	493	235	287	336	383	427	468	507	543
10	211	257	301	341	379	415	448	478	230	280	328	373	416	456	493	528
11	206	251	293	332	369	403	434	464	224	273	320	363	404	443	479	512
12	201	244	284	322	358	390	421	449	218	266	311	353	393	429	464	495
13	195	237	276	313	347	378	407	433	213	259	302	343	381	416	449	479
14	189	230	268	303	335	365	393	418	207	251	293	332	368	402	433	462
15	184	223	259	293	324	352	378	402	200	244	284	321	356	388	418	446
16	178	215	250	283	312	340	364	387	194	236	275	311	344	375	403	429
17	172	208	242	273	301	327	351	372	188	228	265	300	332	361	388	413
18	166	201	233	263	290	315	337	357	182	221	256	289	320	348	373	397
19	161	194	225	253	279	303	324	343	176	213	247	279	308	335	359	381
20	155	187	217	244	269	291	311	329	170	206	239	269	297	322	345	366
21	150	181	209	235	258	279	298	316	164	199	230	259	286	310	331	351
22	145	174	201	226	248	268	286	302	159	192	222	249	275	298	318	337
23	139	168	194	217	239	258	275	290	153	185	214	240	264	286	306	323
24	134	162	186	209	229	247	264	278	147	178	206	231	254	275	293	310
25	130	156	179	201	220	238	253	267	143	172	198	222	244	264	282	298

Length in Feet	12x18 INCHES								12x20 INCHES							
	Thickness of Metal in Inches								Thickness of Metal in Inches							
	1	1¼	1½	1¾	2	2¼	2½	2¾	1¼	1½	1¾	2	2¼	2½	2¾	3
7	263	323	379	433	484	533	579	622	347	408	466	522	576	626	674	720
8	259	317	372	424	474	522	566	608	340	400	457	512	564	613	653	703
9	254	310	364	415	464	509	552	593	330	392	447	500	551	589	643	685
10	248	303	356	405	452	496	538	577	326	383	437	488	537	583	626	666
11	242	296	347	395	440	483	522	560	318	374	426	475	522	566	608	646
12	236	288	337	384	427	468	507	542	310	364	414	462	507	549	589	626
13	230	280	328	373	415	454	490	524	302	354	403	449	492	532	570	605
14	224	272	318	361	402	439	474	507	294	344	391	435	476	515	551	584
15	217	264	309	350	389	425	458	489	286	333	378	421	460	497	532	563
16	211	256	299	339	376	410	442	471	276	323	366	407	445	480	512	542
17	204	248	289	327	363	395	425	453	268	312	354	393	429	463	494	522
18	198	240	279	316	350	381	410	436	259	302	342	379	414	446	475	502
19	191	232	270	305	337	367	394	419	251	292	330	366	399	429	457	482
20	185	224	260	294	325	353	379	403	242	282	319	353	384	413	439	463
21	179	216	251	283	313	340	364	387	234	272	307	340	370	397	422	445
22	173	209	242	273	301	327	350	371	226	263	296	327	356	382	405	427
23	167	201	233	203	290	314	336	356	218	253	285	315	342	367	389	409
24	161	194	225	253	279	302	323	342	211	244	275	303	329	353	374	393
25	155	187	217	244	268	290	310	328	203	235	265	292	317	339	359	377

Length in Feet	14x16 INCHES Thickness of Metal in Inches								14x20 INCHES Thickness of Metal in Inches							
	1¼	1½	1¾	2	2¼	2½	2¾	3	1¼	1½	1¾	2	2¼	2½	2¾	3
7	327	385	440	493	543	590	635	677	376	443	508	570	630	687	741	793
8	323	379	433	485	534	580	624	665	371	437	501	562	620	676	729	779
9	318	373	426	476	524	569	612	652	365	430	493	552	609	664	715	765
10	312	366	418	467	514	558	599	638	359	423	484	542	598	651	701	749
11	306	359	410	458	503	545	586	623	353	415	474	531	585	637	686	732
12	300	352	401	447	491	533	571	608	346	407	465	520	573	623	670	715
13	293	344	392	437	479	519	557	592	339	398	454	508	559	608	654	697
14	287	336	382	426	467	506	542	575	331	389	444	496	546	593	637	678
15	280	327	372	415	455	492	526	559	324	380	433	484	532	577	619	659
16	273	319	363	404	442	478	511	542	316	370	422	471	518	561	602	640
17	266	310	353	392	429	464	496	525	308	361	411	459	503	545	585	621
18	258	302	343	381	416	450	480	508	300	351	400	446	489	529	567	602
19	251	293	333	370	404	436	465	492	292	342	389	433	475	514	550	584
20	244	285	323	358	391	422	450	476	284	332	378	421	460	498	533	565
21	237	277	313	347	379	408	435	460	276	323	367	408	446	482	516	547
22	230	268	304	336	367	395	421	444	268	314	356	396	433	467	499	529
23	223	260	294	326	355	382	406	429	261	304	345	383	419	452	483	511
24	217	252	285	315	343	369	393	414	253	295	335	372	406	438	467	494
25	210	244	276	305	332	357	379	399	246	286	324	360	393	423	451	477

SAFE LOAD, IN TONS, FOR GAS OR STEAM PIPE COLUMNS

Standard Pipe

Estimated diameter Inches	Thickness Inches	W't per foot Lbs.	Length in feet 8 Tons	9 Tons	10 Tons	12 Tons	14 Tons
2.8........	0.204	5.74	5.90	5.51	5.21	...	...
3.5........	0.217	7.54	9.14	8.75	8.35	7.52	...
4.0........	0.226	9.00	11.02	10.66	10.25	9.39	8.62
4.5........	0.237	10.66	14.45	14.11	13.65	12.72	11.78
5.0........	0.247	12.34	16.78	16.33	15.88	14.90	13.98
5.56.......	0.259	14.50	18.76	18.76	18.26	17.31	16.26
6.62.......	0.280	18.76	25.06	25.06	25.06	24.29	23.32
7.62.......	0.301	23.37	32.31	32.31	32.31	32.31	31.32
8.62.......	0.322	28.18	36.63	36.63	36.63	36.63	36.63

Extra Strong.

2.8........	0.56	13.68	14.10	13.04	11.86	....	....
3.5........	0.608	18.56	21.25	20.12	19.04	16.56	....
4.0........	0.642	22.75	27.18	26.02	24.86	22.54	19.89
4.5........	0.682	27.48	35.31	34.15	32.84	30.19	27.57
5.56.......	0.75	38.12	52.78	51.37	49.94	47.06	44.16
6 62.......	0.875	53.11	71.10	71.10	70.58	66.99	64.22

SAFE LOADS, IN TONS (of 2,000 lbs.), FOR STEEL I BEAMS

Extreme Fibre Stress, 16,000 lbs. per Square Inch. Limiting Spans, above which Tabulated Safe Load is apt to crack Plastered Ceilings, are indicated by heavy lines.

Size in Inches	Weight per Foot	DISTANCE BETWEEN SUPPORTS, IN FEET 6	8	10	11	12	14	16	18	19	20	21	23	25	26	27	29	30	31	34
24	100				93.8	86	73.7	64.5	57.3	54.3	51.6	49.1	44.9	41.3	39.7	38.2	35.6	34.4	33.2	30.3
	80				83.2	76.3	65.4	57.2	50.9	48.2	45.6	43.6	39.8	36.6	35.2	33.9	31.6	30.5	29.5	26.9
20	80				70.2	64.4	55.2	48.3	42.9	40.7	38.6	36.8	33.6	30.9	29.7	28.6	26.7	25.8	24.9	22.7
	64				55.5	50.9	43.7	38.2	34.	32.2	30.6	29.1	26.6	24.5	23.5	22.6	21.1	20.4	19.7	18.
15	80			55.9	50.8	46.6	39.9	34.9	31.1	29.4	27.9	26.6	24.3	22.4	21.5	20.7	19.3	18.6	18.	16.4
	60			45.8	41.6	38.2	32.7	28.7	25.5	24.1	22.9	21.8	19.9	18.3	17.6	17.	15.8	15.3	14.8	13.5
	50			37.6	34.2	31.4	26.9	23.5	20.9	19.8	18.8	17.9	16.4	15.1	14.5	14.	13.	12.6	12.2	11.1
	41			30.2	27.4	25.1	21.6	18.9	16.8	15.9	15.1	14.4	13.1	12.1	11.6	11.2	10.4	10.1	9.7	8.9
12	40		31.3	25	22.7	20.8	17.9	15.6	13.9	13.2	12.5	11.9	10.9	10.	9.6	9.3	8.6	8.3	8.1	7.4
	32		24.7	19.8	18.	16.5	14.1	12.4	11.	10.4	9.9	9.4	8.6	7.9	7.6	7.3	6.8	6.6	6.4	5.8
10	33	28.7	21.5	17.2	15.6	14.3	12.3	10.8	9.6	9.1	8.6	8.2	7.5	6.9	6.6	6.4	5.9	5.7	5.5	5.1
	25	21.7	16.3	13.1	11.9	10.9	9.3	8.2	7.3	6.9	6.5	6.2	5.7	5.2	5.	4.8	4.5	4.4	4.2	3.8
9	27	21.8	16.4	13.1	11.9	10.9	9.4	8.2	7.3	6.9	6.5	6.2	5.7	5.2	5.	4.9	4.5	4.4	4.2	3.9
	21	16.7	12.5	10.	9.1	8.3	7.1	6.3	5.6	5.3	5.	4.8	4.4	4.	3.8	3.7	3.5	3.3	3.2	2.9
8	22	16.	12	9.6	8.7	8	6.8	6.	5.3	5	4.8	4.6	4.2	3.8	3.7	3.5	3.3	3.2	3.1	2.8
	18	12.8	9.6	7.7	7.	6.4	5.5	4.8	4.3	4.1	3.9	3.7	3.3	3.1	3.	2.9	2.7	2.6	2.5	2.3
7	20	12.6	9.5	7.6	6.9	6.3	5.4	4.7	4.2	4	3.8	3.6	3.3	3.	2.9	2.8	2.6	2.5	2.4	2.2
	15	9.7	7.2	5.8	5.3	4.8	4.1	3.6	3.2	3.	2.9	2.8	2.5	2.3	2.2	2.1	2.	1.93	1.87	1.7
6	16	8.5	6.4	5.1	4.6	4.2	3.6	3.2	2.9	2.7	2.5	2.4	2.2	2.	1.9					
	13	7.	5.2	4.2	3.8	3.5	3.	2.6	2.3	2.2	2.1	2.	1.8	1.7	1.6					
5	13	5.6	4.2	3.4	3.	2.8	2.4	2.1	1.9	1.8	1.7									
	10	4.4	3.3	2.7	2.4	2.2	1.9	1.7	1.5	1.4	1.3									
4	10	3.4	2.6	2.1	1.9	1.7	1.6	1.3	1.1											
	7	2.5	1.9	1.5	1.4	1.3	1.1	1.	0.84											
3	6	1.55	1.16	0.92	0.84	0.77														

Safe Loads given are uniformly-distributed loads, including weight of beams

SAFE LOADS, IN TONS (of 2,000 lbs.), ON STEEL CHANNELS.

Limiting Spans, above which Tabulated Safe Load is apt to crack Plastered Ceilings are indicated by heavy lines.

Size in Inches	Weight per Foot	DISTANCE BETWEEN SUPPORTS, IN FEET 6	8	10	11	12	14	16	18	19	20	21	23	25	26	27	29	30	31	34
15	33.		27.2	21.7	19.8	18.1	15.5	13.6	12.1	11.5	10.9	10.4	9.5	8.7	8.4	8.1	7.5	7.3	7.	6.4
13	31.5		24.4	19.5	17.7	16.2	13.9	12.2	10.8	10.3	9.8	9.3	8.5	7.8	7.5	7.2	6.7	6.5	6.3	5.7
12	20.		14.1	11.3	10.2	9.4	8.	7.	6.3	5.9	5.6	5.4	4.9	4.5	4.3	4.2	3.9	3.8	3.6	3.3
10	16.5	12.8	9.6	7.7	7.	6.4	5.5	4.8	4.3	4.1	3.9	3.7	3.4	3.1	2.9	2.9	2.7	2.6	2.5	2.3
9	14.	9.7	7.3	5.9	5.3	4.9	4.2	3.7	3.3	3.1	2.9	2.8	2.6	2.3	2.3	2.2	2.	1.95	1.9	1.7
8	11.	7.1	5.3	4.2	3.9	3.6	3.	2.7	2.4	2.2	2.1	2.	1.8	1.7	1.6	1.6	1.4	1.4	1.4	1.2
7	9.5	5.2	3.9	3.1	2.8	2.6	2.2	1.9	1.7	1.6	1.6	1.5	1.4	1.2	1.2	1.2	1.1	1.		
6	8.	3.9	3.	2.4	2.2	2.	1.7	1.5	1.3	1.2	1.2	1.1	1.	.9						
5	6.5	2.7	2	1.6	1.6	1.3	1.1	1.	.9	.8	.8									
4	5.5	1.8	1.4	1.1	1.	.9	.8	.7												
3	5.	1.2	.9	.7	.6	.6														

BEARING PLATES FOR BEAMS OR CHANNELS ON BRICK OR MASONRY

Size of beams or channels	Bearing on wall.—Inches	Size of cast iron bearing plates.—Inches	Weight.—Lbs.	Safe bearing values in tons for plates resting on		
				Common brick	First-class brick	Stone masonry
3, 4, 5 and 6 inches...	6 6	6 x 6 x ½ 6 x 6 x ⅝	4.7 5.9	1.8	2.7	4.5
7 and 8 in..	8 8	8 x 8 x ¾ 8 x 8 x 1	12.5 16.6	3.2	4.8	8.0
9 and 10 in..	8 8	8 x 12 x ¾ 8 x 12 x 1	19 25	4.8	7.2	12.00
12 in., 31½ pounds..	12 12	12 x 12 x ¾ 12 x 12 x 1	28 37.5	7.2	10.8	18.0
12 in., 40 pounds.. 15 in., 42 pounds...	12 12	12 x 16 x 1 12 x 16 x 1¼	50 62.5	9.6	14.4	24.0
18, 20 and 24 inches...	16	16 x 18 x 1¼	94	12.8	19.2	32.0

The above table is the same as the standard one in the Carnegie Handbook, but cast iron plates are figured as they are more used than the steel ones. The thicker plates are used for bearing values exceeding those given for common brickwork. The allowances are 100 pounds per square inch for common brick; 150 for best brickwork; and 250 for ordinary masonry.

SAFE TENSILE STRENGTH

Weight in Pounds Supported by Steel Rods

¾ inch diameter = 4,200 pounds.
⅞ inch diameter = 5,880 pounds.
1 inch diameter = 7,696 pounds.
1⅛ inch diameter = 8,904 pounds.
1¼ inch diameter = 12,474 pounds.

1⅜ inch diameter = 14,784 pounds.
1½ inch diameter = 18,102 pounds.
1⅝ inch diameter = 21,210 pounds.
1¾ inch diameter = 24,402 pounds.

The washers at ends of rods should have the following areas to provide sufficient bearing on the timbers:

¾ inch diameter rod = 4.6 square inches area.
⅞ inch diameter rod = 6.5 square inches area.
1 inch diameter rod = 8.5 square inches area.
1⅛ inch diameter rod = 9.9 square inches area.
1¼ inch diameter rod = 13.8 square inches area.
1⅜ inch diameter rod = 16.5 square inches area.
1½ inch diameter rod = 20.1 square inches area.
1⅝ inch diameter rod = 23.5 square inches area.
1¾ inch diameter rod = 27.1 square inches area.

Where double rods are used the washers must have twice the areas given above and be made of steel or wrought-iron plates of sufficient thickness so as not to bend or shear.

The rods in the above table are not upset. This process increases the strength from 35 to 40 per cent. But in all cases it should be remembered that the diameter is to be taken at the root of the screw, and not the full diameter.

Unit Allowances. — The recommended allowances for tensile or "pulling" strength of metal per square inch of section is given by the Underwriters as follows:

Rolled steel	16,000 pounds.
Cast steel	16,000 pounds.
Wrought iron...	12,000 pounds.
Cast iron.......	3,000 pounds.

This is on the basis of one-fourth of the actual breaking strength; or there is a factor of safety of four.

Rule. — To get the tensile strength find out the exact area in square inches on end of the rod, or bar of steel or iron, and multiply by the number of pounds in the table. But, once again, it must be remembered that the size under the screw is the one. If we have a steel bar 1″ x 1″ a load of

16,000 pounds could be hung to it, on condition that the end that held the weight was of this exact size.

Example. — Suppose we have a steel rod that measures exactly 1 inch after the screw is cut on the end to hold the nut, how much can we hang to it?

Looking in the table of areas of circles we find that 1 inch equals .7854. Multiplying this by 16,000 we get the load of 12,566 pounds, or a little over 6 tons. Now we see how useful these simple decimals are.

Example 2. — Take a bar of wrought iron 3/8" x 2 1/4". The decimals are .375 and 2.25; the square inches by multiplying, .84375 or a little less than $\frac{85}{100}$ of a square inch. Multiplying this by 12,000 we get 10,125 pounds. If the bar is so treated as to give the full bearing at the end this is the allowed load.

Gallery. — Suppose a gallery 8 feet wide extending around a building, with trusses 12-foot centers, and that the weight is hung to them. Half the width rests on the wall, and the other half on the trusses. We have thus a space of 12' x 4' hung from each truss. Let us put the load at 120 pounds, to include everything. This gives a total load of 5,760 pounds.

What section is needed for this weight? It is a problem for simple proportion. If 16,000 requires 1 square inch, how much will 5,760 need? Less, as a matter of course. Dividing 5,760 by 16,000 we get .36 square inches. In the table of areas of circles the nearest figure to this is .38485. Cutting off the useless "mills" and leaving only cents we have .38, which is a trifle larger than we require, and therefore safe. Looking to the diameter column we find that a circle containing this area must have a diameter of .7, or $\frac{7}{10}$ of an inch. We do not usually figure by tenths of an inch in building, although engineers do in their business, and we must reduce to 16ths. Multiplying 7 by 16 we get 11.2, or $\frac{11}{16}$ and $\frac{2}{10}$ of a $\frac{1}{16}$. Under the root of the screw we therefore require fully $\frac{11}{16}$. A 7/8 rod would give plenty of depth for cutting the screw. The difference in cost is so slight that an architect would use a 1-inch or even a 1 1/8-inch rod.

Good Rule. — A good rule to memorize is that which tells us that circles are to each other as the square of their diameters. Take 3 rods, 3/4 inches, 7/8 inches, and 1 inch. Reducing to eighths of an inch we have 6, 7, and 8. The square of 6 is 36; of 7, is 49; of 8, is 64. The area on the end of a ¾-inch rod is just a little over half that on one an inch in diameter. Increasing ⅛ inch thus gives more strength than some would think.

Upsetting. — The cutting of the screw really makes a rod 1 inch in diameter just a trifle over $\frac{13}{16}$. So far as strength goes, then, we have to figure on a $\frac{13}{16}$ rod, although we use 1-inch material. To get over this the ends of rods are upset or hammered to a larger size than the body. But this reduces the strength, and with a 1-inch rod it would not be sufficient to upset it to give room for screw cutting only. More has to be allowed, to get the full strength of the main part. This increases the strength about 40 per cent. if it is well done.

ROPES

Wire Ropes. — Roebling uses a load of only $\frac{1}{5}$ to $\frac{1}{7}$ of the ultimate strength. Use large sheaves. The wear increases

TRANSMISSION AND HOISTING ROPES WITH NINETEEN WIRES TO THE STRAND.—IRON

Trade No.	Circumference in inches	Diameter	Weight per ft. in lbs. of rope with Hemp Center	Breaking strain in tons of 2,000 pounds	Proper work-load in tons of 2,000 pounds	Circumference of Hemp rope of equal strength	Min. size of drum or sh've in ft.
1	6¾	2¼	7.80	74	15	15½	8
2	6	2	6.02	65	13	14½	7
3	5½	1¾	5.08	54	11	13	6½
4	5	1⅝	4.10	44	9	12	5
5	4⅜	1½	3.10	35	7	10¾	4½
6	4	1¼	2.44	27	5½	9½	4
7	3½	1⅛	1.95	20	4	8	3½
8	3⅛	1	1.50	16	3	7	3
9	2¾	⅞	1.14	11½	2½	6	2¾
10	2¼	¾	0.83	8.64	1¾	5	2½
10¼	2	⅝	0.65	5.13	1¼	4¼	2
10½	1⅝	9-16	0.44	4.27	¾	4	1¾
10¾	1½	½	0.35	3.48	½	3½	1½

with the speed, and thus it is better to increase the load than the speed. Do not use galvanized wire. When the surface wears off the rust gets at the iron. Do not coil like a hemp rope. If coiling is done it should be in a large circle.

A cheaper rope is used for guys than for hoisting. The one has 19 strands and the other only 7.

Manila rope is stronger than sisal. The proportion is about 7 to 5. For manila ½ inch in diameter the breaking load is 2,700 pounds; for ¾ inch, 4,500; for 1 inch, 6,200; 1⅛, 8,600; 1¼ inch, 11,600. Wise contractors see if the ropes they are using are not old, and do not load up to the breaking point.

CAST IRON

The Underwriters' test is that sample bars 5′ x 1″ x 1″, cast in sand molds, placed on supports 4 feet 6 inches apart, shall bear a central load of 450 pounds before breaking. Without experimenting one would be inclined to say that a bar of that kind which supported 4½ kegs of nails must be of extra good material.

Tables are given elsewhere for the bearing power of square and round hollow cast iron columns. We have to consider here their bases, connections, and some special requirements.

Sizes. — The Underwriters recommend, to begin with, that cast iron columns shall have a diameter of not less than 5 inches, and a shell of not less than ¾ inches thick. It is risky to cast a column of a less thickness. The core sometimes shifts, the metal runs to one side, and in a ½-inch column it might be only ¼-inch thick. An architect cannot safely figure on such a column. There is too much difference between it and the 2-inch one already referred to.

Dangers. — As noted, one of the government experts at San Francisco said that we should stop using cast iron columns. Jones and Laughlin say that they are easily broken by a side blow, but they manufacture the other kind.

Those who have handled them know that they are rigid and unyielding. You can do something with a bent lug on a wrought iron column, but one of cast iron must stand as it comes from the foundry. Yet with all the acknowledged disadvantages of these columns Kidder thinks they are about as good as the steel ones.

Length. — The second requirement of the Underwriters' code is that cast iron columns shall not have an unsupported length of more than 20 times their least diameter, or size. Kidder allows 36 times; Chicago 24. Once again, the authorities differ radically.

Thickness. — The third structural requirement is that all lugs, flanges, seats, brackets, and other members shall finish at least 1 inch thick.

Other requirements are wide enough flanges to bolt the one column to the other with ¾-inch bolts, and a 1¼-inch cast iron smooth-planed, or ⅝-inch mild steel, plate to go between the two columns.

Diameter. — The smallest diameter of a cast iron column, according to the Underwriters, should be 5 inches. The two stories on top of a building might have this size, then for every two below, the diameter should be increased not less than 1 inch.

Thickness. — The metal should not be less than $\frac{1}{12}$ of the greatest lateral dimension of cross section. In no case should it be less than ¾-inch thick.

Safe Loads for Columns. — In general, a cast iron column for short lengths, not exceeding seven times the diameter or breadth, will support 6 tons to the square inch: for longer lengths, from 5 to 3 tons.

Example. — Take a column 8 inches in diameter with ¾-inch metal. We have first of all to get the area of the metal in square inches to see how much it will support. Turning to the table of areas of circles we find that an 8-inch equals 50.26. With ¾-inch metal on each side the core must be 6½ inches. This is, in decimals, 6.5 inches. If there is no such figure given in the areas of circles take 65. The area of this is 331.83, or practically, 332. Dividing by 10 gives the required area for 6.5. This is 33.2, which, subtracted from 50.26, gives a remainder of close to 17 square inches. The method, as will be seen, is to get the area of the two circles and subtract the one from the other.

At 6 tons to the square inch the load would be 102. In the table for cast iron columns at 8 feet long the weight is given as 101, running less or more, according to length.

With rectangular columns the same method is followed. Get the area over the metal, and inside of it, and subtract the one from the other to see how many square inches there are left for iron.

CAST LINTELS

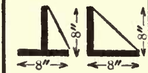
Cheapness has to cut some figure in building as in everything else. If we can get a score of lintels at $2\frac{1}{4}$ cents a pound to span certain openings with perfect safety we are not going to pay $3\frac{1}{2}$. This is one reason why cast iron lintels are used instead of steel ones, although this metal is not well adapted to stand such strains as come upon an opening. But narrow openings arch themselves by the pressure of the masonry after it is built a few feet up. For such openings cast iron is much used.

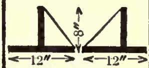
Width. — The Underwriters' code limits the width of an opening at 8 feet for a cast iron lintel, and this for a uniformly distributed load. No part of the metal should be less than $\frac{3}{4}$-inch.

Shapes. — Cast iron lintels are made in various shapes, but the shape in ordinary use is like the capital letter T turned upside down. The L shape comes next, but most architects now employ the rolled steel lintels for this design. Webs and brackets are cast on the lintels that have to carry the heaviest load.

SAFE LOADS, IN TONS OF 2,000 POUNDS, FOR CAST IRON LINTELS.

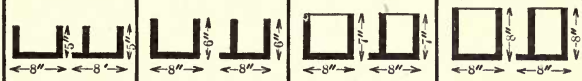
NOTE.—Compiled by Vierling Steel Works, of Chicago and Omaha.

Width of Opening in Feet								
	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	6.9	9.0	9.7	11.8	12.7	16.4	16.0	20.5
3	4.6	6.0	6.4	7.9	8.4	11.0	10.7	13.6
4	3.5	4.5	4.8	5.9	6.4	8.2	8.0	10.2
5	2.8	3.6	3.9	4.7	5.1	6.6	6.4	8.2
6	2.3	3.0	3.2	3.9	4.3	5.5	5.3	6.8
7	2.0	2.6	2.8	3.4	3.6	4.7	4.6	5.8
8	1.7	2.3	2.4	3.0	3.2	4.1	4.0	5.1
9	1.5	2.0	2.1	2.6	2.8	3.7	3.6	4.5
10	1.4	1.8	1.9	2.4	2.5	3.3	3.2	5.0

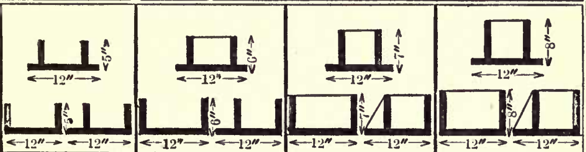
Width of Opening in Feet								
	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	8.9	11.5	14.1	17.1	17.1	22.2	22.0	27.7
3	5.9	7.6	9.4	11.4	11.4	14.8	14.6	18.4
4	4.4	5.7	7.0	8.5	8.5	11.1	11.0	13.8
5	3.6	4.6	5.6	6.8	6.8	8.9	8.8	11.1
6	3.0	3.8	4.7	5.7	5.7	7.4	7.3	9.2
7	2.5	3.3	4.0	4.9	4.9	6.3	6.3	7.9
8	2.2	2.9	3.5	4.3	4.3	5.5	5.0	6.9
9	2.0	2.5	3.1	3.8	3.8	4.9	4.9	6.1
10	1.8	2.3	2.8	3.4	3.4	4.4	4.4	5.5

If load is concentrated in center, use one-half above loads.
Above tables are based on one-eighth the breaking weight.

NOTE.—Compiled by Vierling Steel Works, of Chicago and Omaha.



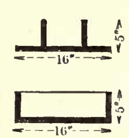
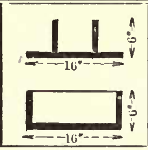
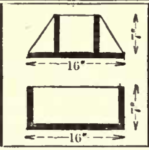
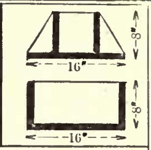
Width of Opening in Feet	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	9.3	11.2	11.9	15.5	16.7	19.9	19.3	25.3
3	6.2	7.4	7.9	10.3	11.1	13.3	12.9	16.9
4	4.6	5.6	6.0	7.7	8.3	10.0	9.7	12.7
5	3.7	4.5	4.8	6.2	6.7	8.0	7.7	10.1
6	3.1	3.7	4.0	5.2	5.6	6.6	6.4	8.4
7	2.6	3.2	3.4	4.4	4.8	5.7	5.5	7.2
8	2.3	2.8	3.0	3.9	4.2	4.9	4.8	6.3
9	2.1	2.5	2.6	3.4	3.7	4.4	4.3	5.6
10	1.9	2.2	2.4	3.1	3.3	3.9	3.9	5.1

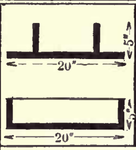
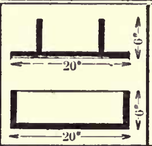
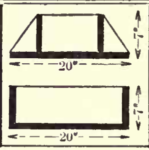
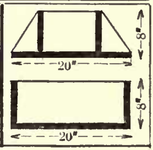


Width of Opening in Feet	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	12.8	14.9	15.8	19.1	20.4	26.3	24.9	33.2
3	8.5	9.9	10.6	12.7	13.6	17.5	16.6	22.1
4	6.4	7.4	7.9	9.6	10.2	13.2	12.4	16.6
5	5.1	6.0	6.3	7.7	8.2	10.2	9.9	13.3
6	4.3	5.0	5.3	6.4	6.8	9.6	8.3	11.1
7	3.7	4.3	4.5	5.5	5.8	7.5	7.1	9.5
8	3.2	3.7	4.0	4.8	5.1	6.6	6.2	8.3
9	2.8	3.3	3.5	4.2	4.5	5.8	5.5	7.4
10	2.6	3.0	3.2	3.8	4.1	5.3	5.0	6.6

If load is concentrated in center, use one-half above loads.
Above tables are based on one-eighth the breaking weight.

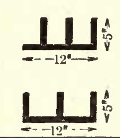
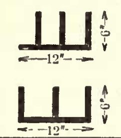
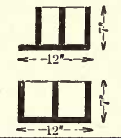
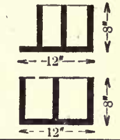
NOTE.—Compiled by Vierling Steel Works, of Chicago and Omaha.

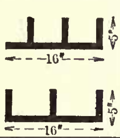
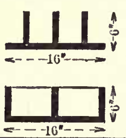
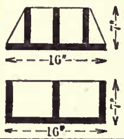
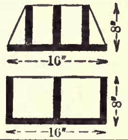
Width of Opening in Feet								
	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	15.1	18.4	19.5	24.6	25.7	32.2	31.4	41.6
3	10.1	12.2	13.0	16.4	17.1	21.4	20.9	27.7
4	7.6	9.2	9.7	12.3	12.8	16.1	15.7	20.8
5	6.1	7.3	7.8	9.9	10.3	12.9	12.6	16.6
6	5.0	6.1	6.5	8.2	8.6	10.7	10.5	13.7
7	4.3	5.2	5.6	7.0	7.3	9.2	9.0	11.9
8	3.8	4.6	4.9	6.2	6.4	8.0	7.8	10.4
9	3.4	4.1	4.3	5.5	5.7	7.1	7.0	9.2
10	3.0	3.7	3.9	4.9	5.1	6.4	6.3	8.3
11	2.7	3.3	3.5	4.5	4.7	5.8	5.7	7.6
12	2.5	3.1	3.2	4.1	4.3	5.4	5.2	6.9

Width of Opening in Feet								
	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	17.2	21.0	22.9	29.5	30.3	37.8	36.6	48.2
3	11.5	14.0	15.3	19.3	20.2	25.2	24.4	32.2
4	8.6	10.5	11.5	14.7	15.1	18.9	18.3	24.1
5	6.9	8.4	9.2	11.8	12.1	15.1	14.6	19.3
6	5.7	7.0	7.6	9.8	10.1	12.6	12.2	16.1
7	4.9	6.0	6.5	8.4	8.7	10.8	10.5	13.8
8	4.3	5.2	5.7	7.3	7.6	9.5	9.1	12.1
9	3.8	4.7	5.1	6.6	6.7	8.4	8.2	10.7
10	3.4	4.2	4.6	5.9	6.1	7.6	7.3	9.6
11	3.1	3.8	4.2	5.4	5.5	6.9	6.6	8.8
12	2.9	3.5	3.8	4.9	5.0	6.3	6.1	8.0

If load is concentrated in center, use one-half above loads.
Above tables are based on one-eighth the breaking weight.

NOTE.—Compiled by Vierling Steel Works, of Chicago and Omaha.

Width of Opening in Feet								
	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	14.2	15.8	18.1	23.1	23.7	30.6	29.1	37.5
3	9.4	10.6	12.0	15.4	15.8	20.4	19.4	25.0
4	7.1	7.9	9.0	11.5	11.9	15.3	14.6	18.7
5	5.7	6.3	7.2	9.2	9.5	12.2	11.5	15.0
6	4.7	5.3	6.0	7.7	7.9	10.2	9.7	12.5
7	4.0	4.5	5.2	6.6	6.8	8.7	8.3	10.8
8	3.5	4.0	4.5	5.8	5.9	7.6	7.3	9.4
9	3.1	3.5	4.0	5.1	5.3	6.8	6.5	7.8
10	2.8	3.2	3.6	4.6	4.7	6.1	5.8	7.5
11	2.6	2.9	3.3	4.2	4.3	5.6	5.3	6.8
12	2.4	2.6	3.0	3.8	3.9	5.1	4.8	6.2

Width of Opening in Feet								
	Thickness of Metal in Inches							
	¾	1	¾	1	¾	1	¾	1
2	17.4	19.5	22.1	27.8	28.4	36.6	35.5	45.7
3	11.7	13.0	14.7	18.5	18.9	24.4	23.7	30.4
4	8.7	9.8	11.1	13.9	14.2	18.3	17.8	22.9
5	7.0	7.8	8.8	11.1	11.3	14.6	14.2	18.3
6	5.8	6.5	7.4	9.3	9.4	12.2	11.8	15.2
7	5.0	5.6	6.3	7.9	8.1	10.5	10.1	13.0
8	4.4	4.9	5.5	6.9	7.1	9.1	8.9	11.4
9	3.9	4.3	4.8	6.2	6.3	8.1	7.9	10.1
10	3.5	3.9	4.4	5.6	5.7	7.3	7.1	9.1
11	3.2	3.6	4.0	5.0	5.2	6.7	6.5	8.3
12	2.9	3.3	3.7	4.6	4.8	6.1	5.9	7.6

If load is concentrated in center, use one-half above loads.
Above tables are based on one-eighth the breaking weight.

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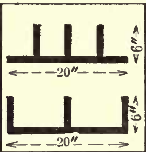
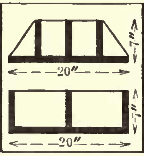
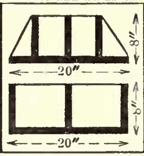
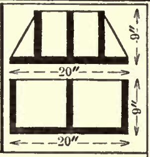
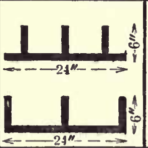
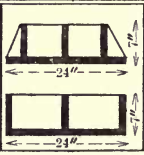
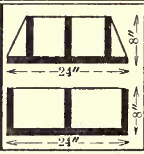
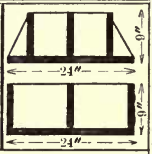
Width of Opening in Feet								
	Thickness of Metal in Inches							
	3/4	1	3/4	1	3/4	1	3/4	1
2	26.1	32.6	33.6	42.2	41.5	53.8	52.1	63.6
3	17.4	21.7	22.4	28.1	27.7	35.9	34.8	42.4
4	13.0	16.3	16.8	21.1	20.8	26.9	26.1	31.9
5	10.4	13.0	13.4	16.9	16.6	21.5	20.9	25.5
6	8.7	10.9	11.2	14.1	13.8	17.9	17.4	21.2
7	7.5	9.3	9.6	12.0	11.9	15.4	14.9	18.2
8	6.5	8.2	8.4	10.5	10.4	13.4	13.0	15.9
9	5.8	7.2	7.5	9.4	9.4	12.0	11.6	14.1
10	5.2	6.6	6.7	8.4	8.3	10.8	10.4	12.7
11	4.7	5.9	6.1	7.7	7.5	9.8	9.5	11.6
12	4.2	5.4	5.6	7.0	6.9	9.0	8.7	10.6

Width of Opening in Feet								
	Thickness of Metal in Inches							
	3/4	1	3/4	1	3/4	1	3/4	1
2	29.8	37.0	37.8	48.8	47.5	61.3	59.1	79.1
3	19.8	24.7	25.2	32.5	31.7	40.8	39.4	49.4
4	14.9	17.2	18.9	24.4	23.7	30.6	29.6	37.0
5	11.9	14.8	15.1	19.5	19.0	24.5	23.6	29.6
6	9.9	12.3	12.6	16.3	15.8	20.4	19.7	24.7
7	8.5	10.6	10.8	13.9	13.6	17.5	16.9	21.2
8	7.5	9.2	9.5	12.2	11.9	15.3	14.8	18.5
9	6.6	8.2	8.4	10.8	10.5	13.6	13.1	16.5
10	6.0	7.4	7.6	9.8	9.5	12.2	11.8	14.8
11	5.4	6.7	6.9	8.9	8.6	11.1	10.7	13.5
12	5.0	6.2	6.3	8.1	7.9	10.2	9.8	12.3

If load is concentrated in center, use one-half above loads.
Above tables are based on one-eighth the breaking weight.

BASE PLATES

Size. — The size of the base plate for a column depends upon the material upon which it rests. If brick in lime mortar will carry 8 tons to the square foot, and hard brick in Portland cement, 15, this means that the plate in the one case may be a good deal smaller than in the other.

Example. — Take a column supporting a floor load of 125 pounds to the square foot. Let the area extend 8 feet from the column on all sides, giving a square of 16′ x 16′. Assume that there are three floors.

Three floors, 256 sq. ft. x 125 lbs. x 3 =	192,000	pounds
Roof, 256 x 50 lbs. . . . . =	12,800	"
Columns and base plate about	4,200	"
Live load 20 per cent. on floors only . .	38,400	"
	247,400	"

This is 124 tons. If we use a concrete base, what area is required? From 12 to 15 tons are allowed in the codes for Portland cement. At 12.4 tons we should need a plate with 10 square feet. Referring to the table of squares to get the square root of 10, we find 3.16. Multiplying the .16 by 12 to bring it to inches we get 1.92 or nearly 2 inches. The plate would thus be 3′ 2″ x 3′ 2″. As all the load would never be put on at one time a smaller size would be sufficient. A loading of 85 per cent. of the total would reduce it to 106 tons. At 15 tons this would require a base of only 7 square feet, or 2.65 = 2 feet 8 inches.

A good deal depends upon the purpose for which the building is to be used. The total load in the above example is 150 pounds to the square foot, and this would seldom be put on in any ordinary structure. On the other hand, some buildings might have machines concentrated on a certain column, and cause overloaded floors.

Sugar. — I went one day into a light manufacturing building with light joists, and found it loaded with sugar. The girders were bending under the load, and things looked as if someone had made a poor design. I asked why the posts were so far apart, and was told that the owner had left out each alternate one to save expense. The architect was not to blame. So you can never tell how a building is to be loaded, and it is best to be safe with base plates.

All base plates have to be reinforced with ribs according to the standard rules.

Standards. — The contractor, whom we are always keeping in mind throughout, would not make details for such work as column connections, caps, bolsters, and base plates, but would order standard patterns and connections. The diameter of the columns would be given, thickness of the metal for all parts of the work, sizes of bearing plates, base plates, and so on. Any foundryman will show just what his ordinary patterns are, and when no lugs or such small members are to be less than 1 inch metal, and columns themselves are specified there is the certainty of safe castings.

Catalogs. — All kinds of catalogs containing valuable information on post caps, bases, girder and joist hangers, and such structural work may be had free. The trade journals contain advertisements from the various manufacturers of specialties. There is no use wasting time making details of work that is on the market for sale just as sugar is. I have often seen draftsmen making details of four-panel doors. The warehouses are full of these doors. Why draw a picture of what is already made? Artists do that.

CHAPTER VI

CONCRETE FORMS AND WORK

Cement. — When the production of Portland cement rises in round numbers from 12,700,000 barrels in 1901 to 64,200,000 in 1910, it means that concrete construction is coming into its own as never before. In 1882 the manufacturers of the United States turned out only 85,000 barrels.

Stability. — One of the government experts said in his report of the San Francisco fire, "Wooden buildings stood well, and reinforced concrete buildings sustained practically no damage." This is a strong point in their favor in earthquake countries.

Costs. — In "The New Building Estimator" complete detailed costs of everything in connection with these buildings are given from the actual records of the largest companies. Here, the construction side only will be dealt with. In large cities the regular companies have their own systems of work, but in the smaller ones, and in towns, the following information will be useful to those who occasionally have a contract of this kind, but do not make a speciality of such construction.

Risk. — To begin with, it may be said that a contractor assumes considerable risk when he agrees to put up a reinforced concrete building designed by a man who has not had much experience in that line. It may be remembered that the courts have held that if a contractor put up a building on a weak foundation and it fall he has to replace it. He is supposed to know a good soil when he sees it. Probably he is also supposed to know a good reinforced design when he looks at the plans, but the general understanding is that he has to rely on the architect. He fails occasionally.

FORMS

Strength. — It is easy enough to say that forms must be strong enough for the purpose for which they are to be used.

That is only reasonable. Yet we often see ⅞-inch boards nailed on studs with such wide spacing that the weight of the wet concrete bulges out the boards and spoils the looks, and sometimes the stability, of the finished work.

Lumber. — Some of the companies tell us that the lumber used should not be kiln dried, but there is little danger of getting that kind. Neither should it be too green. If it is kiln dried it warps out of shape when the wet material is poured in. If it is too green it will not swell and close the joints. Therefore, neither too dry nor too wet should be used, but between the two.

Kind. — The kind used will depend upon the locality of the building. In Oregon, yellow pine will not be selected, and no one in Georgia is going to send for Oregon fir. Any reasonable kind of lumber may be used, but the "bone" dry Y. P. is not suitable for such work. It is like cast iron in being too unyielding.

Fine Surfaces. — For the finest finished surfaces white pine is the best. Indeed, it is best for the all around use of forms, but it costs too much. One warning that an estimator should remember is that when the finest concrete surfaces are called for, the labor on the forms may run to twice as much as for ordinary work. Everything has to be smoothly finished.

Heavy Work. — For the large structures 2-inch plank is used. It should be surfaced on one side. The real market thickness is not more than 1¾, and sometimes only 1⅝ inches.

Widths. — In country work where saw-mills are not available, and ripping has to be done by hand, it would often pay to leave the plank full width and throw in a little extra concrete to save ripping the two sides of beams and columns. No reasonable architect would object to having a column or beam ½-inch, or even 1 inch wider than the figures called for.

Thickness. — In some parts of the country lumber about 1¼ inches thick may be obtained, and it is strong enough for all kinds of forms, except the heaviest, if properly braced. But for beams where there is a heavy weight it is better to use 2 inches in connection with the 1¼ inches.

For much work ⅞-inch boards, well braced, can be used. Among the first months of my apprenticeship I put up a wall lined with ordinary boards on both sides to receive the concrete. There was no reinforcement then.

But the thin boards are so easily split that it often pays to use plank instead, as that can be worked over and over without damage.

Tongued and Grooved boards are better than square edged ones, as the finish is smoother. With the square ones the surfaces may spring apart, while the matched boards keep even.

Costs. — One great expense of this class of masonry is the forms. Many are at work trying to reduce the cost, but in the meantime each one has to follow the ordinary method of work, and use the same forms as often as possible. I have seen expensive forms for heavy mass piers used many times, and this is where the economy lies. When architects design piers for this kind of work they should make as many of them alike as possible. It often pays to use an extra yard of concrete rather than make a new form to suit some trifling line that is often buried below the earth.

Panels. — Wide panels should be well shored up from below. They are sometimes hung from the steel beams above if these are used, as in the Roebling system. This is the same method that the hollow tile men have followed for so many years, except that wire is generally used for reinforced work instead of bolts.

Boarding. — For panels ⅞-inch boards are strong enough if they are well supported. They should be merely tacked and not nailed. The weight of the concrete holds the boards in place.

It is better to have the panel boarding clear of the beams, so that it can be removed independently. The forms for the beams must be left on longer than the ones for the thin panels with little weight to support. This saves lumber.

Nails. — It is better, when possible, to leave the heads of the nails sticking out a little, so that they can be easily drawn.

Studs. — For ⅞-inch boarding the studs should not be more than 24 inches apart, and if square edged boards are used there is apt to be an uneven surface in some places even at this distance.

For 1¼-inch lumber, 3 feet is wide enough; and 4 feet 6 inches to 5 feet for 2-inch plank. To keep the planks from bulging out they are often tied together with wire doubled and twisted with a small piece of stick until it is tight.

The studs have to be of size to suit the work, and should be specified by the architect or engineer. For light work with good bracing 2 x 4's are suitable. The next commercial size, in the West at all events, is 4″ x 4″, and then 4″ x 6″. Good bracing and tying will help wonderfully.

Columns. — When the upright planks are in place for columns they are fastened together with cleats and wedges which must be so put in as to hold when the heavy mass of concrete comes against them. The beams are wedged together also.

Cleaning. — Before using any kind of forms again they should be well cleaned. If any of the concrete is left sticking on the surface there will be imperfections in the finished work.

Oiling. — If the forms are well watered inside before the concrete is poured it will not stick to them so very much. But to make finer work they are often oiled with linseed oil, crude oil, soft soap, mixed lard, and kerosene, or something of that nature. This fills the grain of the wood, and makes a finer surface.

Plaster. — If the concrete is going to be plastered afterwards the surface is better to be rough.

Weights. — Keep floor loads off green concrete. Put any loads closely around a column, or wall where the bearing is good. Most of the wrecks of reinforced concrete buildings have come through taking out the forms too soon, or loading before the work had a chance to harden.

Removing Forms. — No set rules can be laid down for the removal of forms. A good deal depends upon the weather. In damp weather a heavy mass dries slowly, and this is really to the advantage of the work. In dry weather the walls should be protected from the sun with some kind of a sheet, and watered occasionally for about a couple of weeks to keep them from drying too fast.

The size of the member has to be considered. A great column or beam takes longer to harden than a small one; and a beam with a long span should get plenty of time. It is not worth while running the risk of losing all the work for the sake of an extra day or two.

TIME OF REMOVAL OF FORMS

Arches in about a week for an ordinary span, but large ones may require a month.

Beams and Long Span Slabs need from 10 to 14 days in summer, and about half as much more in winter. But ordinary slabs can be taken out in 8 or 9 days in summer and 12 to 14 in winter. As already noted, they should be put in independently of the beams.

Columns 3 days in summer, and 5 in winter. But this is on the supposition that the girders resting upon them are so supported from below that the weight does not reach the columns till all the girder shoring is removed.

Ordinary Conduits require 3 or 4 days.

Walls. — If there is any earth or water pressure behind a wall the forms should be left in for 3 or 4 weeks, and bracing carefully done. We often forget that concrete goes on hardening for at least 3 years. Once more we may consider the crushing strength of concrete per square foot: 15 tons for 1 month old; 60 tons for 6 months old; 96 for 12.

Alignment. — There is one trouble with concrete work that should be noted. I have seen large foundations where the walls were so badly lined up that the superstructure stood over on the outside and had wasted space on the inside. Sometimes too little is allowed by the architect. A building is not a drawing board. Masons need some little leeway. A margin of a couple of inches is not too much on rough concrete, especially when it is hidden below the surface. If too small allowance is made there is more time wasted trying to get straight lines than the value of the concrete saved is worth, ten times over. On a tapered pier an extra inch at top does not amount to much.

Practice versus Theory. — For columns, beams, pilasters, and finished work inside, a variation of $\frac{1}{4}$-inch to $\frac{1}{2}$-inch may be made without anyone being the wiser. A large commercial building, and especially a factory, mill, or warehouse, is not exactly a piece of cabinet furniture. It is certainly possible to get lines and sizes correct to $\frac{1}{8}$-inch, but the waste of time necessary for this fine work, where it is not really required, would be unreasonable. This is where the superintendent who wants to can pile up a heavy expense bill on a contractor. There would be no excuse in making sizes to suit one's own ideas; but little reason in holding a builder down to absolutely straight lines and exact measurements on heavy work.

CONCRETE PROPORTIONS

Theories. — Each French teacher has a system of his own that he is sure is better than that of any other teacher; and each engineer or architect knows what the best proportions for concrete are. The following mixtures are for ordinary, everyday use.

Packed. — The stone or gravel, and sand are measured loose, and the cement packed, or as it comes from the factory in one barrel or 4 sacks containing 3.8 cubic feet. That is all that is allowed for cement, per barrel, but when spread out it increases in volume from 20 to 30 per cent. If it was allowed to be taken loose each barrel would measure 4½ to 5 cubic feet.

Suppose a packed barrel is taken. We have 3.8 cubic feet. On a basis of 1, 2, 4 we should therefore require 1 barrel cement; twice 3.8 or 7.6 cubic feet of sand; and 4 times 3.8 or 15.2 cubic feet of stone or gravel. The following proportions are made out on the basis of the packed barrel.

The courts have had to decide this question of packed or loose. As packed means much more cement, which is higher in price than sand, the contractor should be certain that loose is to be allowed before he puts in any bid.

Class 1. — For reinforced floors, beams, columns, walls, dynamo foundations, or where there is any vibration, use a mixture of not less than 1, 2, 4.

Class 2. — For machine foundations, arches, sidewalks, ordinary floors, light foundation walls, use 1, 2½, and 5.

Class 3. — For retaining walls, heavy walls, piers, and abutments, use a mixture of 1, 3, 6. This makes a concrete of good quality for ordinary work.

Class 4. — For heavy mass foundations without reinforcement, use 1, 4, and 8. This is about the weakest mixture that should be considered, although 1, 4, and 10 has been used with success.

Density. — The concrete that weighs most per cubic foot, in other words, is most dense, is the best. This is the one with the voids all filled. Plenty of cement fills the spaces between the rougher grains of sand; and the right amount of the mixture is used to fill the spaces between the stones.

The Cement Users give their recommended proportions as follows:

A:—1, 1½, and 3. This is the richest mixture for columns, structural work, and the best water-tight requirements. This is 1 packed barrel of cement; 1½ barrels of sand, or 5.7 cubic feet; 3 barrels or 11.4 cubic feet of stone or loose gravel.

B:—1, 2, and 4. This is for ordinary reinforced floors, engine or machine foundations subject to vibration, tanks, sewers, conduits, and ordinary water-tight work.

C:—1, 2½, and 5. This is a medium mixture for ordinary foundations, retaining walls, abutments, thin walls, ordinary floors, sidewalks, and sewers with heavy walls.

D:—1, 3, and 6. This is for heavy mass work for large foundations with heavy loads, and backing for stone masonry.

Measuring. — This is usually done in a wheelbarrow after the first few batches to find out the proper proportions.

Platform. — For small concrete foundations a platform 8′ x 8′ will do, although 10′ x 10′ is the usual size. It should be water-tight to keep the rich cement from flowing away, and have strips around the edges for the same reason. It may be made of ordinary boards, but shiplap or flooring is better.

Method of Work. — The sand should go down first on the platform, then the cement, and the two should be mixed dry so thoroughly that neither sand nor cement can be seen separately, but a new material composed of both. There should be three or four turnings.

Watering. — A hose should then be turned on the stone in the wheelbarrow, or in the pile itself, and it should be thoroughly wetted, then thrown on the pile, all mixed once dry, and then the water should be added gradually. In general, when a hose is used, the water is thrown on with such force that the fine cement is washed away, and some insist that pails be taken to avoid the danger. A hose may be used if it is handled in the right manner.

Wet or Dry. — Neither one nor the other, but about midway between for ordinary work. Heavy mass foundation work should not be soaked with water, for if it is, it takes just so much longer to dry out. But for columns, beams, slabs, and such work if the concrete is not well wetted it will not flow into place, and a poor surface will be the result. The purpose for which the material is used has to be considered.

Laying. — For ordinary work the concrete is best laid in layers of about 8 inches thick, and lightly tamped with a piece of scantling, or something of the sort, until the water rises to the top. As a matter of fact, we see heavy foundation walls and piers run in from the machine several feet deep at a time.

Dropping. — Some engineers object to dropping concrete from a height of more than 3 feet or so. The idea is that the cement and sand are detached from the stone, and that a poorer quality of work is the result. It has been found, however, after a careful examination, that there is no difference between the mass that is dropped 30 feet, and the other that is dropped only 5 feet. Indeed, in one case where the material was dropped 43 feet, the tank was perfectly water-tight.

Fresh Batches. — Use the material as soon as mixed. This is very important. Do not make the batches so large, if mixed by hand, that the quantity cannot be soon put in place. In extreme cases a batch might have to lie for a short time, but if any is not placed in an hour after the addition of the water it should be thrown away.

Freezing. — In freezing weather use a little melted salt to protect the material against the frost. Or heat the sand and stone. Concrete is often covered with dry manure in winter, but if any new work is to be added this is not a very good practice. If it is used the old wall must be carefully swept and cleaned.

Reinforcement. — This must be placed according to the drawings. The architect or engineer is the one to decide everything in connection with reinforcement.

Walls. — The form for the outside walls should be erected first, and the reinforcement stapled against them with as few galvanized staples as possible. Or nails may be used to keep the metal at the required distance from the wood.

Protection. — Many reinforced concrete engineers say that 1 inch of concrete is enough to protect steel from fire, but the insurance companies want at least 2 inches between the metal of all structural members and the surface exposed.

Surfaces. — No patching should be allowed before the surfaces are examined after the forms are off. A careless workman naturally wants to hide bad work, but the safety of the building has to be considered.

Smoothing. — If the walls are rougher than is agreeable to look at, mix a thin mortar of Portland cement and sand in equal parts, and apply with a whitewash brush after having taken off all the loose material and wetted the surface. This is how the cistern builders make a smooth surface. Some of the reinforced surfaces we see, however, are more in need of a spade than a brush. The mixture must be well stirred.

Keying. — Sometimes the surface is left rough and stucco applied in the keys.

Paint does not last very well when applied to the surfaces of concrete buildings, but many of them are painted. One of the advantages of concrete façades, according to the cement companies, is that painting is never required.

Other Finishes. — Occasionally sand blast is used, and hammering, picking, etc., but these treatments are expensive. Further on in this chapter coloring is discussed.

Hammering. — A good deal of work has been hammer dressed. A hammer with 20 to 30 sharp points on the end is used. But the trouble with all finishes that break the surface is with the moisture. This does not need to be considered in dry climates. The fine smooth skin of concrete laid against the well oiled forms is deliberately broken up. The protection is destroyed for the sake of artistic effect. Some say that by using a richer mixture on the outside the moisture cannot enter. In raw lake or sea regions, where the frost penetrates everything, this treatment would seem to be entirely wrong.

Cost. — A laborer can dress from 40 to 50 square feet in a day of 8 hours. At 20 cents per hour this means about 3 or 4 cents per square foot, no scaffolding being included. This is as much as ordinary inside plaster is worth.

Bonding. — In floor slabs the question comes up as to where the stop should be made for the day. On the top of the beam, or in the center of the span? There is a difference of opinion, but the center of the span is usually accepted. This is where the compression is greatest, and thus there is less danger of cracking. The trouble is with dust and dirt. Before joining the new concrete to the old, everything should be scrupulously clean.

EXPANDED METAL SLABS FOR FLOORS, ROOFS, SIDEWALKS, ETC.

(The following tables were sent me for this book by the Northwestern Expanded Metal Company, Chicago. The mesh in all is 3 inches. This size has been proved by experience to be the best. The smaller sizes cut up the concrete too much).

Notes for All Tables

Thickness of slab is the total thickness, in which is included one-half inch of concrete under the steel.

Total load is the sum of the weight of slab and the superimposed safe load.

These tables are all based on sheets 3 feet wide, having a sidelap 1 mesh wide.

"The tables as given below give the sizes according to our uniform standards, to be used by us after January 1, 1910."—

These 4 tables give the sizes most commonly is use.

TABLE I

No. 06-3 North Western Expanded Metal. Weight, per sq. ft., .20 lbs.

Span in Feet		2'	2' 6"	3'	3' 6"	4'	4' 6"	5'	5' 6"	6'
Total Thickness of Slab	Weight of Slab per Sq. Ft.	Superimposed Safe Loads in Lbs. per Square Foot								
		1-2½-5 Broken Stone or 1-5 Bank Gravel Concrete								
2"	24	170	100	60	40	24				
2½"	31	240	140	90	60	37	23			
3"	37	320	190	120	80	50	33	20		
		1-2-4 Slag, Brick or Burnt Clay Concrete								
3½"	43	400	240	150	100	67	44	27		
4"	49	470	280	180	120	80	53	34	20	
4½"	55	550	330	210	140	95	63	40	25	
		Best Quality Cinder Concrete								
5"	48	630	380	240	160	110	74	48	30	
5½"	53	710	430	280	185	125	85	57	35	20
6"	58	780	480	310	205	140	96	64	40	22

TABLE II

No. 11-3 North Western Expanded Metal. Weight, per sq. ft., .34 lbs.

Span		2'	2' 6"	3'	3' 6"	4'	4' 6"	5'	5' 6"	6'	7'	8'
Total Slab Thickness	Slab Weight per Sq. Ft.	Superimposed Safe Loads in Pounds per Square Foot										
		1-2-4 Broken Stone or Washed Gravel Concrete										
2"	24	320	200	130	88	62	44	30	20			
2½"	31	460	290	190	130	93	66	48	34	24		
3"	37	600	370	250	170	120	89	65	47	34		
		1-2½-5 Broken Stone or 1-5 Bank Gravel Concrete										
3½"	43	740	460	310	210	150	110	82	60	44	21	
4"	49	890	550	370	260	190	135	100	75	55	28	
4½"	55		640	430	300	220	160	120	90	66	34	
5"	61		730	490	340	250	185	140	105	76	40	
		1-2-4 Slag, Brick or Burnt Clay Concrete										
5½"	67		820	550	390	280	210	160	115	87	47	20
6"	73		910	610	430	310	230	175	130	98	53	23
7"	85			740	520	380	280	210	160	120	66	30
8"	98			860	610	440	330	250	190	145	79	37
		Best Quality Cinder Concrete										
9"	86			980	690	500	375	285	215	165	90	44
10"	96				780	570	425	320	245	185	105	50

Danger. — As already noted, it is rather risky for an ordinary contractor to attempt to design a reinforced structure of any kind. But ordinary slabs on steel beams are easily enough taken care of if the above, or any standard, tables are utilized. "Weight for weight," says one authority, "expanded metal has greater reinforcing value than any other material." Owing to its shape it has also more of a mechanical bond than some of the other kinds of reinforcement. The sheets lap, and this gives a continuous slab.

Popular Name. — So safe is this system that the Northwestern Company calls it "fool-proof." There is no chance of mistake. The reinforcement and the concrete do the work if the tables are followed.

TABLE III

No. 16-3 North Western Expanded Metal. Weight, per sq. ft., .55 lbs.

Span		2' 6"	3'	3' 6"	4'	4' 6"	5'	5' 6"	6'	7'	8'	9'	10'
Total Slab Thickness	Slab Weight per Sq. Ft.	Superimposed Safe Loads in Pounds per Square Foot											
		1-2-4 Broken Stone or Washed Gravel Concrete											
2"	24	240	160	110	78	57	40	30	20				
2½"	31	430	290	210	150	110	84	64	50	28			
3"	37	560	380	270	200	150	110	87	67	40	21		
3½"	43	700	470	340	250	190	140	110	85	50	29		
4"	49	830	560	400	290	220	170	130	100	63	37	19	
		1-2½-5 Broken Stone or 1-5 Bank Gravel Concrete											
4½"	55	970	660	470	350	260	200	160	120	76	45	24	
5"	61		740	530	390	290	230	180	140	86	52	28	
5½"	67		830	600	440	330	260	200	160	100	60	33	
6"	73		930	670	490	370	290	230	180	112	68	39	17
7"	85			800	590	450	350	270	220	135	84	48	23
		1-2-4 Slag, Brick or Burnt Clay Concrete											
8"	98			930	690	520	400	320	250	160	98	57	28
9"	110				810	610	480	370	300	190	120	70	36
10"	122				890	680	530	420	330	210	130	80	40
11"	135					760	590	460	370	230	150	90	45
12"	147					830	640	510	400	260	160	97	50

Bond. — Reinforcement with plain bars is safe enough, for the concrete takes a strong grip on the metal. But some say that in course of time the bond weakens, and for this reason a mechanical bond is now used with the bars. There are lug bars, and twisted and square and cup ones of various kinds. Expanded metal is so set at an angle as to furnish a good bond of itself without any other reinforcement.

I-Beams and Expanded Metal. — For a plain floor get the size of the I-beams from the floor load, taking care to add the concrete at 145 pounds to the cubic foot if of stone, and 90 if of cinders. Space the beams to suit, and do not go beyond spans of 7 or 8 feet. The Underwriters' code for work of this kind allows only 5-foot centers for stores, warehouses, and factories, and 8 feet for other buildings. The beams

TABLE IV

No. 35-3 North Western Expanded Metal. Weight, per sq. ft., 1.185 lbs.

Total Slab Thickness	Slab Weight per Sq. Ft.	Span 3' 6"	4'	4' 6"	5'	5' 6"	6'	7'	8'	9'	10'	11'	12'
		Superimposed Safe Loads in Pounds per Square Foot											
		1-2-4 Broken Stone or Washed Gravel Concrete											
3"	37	410	300	230	180	140	110	74	48	30			
3½"	43	580	430	330	260	210	170	110	75	50	33	20	
4"	49	820	610	470	380	300	250	170	120	82	57	38	25
4½"	55	950	720	550	440	350	290	200	140	97	68	47	30
5"	61		820	630	500	410	330	230	160	110	80	55	37
5½"	67		920	710	560	460	370	260	180	130	90	64	43
6"	73			790	630	510	410	290	200	140	100	72	49
		1-2½-5 Broken Stone or 1-5 Bank Gravel Concrete											
7"	85			950	760	610	500	340	240	170	125	88	60
8"	98				880	710	580	400	280	200	150	105	72
9"	110					820	670	470	330	240	170	125	85
10"	122					920	760	520	370	270	190	140	97
11"	135						850	590	420	300	220	160	110
12"	147						930	640	460	330	240	170	120

should be bolted together with rods at intervals of not more than 8 times their depth.

Forms. — They may be hung to the beams in the regular way, or shored up from below. If the beams are to be fireproofed, as they should be, a sheet of expanded metal must be put around the lower flange, or some of the other methods used for protecting the metal. Then the concrete can be spread on the forms before the metal is laid. Most of the companies are content with 1 inch thickness, but the insurance authorities want 2 inches between fire and steel.

Strips. — If a wood floor is to be used, wood strips should be bedded in the concrete every 16 inches or so, for a nailing. They should be dovetailed, or made wider on the bottom than the top to keep them secure in place when the concrete hardens.

Some object to strips, and use an under floor laid diagonally. The strips have to be 1¾ inches thick, and this means that a heavy weight of concrete is added to the slab, to hold them in place, without giving any more strength. The Roebling Company prefers the under-floor system, claiming that the strips become useless in a few years through dry rot. The under floor may be nailed directly to the concrete.

If strips and concrete are used, the filling to hold them in place should be as light as possible. One of Portland and 10 of cinders and sand will serve.

But it should be remembered before deciding to use such strips that at San Francisco both floors and strips were burnt out completely.

More Tables. — Another set of expanded metal tables is given below. As will be noticed, there is considerable difference in the loading of these as compared with the set already given. There is no definite, accepted standard of loading as yet among the expanded metal men.

SLAB TABLES, EXPANDED METAL REINFORCEMENT

How to Use the Tables

Example 1. — What expanded metal reinforcement and thickness of slab are required to sustain a live load of 150 pounds per square foot with beams spaced 7 feet 6 inches center to center, allowing a factor of 4 on both live and dead loads?

Answer. — Beginning with Table 1, in the column under 7 feet 6 inches span, read down until the load nearest 150 pounds is reached. This is 154 pounds. Read across the table to the first column, "Slab Thickness," where a 5½-inch slab is indicated. Table 1 is based on the use of Expanded Metal, Style No. 2, which is the reinforcement required.

If a slab thinner than 5½ inches is desired refer to Table 2, which is based on the use of heavier Expanded Metal, Style No. 3. Follow down the column under 7 feet 6 inches span and find the load nearest 150 pounds, which is 158 pounds. Refer across to the first column, where a 4½-inch slab is indicated.

In Table 3, under the 7 feet 6 inches column, we find 151 pounds is the nearest the required live load, and that a 4-inch slab is indicated in the first column. This table requires the use of Expanded Metal, Style No. 4.

Example 2. — (A) What load will a 5-inch stone concrete slab sustain over 7-foot span, center to center, reinforced with

Style No. 2 Expanded Metal providing factors of safety of 4 on both live and dead loads?

(B) Find the thickness, and reinforcement required, for other slabs than given in (A) to sustain the same load, and on the same span with the same factors of safety.

Answer. — (A) Table 1 provides the required factors of safety and is based upon the use of Expanded Metal, Style No. 2. Read down the column under the 7-foot span to the line opposite "5-inch slab" and we find 164 pounds per square foot, which is the load that the slab described would sustain under given conditions.

(B) Refer to Table 2 and read down the 7-foot span column. The nearest load is 167 pounds, which appears in the line opposite 4-inch slab. The reinforcement is Expanded Metal, Style No. 3 (shown at the top of table).

Example 3. — Given a $5\frac{1}{2}$-inch slab reinforced with Expanded Metal, Style No. 2, a live load of 125 pounds per square foot, and a factor of safety of 4 on both live and dead loads required. What is the maximum distance, center to center, of supports?

Answer. — The factors of safety and the style of mesh refer us to Table 1. On line with $5\frac{1}{2}$-inch slab, reading to the right, we come to 125 pounds, which is the given load. Reading up this column to the top we find the span given, center to center, between supports, as 8 feet.

Allowance for Laps

In designing with expanded metal, the usual practice is to allow 6 inches lap on ends of sheets over supports, or 12 inches when the sheets lap between supports. No laps at sides of sheets are necessary. The exact percentage of laps can readily be calculated by reference to the standard sizes of sheets for the style of reinforcement used in the following table:

WEIGHTS, SECTIONAL AREAS, WORKING LOADS, AND STANDARD SIZES OF SHEETS

EXPANDED METAL

Style No.	Size of Mesh Short Way (in.)	Gauge of Metal	Approx. Weight per sq. ft. (lbs.)	Working Load at 16,000 lbs. per sq. in.	Standard Size Sheets in Ft.	
					Long Way of Diamond	Short Way of Diamond
1	3	10 [LIGHT]	.495	2,320	8-10½	4-7
2	3	10 [STANDARD]	.60	2,816	5½-6-6½ 7-7½-8 8½-9-9½ 10-10½	4-6
3	3	10 [PLUS 25%]	.75	3,536		4¾-6¼
4	3	10 [PLUS 50%]	.90	4,224		4-6
5	3	10 [PLUS 75%]	1.05	4,944		4½-6¾
6	3	10 [PLUS 100%]	1.20	5,648		4-6
8	3	12	.408	1,920	4½-5-5½-6-6½ 7-7½-8-10-10½	4-5¼-6
11	3	16	.235	1,104	6-7-8-9-10½	4-5¼-6
13	2	12	.547	2,576	4½-5-5½-6 6½-7-7½-8	4-4½
15	2	16	.351	1,648	6-7-8	3½-4
16	1½	12	.625	2,944	4½-5-5½-6 6½-7-7½-8	3½-4
18	1½	16	.401	1,888	6-7-8	6-7
19	¾	13	.80	3,760	4½-5-5½-6 6½-7-7½-8	4½-5
22	¾	16	.703	3,312	6-7-8	3½-4
23	½	18	.5	2,352	8	5

EXPANDED METAL SLAB TABLES

Showing safe live loads in pounds per square foot.

Stress of steel in tension, 16,000 pounds per square inch. Extreme fiber stress of concrete in compression, 600 pounds per square inch. Concrete in shear, not over 60 pounds per square inch. Ratio of moduli of elasticity taken as 12. Straight line formula. Bending moment, one-tenth WL.

SLAB TABLE NO. 1—FACTORS, LIVE LOAD, 4; DEAD LOAD, 4.
3" No. 10 Expanded Metal, Standard, (Style No. 2.)

Slab Thickness	SPAN.																
	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
3	357	261	197	151	118	92	73	57									
3½	478	350	266	205	161	128	102	81	65	52							
4	572	421	319	247	194	154	124	99	80	64	51						
4½	666	490	371	288	227	181	145	117	94	76	61	48					
5	750	554	420	326	257	205	164	133	108	86	70	55	43				
5½	859	634	483	374	296	236	190	154	125	101	82	66	52	40			
6	953	706	538	417	330	264	213	172	140	114	92	74	60	46	35		
6½	1022	756	576	446	352	282	228	184	150	121	98	79	63	49	37	27	
7	1116	826	626	487	386	309	249	202	164	133	108	87	69	54	41	30	20
7½	1191	880	670	520	411	329	265	215	175	142	115	93	73	57	43	32	21
8	1324	974	744	578	458	367	296	240	196	160	130	105	84	66	51	39	26

SLAB TABLE NO. 2—FACTORS, LIVE LOAD, 4; DEAD LOAD, 4.
3" No. 10 Expanded Metal, Plus 25 per cent. (Style No. 3.)

	SPAN.																
Slab Thickness	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
3	388	284	215	166	130	102	81	65	51	41	32						
3½	550	408	310	240	190	152	122	99	80	65	53	42					
4	730	540	412	322	256	206	167	137	113	93	76	63	52				
4½	841	621	476	371	296	238	194	158	131	108	89	73	60	48			
5	955	710	540	423	337	272	222	182	150	124	103	84	69	56	45		
5½	1087	808	619	484	386	312	254	208	172	143	119	98	81	67	54	44	34
6	1198	890	681	533	424	343	280	230	190	158	132	109	90	74	60	48	38
6½	1322	982	752	587	468	378	309	255	211	175	146	121	100	83	68	55	43
7	1466	1091	836	656	524	424	346	286	237	198	165	137	114	94	77	63	50
7½	1540	1148	880	686	550	440	363	299	248	206	172	143	118	98	80	65	51
8	1654	1334	944	739	589	476	390	320	266	221	184	154	127	105	86	71	55

SLAB TABLE NO. 3—FACTORS, LIVE LOAD, 4; DEAD LOAD, 4.
3" No. 10 Expanded Metal, Plus 50 per cent. (Style No. 4.)

	SPAN.																
Slab Thickness	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
3	420	309	234	181	142	113	90	72	58	46	37						
3½	593	438	334	260	206	164	134	109	89	73	61	48					
4	792	587	448	350	279	226	184	151	125	104	86	71	58	48			
4½	1006	748	574	450	360	292	240	198	164	137	115	96	81	67	56	46	
5	1160	860	660	518	415	337	276	228	191	160	134	113	95	79	66	55	45
5½	1284	959	737	579	464	376	309	256	214	180	151	127	107	90	75	63	51
6	1446	1076	826	649	522	423	348	288	241	202	170	144	121	102	86	71	59
6½	1572	1172	900	707	566	459	378	314	262	220	186	157	132	111	93	78	65
7	1716	1276	981	772	621	504	416	344	288	242	204	172	146	122	103	87	72
7½		1410	1085	855	686	560	460	383	320	270	228	193	163	138	117	99	82
8		1484	1142	899	721	587	472	401	336	283	239	202	170	144	121	103	85

SLAB TABLE NO. 4—FACTORS, LIVE LOAD, 4; DEAD LOAD, 4.
3" No. 10 Expanded Metal, Plus 75 per cent. (Style No. 5.)

	SPAN.																
Slab Thickness	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	8'-6"	9'-0"	9'-6"	10'-0"	10'-6"	11'-0"	11'-6"	12'-0"
3	422	312	236	182	143	114	91	73	59	47	37						
3½	628	465	354	276	220	177	144	117	96	79	65	53					
4	832	617	472	370	295	239	195	161	133	111	92	77	64	53			
4½	1066	791	608	478	382	311	256	212	176	147	125	105	88	74	62	52	42
5	1310	975	750	590	475	386	319	265	222	187	159	134	114	97	82	70	58
5½	1514	1129	870	686	552	450	372	310	260	220	187	159	135	115	98	84	70
6	1678	1253	964	762	613	500	413	344	290	245	208	177	151	129	110	95	79
6½	1852	1387	1067	842	678	554	458	382	322	272	232	198	168	144	123	105	89
7	2016	1496	1156	916	736	601	496	416	349	296	252	215	183	156	134	116	97
7½		1630	1250	990	800	653	540	450	380	322	274	234	200	171	146	126	106
8		1734	1334	1054	854	695	575	480	404	342	292	249	213	182	156	134	114

SLAB TABLE NO. 5—FACTORS, LIVE LOAD, 4; DEAD LOAD, 4.
3″ No. 10 Expanded Metal, Plus 100 per cent. (Style No. 6.)

Slab Thickness	SPAN. 4′-0″	4′-6″	5′-0″	5′-6″	6′-0″	6′-6″	7′-0″	7′-6″	8′-0″	8′-6″	9′-0″	9′-6″	10′-0″	10′-6″	11′-0″	11′-6″	12′-0″
3																	
3½	644	477	364	284	226	182	148	121	99	82	68	55					
4	877	650	498	390	312	253	207	171	142	119	99	83	69	58			
4½	1114	831	640	502	402	328	270	224	188	158	133	112	95	80	67	57	47
5	1390	1035	799	629	506	413	341	284	239	202	172	146	125	106	91	77	65
5½	1674	1244	959	759	612	500	415	346	292	248	212	181	155	133	114	99	84
6	1928	1438	1108	878	708	579	490	402	340	289	247	212	182	156	135	117	100
6½	2117	1577	1217	962	777	637	528	442	374	318	272	234	201	173	150	130	111
7		1721	1326	1051	850	696	579	483	409	348	298	256	218	190	164	143	122
7½		1890	1460	1155	930	765	635	532	450	384	330	280	243	210	182	158	136
8			1534	1214	979	804	687	579	473	402	346	296	255	220	190	166	142

The foregoing tables are those of the General Fire-proofing Company, Youngstown, Ohio. This company makes Trussit, a reinforcement that can be used on roofs without forms. It is also used for walls and partitions. In pounds per square foot 27 gage is .710; 26, .770; 24, 1.02.

A few of the expanded metal lath products of the same company are given below to illustrate the difference of weight, which is often forgotten when purchasing.

HERRINGBONE EXPANDED METAL LATH

"A" Herringbone

For all classes of work.—Weight per square yard

28 Gage . . . . 3 lbs.
26 Gage . . . . $3\frac{2}{3}$ lbs.
Sheets 14″ x 96″ . . 1 square yard.
Packed 20 sheets (20 yds.) to the bundle.

"BB" Herringbone

For all classes of work.—Weight per square yard

27 Gage . . . . 2¼ lbs.
26 Gage . . . . 2½ lbs.
24 Gage . . . . $3\frac{3}{8}$ lbs.
Sheets 20¼″ x 96″ . 1½ square yards.
Packed 15 Sheets (22½ yds.) to the bundle.

KEY EXPANDED METAL LATH

Size of sheets 18″ x 96″; 15 sheets, 20 square yards, in a bundle.

Approximate Weights in Pounds per Square Yard

Gage	Not Coated	Galvanized
27	2.25	2.8
26	2.50	3.1
25	3.00	3.6
24	3.40	4.07

Furnished not coated, painted, or galvanized after being expanded.

Aggregate. — The Underwriters allow almost any kind of aggregate or mixture. Some object to cinders, but they give broken brick, terra cotta, furnace clinkers, slag, stone, or gravel not more than ¾-inch diameter. They require 1 inch under the steel for strength, and ¾-inch more for fire protection.

Proportions. — Their proportions are 1, 2, and 4. For columns 1, 2, and 5 may be used.

CINDER CONCRETE

Weight. — From 70 to 96 pounds per cubic foot. On account of this lightness cinder concrete has been a good deal used for floor slabs. But the cinders are porous, and the mixture lacks the density that means quality. This allows rust and flames to reach the metal with disastrous results. Another danger is that the coal may not be all burned, and this opens the way for fire to destroy the slab.

Report on Rust. — In San Francisco, after the fire, it was noticed that the corrosion was such that a committee was appointed to investigate. The report advised that cinder concrete should not be allowed in fireproof buildings.

The Northwestern Expanded Metal Company says: "Cinder concrete is not recommended by the best authorities on concrete work. The use of this material is rapidly on the decline." As this company naturally would prefer light to heavy slabs, other things being equal, this means that the quality of cinder concrete is not good enough to warrant its use, even when the advantage of lightness is taken into account. Experience seems to have been doing its work, for the expanded metal companies in their 1896 book said: "Cinder concrete weighs from 60 to 80 pounds per cubic foot, or about one-half the weight of the aggregate stone concrete, and has a better fire resistance." Then in the 1900 booklet the companies say, "In most expanded metal floors clean boiler cinders are very much better (than stone), as they make a lighter concrete, and one which at the same time is amply strong for the purpose, while resisting fire better than concrete made with stone. The usual mixture is 1, 2, and 6."

The Ransome Company gives the following opinion:

"**The Use of Slag or Cinder Aggregates.** — The use of slag or cinders as aggregates for concrete should be determined upon only after careful investigation. In many cases the economy effected is only apparent, not real. By reason of the greater percentage of voids in slag and cinders as compared with broken stone, a much larger proportion of mortar is required to secure smooth work, and the resulting concrete is never as strong as good broken stone concrete, where an equal volume of cement is used."

The Test. — In Major Sewell's San Francisco report he says: "None of the columns covered with cinder concrete suffered any serious damage, but there were not many protected in this way. . . . The cinder concrete floor slabs in many buildings were protected for a time by the furred ceilings. Where the ceilings failed at an early stage, or where there had been no ceilings, the damage to the concrete slabs was very apparent. The concrete was dehydrated to a certain extent on its lower surface, and in many of the slabs the reinforcement had become so hot that there was a permanent deflection of greater or less extent, accompanied by cracks on the lower side in the middle of the span. Most of the cinder concrete used in San Francisco was evidently a very inferior article in the first place. . . . A hollow tile floor which comes through a fire without losing any of its webs is as good as it was before; whereas concrete of any kind is inevitably damaged."

Kidder thinks that cinder concrete is better than that made of stone and gravel for spans under 7 feet and loads up to 150 pounds.

The Chicago ordinance also permits it, and gives the least thickness of covering for ordinary members as 2 inches; 3 inches for columns; 3 inches for segmental arches at the crown; 4 inches for slabs up to 8-foot span or less; and 5 inches between 8 and 10 feet.

The Roebling Company says: "The standard concrete, as adopted by this company after ten years' experience, and as the result of numerous tests and a careful study of actual conflagrations, is composed of 1 part high-grade Portland cement, 2½ parts clean, sharp sand, and 6 parts steam boiler cinders." Some of their floor loads are based on 4,000 pounds to the square foot.

Choice. — As things stand now we can use cinder concrete or condemn it as we please, and have good authority on our side.

CEMENT SIDEWALKS

Lumber. — The price has risen so much that we are now driven to cement, sand, and stone; but if we pay a little more for this kind of a walk it is worth the extra cost.

Heaving. — In northern climates there is danger from freezing and heaving after the walk is laid. Sometimes this trouble cannot be altogether overcome. If the ground is wet common drain pipes should be laid with a fall of at least ¼-inch to the foot, one on each side, running to a hole dug outside of the walk and filled with cinders. In wet or soft soil a bed of cinders varying from 5 inches to 10 inches thick is put down. Any other material, such as broken brick, gravel, or stone, may be used, but cinders are so porous as to make the best foundation. A deep base should be watered and tamped in layers.

Excavation. — This should be made to extend 3 inches over on each side, and if the ground is not hard it should be tamped. Most soils are hard enough.

Filling. — If the ground is too low it has to be filled. If more than 12 inches of earth is required it must be flooded with water and tamped in layers of not more than 6 inches. At the level of the walk the earth must extend at least 12 inches outside of the concrete on each side.

Thickness. — The ordinary thickness of a walk is 4 inches, and the cinders or other material should be left this distance down. For some special purposes thicker sidewalks are required. When a walk has to be 6 feet wide, for example, the thickness should be at least 5 inches.

Slab Sizes. — No slab should contain more than 36 square feet, or have a greater dimension than 6 feet, unless reinforced with ¼-inch rods not more than 9 inches apart. Thus, a slab 4′ x 9′ although containing only 36 square feet should not be made.

Forms. — Two lines of 2 x 4's should be laid full length of the walk, unless it is of special length, set at the width required. They should be run on top exactly at the level the finished walk is to be. Boards may be used if they are braced. As the 2 x 4's are only 3½ wide the concrete must be at least ½ inch deeper.

Slope. — If the walk is to be laid to the house with a slope clear to the front of the lot, it should be level the cross way; but if it runs parallel to the gutter the inside edge should be higher to shed the water. A fall of ¼ inch to the foot is enough.

Staking. — The 2 x 4 guides should be well staked down to keep them in place when the tamping begins, but they need not be nailed. The smooth side should go in.

Panels. — The easiest way for many is to cut a 2 x 4 in across where the panels are to be, fill in each alternate space, let the concrete harden a little, and then move the cross piece. This leaves a space to be filled in flush.

A 4-foot walk is usually cut up in 4-foot lengths, a 5-foot in 5 feet, and a 6-foot in 6 feet. The spaces may be arranged to suit the length of the walk, but, as noted, must never be longer than 6 feet.

Mixture. — Mix as directed in this chapter, using a proportion of 1, 2½, and 5, and 1, 3, 5. No stone or gravel should be more than 1½ inches in diameter.

Tamp lightly, and finish up to within 1 inch of the top of the guides. When the cross guides are lifted put a piece of tar paper against the new concrete to keep the slabs apart, and allow for heaving without breaking, if it does take place. Mark exactly where the division comes, so that the wearing surface may be cut directly above the tar paper, and thus a clean cut slab be obtained.

Single Coat. — Sometimes the concrete is filled up clear to the top of the guides for a cheaper sidewalk. The mixture is made 1, 2, 3, and any stones that appear in the surface are pressed down out of sight. It is smoothed over, and the slabs cut in the regular way.

The slabs are better if made about ¼ inch to ½ inch thicker in the center, but this if done has to be on the lower, and not the wearing surface.

Wearing Surface. — This should be at least 1 inch thick of Portland cement and sand or stone chips that will pass through a ¼-inch mesh. The proportion is 1 to 2. It should be mixed so that it works easily, but not be too wet. It must be put on in not more than 50 minutes from the time the concrete for the base is mixed. An expert layer can easily handle the work in long stretches, but amateurs cannot do so, and too much base should not be put down at a time.

In business districts a surface of 1¼ inches should be put on.

Smoothing Down. — When the top material is laid inside the guides take a straight-edge and run it across and work the soft mass down to the level. Smooth with a wooden float, but do not trowel too much. Very smooth surfaces are not desirable for a sidewalk. The regular sidewalk layers run across a roller that indents the surface and roughens it a little. When the grade is more than 5 feet to the 100 this roughening should always be done.

Rounding. — The edges of the slabs should be slightly rounded. The cross lines are rounded also by a special tool that the layers have, but this can be done with an ordinary trowel, although it takes longer and does not make such good work.

Covering. — The work should be covered with straw, grass, sawdust, or anything that will not injure it. Sand is the ordinary material used. After the walk is all finished, it is bad practice to throw on pure cement. This makes it harden sooner, but the hardening process should not be hastened. The covering should be left on for several days, and time given for hardening in the natural way. In the hottest weather it is a good idea to sprinkle with water to keep back the drying process.

Curb. — In the residence parts of cities there is often a space between the curb and the walk which is not concreted. This should slope from the curb up to the walk at about ¾ inch to the foot, and the walk itself should be raised 1½ inches higher than the earth or sod where the joint is made. If curb and concrete join put in tar paper.

Trees. — All over cities we see sidewalks ruined by the roots of trees thrusting them up. Leave a space of 12 inches all around a tree if it can be done. There is no use trying to make a fine finish against the roots, for it simply means a spoiled walk in a few years. If new trees are set out they should really be about 4 feet clear of the walk. The authorities recommend that some kinds of trees like Carolina poplar and elm should be set 10 feet away.

BASEMENT FLOORS

Method. — The same process has to be gone through for basement floors as for sidewalks. But properly there should be only one slab in a floor without any division. The expert floormen lay them that way, but some prefer to handle the work in sections running the full length of the basement.

Dangers. — To protect from rats and damp every house in the residence district of a city should have a concrete floor at least 3 inches thick; and 4 inches should be used for business houses. Really, the minimum thicknesses should be 4 inches for the one and 5 inches for the other. In dwellings the top surfacing should be at least ½ inch; and in business buildings, ¾ inch. Again, ¾ inch and 1 inch would be better.

The Rat Plague. — In the *Technical World Magazine* for June, 1908, we read that the U. S. Department of Agriculture estimates the yearly loss to the nation through damage by rats at $56,000,000. The fire loss due to them is put by the department at $1,000,000, but by the Underwriters at $15,000,000. The city of Washington alone loses each year, apart from the fire loss, $200,000. Rats are an expensive luxury.

San Francisco wanted an ordinance compelling all owners to concrete their cellars and basements to keep down the bubonic plague which is spread by rats. In all model cities of the future this will be done.

STUCCO WORK

Lumber Prices. — Stucco and other products are taking the place formerly occupied by lumber, which is now too high in price. So much of this work is done that a short description of one system is given here.

Weights. — Specify the weight of the metal lath used by the square foot or yard. There is a great difference in weights.

Boarding. — In dry climates the lath is put on without any boarding, but in northern States it is safest to put on the regular covering on the studs. Wood lath may be used on the inside just as under the ordinary system.

(The following matter is from the Trussed Concrete Steel Co., Detroit.)

"Portland cement and sand or prepared plasters compounded especially for exterior work are the best. Ordinary lime should not be used because it weakens the mixture and materially delays the set. Hydrated lime (nothing more or less than a carefully and scientifically slaked lime) may be used in the first coat to the extent of 10 per cent. of the Portland cement, and will be found to greatly assist the workman. Prepared plasters, however, should be used in exact accordance with the instructions of the manufacturer.

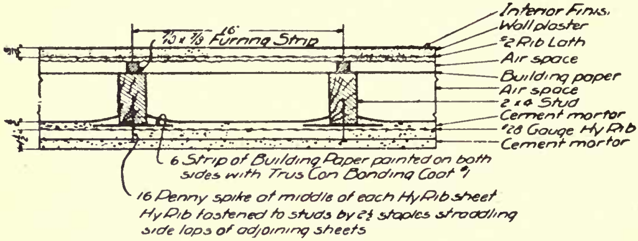
There are three popular finishes for exterior work—"Float," "Rough Cast," and "Pebble Dash."

Float finish is two-coat work and is, therefore, the cheapest of the three. It is best adapted to surfaces of small area.

Rough Cast and Pebble Dash are applied in the third coat and are to be had in great variety of texture and color. Washed pebbles, crushed stone, and even cinders are used to get the desired effect.

Cost depends largely on the location of the work, the amount of scaffolding required, and the handling of the door and window trim. It should not, however, exceed an average of $1.50 per square yard of surface plastered complete, and in small towns and on the farm, where nearly all of the labor involved in putting on the lath and getting ready for the plasterer is done by the owner, it should be much less. We have a record of this work having been done as low as 62 cents per square yard."

"The following method for constructing stucco walls, will give by far the best results.



Set up an ordinary "balloon" frame structure with 2 x 4 studding spaced 16 to 24 inches apart, and put all temporary bracing on the inside. Along the outside of each stud tack strips of heavy tarred paper 6 inches wide. Paint this paper on both sides with Trus-Con Bonding Coat No. 1. On the outside of this fasten Hy-Rib Sheathing with 2½-inch staples, and drive sixteen-penny spikes every 10½ inches along each stud, as shown. Plaster this Hy-Rib on the outside with cement mortar properly water-proofed to a thickness of 1½ inches and give it any finish desired. Then back plaster the Hy-Rib with similar mortar to a thickness of about half an inch.

This construction insures absolute protection for the steel, and when the mortar has set you have a 2-inch reinforced concrete slab solid as rock, and much stronger and more rigid than the ordinary matched sheathing of which it has taken the place.

On the inside of the studding tack thin asbestos board or a very heavy tarred paper, then ¾" x ¾" furring strips, and heavy Rib-Lath, on which plaster a ⅝-inch coat of cement mortar or good plaster, and the regular finish coat.

In this way you have secured a house which possesses the following advantages:

1. Practically fire-proof, due to the heat-resisting qualities of the 2-inch reinforced concrete slab on outside.

2. Absolutely waterproof and damp-proof.

3. Easy to heat in winter and keep cool in summer, owing to the double air space in the wall.

4. Practically indestructible, owing to the permanence of the reinforced concrete wall.

5. No expense for maintenance, such as painting, repairs, etc.

6. Unusual architectural beauty because of the artistic effects that can be secured with stucco.

7. Low first cost.

The method outlined above gives a wall of almost unlimited strength and rigidity, and is suitable for large buildings. For small cottages and for structures in which the total wind pressure will not be great, some saving may be effected by using heavy beaded plate Rib-Lath in place of Hy-Rib, on the outside, plastering it in the same manner on both sides to a total thickness of 1¼ inches or more. (In this stucco construction it must be borne in mind that the only way to insure permanence is to have a real reinforced concrete slab on the outside. Hy-Rib is necessary for medium and large sized residences. For smaller cottages no lath weighing less than 4½ pounds per square yard is strong enough to properly reinforce a concrete wall).

Another method which has been extensively used in our colder climates is to place on the outside of the studding ⅞-inch matched sheathing, heavy building paper, furring, and Rib-Lath plastered 1 inch thick with cement mortar properly water-proofed. This method, though more expensive, has not the strength, durability, or fire-proofness of the method first described.

For our milder climates the furring may be omitted in the first two methods described, and the paper sheathing may be omitted in all three cases. This reduces the cost still further.

"OVER-COATED" HOUSES

The ordinary wooden frame house can be given a cement exterior by applying Rib-Lath, and plastering with cement. Such a house has an artistic appearance, and is protected from attacks of fire.

Three-quarter-inch furring strips 16 inches apart should be nailed to the wooden sheathing, and the lath applied thereto.

HOW TO APPLY STUCCO

For the first scratch coat use a mortar made up as follows:

Portland cement	2 parts.
Sand	5 parts.
Cream of lime	1 part.

Trus-Con Waterproof Filler—2 lbs. per bag of cement.
Sufficient hair for "key."

The lime should be slacked with plenty of water, and allowed to stand at least a week. Use only a high grade of Portland cement and sand graded from coarse to fine. Cement and sand should be thoroughly mixed dry, and sufficient water added to give a good working consistency. Next add the lime, and mix the whole thoroughly. Remember that cement starts to set as soon as water is added, and apply the mortar to the wall as soon after mixing as possible. Mix only so much mortar as can be used immediately. Never allow it to stand over thirty minutes.

When the first coat is still wet scratch over the entire surface to give a better bond to the finish coat, which is applied as soon as the first coat is set sufficiently hard to hold it.

For finish coat use the following mixture:

Cement	1 part.
Sand	3 parts.
Cream of lime	1 part.

Trus-Con Waterproof Filler—2 lbs. per bag of cement.

Protect the finished work from too rapid drying and the direct rays of the sun by means of damp canvas or sprinkling. Too much emphasis cannot be placed on the importance of keeping the stucco well moistened for at least two days after application.

DATA FOR SPACING AND WEIGHTS

Side Walls		*Ceilings*	
Spacing of Studs	Weight of Lath per sq. yd.	Spacing of Studs	Weight of Lath per sq. yd.
12″	2.75 lbs.	12″	3.25 lbs.
16″	3.25 lbs.	16″	3.70 lbs.
18″	3.75 lbs.	18″	4.50 lbs.
24″	4.50 lbs.	24″	5.00 lbs.

All lath shall be painted.

COLORING

Coloring-matter mixed in mortar is sometimes used to give a uniform color to the entire wall. The cement, sand, and coloring-matter are mixed together dry, and it is advisable to experiment a little to find how much color is needed to give the desired shade. The mortar will appear several shades darker while wet than after it has dried.

The Ohio State geologist gave the following table. Three authorities are given, and this explains the slight difference in allowances:

MATERIALS USED IN COLORING MORTARS.

Color	Mineral	Pounds of color to 100 pounds of cement		Pounds Color to BBl. of Cement
Gray	Germantown Lamp Black	1–4	1–2	2
Black	Manganese Dioxide	12	00	48
Black	Excelsior Carbon Black	00	2	00
Blue	Ultramarine	5	5 to 6	20
Green	Ultramarine Green	6	6	24
Red	Iron Oxide	6	6 to 10	24
Bright Red	Pompeian or English Red	6	6	24
Sandstone	Red-Purple Oxide of Iron	6	00	24
Violet	Violet Oxide of Iron	6	00	24
Brown ...	Roasted Iron Oxide or Brown Ochre	6	6	24
Yellow or Buff ...	Yellow Ochre	6	6 to 10	24

By mixing five pounds of coloring-matter with a bag of cement, the following colors are obtained:

Raw iron oxide will give bright red.

Roasted iron oxide will give brown.

Ultramarine will give bright blue.

Yellow ochre will give buff to yellow.

Carbon black or lampblack will give gray to dark slate.

Manganese dioxide will give black. (Use eleven pounds per bag of cement.)

A mixture of equal parts of carbon black and red iron ore gives dull reds. In all cases the addition of mineral colors causes a loss of strength, but this is not important, since the color is used only in the surface coat. Lighter shades may be obtained by using $\frac{1}{2}$ to $\frac{1}{3}$ the quantities of coloring-matter given above.

The additional expense of coloring a surface layer $\frac{3}{4}$ of an inch thick will vary from half a cent to two cents per square foot.

WATER-PROOFING

Proportions. — For ordinary protection use a mixture of 1, 2, and 4; for better work, 1, $1\frac{1}{2}$, and 3. Mix to a mass like jelly, but not too wet, and it will serve for retaining walls, tanks, and such work without further trouble. This means a packed barrel basis.

Lime. — In reservoir work 10 per cent. of hydrated lime, or lime mixed to a paste with pure water, is sometimes added to the concrete for a safer waterproof mixture. But this is only on the top surfacing, and not as a part of the mortar for the masonry. For this Portland cement mortar alone is best.

Plastering. — On the outside walls of houses below grade in damp climates a thin coat of Portland cement mortar, 1 to 2, or at most, 3, should be put on. This is an excellent safeguard.

Floors. — With floors exposed to dampness, or to any risk of water rising, there must be no joints. The slab must be continuous, just as it always is when laid by a regular cement worker. The easier way of laying in long slabs already spoken of does not apply where there is moisture to contend against.

Felt. — An ordinary method of protecting floors of this kind is to lay a few inches of concrete for a bed, preferably on cinders, then 3 or 4 plies of felt well saturated with asphalt, and put several inches of concrete on top in the regular way. The felt must be made continuous in the manner used for a gravel roof, and it must also be carried up on the sides of walls, columns, machine foundations, etc., for a height of 6 or 8 inches. The footings of columns are protected in the same way. The whole idea is not to leave a crevice at any point where the water can force its way up. The felt must be as carefully joined as for a roof.

Thickness. — The thickness of concrete depends upon the pressure of the water. In an ordinary soil 2 inches below the felt, and 3 inches above is enough. Twice as much might be necessary.

Cement Fillers. — There are several preparations to keep down damp and dust on cement floors. In garage floors the oil should not be allowed to penetrate the surface.

Damp Course. — In masonry after the footings are up about a foot a course of boiled asphalt is often spread over to keep down damp.

CHAPTER VII

CONSTRUCTION NOTES FROM THE SAN FRANCISCO FIRE

Experts. — Richard L. Humphrey of the U. S. Geological Survey, and Major Sewell of the Engineers, who had investigated Baltimore, were sent to San Francisco to make a report for the United States Government.

First of all come some notes from Mr. Humphrey's report:

Inferior Work. — The first conclusion he reaches is that except at the very tract of the earthquake all buildings would have been saved from damage had they been properly constructed. This is rather a serious charge against the building fraternity, and especially against architects, who are responsible for the quality of the work. Of what use is artistic decoration if the construction is bad? I would rather own an inartistic building that stood than an artistic one that was needlessly destroyed. Contractors who learn from this book to put up a safe building are at least as far on the road to perfection as those who can decorate poor construction.

In San Francisco an army of 200,000 people was rendered homeless, 490 blocks, or 4 square miles were burned, and there was a loss of about $500,000,000, with only half of it insured. Nearly all the fireproof buildings were gutted.

Reinforced Structures. — These were few and stood the test remarkably well. Wooden buildings stood well, the chief damage being to chimneys and plaster. The destruction was greatest on filled ground.

Mortar and Anchoring. — Now we come to the standard trouble of these United States in the building lines:

On First Street " lime mortar, flimsy framing, poor design, and lack of tie between floor and roof members and walls were the causes of these failures."

In the Stanford University " the roof trusses were not anchored to the walls, but butted against them; the floor joists rested in the walls and were not tied. Under the vibration the walls were pushed out of plumb and, having no proper connection with the floor and roof members, collapsed."

In another building "the concrete block walls 13 inches thick, laid in cement mortar, were not braced in any way—the joists $1\frac{1}{2}$ by 13, simply resting upon the wall. When the building vibrated, the wall was pushed out, and collapsed because there was nothing to restore it to its normal position."

"The city hall, the court-house, the Masonic Temple, the Keegan-Brush building, and the St. Rose Hotel were all completely wrecked, and added their testimony against poor mortar in brickwork, light wooden frames, and insufficient bracing."

"The brick walls which failed were laid in lime mortar with few header courses, and generally had wooden frames with little or no tie to the walls. Where the walls were laid with hard brick, with plenty of headers and with Portland cement mortar, and were properly tied to the roof and floor members there was little if any damage."

All through, it is a story of bad mortar and worse anchorage.

The Sewell report says: "As a rule brickwork in San Francisco was laid in lime mortar or in lime mortar gaged with a small amount of Portland cement. Wherever such masonry was subjected to serious earthquake shocks it was very badly shattered. Much of it came down in the ruins, and much of that which remained in place was reduced to a loose pile, without any adhesion between the mortar and the bricks. Where brickwork was solidly laid up in good Portland cement mortar, the damage generally appeared in the form of well defined cracks, which could have been easily pointed up, so as to leave the wall almost as good as it was before."

Yet we have the "stop-watch" heroes shouting, "Faster! Faster!" to the bricklayers. We require better work, and not more of it.

Headers. — The outside courses of pressed brick fell off entirely in Baltimore and San Francisco. But there was no damage done to eight or ten houses observed with a Flemish bond front. This means that headers should run clear through the finest fronts, and that metal ties, back bonding and such secret connections do not amount to much.

Reinforced Concrete. — As already said, these structures stood the test remarkably well. "Where reinforced concrete was used the ceilings were free from cracks. The excellent qualities of reinforced concrete and its ability to stand earthquake shock were strongly demonstrated." (Humphrey.)

"Within a few feet is the bell tower, a reinforced concrete structure, 80 feet high, with walls 4 inches thick, which was not damaged in the slightest degree." (H.)

"The ¾-inch or 1-inch thickness of concrete which covered the reinforcing bars proved insufficient in the basement, where the fire was fairly hot. The heat expanded the bars, thereby ripping off the concrete layer, and leaving the rods exposed." (H.)

In the 10-story Aronson building "two columns in the basement were fire-proofed with concrete, and remain in first-class shape, but near them are two badly buckled columns which were fire-proofed with terra cotta. The result is an excellent object lesson on the merits of the two systems of fire-proofing." (H.)

"The walls of the Bekins Building were badly cracked by the earthquake, but the reinforced concrete was not injured." (H.)

In the Bullock and Jones building, "the hollow tile failed badly." (H.)

In the Pacific States Telephone and Telegraph Company's building "the girders and columns supporting the floors were fire-proofed with concrete, and were in excellent shape after the fire."

"Concrete is probably the best fire-proofing material." (H.)

"Brickwork suffered most from the earthquake, and least from fire. Concrete proved superior to brick as a fire-proof medium." (H.)

"The lower webs of floor tile came off to perhaps a greater extent than in the Baltimore fire."

"Of the fire loss perhaps 75 per cent. was in the trim and ornamental work." Artistic architects are expensive luxuries. Business buildings should be put up in what might be called the battleship type—stripped for action, with no useless ornament. The Beaux Arts graduates have been a sore expense to owners in the first place, and to a long-suffering public in the next.

"The cinder concrete floor slabs in many buildings were protected for a time by furred ceilings. Where the ceilings failed the damage to the concrete floor slabs was very apparent. Most of the cinder concrete used in San Francisco was evidently a very inferior article in the first place." (Sewell.)

"Of all the structures which were manifestly exposed to severe shock the concrete buildings at Palo Alto stood best." (S.)

"The results at Baltimore and San Francisco did not, by any means, indicate that either hollow tile or concrete is altogether a failure or altogether a success. Both fires indicated very clearly that commercial methods of applying both materials are inadequate, but also that successful results can be attained with both materials. . . . It would seem that wherever reinforced concrete floor construction is used a heavy furred ceiling below it should be absolutely required." (S.)

"For buildings of moderate height, say up to 125 feet as an extreme limit, reinforced concrete alone can undoubtedly be so designed as to give very good results when subjected to either earthquake or fire." (S.)

"Reinforced concrete proved itself superior to brick beyond any doubt, but neither concrete nor terra-cotta won the fight. It was a 'draw.'" (S.)

Another government expert, Mr. Soule, stands for structural steel. He says: "Constructors in San Francisco feel that this material has safely and triumphantly passed through a most trying ordeal."

Those who have *Carpentry and Building* for May, 1907, will find an excellent report on the fire by the American Society of Civil Engineers.

In general, it might all be summed up in poor design, poor superintendence, poor workmanship, because too hurried, and poor materials.

CHAPTER VIII

A SHORT CHAPTER

Plumbing is gone into in "The New Building Estimator," and is therefore not discussed here. So also is heating. With respect to heating I think we are far behind the times. Probably a change is coming. I have given prices on furnaces, etc., in the "Estimator," but their day may be gone in cities in the near future.

We are told that the city of Omaha, with 125,000 people, burns on an average 70 pounds of coal per family per day for residences alone; and that 100 pounds is about right for a two-story house. It is estimated that for business blocks and all other heating the daily average of this city is 3,000 tons in cold weather. At least one-fourth of it is hard coal at $11 per ton. The total bill is said to be about $17,250 per day.

In all new villages and towns each one has to sink a well, and, if he wants it, a cesspool. Kerosene lamps make the illuminant for each individual house. Later on the city water is "laid on," in the old phrase, and what was individually done is now done by all together. They have made wonderful progress, and instead of drinking water too often befouled with sewage from cesspools they drink pure water from the same canteen, or reservoir. Later still comes gas; and then sewers, and a new "metropolis" of somewhere is on the map.

We have since wondered why we were so long in adopting open plumbing; another wonder in a few years will be why we were so long in putting in a heating system for cities just the same as one for water, sewerage, telephones, electric light, gas, or anything else.

I heard of one place that does this, and thought that a few notes on the subject would interest builders. This is Oak Park, Ill. I wrote for some information of this interesting system which will probably be adopted by all progressive cities in the future.

When in railroad work I noticed that long lines of steam pipes were laid—some of them about half a mile. This Oak Park line extends for a mile from the power-house. A central station could heat a mile in every direction, and this of itself would take in a city of 50,000 or 60,000 people.

But it would not be necessary to have such a large power-house as that would mean. Half a dozen could be placed near the railroad tracks or switches if necessary. Our heating engineers could easily plan a city heating system.

The Oak Park heating is by hot water for the residence section, and steam close to the power-house. There are nearly 700 buildings served by the system. The same company furnishes electricity, and the exhaust steam is utilized.

A cheap coal can be used. The $11 per ton kind runs too deep in the bank account for ordinary boiler work.

The cost is the interesting feature. For a 7 or 8-room house heated as it should be by a furnace, about a ton per room of hard coal is required. Some in sheltered locations and not too much zero weather take less. Allow 7 tons for illustration. At $10 this means $70, and taking in coal and out ashes, with a vast amount of responsibility for keeping the house warm. A man's time at home is figured like a woman's—of small account. Let us put it at $1 per month, making a total of $75 for about 5 months—for not more than six, at worst or best.

The Oak Park rate is $\frac{4}{9}$ cent per cubic foot heated. This is for the outside measure of the first and second floors only. If heat is wanted in the basement or attic it must be paid for at the rate of 20 cents per square foot of radiation.

The season lasts $8\frac{1}{2}$ months—from September 15 to June 1. Taking a house of the average kind built for a small family the cost would be about $55 for the season.

There is no coal to be taken in. There are no ashes to be taken out. What do you think of it?

There are many such plants, but this one at Oak Park is the largest, I have been informed. There are several in Toledo, Ohio, and one in Detroit.

The difficulty comes with our system of land tenure. There is too much speculation, and such cities as Omaha, for example, cover just about four or five times more territory than they should. This would make the work of installation expensive.

But in a model city with every lot occupied, while yet giving plenty of room for ventilation, and better assurance of fire protection than in cities now where scores of houses are built within two feet of each other, such a system would be a success.

Let the "American Radiator" finish this chapter and this Book II by telling you which system is the best:

HOW BEST TO WARM OUR HOMES.

	HOT AIR	STEAM	HOT WATER
First Cost.............	Small	Moderate	Reasonable
Coal Consumption....	18½ Tons	13½ Tons	10 Tons
Average Durability...	12 Years	Indestructible	Indestructible
Heat Distribution....	Uneven, Difficult	Positive	Unsurpassed
Temperature	Variable	Uniform	Unexcelled
Ventilation	Bad, Draughty	A-1 with Indirects	A-1 with Indirects
Quality of Heated Air	Scorched, Burned	Good	Genial and Fresh
Dust and Dirt.........	Much	None	None
Danger of Fire......	Little	None	None
Danger of Explosion.	Slight	None	None
Noise	Pipes Conduct Much	Noiseless	Noiseless
Management	Troublesome	Easy, Automatic	Easy, Automatic
Relative Cost of Apparatus	9	13	15
Fuel Economy.........	Extravagant	Reasonable	Full Value

BOOK III

THE CONTRACTOR AS A TAXPAYER

CHAPTER I

FIRE LOSS AND SAFE BUILDING

Over one-fourth to one-half of our new buildings we might put up the sign, BUILDINGS TO BURN.

The loss in the United States for the year 1907 was $456,-485,000. No, that was not the San Francisco year. That one cost about $300,000,000 more.

In the face of such frightful waste we have a class rising in the building world who seem to have the brains of excitable, thoughtless schoolboys in the bodies of men. They are around with their stop watches and their flags trying to get "every ounce of energy" out of building tradesmen, who, at worst, cannot have less good common sense than their tireless, fault-finding critics. To the ordinary observer there does not seem to be much use in "speeding up" merely to feed the fire.

One investigator says that our annual average loss, taking everything into account as well as the fire loss proper, is $600,000,000. That seemed unreasonable, yet in February, 1910, the U. S. Geological Survey, after a careful investigation, gave out the figures for the year 1907 as $456,485,000.

In that year the cost of building in 49 leading cities amounted to $661,976,286 for a population of less than 13,000,000. The cost of the new construction in the entire country is conservatively set at $1,000,000,000. So it appears that in an average year we lose about half as much as we build, when we consider the cost of maintaining fire departments, the amount of insurance premiums paid less the amount returned, the cost of protective agencies, the additional cost of water supplies, and other factors.

Yet at least half of it need not afflict us. With proper laws and care probably three-fourths of it might end. In the city of Berlin, for example, the annual fire loss averages $150,000. In Chicago it runs to $5,000,000. Berlin has 3,000,000 people, and Chicago 2,000,000. This means that the business men of Chicago, who really control matters, are not nearly so capable as the men of Berlin. When they can bring the loss down to $450,000 a year, which is the Berlin loss multiplied by 4½, taking population into account, they may begin to get into a higher classification so far as ability is concerned.

The fire loss in several European countries is 33 cents per capita. In the United States it is $2.70. This is only the fire loss proper.

The United States government beats the average business man "all hollow." There are now about $300,000,000 worth of fireproof buildings owned by the government, and no insurance is carried on them. It would cost too much to insure them. There is a cheaper way, and that is to make them safe. About $20,000,000 a year are added to the U. S. building values for new construction.

Cost of Fire. — It is pathetic in a way, disgusting in another, to think that there are so many people who imagine that fire losses fall merely on the merchants who are burned out, or upon the insurance companies. They fall on every citizen. When there are too many fires in a town, and the equipment is out of date, it means either new equipment, and consequently higher taxes, or else higher insurance rates. When the rates go up the rents go up, and so do the dry goods and other necessities. Some say, "Oh, the insurance companies are rich. They can stand it." Or, "It will give work." The insurance people transfer the cost to the insured, as far as they can; and they in their turn raise the price of their goods. Rebuilding undoubtedly gives work, but what kind of work? Necessary, or useless? How would it do to build a pyramid in each state? Would that not give work?

In 33 years the loss from fire proper has amounted to $4,500,000,000. But from 1872 to 1882 the losses ran to only about $75,000,000 a year. Most of the trouble comes from frame buildings. How would it do to follow the plan of Denver and forbid them altogether?

Number of Fires. — In 43 European cities there are .86 fires to the 1,000 population. In the United States, 4.05, or between 4 and 5 times as many. In London with a far larger population than New York there are 3,843 fires in a year, while New York has 12,182.

Foot Power versus Horse Power. — When serving my apprenticeship in a Scotch town of 20,000 people I was always anxious to see a fire, but never had the pleasure during 6 years—one as a journeyman. There were a few in that period, but my luck was against me. But I had not long to wait when I reached the United States.

I remember that we were once working on a building 3 or 4 miles from town. One of the "firemen" was a carpenter working with us. On looking townward we thought that smoke was rising in the air. The fireman laid down his tools and walked and ran to town to do his part.

That kind of a department looks rather funny, but whether is it better to so build as to make fires next to impossible or to expend millions in getting the finest fire departments in the world, as American ones are, merely to keep down flames that should never rise? Instead of being proud of our fire departments we should look upon them as our disgrace. But when we build 60 per cent. frame in 1908 and only 2¼ per cent. fireproof we are providing more trouble and exciting runs for the departments. Only about .005 per cent. of the buildings in the United States are fireproof. Why should we be surprised when a great conflagration like that of San Francisco raises our per capita waste from fire proper to more than $6? One of the greatest wastes is seldom calculated, and that is the loss and disarrangement through interrupted business.

Building Codes. — Some years ago I went over a dozen codes for a particular purpose, and a few suggestions will be of service here as to how they might be improved. Especially will this be true for country districts and farmhouse work where codes do not apply.

Distance Between Walls. — In almost all cities we see frame houses within two feet of each other, and the cornices touching. A law forbidding a less distance than 8 feet between the walls and 5 feet between the cornices would be of much value for fire protection, light, and ventilation. A distance of 10 feet would be better, we all know, but we cannot go so far. There are many who have to be content with a half lot, and paving and other improvements cost money. The smallest possible frontage has to be made to serve, and we could not cut 10 feet off some lots.

The cornices in the above suggested law are restricted to 18 inches. They are now made nearly twice as wide. They are like the "Merry Widow" hats. We see some of them about 4 feet wide on bungalows. If there is plenty room on the lot that is the owner's business, but no one has the right to start a conflagration, and on small lots no cornice should come nearer to the other than 5 feet. Personally I should like to make it 8 feet.

In the new model city which I have been trying to interest people in for some time, there would be a chance of beginning with a good code. Land would be cheap, and cornices could have 10 feet between them at the nearest point.

Masonry houses take fire through the openings. The same distance should be observed with them. Of course as long as the building laws allow us we are going to use all our ground. In many cities we are allowed to go within 18 inches of the lot line. For two houses at that distance this means cornices almost touching.

Shingles. — It would be difficult to say too much in favor of what the wood shingle has done for the United States. It has supplied a cheap and excellent roof covering for generations. It is light, warm, and looks well—but it is too dangerous in cities on account of fire. The Underwriters want laws forbidding the use of shingles. It is not likely that in such states as Washington and Oregon, where lumber is still reasonable in price, that their desire will be granted, but good shingles cost so much now in many parts of the country that substitutes are being used far more than formerly. Taking everything into consideration, it would now pay a city far distant from the lumber fields to bid a sorrowful farewell to the wood shingles of the fathers, and turn to other materials, such as tin, galvanized iron, asphalt, and asbestos cement shingles.

Siding. — This product is also becoming too high priced, and thousands of houses are now covered with plasters of various kinds. One of the coming orders to the building trades, far from lumber districts, is to use as little wood as possible, and put unburnable materials in its place. In a really model code, if frame houses were allowed at all, wood siding would be forbidden unless far away from fire and risk.

Yet it is with a feeling of sorrow that we think of the time when the fine American wood house will be a rarity. Apart from fire risk there is no healthier and better looking house built.

Reinforced Walls. — The expanded metal companies are now strongly advertising houses built practically without studding and sheeting. They use only a few studs for floor supports, put on expanded metal lath, and plaster outside and inside with tar paper between, and this makes the wall, usually with a double air space. As the carpenter goes out the plasterer comes in.

Properly built this style may take the place of the wooden walls. For some years I ran across quite a number of plans for wood ice-houses. When I began on the first plan I wanted to fill in the air space with sawdust as I had built refrigerators, but was told that the air space was left unfilled. The reliance is put on thicknesses of paper to exclude air. Now, if paper will keep out hot air it will do the same thing for cold air. The main thing is to make the insulation perfect. This means that boarding would be no longer used.

Brick Openings. — Have as few openings in interior brick walls as possible. Fill up with masonry those that are not indispensable, and put fire doors on the others. Make these doors of two thicknesses of crossed flooring covered with I. C. tin, lock-jointed and not soldered. The door must be covered all around, including the edges.

Hang on barn door rollers like a sliding door, and hold them in place with a fusible link that will melt when the fire starts, and let the door roll down its inclined track over the opening.

Parapet and Dividing Walls. — Run up exterior walls about 3 feet above the roof on a flat building, and the division walls at least 2 feet.

Metal Frames. — Do not use wood frames or sash in buildings that are exposed to danger from the outside. Put in metal frames and sash filled with wire glass. With the exception of the front door, which is expected to be of a somewhat ornamental nature, fill all door openings with double flooring covered with tin. If any lights are used in them they should be wire glass. This applies to business buildings.

Size of Glass. — The Underwriters do not allow any window that measures more than 45 square feet in area, or more than 5 feet wide x 9 feet high. These dimensions must not be exceeded, no matter if the area is less than 45 square feet. For example, a window 4 x 10 or 6 x 7 would not be allowed.

If wider windows are required there must be a mullion with a 5-inch I-beam covered all around with at least 2 inches of concrete.

No light of glass should be more than 40 inches wide or 48 inches long, or exceed 720 square inches.

Shutters. — Iron shutters are used on many buildings. The danger is that they are left open. To be of any account they should be closed every night. Wire glass is always in shape to resist a fire. Sometimes these shutters are swung in the regular way on hinges, and again they are arranged on batteries on rollers to be operated with a crank that closes an entire side of a floor.

Rolling Shutters for Stores. — The retail districts in American cities look much pleasanter in the evening after business hours than those of Europe, for nearly all the windows are left well lighted. Many of the retailers here have gone back to the European system of rolling shutters, however. They make a good fire guard, and save breakage of glass.

Stairways. — One of the great safeguards from fire in business buildings or private residences is to enclose the stairs and shut off one story from another. This plan should be enforced in all business buildings, boarding houses, some kinds of hotels, and probably schools, but would not be accepted in private residences. The stair hall is looked upon as an ornament of the house, and most people would object to enclosing it.

In many business buildings masonry walls should be obligatory, and they should run clear up and form a parapet above the roof. Tile partitions might be used in lighter buildings, but the tile should not be less than 6 inches thick. In ordinary work a stud partition covered on both sides with expanded metal lath and plaster would serve. All that could be expected would be a short check upon the flames that might give the fire department time to reach the building.

A chain, we have been often assured, is no stronger than its weakest link, and a partition of this kind would be no better fire resistant than the wood door at the top of the stair. Properly this should be tinned on both sides, and be made to swing shut.

Doors Opening In. — We have probably forgotten the Collingwood school, where a little regiment of scholars was burned because the doors swung in instead of out. In all public buildings, manufacturing establishments, and other special structures doors should swing out.

Elevators. — If possible the shaft should be independent of the rest of the building and enclosed with masonry clear above the roof. The tinned doors should be hung on inclined tracks, and be held in place with fusible links. They should be shut every night.

Chimneys. — We are told that 30 per cent. of the fires in dwellings originate in defective flues. Some of the insurance companies would like to use 9-inch walls, and a flue lining besides; but while this is desirable, it is not really necessary. If a single course of brick is well laid in good mortar and a flue lining put on the inside there is no danger from fire. It should be remembered that much lime mortar becomes practically worthless in a few years. For chimneys, at least $\frac{1}{3}$ of the mortar should be Portland cement, and one foot below the roof to the top should be of Portland cement mortar only.

Do not build a chimney without a flue lining. If it really has to be done in a farmhouse or where linings are not easily obtained, use the best mortar, and strike the joints on the inside. Do not plaster all over the brick. The heat soon burns the plaster off, and leaves the joints exposed. In such a case a 9-inch wall is safer. It is also better to build all chimneys clear down to the ground.

Stacks. — In general, it is customary to use fire brick on the inside. This is the wisest course for ordinary stacks. But the radial brick ones are not lined. Boiler rooms should be completely enclosed with thick brick walls.

Wood Plugs. — The most dangerous place to drive wood plugs is into the joints of a chimney, especially if there is no flue lining. Metal plugs should be used. As a rule, a good carpenter can contrive to get along with few plugs in such a place by nailing well at the corners.

Pipes. — Hot air and steam pipes should never rest against wood, but be cut free for at least 1 inch all around for steam and 2 inches for hot air.

Ashes. — All over Denver there are little brick receptacles in the backyard that look like beehives on a large scale. They are for ashes. When hot ashes are laid against wood there is apt to be a fire.

Stovepipe Holes. — Keep them closed. If a pipe runs from one room to another use a double metal thimble with an air space. This is bad practice to so arrange for heating, but to save a chimney it is sometimes done.

Electric Work. — There is a National Electrical Code that the National Board of Fire Underwriters put forth as a standard. Insist that all wiring and work should be done according to the requirements of this code, and put this condition in the specification. If this is not done it may—likely will—make trouble with the insurance.

Fire Fighting Tools. — Every house should have, and few houses do have, some kind of provision for fighting fire at the first alarm. In cities the first thing is to notify the department. But a couple of pails of water standing ready in a place well known to every member of the family would often check a fire before it got the upper hand. It takes some time to fill a pail.

Extinguisher. — Another good idea is to have some kind of a chemical extinguisher. Any local insurance agent will give a list of good ones. Business buildings should have standpipes and hose ready, pails on every floor full of water and not of air, and an automatic sprinkler where there is pressure enough to keep the pipes full.

Autos. — In country districts now the proper thing is to have a motor truck with a chemical outfit. It can go about a mile a minute. The engine gives power to work the chemicals when the fire is reached. One fireman lives beside the machine, and is ready to start in two minutes after the alarm is given. Most farms near villages and towns now have telephones.

Cellars. — A good law in New York City makes the first floor of tenements fireproof, and this keeps down the risk, especially when there is a fire door at the head of the stair. All manner of rubbish is thrown down in the cellar. There should be an inspection made regularly of such places. We have read that the kick of a cow burnt the city of Chicago.

Fire Stops. — They should be put in all frame buildings. Some of the insurance companies would like to see a space at the end of the floor joists and partitions of the second story, and 6 inches or so above, filled with concrete to block the fire, but this is not likely to be done, on account of expense.

Where walls are furred one good method is to corbel out the brickwork between the joists as far as the face of the furring strip, and thus block all chance of a draft running from one story to the other.

The usual method in a frame building is to cut in a 2-inch piece between the studs at the level of the ribbon strip.

Gas, Gasoline, and Kerosene. — Never use a swinging gas bracket. When gas is escaping do not hunt for it with a lighted match. First of all open the windows and doors, and then make the search when most of the gas has escaped. It would be well if we all knew how to shut off gas at the meter just as we do water.

Gasoline is exceedingly dangerous. One pint, we are told, will impregnate a space of 200 cubic feet, and make it ready for an explosion. This is 5 x 4 x 10. Keep it out of the house.

Kerosene lamps start about 2,000 fires in a year. It is useless to tell a certain class of women not to light fires with kerosene. They know better. Every week, or often day, one may pick up a newspaper which shows that the dauntless females are still keeping up the fight. When they go to the next world in a flame of kerosene they are put beside the foolish virgins who, bad as they were, knew enough to go with empty lamps rather than take kerosene.

Matches. — About 1,000 dwellings are set on fire every year by matches. The safety ones are the best. One advantage of electric lighting is that it does away with the use of matches. If we were all rich enough to put in conduit work where the wires are run in pipes, the fire danger would be lessened.

Wainscoting. — The old style kitchen was lined with wood up several feet. The new one is plastered. Keep the heating stove at a reasonable distance from the wood. Keep all kinds of timbers and woodwork clear of heat.

Smoking Room. — A place for men to smoke would be of much value in some plants. They would be better without tobacco, but as long as they will use it we ought to take care that matches and cigar ends are not thrown where they will start a fire.

Fire Escapes. — They save lives and damage suits. The Underwriters want steps not less than 6 inches wide and not more than 9 inches high. Some states have regulations as to fire escapes.

No matter if the building is fireproof, a system of fire escapes ought to be installed, for the contents may be burnt. At a fire in New York in 1911, in a fireproof building, 147 people lost their lives through insufficient exits and locked doors.

Fire Limits and Safeguards. — Much loss would be avoided if the foregoing safeguards were attended to. It would be easy enough to add more, but the principal dangers are indicated.

A proper municipal code would set apart a certain section of a city where none but fireproof buildings were allowed; and many other changes from the regular codes would be made. Probably even a few lightning rods would be installed. Perhaps we were too rash in saying that they are of no value.

Several good building codes have been compiled, but they are of no use unless they are followed. Even if a city gets a good one the council will often render it useless by giving special permits.

And while you have been reading this chapter the buildings have been burning, and the Excitable Men have been waving flags, and looking at their stop watches, and shouting, "Lay more brick! Hoist more timbers! Faster! faster!"

CHAPTER II

WHERE TO LOCATE

Someone has said that wherever Americans are they want to be elsewhere. When I would suggest improvements to my more experienced grandmother she would reply, " Changes are lightsome, and fools are fond of them."

But while environment does not mean everything, it means a good deal. Some of the best Australian families are descended from British convicts who got a better chance in the new land. Quite a few shady characters also came here and reformed under better conditions than they could find at home. This means that there is hope for us all.

From the beginning of this republic there has been a trek from East to West. Most of the people were seeking and finding better environments. They were not seeking a better Declaration of Independence nor another Constitution, for these belonged to the East as well as to the newer portions of the continent. They wanted more favorable environments.

There are plenty who make a great success in all lines back in Europe, but on the average not nearly so many as in this country; and likewise there are many who make a success in the Eastern states, but not such a large percentage as in the newer ones. The man who says that environment does not count, and we have quite a few of this class in pulpits, simply puts himself athwart the path of scores of millions who left Europe for Australia, South Africa, South America, and the United States; and who, in our land, later on, left the East for the West, until now they are stopped by the Pacific Ocean. Environment will not make any man anything else than human, but it ought to help to make him a better human. That hundreds of thousands with the best environments trample everything beneath their feet does not prove any more to-day that it did of old when swine did the same with pearls.

In all this broad continent, then, where should a contractor go? For one thing, he must settle where there is building going on. No matter how well equipped he may be to do business if there is none to do he might as well pack up his belongings.

Some of the Eastern states might as well be in Europe so far as growth is concerned. As they were a score of years ago, so practically they are for the 1910 census. In others while the state as a whole grows, there are many towns and villages that stand still. They are often pleasant places for those who have an assured income, but for others who have to make their way there is little chance of advancement. Young men are to be encouraged rather than lectured when they want to go somewhere else.

According to the 1910 census Iowa has fewer people than she had in 1900, and this in spite of the usual excess of births over deaths. It stands to reason that few new houses are required there.

Roughly speaking, this continent might be separated into 7 great divisions: (1) The Northeastern states as far down as Maryland, and as far West as the Alleghanies; (2) the Southern states of the old days; (3) the Ohio Reserve territory from the Alleghanies to Chicago; (4) the former "West" of only a score of years ago, but now the Middle West from Chicago to Wyoming; (5) what we now call the Northwest or the Far West, from Wyoming to Seattle; (6) the new Southwest of Arkansas, Oklahoma, and especially that great empire of Texas; (7) and the southern sections of California, Nevada, and Utah, with Arizona and New Mexico, might almost be put in a classification by themselves. Southern California, especially, looks like a paradise to Northern people.

In Europe when a man moves over a frontier he is among another people who do not understand his language. We can move among fifty nations all practically the same, but with such a variety of climate, resources, and attractions as ought to satisfy the most fastidious.

Probably many a contractor who wants to change might be better off where he is. No set rule can be laid down to suit all.

If a Western city is decided upon there are several to choose from. I prefer Omaha, although it has some drawbacks. Los Angeles would be my next choice, Denver would be the third, and one I have never visited, Seattle, the fourth.

Los Angeles and Denver are two of the cleanest cities one can find. They have what the Missouri Valley cities sadly lack—attractions within reasonable distance. The prairie country is rich, for one agricultural authority says that measuring 150 miles in all directions from Omaha there is no better land on the face of the earth. But there are no lakes worth speaking of, the rivers are tolerably muddy—we are forced in candor to admit that much—and there are no mountains. The prairie has a strange attractiveness of its own, but some accustomed to other scenery might find it monotonous and sigh for sea or snow peaks.

But Los Angeles and Denver are singularly well supplied with ocean and mountain, in the one case, and great mountains in the other, within a day's ride. Both are crowded with tourists at the right season of the year. The chances are that they will always be, but "more so."

There are thousands who do well in the older sections of the country, but the competition is greater in one way—the old established businesses get the best work. They are more cautious in taking hold of a stranger.

But the old states, as we might call them, have one great advantage over the newer ones. The East is a land of factories. It is so full of them that they are overflowing South to get cheaper material and wages. There is a great field for the builder in this factory land.

It looks, as a general rule, which has as usual many exceptions, that the best field is west of the Missouri River. Even the cities of Iowa and Illinois are already looked upon as old in a way that does not apply to those further west. Like some Eastern cities they stay safely about the same population from one census to another.

For a man with children the West is to be preferred. It is going to grow all the way from the Missouri River to the Pacific. Irrigation is opening up a new West that is startling. Land that was formerly worth a dollar an acre in Western Nebraska has been sold for $350. What we all laughed at a score of years ago has become the best in the state.

So the same story goes where the water has been turned on. One advantage of this arid territory is that there is only land

—just land. There are no great forests like those of Michigan to be cut down, leaving a desert to be deserted, and investors with property on their hands that becomes worthless as soon as the lumber is used; and there are no mines to be exhausted. But there is land that with proper treatment will endure as the source of wealth from generation to generation.

In the Old South there are undoubtedly good chances, but they ask who your grandfather was, and their ways are not exactly Northern ways. The climate is also a trifle hot. Many Northerners are going down to find pleasant homes, nevertheless.

The new Southwest has been growing fast in the last decade. There is to be a still greater development down there. Kansas City and St. Louis have waxed fat off the trade of Oklahoma and Texas.

Beyond Texas lies Mexico. It has been estimated that already there is the immense sum of $1,000,000,000 of American money invested in that country. This means American machinery and supplies by the trainload, and it is only the beginning. Some say that this $1,000,000,000 sent the army down there in 1911.

In the Far West we have to deal in big words. Mr. Roosevelt was probably about right when he said that it would come to be New York first, Pennsylvania second, and Washington third. In the last decade the growth of Washington, Oregon, Southern California, Oklahoma, and Texas has been wonderful.

For those in doubt and who feel that the call of the West is in their blood one would say, "Go west of the Missouri River as far south as Kansas City, and keep west of a line drawn from there to Galveston."

Climate. — It is tolerably hard to get a perfect climate. There is sure to be something wrong. In New York City it is the humidity in summer, and the raw Atlantic atmosphere in winter; in the Old South it is too hot, except in the mountainous regions, where there is much moonshining and little building; in the new Southwest there are heat and fleas that make one sigh for the North, for fleas, trained or untrained, are uneasy bedfellows; in the Puget Sound regions west of the Cascades, when it is not snowing it is raining, according to some who do not like it; while on the east of the range, and clear down to Arizona and Utah, there is no rain, and the dust is annoying.

In Nebraska there is as healthy a climate as a man could wish for, but the high winds are at times trying on the temper, and in the cities that are not so clean as they should be the dust and refuse of the streets fills the eyes and ears. Yet far back in the old *Encyclopedia Britannica* these same high winds are cited as one cause for the wonderful healthfulness of the state, so what is an affliction in one sense may in reality be a blessing.

One man has recently told us that all prairie states could, by erecting larger windmills than the ones in use, store compressed air, and light, heat, and furnish power to every family. Once upon a time, and it is not so long ago, we did not think that our waterfalls were of any account. They used to be for the old-time miller, but we thought we had advanced beyond them. Now we know better. Perhaps we shall one day harness the wind.

In Los Angeles there is an ideal winter climate, but there are winds also. This continual smiling climate may become a trifle monotonous. It is one thing to visit a region and another to stay there.

All through the corn country of the Missouri Valley, stretching from North Dakota down to Oklahoma, there is the same healthy climate. Here in Omaha, for example, we are 1,000 feet above sea level. On some days in summer the heat is trying, but it is not humid. In fall, and late fall especially, from the middle of October to the end of November, and sometimes with an occasional storm, clear up to Christmas, one could scarcely say too much in praise of the climate. It is the Indian summer at its best.

The winters are not severe, and they are dry, unlike the air around the sea or the large lakes. Spring is backward. It sometimes seems as if it would never come.

All through this prairie region and on to Denver the air is clear overhead, and especially good for those with lung troubles.

It is a great land, and it is growing and going to grow. Years ago Thomas Brackett Reed spoke of "the omnivorous West."

The 1910 census showed that all states west of the west line of Nebraska gained 50 per cent. and over. Most of them gained 70 per cent. Colorado and Utah gained from "30 to 50," as two exceptions. The empire of Texas had from 20 to 30 per cent. gain, but certain sections had much more. Oklahoma gained over 50 per cent. Oklahoma City rose from 10,000 to six times as many. Los Angeles increased from 102,479 to 318,000. What are the prospects for building in such states and cities as compared with some eastern states, Iowa, and Indiana?

Summed up, if I should be asked where there will be most building done before the next census of 1920, I should say in the Southwest, and I have examined the field in all directions. The Northwest also will grow wonderfully. But we often forget that Texas alone is larger than France or Germany. She had only four million people in 1911; yet if she had the whole population of the United States there would be fewer to the acre than in Massachusetts now. Land is already high-priced in many states that were settled only a few years ago; it is still cheap in the Southwest. In 1911 excursion trains were running down there in double sections.

A contractor or architect starting in business, in most cases, *must* go where there is building to be done, or waste too much of his life fighting for an opening among established competitors. There is no choice in the matter.

CHAPTER III

THE IDEAL EDUCATION FOR A GENERAL CONTRACTOR

"We are always in these days endeavoring to separate intellect and manual labor; we want one man to be always thinking, and another to be always working, and we call the one a gentleman and the other an operative; whereas the workman ought often to be thinking, and the thinker often to be working, and both should be gentlemen in the best sense. As it is, we make both ungentlemanly, the one envying, the other despising his brother; and the mass of society is made up of morbid thinkers and miserable workers."—Ruskin, for the United Kingdom.

"But what is education? Of course it is not book-learning. Book-learning does not make 5 per cent. of that mass of common sense that 'runs' the world, transacts its business, secures its progress, trebles its power over nature, works out in the long run a rough average justice, wears away the world's restraints, and lifts off its burdens. The ideal Yankee who 'has more brains in his hand than others have in their skulls,' is not a scholar; and two-thirds of the inventions that make Old and New England the workshops of the world, did not come from colleges, but struggled up from the irrepressible instinct of untrained natural power. Her workshops, not her colleges, made England, for a while, the mistress of the world; and the hardest job her workman had was to make Oxford willing he should work his wonders. . . . In this sense the Fremont campaign taught Americans more than a hundred colleges; and John Brown's pulpit at Harper's Ferry was equal to any ten thousand ordinary chairs."—Wendell Phillips, for the United States.

That is what Ruskin told the world in general; and Wendell Phillips the professors and students of Harvard in particular.

SECTION I

AT SCHOOL

Education, we have been often told, is a leading out. It is to develop, but some minds cannot be developed except in particular directions. You cannot make a silk purse out of a sow's ear. Some of the most brilliant men have been dunces in certain departments of human interest.

Dombey and Son. — There is an interesting book with this title. Dombey wanted his son to carry on the business after his own death. This is a natural feeling. Kings, aristocrats, plutocrats, ordinary millionaires, and common building contractors have it. It is love for their own young that all animals, including wolves, and tigers, have. We have no reason to be ashamed of it, and none to be particularly proud.

What, then, would be an ideal education for young Dombey, supposing Dombey, Senior, to be, for the moment, a general contractor, and that the young man was willin' to follow in the steps of his father? No matter what his talents may be they have to be led out or developed.

Ordinary Education. — In the first place we shall assume that Dombey, Jr., has been sent to school, and has gathered the usual amount of wisdom dispensed there in tabloid or other shape. This is the lot of all American children, where the taxpayers erect schools enough, and need not occupy us here.

Perhaps, in the course of human events, the youth had to take up certain subjects that neither he nor Dombey, Sr., approved of, but the ordinary routine cannot be set aside for anyone. It is a table d'hôte dinner that is provided for all, and not a dinner à la carte.

Handwork. — In many schools the pupils are now taking a course in manual training, and for anyone who is to engage in building as a lifework this is of great value. It is not merely a training in one branch of mechanical work, but in several, and while it is necessarily of an elementary nature it is none the less of importance.

Drawing. — A course in simple geometry and drawing usually goes with the manual work, and gives an insight into the principles of design that saves much searching of heart and puzzling when actual plans are spread out for a building.

Upward. — In many cases young Dombey is sent to the High School, and is then addressed as "Mister." But only a comparatively small percentage of American boys ever reach so far. In Cleveland in 1906, for example, there were more than 32,000 boys in the grades. Only 2,000 reach the High School, and 300 the day of graduation.

Waste. — There is a good deal of dissatisfaction with the curriculum of the High School. If something is lost by not being able to attend, there is also a gain in the saving of time devoted to useless subjects.

Necessary Courses. — Certain subjects must be learned by all pupils. We have agreed that everyone should master what have been called the three R's—Readin', Ritin', and Rithmetic. Geography, a little history, the less grammar as she is taught the better, spelling, and so forth, make up the list. I wish that Dombey might also master simple decimals, as they are so useful in the business for which we are going to carefully groom him.

Discord. — So far, we are all agreed, but about this point trouble larger than a man's hand begins to cloud up. This starts at the doors of the High School.

Excavation. — We should like to compromise on Greek and Latin roots. Further on in this chapter something will be said of the other work required for the erection of a building, but nothing on excavation. That hard part of the common task we leave for the "Dagos," who come from the classic land of Augustus; but we should like to persuade young Dombey to excavate roots enough of the right kind to save him lots of dictionary chasing through life. If the professors would only let the classical part stop there we could walk through life harmoniously instead of scowling at each other as we are now almost forced to do.

Words. — But the courses are made out, and they insist that Latin or German, or Greek, or Pawnee shall be carefully studied by our hero, whom we have decided to decorate with other trimmings. It is all well enough for a chemist, doctor, lawyer, or preacher to learn Latin, Sanscrit, Hebrew, or Pawnee if he wants to; and French and German are undoubtedly useful in some walks of life, but building contractors in the United States generally address their men and do business in English, when a wave of the hand is not sufficiently clear to the man on the ridge or in the basement.

This language fight is an old one; and before deciding that your heir apparent shall be ground through the mill it might be worth while to consider the nature of education.

What is Education? — It is undoubtedly a leading out, but we have power to go or be led out in different directions. Those of us who have spent our time in building know that there is a wide field that we have not yet explored. There is much to learn in the old paths; and new ones are daily being opened up. How much do you know about reinforced concrete work? Not so very much, likely enough. We are all in the alphabet there.

Whether is it wiser to send Dombey along the paths that have to be traveled, or along the useless language road? Emerson, who knew several languages, said that he preferred to read English translations of foreign books. Not much of value is lost.

Mind Training. — But they say that the study of languages trains the mind and makes it a more powerful instrument, a better tool to work with; and if this is the case, tool and machinery handling men, like builders, are not apt to slight anything that gives more power to the principal tool of all— the human mind. But is it the case?

The Jews. — One of the greatest peoples that ever rose in the world was the Jews of Biblical history. It is not recorded that they spent much of their time learning foreign languages. One of their greatest men, and one of the greatest of the world also, was Moses. He had all the wisdom of the Egyptians, languages among the rest of it, likely enough; but he had to give it all up and go to handwork, to sheep-herding for forty years, to get the rubbish "out of his system," and fit him for his great task. He had been dealing too much in words, and thinking the thoughts of other men; and he had to chase refractory sheep, and tar them to gain wisdom. Language, indeed!

The Greeks. — Another nation that highly distinguished itself in all the arts, and especially in architecture, was the little one that lived in little Greece some two or three thousand years ago. We try to copy their work to-day, so that, like the crab, we have been walking backward. There has never been an artistic revel like theirs on earth—and their sons are to-day shining shoes in Omaha, Nebraska, U. S. A. To that black complexion has it come at last.

We have measured their great stone columns by all our fine rules, and they are true to the sixteenth part of an inch. They knew how to make columns better than we do, and several other things besides. How was it all possible, with their minds untrained by the study of languages? The general understanding is that the Greeks knew only their own, and found it sufficient.

The Romans knew Latin, and even their children spoke it. Some of them learnt Greek, but the general rule was for the conquered nation to learn another language than its own. One was enough for the conquerors.

Judging from these peoples it would seem that progress does not depend upon what Carlyle used to call "gerund grinding."

One writer who had been run through the ancient and modern language mill said in "The Old Order and the New," "Let the best possible translation be executed of all that is excellent in form or substance in the dead languages, and then be done with them forever. Let the dead past bury its dead. Such pretended 'seats of learning' as Oxford and Cambridge are mere seminaries for the acquisition and diffusion of *useless* knowledge. All the modern languages—and, for the matter of that, the ancient ones also—are but jungles of verbiage, which retard rather than facilitate human thought and progress."

Experience. — I took a fancy to learn a little Spanish shortly after school days. I kept up my studies until I could read it almost as easily as English. I read what many call the greatest novel of the world, "Don Quixote," about half a dozen times in the original. The spelling is beautifully simple. There is not so much trouble with a world writer like Cervantes, but I noticed that when I tried the "Elogios" of some of the fearfully learned men of the academy I had to run hot-foot for the dictionary to get the meaning of the jaw-breakers of words. They could not tell us of their great countryman unless they used words of many letters.

I remember enough of this language to be able to easily read the New Testament. And this great book is also written in plain language. In fact, all first-class writers can easily make themselves understood. It is the D. C. L., Ph.D., Oxon. tribe that trouble our sleep.

Later on I studied French for three years, under a native teacher, and lived for about a year in a house where we spoke nothing else. I found it convenient when staying for a few weeks in Paris, where even on the Rue de Rivoli they speak French. One winter when building was dull I read it for ten or twelve hours a day.

Pedantry. — A distinguished American, who had lived in Paris nearly all his life, once wrote that he had met only one English-speaking person who could really speak French. The other thousands merely made a more or less successful "bluff" at it. This is too much of the Ph.D. way of looking at things, but the truth is that all thousands of us manage to acquire is just a fair workable article of commerce, as it were, which needs to be taken with quite a few grains of charity. It is not by any means the French of Paris. Never believe it. It is like the Canadian article—only worse.

Not Theory. — This much to show that I do not write altogether from theory. Some men have learned fifty languages, and they can speak with more authority. Our question here comes to be, Is it worth while for young Dombey? Most contractors would say no, and I think they would be right.

Line of Study. —It is true that in almost all technical, engineering, and architectural schools French and German make up a part of the course, but why it would be hard to tell. It is a fashion that one copies from another. It is well enough in Europe, but hardly necessary here. Anything of importance in the technical world appearing in a foreign journal is soon translated.

French is a useful enough language for many architects, of course, and especially for those who attend the École des Beaux-Arts; but if we are to believe a writer in the *Architectural Record* for April, 1908, this course is no longer necessary for American students, but is often a positive drawback.

Posing versus Mind Training. — There is no great intellectual effort required to learn a foreign language as it is mostly learned. To learn languages in such a way as to be a teacher is another thing. Even English cannot be learned by English-speaking people in a lifetime; and study is so far from being the only requirement that John Bunyan, a common tinker, wrote better than any of the professors. It sometimes seems that the educational brigade, hopeless of distinguishing itself in any other way than by a parrot-like repetition of words, tries to make us believe that it is a highly intellectual accomplishment to know how to name a cow in several languages. It has been successful enough to impress this belief on the minds of the "old folks" who have come to think that, somehow or other, it is "the thing" to grind their young hopefuls through the language mill.

First. — But if young Dombey wants to learn a language it ought to be Spanish, and neither French nor German. As already said in another chapter, it has been estimated that Americans have invested $1,000,000,000 in Mexico; and we have now to deal with Porto Rico and the Philippines. Of course the money side is not the only one, but it is one; and Spanish offers the best opportunity to make money. Scores of American firms now issue catalogs in this language, and with the certain increase of the South American trade more of them are going to do so. In the building business, just to quote one example, the Northwestern Expanded Metal Company issues a Spanish booklet, and advertises for Central and South American trade.

Why learn German or French? On the slightest notice a trainload of bi-lingual workers of all kinds with fourteen kinds of German at the ends of their fingers could be delivered F.O.B. from Milwaukee to any part of the United States; and Quebec and our Eastern states are full of people who speak either French or English. New Mexico and Arizona have quite a few Spanish-English people, but they are not, as a rule, the kind that will chase after trade to the South. They do not compare well with the Milwaukee brand of human in this respect.

The Mind. — When all this is said our school friends fall back on the "training of the mind." The mind, like the body, will grow on any reasonable kind of food. It can be trained by studying architecture, physiology, Hebrew, weaving, pottery, woman suffrage, Shakespeare-Bacon controversies, chemistry, varnishing, and even law. The mind is no more dependent on a certain class of studies than the body is on breakfast foods.

All of this does not mean that young Dombey should not learn a language if he has time and opportunity because of mere laziness.

Shorthand. — This is a splendid labor-saving tool. I learned it when a boy, and reported in church for several years until I became fairly saturated with sermons. I have found it very useful in copying specifications when in a hurry, and for writing this and other books. According to my way of thinking it is worth any half-dozen languages, dead or alive, and it can be learned well in one-third of the time that a language needs to be learned in rather a poor way at best. The shorthand teachers say that there is no study like this for "training the mind."

Choice. — At the door of the future High School one will be able to choose the line of study he wants, and not be compelled to grind through what somebody else says is good for him. If young Dombey can go through the High School it will do him no particular harm, as things are, but not so very much good as to astonish us. It might keep him from being so narrow-minded in after life as to think that the Hand is ahead of the Brain. Having got so far how would it do to read Mr. Ruskin's words at the beginning of this chapter?

THE BUSINESS COLLEGE

Black Eye. — It is not much of a compliment to our High Schools that when many of the pupils graduate from them they turn to the Business College, or the Technical School; and that thousands go to these institutions when their grade studies are finished without even peeping in on the "regulars" to get their minds trained. They go without the old line insurance, as it were, and take the policy of the fraternal orders. But why should builders and supply men have to pay for this outside training for their sons while the High Schools are free?

The High School is deficient because it does not give the training required for business or building. It takes the taxes cheerfully enough, and asks for more, and still more, but applies them in one direction only, and that not the one tradesmen need.

Valuable Course. — Much of value may be learned in a

Business College by Dombey, Jr., if the High School mistake is not repeated. A contractor is not a banker, nor an accountant, nor a bookkeeper, nor a stenographer. Whatever is required to make him a better building contractor should be taken from the Business College, and only that. In another chapter a pruned down system of bookkeeping is presented that every Business College in the land would condemn. They forget that a contractor wants as little of that as he can get along with, and it is often wonderful how little can be made to serve.

The arithmetical "stunts" and accomplishments that are valuable enough for a professor are useless for a bricklayer. It is a hundred times more important for a contractor to be a good estimator of everything in connection with a building than an expert at juggling interest and discount tables, and adding 14 columns of figures with one hand tied behind his back. As to arithmetical exercise every builder gets all of that he needs. Some contractors figure in their sleep. To tell one to take arithmetical exercise is like recommending a mail-carrier to walk for his health.

THE TECHNICAL SCHOOLS

We now come to a class of educational factories that do work of a more practical nature. The training in these schools, apart from the language grind, is closely related to the actual requirements of the building business. They are doing excellent work, and there ought to be more of them—say one free school in every city. Our student should take only what he requires from the Business College, and spend the rest of his time in the Technical School.

Dangers. — But there are at least two dangers that need to be guarded against here: Someone has said that the greatest profession of our day is business. Now our student is preparing himself for this profession, and not for that of architect, or engineer, or language teacher. The course should be laid out to suit his needs and not those of an architect. Somehow or other the theorists always repeat the mistake of the High Schools, and try to make our young Dombey go in ways that lead to the wrong terminal. They start him off all right, but switch him on to a side track. To repeat the illustration already given, it is far more important that estimating should be thoroughly studied than the differences of the various architectural styles. If the proposition is reversed the situation can be seen at a glance. Suppose a young man is in a technical school studying architecture, what would you think of the wisdom of those who made him spend his time learning how to estimate buildings? That is a necessary part of his training but a subordinate part, and he can gather as much knowledge as he requires as he gets acquainted with contractors. His principal studies have to be devoted to the art and science of building, and not so much to the cost side.

But the prospective builder has to approach the problem from the other end. The more he can learn of the architect's work the better, but something else has to come first. The architect and builder are to be complementary to each other. Neither one is to "know it all," but each is to understand a part. Each is to be one leg of a pair of scissors, that when joined will cut the cloth to perfection. But some of the professors would do all the sharpening and oiling on one leg only.

Young Bones. — The other danger is that young Dombey will stay too long in this new school.

There are many families that have been in the circus business for generations. Almost from the time their boys and girls are able to stand, the training begins and is kept steadily up, with what results we know when we hold our breath and see them swinging in the air. If the trainers waited till the young bones had set there would be no such success.

So it is with trades, learning languages, and mostly everything else. One learns best when young. This does not mean that children should be sent out on buildings, for in general no one under sixteen should be allowed on them, and the trade and manual training schools give the necessary dexterity in safer surroundings; but it does mean that it is a mistake to keep a boy in a Technical School until he is twenty years old and educate him away from his life business. Between sixteen and twenty he can learn a trade better than between twenty and twenty-four.

Many who cannot take a course in such schools through the day can do so in the evening.

SECTION II

BUILDING THE SCHOOL

"Stamp each stone with earnest feeling,
In the rock thy soul revealing."

Bad Types. — There are some correspondence schools which seem to think it necessary, in the endeavor to make more money than their owners really require, to send out a few rather vulgar advertisements which would not have received much favor from the old-time class of American mechanics.

They want their students to "step out of the dinner pail class." That is good advice in one way, for we are now so close to the billionaire that men on buildings and elsewhere should be able, as a general rule, to get their necessary food without having to carry it in a pail like horse feed to be swallowed cold at the side of a building. But this is not the meaning. The underlying idea is to step out of the class that labors with its hands.

The illustrations show one of their graduates with an imperious, Julius Cæsar mien, ordering some poor looking sneak with tools in his hand to go thus and so, and to be tolerably lively about it.

Mistaken Idea. — If young Dombey thinks that he is going to enter among a class of men of the kind represented in such pictures, and merely wants to learn their business to some extent and get away from them as soon as possible to put on the "harsh exterior" and play Napoleon Cæsar with the fierce mien ever afterwards, he is sadly mistaken, and should choose another calling. Building mechanics have their faults, but they average up fairly well—well enough to make anyone suprised to think that any reputable institution would not know better than send out such sneak pictures to make money.

Trade Course. — Remembering always that a good deal of useful information and skill have been acquired in the manual training classes, how would the following "curriculum" do?

Two years at bricklaying and masonry.

Two years at carpentry and planing-mill work.

One year at plastering.

One year at plumbing and heating.

Six months at structural iron work.

Six months at painting.

Three months at electrical work.

Or 3 years might be taken at carpentry or masonry, including stone cutting, and plumbing and heating omitted, as these branches are not often included in a main contract. In Northern climates bricklaying could occupy the summer months and planing-mill work be taken up in winter. This would shorten the course.

When men say that they keep on learning something new in their trades all their lives no one should expect to master any trade in a year or two, but a good sound practical knowledge can be obtained. In after life, as a contractor doing all kinds of work, this knowledge would be useful to young Dombey. His men would soon understand that they were not dealing with a novice. In this connection the following paragraph from *Machinery* is worth reading:

" In these days when so much has been said about specialization and about the necessity for any young man in the technical field to devote himself exclusively to a certain branch, it may be well to accentuate the point that specialization may be carried too far. The man who becomes too one-sided in his work may be useful to a less extent than he would have been had he, while making a particular study of a special field, devoted some time to broadening his intellect in various ways. The truly great men of this, as well as former, ages are men who have not confined themselves to a small sphere of usefulness. It is true that it will not do to divide one's interests between too many things at a time. Do one thing at a time, and do it well, but do not think that the time has come when general information in regard to all the things that surround us in life is useless simply because it is not possible to become master of all the arts. Perhaps, on the other hand, there never was a time when the man with a broad view had a greater chance. The specialization in all lines of industry has limited the opportunities for the development of men of varied experiences, but such men are necessary for the executive positions. There is for this reason a premium on the services of the man who has been able to acquire a general, even if limited, knowledge of the industries, the business and other conditions outside of his own branch; and because such knowledge is becoming more scarce, as the specialization becomes more systematized, there is all the more reason for not being deluded by the general outcry that a man to be truly successful must be a specialist, and nothing but a specialist. To a certain limit the man who is a specialist, and nothing but a specialist, is more successful than his fellow-workers; but this is in the secondary positions, when he is working under the guidance of men who can supplement his lack of general development. When the moment comes that the place of managing the whole concern is to be filled, the specialist is left where he is, because he is filling his place so exceeding well, and the man who never was thought much of where but one of his many faculties came into play, is promoted to the place where he can give full sway to his general knowledge and his varied interests; and the specialist who in his one-sidedness thinks that he was the person logically fit for the promotion, thinks himself badly ignored and his ability misunderstood; he does not realize that with all our specialization the 'all around man' still holds his own."

While the trade course was going on, a few evenings per week in winter could be occupied with architecture, estimating, and the reading of trade papers. When the time came and the course was ended our student would have a far broader grasp of the building business than most have who are in it. We may at least set up a high ideal, if we cannot all attain it.

Two Ways. — Dombey, Jr., would have found out that there are two ways of learning, and this is something that many never discover. There is the school way and the trade way. Knowledge is knowledge, no matter how obtained; and brick bonds, for example, may be learned better on the wall than in the classroom. Some of the classroom work is of no use around the building proper, and gives not one whit of power to its possessor. So far as a knowledge of language goes, or trigonometry, or engineering problems, they are useless around a building. A builder might as well study dentistry or the making of caramels as these things which have their proper place. Yet we have shallow men who plume themselves upon being "educated" because of such knowledge, and look upon tradesmen as uneducated on account of their lack of the diploma.

Post-Graduate Course. — It is to be hoped that Dombey, Jr., would not think it necessary, like so many Americans, to go to Europe to complete his school or technical education. Many of us who are "imported goods" ourselves would like to believe that the European finish is superior to the one supplied in this republic, and thus required for all model citizens, but with 90,000,000 people to consider, it is hard to do so. It may be that for some special subjects it is well to go there, but nine times out of ten it is the fad of the snob. It is akin to the idea of some kinds of Westerners we have, that children must go to the Eastern states to be educated. The inference in both cases is that there is nothing fine enough at hand to educate the prodigies, and this is nonsense.

Nevertheless, Europe is an interesting continent, and Dombey, Jr., should see it if possible as a part of the wider education than is taught in schools.

Wider Field. — The greater problems of citizenship do not belong here. It may be sufficient to say what the chapter on "Big Contracts" will enforce, that material grandeur and building by the square mile will all be useless unless we come to understand that for thousands of years one nation after another has been cast aside because it failed to go forward. They could cover the earth with buildings, yet went in the dust because they would not accept brotherhood instead of the masterhood that our maddened plutocrats are fiercely chasing after to-day.

On this American continent already two nations have been tried and thrown aside—Spain and France. It is now "up to us." While we are all deeply interested in everything relating to building we might as well understand that our problem is deeper than merely to repeat what has been done on a greater scale from Egypt down to Versailles.

CHAPTER IV

THE HIGH SCHOOLS, LIBRARIES, AND TRADESMEN

The Herr Doctor Nathaniel Butler, professor of education in the University of Chicago, said to the teachers of Central Ohio in November, 1909, at Toledo:

"The present strong tendency to emphasize industrial and commercial education brings with it the necessity of not forgetting that there are other practical ends of education besides those related to vocation.

"The grade or high school teacher is not charged with responsibility for a pupil's vocation and career, but is charged distinctly with the other functions of making him an intelligent human being and useful citizen."

This may be true, but many are now asking how it comes that a knowledge of a language or a science makes anyone more intelligent and useful than an ability to lay brick, make the truss for a roof, carve wood, or design a scheme of electric lighting.

The professors should read what Wendell Phillips said about the proportion of book knowledge that runs things in general.

When twenty or more of Mr. Carnegie's superintendents were gathered around a table the great Austrian said, "I suppose, Mr. Schwab, that most of these men have received a technical education?"

"Only three of them had any training. All the others rose from the ranks as I did," was the reply.

Taxes. — In the trades, railroad work, and transportation in general, there are about 5,000,000 people engaged, and so far as most of them are concerned the High Schools might just about as well not exist. But they have to pay their share of the taxes. They are willing to let the professors go on in their headstrong way and teach all the botany, physiology, and German that they please, but they want room for something else as well.

Bad Foundation. — As soon as we pass out of the A B C stage the underlying wrong idea is to prepare everybody for the High School, the College, and the University, as these are at present organized.

Supposing you had 97 men going to Greenland and 3 to the Equator, would you equip the 97 with the light clothes required for the 3? You would rather give them what they needed, would you not? Or would you freeze them for the sake of uniformity and the carrying out of your pet theories? That is what is done with the High Schools—97 are frozen out for the sake of 3. The literary side of civilization alone is presented. Take it or leave it; like it or lump it, and don't forget to pay your taxes.

Chestnut. — This is the old European idea, but Germany has done more to show its worthlessness than any other nation. After the war of 1870 she remodeled her school system, and has made wonderful progress, world progress, since then.

Oxford and Cambridge have carried out this ancient idea to the limit, and while splendid men have been turned out of these universities, in spite of the classical load they bent under, John Brisben Walker went so far the other year as to challenge anyone to point out a really first-class man produced by either, —such a man, for example, as Abraham Lincoln, who knew English, and found it sufficient. Of course the president of a Western university said that Lincoln would have been less of a boor if he had had the advantage of a college training, but we had our doubts about that, and also about the benefit of such a course when it left one of its chief products capable of applying such a word to such a man.

Figures. — The following statistics will show just about how matters stand in the field of the "higher education." They are from an excellent article by F. W. Beckman, published on October 31, 1909.

Proportion. — Of 500 who are enrolled in the first and second grades not more than 100 will get into the grammar grades; only 35 or 40 will get into the High School; not more than 10 or 12 will complete the work there, and only 1 will go to college.

Think of it—1 in 500. And the taxes are paid for this kind of nonsense.

The present educational system is based upon the requirements of the few instead of on the needs of the many; and the subjects for all above the earlier grades have to be arranged to suit Sophocles Johnson, Esq.

Number of Scholars. — Only about half of the population of school age below 18 are actually enrolled. In St. Louis about 2 per cent. finish the High School course; in Boston, 4 per cent.; in Chicago, 3 per cent.

In 1907 with a school population under 18 of 24,262,930 in the United States the total enrollment in the High Schools was 770,456; and the graduates of that year numbered 90,391 or about 12 per cent. Of these only one-third intended to enter college. This makes about one-tenth of one per cent. of the total school population of the United States. Of the 24,262,930 only 16,890,818 are enrolled, and less than 12,000,000 actually go to school.

Reasons. — Half of the pupils leave school, according to some statistics collected, because they find it of no use. They can take Latin, but not practical electrical work. Yet, of 100 who earn their living 80 must work with their hands, 17 go to some business or clerical pursuit, and only 3 or 4 enter the professions.

Trade Schools in Germany. — In the United States there are in all about 250 trade schools, while Bavaria alone has 290. Nearly everything of a practical nature is taught. They are High Schools, in a sense, but not for the study of irregular verbs. These are good enough in their place, which one might be pardoned for wishing were anywhere else than on earth, but even here they do not make up all of life.

The population of Bavaria is just about the same as that of New York City. Imagine 290 trade schools there.

In Berlin 55 per cent. of boys between 14 and 16 are in the industrial schools; in Chicago one-tenth of one per cent. In Munich there are 38 different kinds of technical schools.

The German Commissioners to the St. Louis Exposition reported when they went home that their country had nothing to fear from the competition of the United States, as our strength had hitherto been in our power to form great combinations of capital like the trusts, and in the enormous supply of raw material; but that our efficiency is declining, owing to the want of training the workmen. It is an old saying that the judgment of foreigners is the judgment of posterity. They are not blinded by national feelings and vanity. The Verb Men and Women are landing us in trouble, and even for their own sake we must gently lead them away from Sappho and Helen of Troy and other ladies of ancient times of whom we have heard somewhat too much.

New Tide. — There are signs that the tide is on the turn, and that it will flow and flood the land in spite of the Herr Professor Butler and his cohorts with their brooms trying to hold it back.

In the *Technical World Magazine*, for December, 1909, there is an article entitled, "Making the High School Democratic." It tells of the progress of the new kind of High Schools in England, Germany, and the United States. They are turning out boys and girls with trades already fairly well learned.

Fitchburg, Lynn, with her bells, and Ludlow, in Massachusetts; Freeport, Ill.; Cincinnati, Chicago—these and other cities have taken up the system of the New Order, which has been in vogue in Omaha for years.

The *Building Age*, for February, 1910, tells us that Newark, N. J., is about to invest $600,000 in a Technical High School. It is to be well equipped for both boys and girls. No wonder that poor Niobe has been so long in tears. They have been thrusting Latin and algebra upon her instead of the Domestic Science that progressive Newark is to offer.

In Minnesota, in 1907, there were only 17 schools for manual training, with 2,039 students; in 1909, 84 and 4,233. That is reasonably good progress in two years.

But the university professors in that state want another kind of a reformation, a new way of selecting their species. They want to give the High School teachers the right to say which of the pupils shall be allowed to go forward to the university. According to them 64 per cent. of the freshmen who failed in one year might have been kept at home if the proper authority had been vested in the teachers. Only those are wanted who can absorb Greek and Trojan lore.

Yet in the past Dr. Chalmers, Sir Isaac Newton, Sir Walter Scott, Charlie Darwin, who wrote two good novels; Henry Ward Beecher, Adam Clark, and many others well known were called dunces by the men who taught them and insisted on feeding them with the regulation, wrong kind of food. The Herr Professor Achilles Hercules will make everyone swallow shredded wheat, made from Minnesota hard, or die in the attempt.

PUBLIC LIBRARIES

Too Much Goth and Hun; Too Little Johnson. — An important adjunct of the High School is the Public Library, but it also needs a good sweeping out.

American libraries are, taking everything into consideration, the best on earth, but they are yet a few laps short of perfection. With respect to books, magazines, and papers they are deficient on the trade side, and some of them are too prejudiced. I could not find "The First Battle," by that publicist, Jennings Bryan, in a great library controlled by "gold bugs."

But if deficient in some lines they are filled to the topmost shelf with literature on others. They have a carload of books about the Punic wars, Goths and Vandals, Medicean beasts of prey, "Shakesperiana," and there are novels enough to fill several boxcars and sink a civilization. Excellent as good novels are, is there to be no limit? Must the forests be made into pulp for paper, and our shingles get so high-priced that we cannot use them? Dunlop, who grouped the history of all the novels of all Europe into one essay, says that in the nations of modern Europe there have been only 250 or 300 distinct stories. He also said that at least 200 of them are more than 2,000 years old. It would seem that we have already had 300,000 variations of the original text, with more a-coming:

> "The loaded press beneath her labor groans,
> And printers' devils shake their weary bones."

Usefulness. — It would be almost as foolish to try to get along without a first-class Public Library as without a fire department, but it is possible to overdo the buying of the wrong kind of "supplies."

Cities. — The coming age is to be that of the municipalities. It has been often pointed out that the one great failure in the United States is the government of the cities. Yet a republic must excel in every respect, and this bad state of affairs will have to be changed. But how little there is on the physical side of development in the average library to help us on the way! Hun, yes; Goth, OB, shelf 3, lefthand corner; but Johnson is too plebeian to be even listed. He is Johnson of Ours merely, and carries no helmet and spear, but walks sedately along in No. 10 shoes that gripe his feet.

More Books. — We need more and better popular and technical books on paving, sewers, subways, transportation, waterworks, ice-plants, public markets, light, heat, and power, milk supply, cemeteries, garbage disposal, messenger and express service, building books, books on fire protection, model charters, municipal ownership, and a score of other questions in connection with the cities of the future.

A library can be made a good paying investment if kept up-to-date.

Lifeless. — Perhaps you have seen a mummy in its case. The Thing inside was once alive, but it has been long dead. So with too many books that fill the shelves.

An assistant to a scientist once asked him what to do with certain scientific books. " Take everything more than 10 years old and throw it in the cellar," was the order.

If certain kinds of trade books are not kept up-to-date their value ceases. Instead of building more shelves to hold more books many of those now there should be used for fuel. Blessings on the man who burnt the Alexandrian library! He is generally execrated, but he was one of the great benefactors of the race.

How Many. — Probably in the whole world there are not 10,000 books worth preserving. Let us be liberal and call it 20,000. It is likely that the human race would get along better if all the rest were burnt and ended forever. Since writing this I have noticed that Professor Eliot says that all we really need can be put on a 5-foot shelf. There is some hope for the professors even yet. Carlyle, at the end of his life, got down to two books—the Bible and Shakespeare.

Yet we have libraries with millions of volumes, and their dust-fighting attendants groan for more. More are needed, but we are tolerably well supplied with Greek and Trojan wares just now, thank you. Some other day, perhaps——

The Library of Congress has room for 2,500,000 books, not including the roof; and the New York Public Library for 4,000,000. If books would only save us our calling and election were sure!

It is hard on the taxpayer, and at least half of it is useless.

The one Irish chief wrote to the other, "Pay me my tribute, or else——!" The other replied, "I will not pay you your tribute, and if——!"

We have been paying tribute in schools and libraries to the Literary Ideal and the classical forces too long, and they must now agree to share the "swag" for another kind of schools and books, or else——!

Mr. Roosevelt, in an address to the students of the Agricultural College of Michigan, at Lansing, said: "Our engineering schools compare favorably with the best in Europe, whereas we have done almost nothing to equip the private soldiers of the industrial army—the mechanic, the metal worker, the carpenter. Indeed, too often our schools train away from the shop and the forge. . . . The painter, the electrical worker, the foundryman should be trained alike in head and in hand . . . To train boys and girls in merely literary accomplishments, to the total exclusion of industrial, manual, and technical training, tends to unfit them for industrial work; and in real life most work is industrial."

CHAPTER V

A LITTLE LIBRARY

Inquiries are often made as to what books it is advisable to purchase. A contractor cannot afford to run to a library for a technical work. "When he wants it he wants it badly," and he ought to own at least a few standard works. When he becomes rich he may buy more.

The David Williams Company lists the following books, including, it will be noticed, a good cheap arithmetic, where rules are laid down for simple problems in mensuration and decimals:

AUTHOR	TITLE	PRICE
Arthur.	The New Building Estimator	$2.50
Baker, M. N.	Municipal Engineering and Sanitation	1.25
Baker, W. H.	Cement Workers' Handbook	.50
Birkmire.	American Theaters	3.00
Blakely (Passaic Steel Co.)	Manual of Structural Steel	5.00
Building Age.	Series of Designs (5 vols.)	5.00
Cambria Steel Company.	Handbook	2.00
Carnegie Steel Company.	Pocket Companion	2.00
Carver.	Handbook for Inspectors of Reinforced Concrete	.50
Cosgrove.	Principles and Practice of Plumbing	3.00
Crosby.	Building Code of New York, etc., 1911	3.00
Edminster.	Architectural Drawing	2.00
Gilbreth.	Bricklaying System	3.00
Gilbreth.	Concrete System	3.00

AUTHOR	TITLE	PRICE
Gillette.	Handbook of Cost Data	$ 5.00
Hodgson, F. T.	Estimating Frame and Brick Houses	1.00
Hodgson, F. T.	Concretes, Cements, Mortars, Plasters, and Stuccos	1.50
Hodgson, F. T.	Light and Heavy Timber Framing	2.00
Hicks, I. P.	Builders' Guide	1.00
Hicks, I. P.	Estimators' Price Book	1.00
Jacoby.	Structural Details or Elements of Design in Heavy Framing	2.25
King, A. G.	Practical Steam and Hot Water Heating	3.00
Lewis.	Handbook for Cement Users	2.50
Hendricks.	Commercial Register	10.00
Jones & Laughlin.	Useful Information	.50
Joslin.	Estimating the Cost of Buildings	1.00
Kent.	Mechanical Engineer's Pocket-Book	5.00
Kidder.	Architects' and Builders' Pocket-Book	5.00
Kidder.	Building Construction and Superintendence:	
	Part I, Masons' Work	6.00
	Part II, Carpenters' Work	4.00
	Part III, Roof Trusses and Trussed Roofs	3.00
Kidder.	Strength of Beams, Floors, and Roofs	2.00
Maginnis.	How to Frame a House	1.00
Maginnis.	Roof Framing Made Easy	1.00
Maginnis.	Practical Centering	1.50
Melsy.	Progressive Carpentry	1.00
Milne.	Standard Arithmetic	.75
Radford.	Practical Carpentry (2 vols.)	2.00
Radford.	Steel Square and Its Uses (2 vols.)	2.00
Radford.	Framing	5.00
Richey, H. G.	The Building Foreman's Pocket-Book and Ready Reference	5.00
Richey, H. G.	Handbook for Superintendents, Architects, Builders, and Building Inspectors	4.00
Richey, H. G.	Stone and Brickmasons' Ready Reference	1.50
Richey, H. G.	Carpenters' and Woodworkers' Ready Reference	1.50

AUTHOR	TITLE	PRICE
Richey, H. G.	Cement Workers' and Plasterers' Ready Reference	1.50
Richey, H. G.	Plumbers' and Steamfitters' and Tinners' Ready Reference	1.50
Snow, W. G.	Furnace Heating	1.75
Snow, W. G.	Principles of Furnace Heating	2.00
Starbuck.	Standard Practical Plumbing	3.00

A correspondent of *The Engineering News* sent the list below for young engineers:

1. American Civil Engineer's Pocket-Book.
2. Searle's Field Engineering.
3. Kent's Pocket-Book.
4. Waddell's De Pontibus.
5. Carnegie's Handbook.
6. Byrne's Inspection of Materials and Workmanship.
7. Lanza's Applied Mechanics.
8. Merriman & Jacoby's Roofs and Bridges.
9. Merriman's Hydraulics.
10. Webb's Railroad Construction.
11. Wellington's Location of Railways.
12. Johnson's Modern Framed Structures.
13. " Materials of Construction.
14. " Theory and Practice of Surveying.
15. " Contracts and Specifications.
16. Folwell's Sewerage.
17. Folwell's Water Supply Engineering.
18. Baker's Masonry Construction.
19. Baker's Highway Construction.
20. Patton's Civil Engineering.
21. Patton's Treatise on Foundations.
22. Wilson's Irrigation Engineering.
23. Vega's Logarithms.
24. Reinhardt's Lettering.
25. Reinhardt's Technic of Mechanical Drafting.
26. Edminster's Structural Drawing.

Any of the books listed above may be purchased through the David Williams Co., 239 W. 39th Street, N. Y. See their catalog at the end of this volume.

REMARKS

List prices are given. If several books are bought at once a reduction may be secured.

It will be noticed that there are no books listed that deal exclusively with reinforced concrete work. The lists are for the use of CONTRACTORS, and not architects and engineers. For a contractor to buy ninety-nine out of a hundred books listed on reinforced work would be to throw away money. But full details of quantities and costs are given in the "Estimator."

Three structural steel books are listed. They give size and weight of all steel shapes. A builder needs only one, but sometimes he can get this one free of cost, and a choice is given. If he is buying steel either directly or through a subcontractor he can usually secure a copy.

"Useful Information" is an old favorite in the building trades. It has 500 pages, and is now in its 16th edition. It measures only $2'' \times 3\frac{1}{4}'' \times \frac{5}{8}''$, and is thus easily carried in the pocket.

Gillette's "Handbook" is for engineers, and while useful enough for a building contractor is not really necessary. It is full of valuable statistics on heavy engineering work. Ten thousand copies were sold in the first two years of publication.

I can strongly and conscientiously recommend the chapter on the cost of erecting buildings. When I looked through it I was impressed with the fact that I had written a good deal of it myself, not exactly in my dreams, but in the pages of the "Estimator." To see one's data lifted wholesale is complimentary. It makes him feel that his work all through must be like Ivory soap—$99\frac{4}{10}$ per cent. pure.

Kidder's "Pocket-Book" needs no praise. It is standard all over. It furnishes a quarry from which all builders and book writers take an occasional stone, if their modesty keeps them from filling a wagon. The Chicago architect, who was the "father of the skyscraper," strongly recommended all young architects to buy Kidder.

Trautwine's "Handbook" is another great publication for engineers. A thoroughly revised edition was issued in 1911.

An interesting fact in connection with "Trautwine" is that three generations of the family have written and revised it.

The "American Civil Engineers' Pocket-Book," published in 1911, has proven a very valuable reference work. It was written by a corps of experts, each section being prepared by a specialist in the subject under discussion.

Kent's book is for mechanical engineers, and not of much use to builders, except for chimneys, boilers, and such work. More than 40,000 copies have been sold.

Baker's "Municipal Engineering and Sanitation" is a book I like to recommend. It is an excellent popularly written work on the New Cities of the future.

A great book for addresses is Hendricks' "Commercial Register of the United States." But it is expensive.

FREE LITERATURE

There is no country like this for sending out so much valuable literature "free, gratis, and for nothing." The advertisements in the trade papers should be watched for catalogs and handbooks. A few are listed below:

Sweet's Index is the best of all if you can get it. About 10,000 copies are sent out every year. All architects get one, large contractors, engineers, purchasing agents, and city, state, and government officials. The old copy may be obtained from an architect when he gets a new one. In one year 4,000 were transferred in this way. Any copy, old or new, is worth having.

It is purely an advertising scheme, a catalog of catalogs, but it seems that everything worth listing in connection with building is to be found in its pages. Instead of a thousand and one leaflets and catalogs of different sizes there is a bound book of more than 1,400 large pages carefully indexed. It is to the trades what Poole's Index is to the libraries.

It is published by the "Architectural Record Company," New York.

Another first-class book is the "Building Code Recommended by the National Board of Fire Underwriters," New York. It has been quoted from often enough in this volume to show its value. To go through it carefully is like taking a course in good building construction.

"Concrete Construction About the Home and on the Farm" is an excellent pamphlet sent out by the Atlas Portland Cement

Company, New York. The fifth edition, 1905, was of 400,000 copies. The 1909 edition has 170 pages, and is well illustrated.

The Northwestern Expanded Metal Company, Chicago, sends out several booklets.

The Trussed Concrete Steel Company of Detroit, has some free publications that deal with the new styles of building.

The Tin Roofers' Handbook is supplied by E. L. Seabrook, 2213 Chestnut Street, Philadelphia.

The Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia, distributes about 20 free bulletins about all kinds of cement and reinforced concrete work.

The Departments of the United States Government send out good building information such as the Report on the San Francisco fire.

Millbooks are free in the West to builders. Sears, Roebuck & Company, The Chicago House Wrecking Company, Schaller-Hoerr Company, all of Chicago, send out free mill and other books. Gordon, Van Tine & Company, Davenport, Iowa, sends out mill and lumber books.

This is but a hint of the richness of the "free-lunch" counter of the Building Business.

Some readers may wonder what the title of No. 4, on page 344, means. It is a bridge book, and furnishes an amusing illustration of the language nonsense that I have dealt with on page 325. When the author was asked why he chose a Latin title for his work in a land where most people use English, he said that he had never had a chance to apply his linguistic knowledge since leaving college, and never expecting another, he took the one opportunity of a lifetime.

How long, do you suppose, preachers, schoolmasters, philologists, and their kind would study bridge work, roof construction, reinforced concrete designs, etc., if we told them it was to "train their mind," when they got only one chance of a lifetime to use the knowledge? Not many years. There are too many simple Simons in the construction and transportation businesses—also in others.

CHAPTER VI

BIG CONTRACTS

"We have an undue appreciation of ourselves, an exaggerated estimate of our achievements, of our inventions, of our contributions to public comfort, of our place, in fact, in the great procession of the ages. We seem to imagine that whether knowledge will die with us or not, it certainly began with us." —WENDELL PHILLIPS, in *The Lost Arts.*

We live in a wonderful age of steam, gas, compressed air, telegraphs, telephones, electricity, flying machines, and even talking machines and moving pictures. If it had all been suddenly thrown before the men who founded this republic their hearts would have failed them for fear. If the British redcoats had seen a train coming towards them at 60 miles an hour they would have taken to their heels—at least those of them who had not fainted. It is astonishing even to us who can look back only a few decades. And where it will end no man can say.

And yet when reading of what other civilizations have done it sometimes seems that we are but children. In a score of ways they outshone us.

The colors of the old civilizations last for a thousand years and beyond, but ours fade in a century. The glass we put in our modern cathedrals is not nearly so rich as that in the ones built in the "dark ages," as they would look to us if we went back by some miracle. We pride ourselves on the fact that we can partly reproduce some of the Greek buildings. We try to copy their sculptures, but cannot equal them.

The gems in an Italian museum are so finely carved that a microscope is required to look at them. On a little ring three-quarters of an inch in diameter there is a figure of Hercules, and the hair on the eyebrows can be counted. On another ring that Michel Angelo used to wear, two thousand years old it is, there are seven women engraved.

Our best surgeons' tools rust in India, but the steel made in Damascus at the time of the Saracens did not rust.

These are a few of the things they did in minute work. They could make colors that lasted, carve hairs on eyebrows that were no larger than the head of a pin, and make flexible steel and things of that kind without end, but could they build?

No Portland. — In some of their fine stone buildings they did not use cement, but made the joints so close and smooth that a knife blade could not be forced in between them. And they carried through some big contracts. It may temper our pride and do us good just to glance at a few.

THE WALLS OF BABYLON

We used to think of the Chinese Wall as the greatest of all the walls, but the one at Babylon, that London of the past, was 60 miles around, about 90 feet thick, and 350 high, of solid brick. There is a contract large enough for any builder from Chicago to Seattle.

This wall had 9,979,200,000 cubic feet, which at 22½ for brick of wall measure means 224,532,000,000, or in actual, kiln count at the national size, 164,657,000,000. Laid in the best manner, as all ancient work was, in Portland cement grouted we may put it at $10 per 1,000, wall measure if done here now. That contract would amount to $2,245,320,000. What guaranty company would go your bond for the full amount of this contract? Where would you buy cement for it? It would take 200,000,000 barrels and more, or all the output of the United States for four years just for one wall. For every human being in the country to-day there would have to be dug a yard of sand, or 90,000,000 yards.

Yet Babylon was founded about 4,000 years ago, and lasted down to 500 years before the Christian era.

Chicago, bragging, swaggering Chicago, the pride and shame of the great West, uses 900,000,000 brick in a year. It would have taken this supply for more than 180 years just to build the outside wall of Babylon, with nothing left for the inside one—some say that there were two walls inside—and not even a brickbat for the city itself.

The Gardens. — Babylon occupied about 5 times as much area as London, and three-fourths of it was in parks and gardens. Our cities with their little green corners in a wilderness of tenements do not begin to compare with the old ones.

The hanging gardens were raised as high as mountains, terrace upon terrace, and covered with palaces and glory. Even the king, who did most to make a wonder of this city, looked upon these gardens as the great triumph of his life.

In the old times they had the tower of Babel, the first sky-scraper, and later on the temple of Belus, which covered 32 acres, had a base 3,000 feet in circumference, and walls 30 feet thick.

No wonder Nebuchadnezzar got the "Big Head," and swelled up and said, "Is not this great Babylon that I have built by the might of my power and for the honor of my majesty?" He became so cruel and strutted so much that he had to be sent to grass—this great man who owned Babylon actually had to eat grass. There are some to-day who would do well to think of him. They are pigmies in power to what he was, but even he had to eat dirt.

Nevertheless, what a fine order it would be on a spring morning for 165,000 million brick at $7 = $1,155,000,000.00; for $350,000,000 worth of Portland cement; and $82,000,000 worth of sand. The danger is that if a Chicago man got such an order he would erect 25 gates of solid brass such as they had soaring in the wall at Babylon, and put them up in his own city.

They had "technical" men there, too. They knew mathematics, and a great many other things, and yet went all to the devil. Abraham Lincoln's favorite poem was, "Why should the spirit of mortal be proud?"

One night in Babylon the handwriting on the wall appeared, and His Serene Highness lost his serenity and shook; and that was the beginning of the end that came long ago and left but miles of sand and ruins.

NINEVEH

This city was 15 miles long and 8 wide. The wall was 100 feet high and thick enough for three chariots to drive abreast. Big, certainly, but far behind the one at Babylon.

This was another revel of building, building, and more building. The architects were so busy with one palace after another that they had no time to eat; and the air was filled with the smoke of the brickyards.

This empire and civilization with its great capital went to grass also. Even Big Building and Big Business did not save it.

THE CHINESE WALL

We do not expect much from "Chinks," but even they have carried through some tolerably large contracts of masonry and sculpture. The great wall took about 100 years to build, and it was finished over 2,000 years ago.

The Chinese wall was 1,200 miles long, from 15 to 30 feet high, and wide enough for half a dozen people to ride abreast. This is not nearly such a wall as the one at Babylon, but is still considerable of a structure. Not many bricklayers would care to take a time contract for a 1,200 mile structure either by lump sum, percentage, or cost plus. It would require too many stop watches and flags, not to say anything of brick and mortar. How could the bricklayers at Toledo know what was going on near New York? The flags could never be seen.

Averaging the height at 22 feet, and the width at 25, we have 78,400,000,000 brick in wall measure, which, laid at $10, amounts to $784,000,000, or about one-third of the cost of the one at Babylon. But that would build two Panama Canals.

Bridge. — Some would have us believe that the Lagang bridge in China is the greatest work ever erected by man, but they have evidently not heard of Babylon.

This bridge was built exclusively by Chinese engineers, who really seem to know something after all. It is nearly 6 miles long, and has 300 stone arches 70 feet high. It was finished in 1885.

GREAT EGYPT

Bigness. — Those who think we are making wonderful progress in large scale work might advantageously look back at Old Egypt.

Away back about 4,500 years ago they built the great pyramid, and if there is a larger structure on earth it has not yet been heard of, for, unlike the wall of Babylon, this mass still stands.

The engineers of our day could not handle the blocks of stone that the Egyptians tossed around. One of them weighed 900 tons.

None of the stones of the pyramid was less than 30 feet long, and from 2 to 5 thick. The great mass contains 85,000,-000 cubic feet. At 20 cents a foot for concrete that would be $17,000,000, but concrete was not used.

The road to bring down the great blocks was three-fourths of a mile long, of polished stone, and carved figures relieved the monotony. This road took 10 years to build. The pyramid took about twice as long. It covers 13 acres, and is 481 feet high. On top the platform is only ten feet square.

For 20 years 100,000 men worked on it. On our basis of wages for stonecutters and laborers we might average $600 per year for each. The wage bill is too large to set down. Hoisting blocks 30 feet long by 5 feet thick, nearly 500 feet in the air is no trifle. Let us guess $3 per cubic foot, and "call it square" at $255,000,000 in granite, but conclude to try mass concrete for the one we build, on the cost plus system.

This is the Great Pyramid, but there are about 70 others. The pyramid business seems to have been slightly overdone in the Nile country. They were used as tombs. The living wretches had to pass their lives in hovels, and dead tyrants got 85,000,000 cubic feet of granite piled above their bones. Our modern plutocrats and their architects need not try to astonish us with their "mausoleums." That business merely makes us yawn. If a Beaux-Arts architect has no other work for his brains than build such useless structures he would have been a better American citizen if he had stayed in America and hoed potatoes.

The American orator was over in Europe, and the sexton was telling him of the tomb of some dead hero, and describing how many tons of granite and marble were in it. The orator said solemnly, "Well, you've got him safe enough. If he escapes cable me at my expense." The old tyrants are safe enough under their pyramids also.

The Sphinx. — As a carving contract, this figure seems to hold the record. It is cut out of the solid rock. It has the body of a lion. From the platform on which this fine animal lies to the top of the head is 100 feet; it is 146 feet long, and measures 34 feet across the shoulders. From the top of the head to the chin is more than 28 feet. A lion of even half that size would send us all to Phœnix, Arizona, to look at it.

Recessional. — When we want a beamed ceiling we nail up the beams, but the Egyptians cut temples out of the solid rock, and paneled all the ceilings with stone beams. They, especially, had a perfect delirium of heavy building.

Karnac had an avenue 2 miles long, bordered with scores of great sphinxes. Ten other avenues have been discovered. The greatest masonry on earth is found there, mostly in ruins.

Thebes had the block of stone weighing 900 tons, and it was all polished to a finish. Who wants the contract for hoisting that one?

The largest block of marble ever quarried in the United States measured 27′ 2″ x 4′ 4″ x 4′ 3″. This is a total of 500⅛ cubic feet, weighing 50 tons. It was for a column of the State Savings Bank, Detroit, and was handled by Norcross Brothers Co. It would have been looked upon as a toy back in the Nile country more than 4,000 years ago. They took obelisks, columns, and pillars of all kinds and sizes, and scattered them around their temples as we do ordinary cast iron columns.

Big Room. — The main hall in the Vatican Library is a fine one, 52′ x 240′, but one of the temples at Karnac had an apartment 170 x 340. There were columns in it 12 feet in diameter, and 62 feet high, with capitals measuring 22 feet across. Ask your stonecutter how much he wants to cut and set such a column.

How would you like to bring an obelisk weighing nearly 300 tons from a quarry 100 miles away? And set it high above the ground on its pedestal?

City upon city was filled with the wonderful buildings of the Egyptians of the old days thousands of years ago. At our best, we are far behind the ancient builders so far as size and weight and surface go. We are more sensible, however, for we build cottages instead of palaces, and schools instead of Babylonian walls and Egyptian pyramids.

SOLOMON'S TEMPLE

For splendid finish, however, the best of all the temples was the one built by the wise-foolish king. It was roofed with gold tiles, and they were nailed on with gold nails. A modern roofer from Cincinnati could not be trusted on that work. He would come out a millionaire.

The floors, doors, and everything on the inside was covered with gold. Much fuss was made the other year when one childish millionaire used gold hinges for a door, and another covered his with gold leaf. They are only poor little "pikers" after all, and need not try to astonish us, for we have heard of Solomon, in all his golden glory.

At the door of the porch there were two bronze columns 33 feet high and 7 feet in diameter. Which founder would care to make them in one piece to-day?

Someone has computed the wage bill on this temple if done on modern American lines. It runs to $275,000,000. Yet the building was not very large. It was only 110 x 36 x 55 high. And all the stones came prepared to go to their place as marked.

ST. PETER'S

Rome has the largest of the temples in our day. It is 612 x 446. The dome is 448 feet above the pavement; the cupola, 193 feet in diameter. It is said to have cost $70,000-000. Probably if built in the United States to-day it would foot up $250,000,000. Who wants the contract?

THE TAJ MAHAL

The Egyptian pyramids were the biggest of the tombs, but no one would call them beautiful. They were massive—or rather they are massive, for they are still there to make us wonder.

But of all the tombs that were ever built the Taj Mahal, at Agra, in India, is the most beautiful. There are respectable looking ones for Napoleon at Paris, and for Grant at New York, but they would only be lodge gates for the Taj.

Base. — First of all comes a terrace of pink sandstone 330 feet wide by 960 long. Before you go further count how many of your city lots that would cover. One side of this slopes into the waters of a beautiful lake, and the other side into the gardens of the gods this time, and not like the ones in Colorado.

Springing from this terrace is a square of white marble 285 feet on the side, and 15 feet high. On each corner is a cupolaed minaret that rises lightly to a height of 150 feet. In the center of that is the mausoleum itself in octagon form with sides of 120 feet, crowned with terraced roof and domes and minarets.

Ornament. — The tracery fairly covers the walls, and it is as fine as lace. Flowers, fruit, birds, and all manner of beautiful figures are there to make the world marvel. Texts from the Koran are written with precious stones, such as diamonds, lapis lazuli, emeralds, and the rest of them. The tomb was built in honor of the dead sultana. In the midst of wild luxury like this on one side the poor wretches worked for ten cents a day, and lived in hovels.

Big Job. — It took 20,000 men 22 years to build it, and they never had to "lay off." Our carvers who covered every foot of such a structure with lace carving would have to be well paid, and so would the stonecutters and setters. Let us call the wage bill for the one we will build in the United States $300,000,000.

Finis. — The human race should have said FINIS to the tomb building industry after the Great Pyramid, and The Taj. The limit had been reached both as to size and beauty. And, besides, what is the use anyway? It is not worth while going to the architectural schools if the students are going to waste their time on "mausoleums." All over the ancient world that business was worked to a frazzle—worked too much for little "pikers" of multi-millionaires and their architects ever to make it again respectable.

ELLORA

Have you ever heard of the place where they excavated for miles into the rock, and carved their pillars, columns, beams, and entablatures out of the solid? Whenever they wanted light and air they threw up a shaft and carved it to the king's taste.

India is full of temples and building glory. Compared with the men there we are only baby builders.

Chaldea, Persia, Asia Minor, Egypt, India—thousands of years ago their wonderful structures arose. Greece came later on, and had the most refined revel of them all.

If men and women could only save themselves by buildings and books, once more we may say, their calling and election were sure.

THE ROMANS

The Romans simply had to repeat the story. They did not know any better. They put their trust in a whirl of materialism, and might as well have put batter for brains.

Their Colosseum held 90,000 persons and measured 622 x 528. We have a "Colosseum" in Omaha that is made of studs and boards. The walls are not 200 feet high like those of the Roman one, but they are like them in having no mortar in the joints.

Bridges, aqueducts, roads, arches,—the power of Rome covered the earth, and her builders could not be equaled. But the end was even as the others. FINIS.

Big Bells and Buddhas. — About the year 1252 a Buddha was cast in Japan. It is nearly 50 feet high, and 100 in circumference. The face is 8 feet 6 inches long—the longest face in the world—and the nose 3 feet 9 inches, which is the length of the one on the Statue of Liberty, New York.

There was a bell cast in Moscow in 1733. It was 21 feet high, 21 in diameter, and weighed 216 tons.

There is another in Burma weighing 130 tons; also a Big, Big one in the city hall, New York, that weighs 12½ tons.

CENTRAL AMERICA

Fifty or sixty cities have been discovered in this region, and they have pyramids, temples, and palaces enough to satisfy any reasonable human. The pyramids are small as compared with the old timers near the Nile. But one of them measures 280 feet square, and the base is 60 feet high. The temple proper comes on top. It would make a fairly large contract for a modern construction company.

All the way down to Peru they built aqueducts, temples, tunnels, roads, and everything that could be constructed of masonry.

In Cuzco, Peru, they had a building with walls of marble, green stone, and porphyry elegantly carved, and sculptured, and lined with gold inside. On the sides were thrones of gold. In the ornamentation were jewels to the value of $200,-000,000. Once more we have to repeat that the little New York "pikers" might just as well stop trying to dazzle us.

I think it is Prescott who tells us that down there in the midst of wonderful buildings they did not know enough to make a tenon and a mortise. The thought had never come to them. We must remember that for untold centuries men did not know how to build an arch.

MODERN GLORIES

In comparatively modern times we have had the Alhambra, St. Sophia's, St. Peter's, and cathedrals without end.

The Alhambra is said to be the finest palace that man ever built, but you can never tell. Babylon had a few, also Nineveh, and quite a number of other cities. Nevertheless, this Saracenic beauty sat in the midst of an earthly paradise, and was not out of place, but matched it well.

The Saracens were splendid and graceful builders. In Cordova they filled one great hall with a forest of 1,000 columns made of alabaster, marble, porphyry, and jasper.

One of the most fascinating periods of history is that of the Moorish occupation of Spain. The older generation of Americans seemed to be particularly interested in it. Irving, Longfellow, Lowell, and others listened to the mule bells on the old hills.

The Moors swept everything before them until they met Charles the Hammer at Tours. He hammered them for seven long days, hammer and tongs, and finally they had to give in, and from that time on the contractors were to build cathedrals all over Western Europe instead of mosques.

They built them; and in some ways they are the most beautiful structures ever erected by man. The glories of the great white marble cathedral at Milan, says one writer, can never be excelled. There are nearly 5,000 marble statues on its walls and towers. Who wants such a contract?

At Ravenna there is said to be a cupola 38 feet in diameter and 15 thick. This is far below the stones the Ancients used to swing in the air, but is a good-sized block nevertheless. Who wants to place such another on top of a dome?

Leaning Work. — Who would want to erect the leaning tower of Saragossa? Or the still greater marvel at Pisa, 180 feet high and 14 out of plumb, and give a bond that it would stand for six centuries? Is the Caucasian played out? Is our civilization a failure?

Not so long, say the moderns, as we can build 700 feet high, and look at the flying machines far above us. Not so long as iron shall endure, said Gibbon, whose historical studies left him blind to the fact that things that can be weighed and measured never save a civilization.

But we are still building some good-sized structures from the modern standpoint. Let us finish by glancing at one and reading a description of the other from the New York *World.*

The Grand Opera House, Paris, required 30,000 drawings, and 14 years to build. It has what is probably the most beautiful stairway in our modern world. The steps are of white marble, the balusters of alabaster, the handrail of African onyx. There are 24 colored marble columns rising to the height of the third floor. It cost $7,000,000. Probably, considering the difference in wages at the time it was built, and in Paris, and what they are now in our large cities, the cost might be here $12,000,000.

Now we can read about the "Sky-Piercer."

ONE OF NEW YORK'S SKYSCRAPERS

It is Thirty-One Stories High and Cost $8,000,000.

One of New York's finest skyscrapers casts its shadow over the Battery.

Towering 31 stories above the ground, it contains 11,000,000 cubic feet with a rentable area of 550,000 square feet. It has 10 miles of plumbing, 20 miles of steam pipe, 65 miles of conduits and wiring, and 3,000 electric fixtures.

From curb to roof it measures 416 feet.

In building it were used 14,000 tons of structural steel, 7,500,000 common bricks, 900,000 face bricks, 45,000 barrels of cement, 535,000 square feet of floor arches, 266,000 cubic feet of cinder fill, 125,000 square feet of girder covering, 450,000 square feet of partition tile, 120,000 square feet of column covering, 210,000 square feet of wall furring, 5,000 cubic yards of caissons, 17,000 cubic yards of earth excavation, 3,150 cubic feet of granite, 20,000 cubic feet of Indiana limestone, 3,000 tons of ornamental terra cotta, 65,000 square feet of wire lath, 85,000 square yards of plaster, 400,000 lineal feet of spruce sleepers, 800,000 feet of comb grain yellow pine flooring, 2,300 windows, 60,000 square feet of glass, 3,000 doors, 280,000 pounds of window weights, 30,000 feet of copper chain, 450,000 feet of grounds, 80,000 feet of picture mold, and 80,000 feet of base.

Cinders required for floor arches and between sleepers of the floors fill 500,000 cubic feet—approximately 25,000,000 pounds. It represents the consumption of 125,000 tons of coal, sufficient to develop 55.000,000 horsepower hours of energy.

There are 2,100 horsepower in boilers, 2,000 horsepower in engines, 1,200 kilowatts in generator capacity, 65,000 square feet of radiator surface, 190,000 candlepower in electric lights.

The structure is an addition to the 25-story Whitehall building, fronts 307.2½ feet on Washington Street, and 160.8 on Battery Place, covering 51,515 square feet, or 20 city lots.

Chicago used to lead in high buildings, but New York now has that honor. The Singer and the Metropolitan soar far above the Whitehall, and the Woolworth is to be the highest in the world, for the Eiffel Tower is not used as a building.

The Woolworth will reach 750 feet up from the sidewalk, and go 130 feet below for foundations. The main structure will be 27 stories, and the tower 24. There will be 13,000,000 cubic feet in the structure. The tower light will be seen for fifty miles. The cost will be about $12,000,000. The owner started the five and ten-cent stores. Many nickels make a muckle.

The design is beautiful, and has been copyrighted—probably lest any of us should spend $12,000,000 in duplicating the building.

After all, we can at least build higher than the ancients.

CHAPTER VII

MISCELLANEOUS

(1) THE METRIC SYSTEM

Who Use It. — With the exception of the English-speaking nations and Russia, practically all civilized countries use this system of weights and measures. Our system serves 140,000,000 people; the metric, 500,000,000. It was legalized in the United States in 1886, and in the United Kingdom in 1897.

The dollars and cents system of this country is much simpler than the old one of pounds, shillings, and pence, because it is based on decimals. The other is based on custom. The Metric is a decimal system also.

Education. — It is calculated that each school pupil loses a year by having to grub among the weights and measures that we have as compared with the time that would be required for the Metric system. Think what this means for the millions now at school, and the greater millions yet to come.

The Objectors. — The manufacturers who have their machines, scales, and all their equipment based on the present system are not to be too much blamed because they object to change, but other nations have made the leap, and found that it paid in the long run. Our technical books would all have to be re-written, and that would be the salvation of some of them that are now gray-haired.

Latin Trade. — All the countries south of us use this system. It is really a Latin triumph. It was introduced by France in 1801. Germany adopted it about 1877, and has reaped a rich reward with her South American trade. Her standards require no changing to suit the customers of that great continent.

Tables. — Enough of the system is presented here for practical use. The friends of the metric reform should not go into details that are not required, but should keep the figures down to the simplest and smallest limits.

In the table of "Precise Equivalents" the denominations in everyday use are presented. In the first column the figures are given sufficiently close for practical use; in the second they are more exact.

TABLES OF THE SYSTEM

Length. — The denominations in practical use are millimetres (mm.), centimetres (cm.), metres (m.), and kilometres (km.).

10 mm. = 1 cm.; 100 cm. = 1 m.; 1,000 m. = km. Note.— A decimetre is 10 cm.

Weight. — The denominations in use are grams (g.), kilos (kg.), and tons (metric tons).

1,000 g. = 1 kg.; 1,000 kg. = 1 metric ton.

Capacity. — The denominations in use are cubic centimetres (c. c.) and litres (l.).

1,000 c. c. = 1 l.

Relation of capacity and weight to length: A cubic decimetre is a litre, and a litre of water weighs a kilo.

APPROXIMATE EQUIVALENTS

A metre is about a yard; a kilo is about 2 pounds; a litre is about a quart; a centimetre is about $\frac{1}{3}$ inch; a metric ton is about same as a ton; a kilometre is about $\frac{5}{8}$ mile; a cubic centimetre is about a thimbleful; a nickel weighs about 5 grams.

PRECISE EQUIVALENTS

1 acre	=	.40	hectar	.4047
1 bushel	=	35	litres	35.24
1 centimetre	=	.39	inch	.3937
1 cubic centimetre	=	.061	cubic inch	.0610
1 cubic foot	=	.028	cubic metre	.0283
1 cubic inch	=	16	cubic cent.	16.39
1 cubic metre	=	35	cubic feet	35.31
1 cubic metre	=	1.3	cubic yards	1.308
1 cubic yard	=	.76	cubic metre	.7645

1 foot	= 30	centimetres	30.48
1 gallon	= 3.8	litres	3.785
1 grain	= .065	gram	.0648
1 gram	= 15	grains	15.43
1 hectar	= 2.5	acres	2.471
1 inch	= 25	millimetres	25.40
1 kilo	= 2.2	pounds	2.205
1 kilometre	= .62	mile	.6214
1 litre	= .91	quart (dry)	.9081
1 litre	= 1.1	quarts (liquid)	1.057
1 metre	= 3.3	feet	3.281
1 mile	= 1.6	kilometres	1.609
1 millimetre	= .039	inch	.0394
1 ounce (avoirdup's)	= 28	grams	28.35
1 ounce (Troy)	= 31	grams	31.10
1 peck	= 8.8	litres	8.809
1 pint	= .47	litre	.4732
1 pound	= .45	kilo	.4536
1 quart (dry)	= 1.1	litres	1.101
1 quart (liquid)	= .95	litre	.9464
1 square centimetre	= .15	square inch	.1550
1 square foot	= .093	square metre	.0929
1 square inch	= 6.5	square centimetres	6.452
1 square metre	= 1.2	square yards	1.196
1 square metre	= 11	square feet	10.76
1 square yard	= .84	square metre	.8361
1 ton (2,000 lbs.)	= .91	metric ton	.9072
1 ton (2,240 lbs.)	= 1	metric ton	1.017
1 ton (metric)	= 1.1	ton (2,000 lbs.)	1.102
1 ton (metric)	= .98	ton (2,240 lbs.)	.9842
1 yard	= .91	metre	9144

MEASURES OF LENGTHS

Metric Denominations and Values		Equivalents in Denominations in Use	
Myriametre	10,000 metres.	6.2137	miles.
Kilometre	1,000 metres.	0.62137	mile, or 3,280 ft. 10 in.
Hectometre	100 metres.	328	feet 1 inch.
Dekametre	10 metres.	393.7	inches.
Metre	1 metre.	39.37	inches.
Decimetre	1-10 of a metre.	3.937	inches.
Centimetre	1-100 of a metre.	0.3937	inch.
Millimeter	1-1000 of a metre.	0.0394	inch.

MEASURES OF SURFACE

Metric Denominations and Values		Equivalents in Denominations in Use	
Hectare	10,000 square metres.	2.471	acres.
Are	100 square metres.	119.6	square yards.
Centare	1 square metre.	1,550	square inches.

MEASURES OF CAPACITY

Metric Denominations and Values			Equivalents in Denominations in Use		
Names	Number of Litres	Cu. Meas.	Dry Meas.	Liquid or Wine Measure	
Kilolitre or stere	1-000	1 cu. metre	1.308 cu. yds	264.17	gals.
Hectolitre	100	1-10 of a cu. metre	2 bush.& 3.35 pks.	26.417	gals.
Dekalitre	10	10 cu. deci	9.08 quarts	2.6417	gals.
Litre	1	1 cu. deci	0.908 quart	1.0567	qts.
Decilitre	1-10	1-10 of a cu. deci.	6.1022 cu. in	0.845	gill.
Centilitre	1-100	10 cu. centi	0.6102 cu. in	0.338	fld. oz.
Millilitre	1-1000	1 cu. centi	0.061 cu. in	0.27	fld. drm.

WEIGHTS

Metric Denominations and Values			Equivalents in Denominations in Use	
Names	Number of Grams	Weight of What Quantity of Water at Maximum Density	Avoirdupois Weight	
Miller or tonneau	1,000,000	1 cu. metre	2204.6	lbs.
Quintal	100,000	1 hectolitre	220.46	lbs.
Myriagram	10,000	10 litres	22.046	lbs.
Kilogram or kilo.	1,000	1 litre	2.2046	lbs.
Hectogram	100	1 decilitre	3.5274	oz.
Dekagram	10	10 cu. centimetres	0.3527	oz.
Gram	1	1 cu. centimetre	15.432	grains.
Decigram	1-10	1-10 of a cu. centimetre	1.5432	grains.
Centigram	1-100	10 cu. millimetres	0.1543	grain.
Milligram	1-1000	1 cu. millimetre	0.0154	grain.

"In Germany it is becoming the practice to leave out of account all but the principal measures, such as the kilometre, the metre, the centimetre, and the millimetre; and in measures of weight the kilogramme, the gramme, the centigramme, and the milligramme; and these are written decimally." For example, we should write 3471.927 metres. If we want to know how many kilometres that is all we have to do is to move the point 3 figures to the left, thus dividing by 1,000 = 3.471927.

Contracts. — The British are losing so many contracts for engines, boilers, and machinery of all kinds, owing to retaining the present system, that they are between two fires. A change means expense; and the loss of trade hurts also.

Book. — A former member of the British Government, Mr. Arnold Foster, has written a book entitled, "The Coming of the Kilogram," Cassell & Co., New York, 25 cents. What he says applies to us here also. In the United Kingdom the Educational Department has made a knowledge of the Metric System compulsory.

We are told that an ideal system should be, "Uniform, accurate, easily understood and used, widely known, and simple in calculation."

"Measurements are now made to the one-millionth part of an inch, and quantities as small as the ten-thousandth part of a grain are weighed."

"At one time nearly all civilized people used the Roman figures, and were accustomed to write LXXXVIII for 88, and CCCCLIX for 459; but fortunately the common sense of the world got rid of the Roman figures and adopted the Arabic ones in their stead."

How would you like to multiply LXXXVIII by CCCCLIX? Yet the Roman architects used that system.

If Germany, Turkey, and all the other nations changed, why can we not? "There is really only one way (of changing), and that is to fix on one set of weights and measures by law," and forbid the use of any others. "No German would now think of going back to the old German weights and measures, which were stupid and complicated."

"One after another the different civilized nations of the world have made up their minds to get rid of the bad, complicated weights and measures, and adopt a new system. In every single case, after carefully considering all that could be said on the point, they have decided to use the Metric System."

"It is an acknowledged fact that calculations in the Metric System necessitate less than one-half the number of figures required by the present system."

Mr. Balfour, the leader of the British Conservatives, said: "There can be no doubt, I think, whatever, that the judgment of the whole civilized world, not excluding the countries which still adhere to the antiquated system under which we suffer, has long decided that the Metric System is the only rational system."

With the adoption of this system and a reformed spelling two wasted years would be saved to all English-speaking children.

For the United States there is a free pamphlet published by the Department of Commerce and Labor, entitled, "The International System of Weights and Measures." It is meant to save the Department from making special answers on this interesting reform.

There is first the legalizing in 1866.

Post-Office. — The Postmaster-General is to furnish certain post-offices with balances to weigh the mails.

Coinage. — The weights and accounts are now given in the Metric System.

Electric Work. — The legal units of electrical measures in the United States are based on the Metric System (1894).

Medical. — "The Metric System shall hereafter be employed in the medical department of the Navy." April 15, 1878. And also in the War Department, 1894.

Public Health and Marine Hospital. — For certain purposes, November 21, 1902.

Beyond. — In Porto Rico and the Philippines the system is obligatory.

THE HEIGHT OF BUILDINGS

The "Sky-Piercer" is now "in our midst." It runs up from 600 to 750 feet, with more than 50 stories; and the latest one proposed is set at 1,200, or higher than the Eiffel tower.

The Singer Building has 41 stories, a capacity of 6,000 people, a tower that weighs 23,000 tons, and a weight of 1,600 tons on one column.

The Metropolitan Life Insurance Company has another of the same high type. They are to the ordinary sky-scraper what the Dreadnaughts are to the former type of battleship.

Will 1,200 feet be the limit? We used to think the 20-story Masonic Temple of Chicago about the highest building that would ever be erected.

Is it really necessary to rise so high in the air? Does it pay? Is there not too much space lost by the elevators?

There is an excellent article on the subject of the Piercers in *The Saturday Evening Post*, for November 13, 1909. A few extracts will be of value, for builders should stand on the side of the Piercer if it is desirable, or change their codes to forbid it if it is not.

When we read the following it is clear that every owner cannot put up a Piercer even if he has the money: "If Manhattan Island, from Fourteenth Street to the Battery, were entirely occupied by buildings 20 stories high, and all the offices were occupied by an average working force, it would, in the morning and evening, require 7 times the present street area to allow all of them to reach and leave their offices promptly."

They would have to get 7-deck streets, or make them wider. "As a rule, one building of 14 stories occupying one-fourth of a square, and 6-story buildings over the remaining three-fourths, will give ample accommodation to all the people who will transact business within that square."

"If builders in lower New York had limited themselves to structures not over 15 stories high, business in that city, so far as it relates to rental and management of office-buildings, would be in better shape than it actually is at the present time."

The writer of the article thinks that just as the Tower of Babel was a mistake in the sky-piercing line, so the present structures also are. At the time the article was written there were 1,815 vacant offices in New York—about 10 acres of space without tenants.

Cost. — This mounts up in a discouraging way as we get near the stars. The cost per rentable square foot, not the constructive cost, is put on a high building at $10 for the ground floor and basement combined, $5.25 for the second floor, $5.75 for the third, $6.30 for the fourth, and $123.75 for the sixty-second.

Another building is detailed for cost by Mr. Beach, the writer, as follows:

"Following is the method by which the ground value may be determined from the rental revenue, provided the building is of proper size for the ground upon which it stands.

"This hypothetical building is 20 stories high and occupies the same area on lower Broadway as that upon which the 62-story building previously mentioned was to stand—49,250 square feet.

"Although such is seldom the case, it will be assumed that the earnings of the basement will equal 6 per cent. of its cost. The construction cost of the ground floor is $20 per rentable square foot; the average rental per rentable square foot is $10. Deducting the operating charges and the interest on the cost of the building from this amount, we find the net revenue as income to the ground value would be $6.95 per rentable square foot of building space. The ratio of rentable area in the building to the total ground area is 60 per cent., giving, therefore, to 1 square foot of ground a rental value of 60 per cent. of $6.95, which is $4.17, and a total value per square foot of ground of $69.50, based upon the earnings of the first floor.

"The construction cost per rentable square foot of the second story will be $18, the average rental revenue per square foot will be $8, the net revenue as income to the ground will be $5.37, and the net revenue to 1 square foot of ground will be, estimating the ratio of rental area to total ground area at 50 per cent., $2.68, giving a ground value of $44.50, based on the earnings from the second floor.

"Assuming that the construction cost per rentable square foot of the 18 upper stories will be $14—which is not exact, as every floor above the second costs more than the floor immediately beneath—and estimating the average income per rentable square foot at $2.50, and the ratio of rentable to ground area at 45 per cent., we have a net revenue to 1 square foot of ground of 42 cents, or a ground value per rentable square foot of $7 from all of the upper eighteen floors. This gives a ground value of $240 per square foot, or $11,820,000 for that tract of ground."

Elevator Service. — Here we come to another trouble with the high building that makes us think of those owners who always maintain that the lower floors are the ones that really pay.

"For example, in a building 12 stories high the cost of elevator service is, per square foot, up to the tenth or twelfth floor, about 12 cents per annum, while it is not over 7 cents to the fourth floor."

New York and Philadelphia have no limit to height; Chicago allows 260 feet; Denver, 125; Underwriters, 125; Omaha has no limit. At this writing one sixteen-story building is finished; and another of 18 stories is about to be begun.

Model City. — In a model code I compiled several years ago for an ideal city plan a limit of 7 stories was set. This is high enough for any city, no matter what its population. But now I should revise that requirement. Leaving the 7-story height for the city at large, a good idea would be to permit any height at certain points, such as small parks near the center of the city, or corners of streets. This would be a good advertising idea. People go hundreds of miles to see the Singer Building and the Metropolitan. Every city ought to have a Babel Tower for the neck stretchers. It pays.

In an old city, however, it would be hard to establish a rule that allowed one to use his property for a high structure, and restrict another. The truth is that all Western cities are glad to get sky-scrapers, and the higher they are the better they like them.

But in the long run a 7-story limit would pay everybody better.

The best plan, the ideal plan, would be a limit to height in general, but an exception in particular for the benefit of our country cousins,—and our own, when we scrape in their dollars over the hotel and other counters.

"THE ISLES OF GREECE, THE ISLES OF GREECE"

In a former chapter Mr. Humphrey stood on the side of the reinforced concrete work of San Francisco. The following interview from the *Plain-Dealer* shows that he believes it is possible to equal Greece if we will only accept the new material. Greece had such fine buildings that this is good news.

"Until the concrete era, Humphrey says, Cleveland will not be safe, either from fire or from disease. When that time comes Cleveland will be like a Grecian city of marble, brilliantly white. One will speed past it on trains running on concrete beds. One will see clean, light-colored farmhouses of concrete, artistic barns, windmills, water towers, even pigpens, all white and clean.

"Mr. Humphrey was picked out by the United States government as being best equipped to investigate the building material problem, and has been investigating it for years. The government has put a large testing station at St. Louis at his command.

"'Cleveland at present is full of fire traps,' said President Humphrey, Thursday. 'There's hardly a building here really fireproof. The so-called fireproof buildings of steel and terra cotta are not fireproof. They are all liable to be burned.

"'In case of a big fire Clevelanders down town could escape with their lives, for the streets are wide. In New York, however, a big conflagration would kill thousands in the narrow streets. What they should do there is to double deck the streets.

"'But concrete, cheap and beautiful, will be the building material in 1919. Everything will be made of concrete then. In 1893 there were only about 300,000 barrels of cement manufactured. Last year 50,000,000 barrels were made. You can imagine what the output will be 10 years hence, with lumber decreasing in quantity and increasing in price.

(In 1910 the total output of Portland cement was 64,200,000 barrels.)

"'Ten years from now all the sky scraping buildings will be of concrete, and they will be fireproof. No matter what the weight is above, the concrete on the steel reinforcements is sufficient to protect the steel so the building will not be injured.

"'Ten years from now Clevelanders will come down town part of the way over concrete streets and part of the way in a clean concrete subway. They will walk on concrete stairs and sidewalks to their offices, which will be concrete. Their homes will be of concrete. Both office and house rent will be less, by reason of the smaller original investment and the reduced cost of upkeep. There will be practically no insurance to pay. Houses will last forever, nearly.

"'The rent saved in Cleveland alone will probably mount into the hundreds of thousands in a few years. The taxes will be less by reason of the absence of an expensive fire department. Just an occasional engine house will be required to take care of fires inside the buildings.

"'Clevelanders will ride out of the city on safe trains. They will find the country beautified by concrete houses—yes, even to the pigpens. Out West even now farmers are building concrete pigpens, for they find that it is cheaper; they save the feed that is ground into a mud pen and lost.

"'If Cleveland were rebuilt to-day with concrete $53,000,000 would be saved the people. On municipal buildings, sewers, paving, sidewalks, and bridges, the saving, if they were built of concrete, would be about $6,800,000, and figuring from the tax duplicate for this year that $231,500,000 represents buildings, the saving would be about one-fifth that, or about $46,000,000. The fire loss in Cleveland, I understand, will amount to something like a million for the year. Of this, the loss of some $700,000 on buildings would be entirely saved and the loss of some $400,000 on contents would be but one-tenth of that.

"'Cleveland is a beautiful city now, but 10 years from now, if you were to come here from a foreign land, you might think you had come to Greece of several thousand years ago, it would be so changed by the concrete architecture.'"

Mr. Humphrey is not the only one who is dreaming reinforced concrete dreams. In the *Cosmopolitan* for February, 1911, Mr. Edison says we are foolish in sticking to old materials. "Builders who stick to brick and steel are behind the times. Within thirty years all construction will be of reinforced concrete."

The age of reinforced concrete is certainly before us,—but the age of stone, steel, and brick is not gone. "Never prophesy unless you know," is an old maxim, and all we can do is to make a guess. Here is mine:

Granite, marble, stone, brick, terra cotta, steel, and reinforced concrete will be the coming materials, and the old-timers will be used more than they are now. There is room enough, and glory enough for all, including the newcomer, at which the stone journals might as well stop jeering to please their advertisers, who will not let them tell the truth.

But granite, marble, and limestone will be used more for useful buildings than for useless mausoleums. That memorial business will die out as it deserves to. Properly understood, Egypt and the Taj Mahal were the end of it—size for Egypt, and beauty for the Taj. There will be splendid work for stone workers in the future, but it will be useful as well as beautiful. To wood houses and tombs the age says,

FINIS.

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student to execute almost any kind of practical and artistic work. Covers all important subjects, such and bond, ornamental brickwork, damp courses, quality of brickwork, forming of pilasters, quoins, skew arches, splay work, brick joints, chimneys, fireplaces, flues, brick pavings, etc.

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