THE

Smith's Pocket Companion,

CONTAINING

USEFUL INFORMATION AND TABLES

ON

IRON AND STEEL,

For the Use of Smiths and Steel Workers.

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PREFACE.

This volume is intended as a hand-book and guide for smiths and men working in the shop; I have tried to make the contents as simple as possible in order to enable those who have not had the chance of obtaining a good education, to master it with ease.

The art how to work and turn iron into all required shapes and forms may be considered the profession; this can not be obtained by the wave of the hand. It takes years of practice and close attention to the trade, and by faithfully studying theoretically as well as practically, a man may become a master of his trade.

The smith's trade has been greatly neglected in modern technical literature. Almost all other professions have scores of works up to expensive folios, devoted to their elevation and education.

The present being, therefore, probably the first English book on the subject, may not be as perfect as I could have wished, notwithstanding that great care has been bestowed upon it in selecting very carfully all the material from the manufacture of iron to the last table.

In the production of this book I do not claim the whole of its contents as being original. I make this acknowledgement, to those whose works I have consulted for information. From Haswell I have received valuable assistance; and with the consent of the Cresent Steel Co., Miller, Metcalf, and Parkin, I am enabled to give a good fundamental theory on steel. The large majority of problems contained in it, are the product of study during my spare time. It is issued with the hope of making some contribution, however humble, to the true and permanent elevation of my fellow craftesmen.

I trust the work in this form may promote this education and that a direct and wide influence for good may be obtained.

CONTENTS.

REMARKS.

Page 46, fifth line below Figure XXXI, the word *tick* should read *the*.

Page 29, sixth line above forge fires the word *material* should read *natural*.

Page 85, "Copper .67 and Zinc .33" means that "Brass is composed of .67 parts of Copper and .33 parts of Zinc.

Manufacture of Iron.

(From Haswell.)

The foreign substances which iron contains mortify its essential properties. Carbon adds to its hardness, but destroys some of its qualities and produces cast iron or steel according to the proportion it contains. Sulphur renders it fusible, difficult to weld and brittle when heated or "hot short." Phosphorus renders it "cold short;" but may be present in the proportion of $\frac{2}{1000}$ or $\frac{3}{1000}$ without affecting injuriously its tenacity. Antimony, arsenic, and copper have the same affect as sulphur, the last in a greater degree.

THE PROCESS OF MAKING IRON.

Cast iron varies much upon fuel used. A larger yield from the same furnace and a great economy in fuel are affected by the use of a hot blast. The greater heat thus produced causes the iron to combine with a larger percentage of foreign substances. Cast iron for purposes requiring great strength should be smelted with a cold blast. Pig iron, according to the proportion of carbon which it contains, is divided into

Foundry iron and Forge iron, the latter adapte only to conversion into maleable iron, while th former, containing the larger proportion of cai bon, can be used either for castings or bars There are many varieties of cast iron, differin by almost insensible shades; the two principa divisions are gray, and white, so termed fror the color of their fracture. Their properties ar very different. Gray iron is softer and less bri tle than white. It is in a slight degree maleabl and flexible, and is not sonorous. It can b easily drilled in a lathe, and does not resist th file. It has a brilliant fracture—gray or some times blue-gray color; the color is lighter tha the grain, becomes close, and its hardness ir creases at the same time. It melts at a lowe heat than the white iron and preserves its fluic ity longer. The color of the fluid metal is re and deeper in proportion as the heat is lower; does not adhere to the ladel, it fills the moulc well, contracts less and contains fewer cavitie than white iron; the edges of its castings ar sharp, and the surface smooth and convex. medium bright and gray color, fracture sharp t the touch and a close, compact texture indica a good quality of iron; a grain either very larg or small, a dull, earthy aspect, loose textur dissimilar crystals, mixed together indicate a inferior quality. Gray iron is used for m chinery and ordinary purposes where the piec are to be bored or fitted. Its tenacity and sp cific gravity are diminished by annealing. I mean specific gravity is 7.2.

White iron is very brittle and sonorous, ar it resists the file and chisel. It is susceptible light polish, the surface of its casting concav the fracture presents a silvery appearance generally, fine grain and compact, sometimes radiating or lamellar; when melted it is white and throws off a great many sparks, and its qualities are the reverse of those of the gray iron. It is therefore unsuitable for machinery purposes: its tenacity is increased and its specific gravity diminished by annealing. Its mean specific gravity is 7.5.

Mottled iron is a mixed of white and gray; it has a spotted appearance, it flows well and with few sparks; its castings have a plain surface with edges slightly rounded. It is suitable for shot and shells. A fine mottled iron is the only kind suitable for castings which require great strength, such as beams, centers, cylinders and cannon. Besides these general divisions, the different varieties of pig iron are more particularly distinguished by numbers, according to their relative hardness.

Number one is the softest iron, possessing in the highest degree the qualities belonging to gray iron. It has not much strength, but on account of its fluidity when melted and of its mixing advantageously with old or scrap iron and with the harder kinds of cast iron, it is of great use to foundries and commands the highest price.

Number two is harder and closer grained, and stronger than number one. It has a gray color and considerable lustre. It is the character of iron most suitable for shells.

Number three is still harder than number two. Its color is gray, but inclined to white. It is principally used for mixing with other kinds of iron.

Number four is bright iron; number five mottled, and number six white, which is unfit for general use by itself. The qualities of these various descriptions depend upon the proportion of carbon and upon the state it exists in the metal.

In darker kinds of iron where the proportion is sometimes seven per cent., it exists partly in the state of graphite or plumbago, which makes the iron soft.

In white iron the carbon is thoroughly combined with the metal as in steel.

Cast iron frequently contains a proportion of foreign ingredients from the ore, such as earth or oxides of the other metals, and sometimes sulphur and phosphorus, which are all injurious to quality.

Sulphur hardens the iron, and unless in a very small proportion destroys its tenacity. These foreign substances and also a portion of the carbon are separated by melting the iron in contact with air; and soft iron is thus rendered harder and stronger.

The effect of remelting varies with nature of the iron and the character of ore from which i has been extracted; that from hard ore such as the magnetic oxides, undergoes less alteration thar that from the hematites; the latter being some times changed from number one to whites by a single remelting in an air furnace. The colo and textures of cast iron depends greatly upon the volume of the castings and rapidity of it cooling. A small casting which cools quickly i almost white, and the surface of large casting partakes more of the quality of white metal tha the interior.

All cast iron expands at the moment of be coming solid and contracts in cooling; gray iron expands more and contracts less than other iron.

The contraction is about $\frac{1}{100}$ for gray and strongly mottled iron, or $\frac{1}{8}$ of an inch per foot.

Remelting iron improves its tenacity.

Thus a mean of fourteen cases for two fusions gave: for first fusion, a tenacity of 29,284 pounds; for second fusion, 33,790 pounds; for two cases: for first fusion, 15,129 pounds; for second fusion, 35,786 pounds.

WROUGHT IRON.

Wrought iron is made from the pig iron in a bloomery fire or in a puddling furnace—generally in the latter.

The process consists in melting it and keeping it exposed to a great heat, constantly stirring the mass, bringing every part of it under the action of the flames until it loses its remaining carbon, when it becomes malleable iron. When, however, it is desired to obtain iron of the best quality, the pig iron should be refined.

REFINING.

This operation deprives the iron of considerable portion of its carbon; it is effected in a blast furnace, where the iron is melted by means of charcoal or coke, and exposed for some time to the action of the geat heat; the metal is then run into a cast iron mould, by which it is formed into a large broad plate. As soon as the surface of the plate is chilled, cold water is poured on to render it brittle.

The bloomery resembles a large forge fire, when charcoal and a strong blast are used; and the refined metal or pig iron after being broken into pieces of the proper size, is placed before the blast, directly in contact with charcoal; as the metal fuses, it falls into a cavity left for that purpose below the blast, for the bloomer works it into the shape of a ball, which he places again before the blast with fresh charcoal; this operation is generally again repeated when the ball is ready for the shingler.

PUDDLING FURNACE.

The puddling furnace is a reverberatory furnace, where the flame of bituminous coal is brought to act directly upon the metal.

The metal is first melted; the puddler then stirs it, exposing each portion in turn to the action of the flame, and continues this as long as he is able to work it.

When it has lost its fluidity he forms it into balls weighing from 80 to 100 pounds, which nex pass to the shingler. Shingling is performed in a strong squeezer or under the trip hammer. Its object is to press out as perfectly as practicabl the liquid cinders which the ball still contains; i also forms the ball into shape for the puddl rolls. A heavy hammer, weighing from six to seven tons, effects this object most thoroughly but not as cheaply as the squeezer.

The ball receives from fifteen to twent blows of that hammer, being turned from time to time as required; it is now termed a bloom, and is ready to be rolled or hammered; or the ball i passed once to the squeezer, and is still ho enough to be passed through the puddle rollers.

PUDDLE ROLLERS.

By passing through different grooves in thes rollers, the bloom is reduced to a rough bar fror three to four feet in length, its name converging an idea of its condition, which is rough and imperfect.

PILING.

To prepare rough bars for this operation, they are cut by a pair of shears into such lengths as are best adapted to the size of the finished bar required; the sheared bars are then piled one over the other, according to the volume required, when the pile is ready for balling.

BALLING.

This operation is performed in the balling furnace, which is similar to the puddling furnace, except that its bottomed hearth is made up from time to time with sand; it is used to give welding heat to the pile to prepare them for rolling.

THE FINISHING ROLLERS.

The balls are passed successively between rollers of various forms and dimentions, according to the shape of the finished bars required.

The quality of the iron depends upon the description of pig iron used, the skill of the puddler and the absence of the diliterious substances in the furnace. The strongest cast iron produces the strongest malleable iron, for many purposes, such as sheets for tinning, best boiler plates and bars for converting into steel; charcoal iron is used exclusively, and, generally, this kind of iron is to be relied upon for strength and toughness, with greater confidence than any other; though iron of superior quality is made from pigs made with other fuel and with the hot blast. Iron for gun barrels has been lately made from anthracite hot blast pigs. Iron is improved in quality by judicious working, reheating and hammering and rolling. Other things being equal, the best iron is that which has been wrought the most.

STEEL.

Steel is a compound of iron and carbon, in which the proportion of the latter is from 1 to 5 per cent and even less in some kinds. Steel is distinguished from iron by its fine grain, and by the action of diluted nitric acid, which leaves a black spot upon steel, and upon iron a lighter color in proportion to the carbon it contains.

There are many varieties of steel, the principal of which are:

Natural Steel—Obtained by reducing rich and pure descriptions of iron ore, with charcoal, and refining the cast iron so as to depreciate off a sufficient portion of carbon to bring it to a malleable state. It is used for files and other tools.

Indian Steel—Termed Woots, is said to be natural steel; containing a small portion of other metals.

Blistered steel, or steel of cementation, is prepared by the direct combination of iron and carbon; for this purpose the iron in bars is put in layers alternating with powdered charcoal; in a close furnace, and exposed for seven or eight days to a heat of about 9,000° and then put to cool for a like period.

The bars on being taken out, are covered with blisters, have acquired a brittle quality, and exhibit in the fracture a uniform of crystalline appearance. The degree of carbonization is varied according to the purposes for which the steel is intended, and the best qualities of iron (Russian and Swedish) are used for the finest kind of steel.

Tilted steel is made from blistered steel moderately heated, and subjected to the action of a tilt-hammer, by which means its tenacity and density are increased.

Shear steel is made from blistered or natural steel, refined by piling thin bars into fagots which are brought to a welding heat in a reverberating furnace and hammered or rolled again into bars. This operation is repeated several times to produce the finest kinds of steel, which are distinguished by the names of Half Shear, Single Shear, and Double Shear steel, or steel of 1, 2, or 3 marks, according to the number of times it has been piled.

Cast steel is made by breaking blistered steel into small pieces and melting it in close crucibles, from which it is poured into iron moulds; the ingot is then reduced to a bar by hammering or rolling. Cast steel is the best kind of steel, and best adapted for most purposes. It is known by a very fine, even, and close grain, and a silvery, homogeneous fracture. It is very brittle, and acquires extreme hardness, but is difficult to weld without the use of a flux. The other kinds of steel have a similar appearance to cast steel, but the grain is coarser and less homogeneous. They are softer and less brittle and weld more readily. A fibrous or lamellar appearance in the fracture indicates an imperfect steel. A great toughness and elasticity, as well as hardness, is made by forging together "steel and iron," forming the celebrated

Damask steel which is used for sword blades, springs, etc. The damask appearance of which is produced by a diluted acid which gives a black tint to the steel, while the iron remains white.

Various fine steels or alloys of steel, platinum, rhodium and aluminum, have been made with a view to imitating the Damascus steel, woots, etc.; and improving the fabrications of the finer kinds of surgical and other instruments.

HARDENING AND TEMPERING.

Upon these operations the quality of manufactured steel in a great measure depends.

Hardening is effected by heating the steel to a cherry red, and plunging it into cold water or some cooling solution; the degree of hardness depends upon the heat and rapidity of cooling, the steel is thus rendered so hard that it resists the hardest file, and it becomes at the same time very brittle.

The degree of heat and the nature of the cooling medium must be chosen with reference to the quality of the steel and purposes for which it is intended. Cold water gives it greater hardness than oils and other fatty substances. Water, acids and salts render it the hardest at any rate.

Tempering steel in its hardest state being too brittle for most purposes unless the tools are very heavy, as rock and granite tools or drills, on which no temper must be drawn.

The requisite strength and elasticity are obtained by tempering and then drawing the temper by heating the hardened steel to a certain degree and then cooling it suddenly.

The proper heat is usually obtained or ascertained by the color which the surface of the steel assumes from the film of oxides thus formed. The degree of heat to which these several colors correspond are as follows:

At 430° a very faint yellow	Drills for hard substances.
At 450° a pale straw color	
At 470° full yellow	Shears, turning tools, etc.
At 490° brown color	
At 510° brown, white purple spots	Hammers.
At 538° purple	Punches, dies, taps
At 550° dark blue	Cold chisels.
At 560° full blue, or sky blue	Cutting tools, as cutlery.
At 600° grayish blne, verging on black	Saws, springs, swords.

CASE HARDENING.

This operation consists in converting the surface of wrought iron into steel by concentration for the purpose of adapting it to receive a polish or to bear friction, etc. This is done by heating iron to a cherry red in a close vessel in contact with carbonic materials and then plunging it into cold water.

Bones, leather, hoofs and horns of animals are generally used for this purpose after having been burned or roasted so that they can be powdered or pulverized. Soot is also frequently used.

Condensed Suggestions For Steel Workers.

(From Miller, Metcalf & Parkin.)

ON ANNEALING.

Owing to the fact that the opertion of rolling or hammering steel makes it very hard, it is frequently necessary that the steel should be annealed before it can be conveniently cut into the required shapes for tools.

Annealing or softening is accomplished by heating steel to a red heat and then cooling very slowly, to prevent it from getting hard again.

The higher the degree of heat, the more will steel be softened, until the limit of softness is reached, when the steel is melted.

It does not follow that the higher a piece of steel is heated the softer it would be when cooled; this is proven by the fact that an ingot is always harder than a rolled or hammered bar made from it.

Therefore, there is nothing gained by heating a piece of steel hotter than good bright cherry red; on the contrary, a higher heat has several disadvantages. First, if carried too far, it may leave the steel actually harder than a good red heat would leave it.

Second, if a scale is raised on the steel, this scale will be harsh, granular, oxide of iron, and will spoil the tools used to cut it. It often occurs that steel is scaled in this way, and then, because it does not cut well it is still customary to heat it again, and hotter still, to overcome the trouble, while the fact is, that the more this operation is repeated the harder the steel will work, because of the hard scale and the harsh grain underneath.

Third, a high scaling heat, continued for a little while, changes the structure of the steel, destroys its crystaline property, makes it brittle, liable to crack in hardening and impossible to refine.

Again, it is common practice to put steel into a hot furnace at the close of a day's work and leave it there all night.

This method gets the steel too hot, always raises a scale under it, and, worse than either, it leaves it soaking in the fire too long, and this is more injurious to the steel than any other operation to whieh it can be subjected. A good illustration of the destruction of crystaline structure by long continued heating may be had by operating on chilled cast iron. If a chill be heated red hot and removed from the fire as soon as it is hot it will, when cold, retain its peculiar crystaline structure; if now it be heated red hot, and left at a moderate red for several hours, in short, if it be treated as steel often is. and be left in the furnace over night, it will be found, when cold, to have a perfect amorphous structure, every trace of chill crystals will be gone, and the whole piece be non-crystaline gray cast iron. If this is the effect upon coarse cast iron, what better is to be expected from fine cast steel?

A piece of fine tap steel, after having been in a furnace over night, will act as follows:—It will be harsh in the lathe and spoil the cutting tools.

When hardened it will almost certainly crack; if it does not crack it will have been a remarkably good steel to begin with. When the temper is drawn to the proper color and the tap is put into use, the teeth will either crumble off or crush down like so much lead.

Upon breaking the tap, the grain will be coarse and the steel brittle.

To anneal any piece of steel, heated red hot, heated uniformly and heated through, taking care not to let the ends and corners get too hot. As soon as it is hot, take it out of the fire, the sooner the better, and cool it as slowly as possible. A good rule for heating is to heat at so low a red heat that when the piece is cold it will still show the blue gloss of the oxide that was put there by the hammer or rolls.

Steel annealed in this way will cut very soft; it will harden very hard, without cracking, and when tempered it will be very strong, nicely refined and will hold a keen, strong edge.

ON HEATING TO FORGE.

Fully as much trouble and loss are caused by improper heating in the forge fire as in the tempering fire, although steel may be heated safely very hot for forging if it be done properly; but any "high degree of heat," no matter how uniform it may be, is unsafe for "hardening."

The trouble in a forge-fire is usually "uneven heat," and not too light heat. Suppose the piece to be forged has been put into a very hot fire, and forced as quickly as possible to a high yellow heat, so that it is almost to the scintillating point. If this be done, in a few minutes the outside will be quite soft and in nice condition for forging, while the middle parts will be not more than red hot. The highly heated soft outside will have very little tenacity: that is to say, this part will be so far advanced toward fusion that the particles will slide easily over one another, while the less highly heated inside parts will be hard, possessed of high tenacity, and the particles will not slide so easily over each other.

Now let the piece be placed under the hammer and forged, and the result will be as shown in Figure 1.

The soft outside will yield so much more readily than the hard inside that the outer particles will be torn asunder, while the inside will remain sound and the piece will be pitched out and branded "burned."

Suppose the case to be reversed and the inside to be much hotter than the outside: that is, that the inside shall be in a state of semi-fusion, while the outside is hard and firm. Now let the piece be forged and we shall have the case as shown in Figure 2. The outside will be all sound and the whole piece will appear perfectly good until it is cropped, and then it is found to be hollow inside, and it is pitched out and branded "burst."

In either case, if the piece had been heated soft "all through" or if it had been only red hot "all through" it would have forged perfectly sound and good.

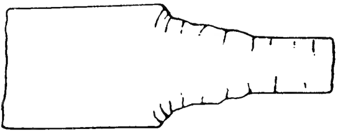


FIGURE 1.

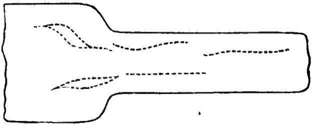


FIGURE 2.

If it be asked, why then is there ever any necessity for smiths to use a low heat in forging, when a uniform high heat will do as well?

We answer—In some cases a high heat is more desirable to save heavy labor, but in every case where a fine steel is to be used for casting purposes it must be borne in mind that very heavy forging refines the bars as they slowly cool, and if the smith heats such refined bars until soft he raises the grain, makes them coarse, and he cannot get them fine again unless he has a very large steam-hammer at command and knows how to use it well.

In following the above hints there is a still greater danger to be avoided: that is incurred by letting the steel lie in the fire after it is properly heated. When the steel is hot through it should be taken from the fire immediately and forged as quickly as possible. "Soaking" in the fire causes the steel to become "dry" and brittle, and does it more injury than any bad practice known to the most experienced.

ON HEATING.

Owing to varying instructions on a great many different labels, we find at times a good deal of misapprehension as to the best way to heat steel; in some cases this causes too much work for the smiths, and in other instances disasters follow the act of hardening.

There are three distinct stages or times of heating:

First, for forging.

Second, for hardening.

Third, for tempering.

The first requisite for a good heat for forging is a clean fire and plenty of fuel, so that jets of hot air will not strike the corners of the piece; next, the fire should be regular, and give a good uniform heat to the whole part forged. It should be keen enough to heat the piece as rapidly as may be, and allow it to be thoroughly heated through, without being so fierce as to overheat the corners.

Steel should not be left in the fire any longer than is necessary to heat it clear through, as "soaking" in the fire is very injurious; and on the other hand it is necessary that it should be hot through to prevent surface cracks, which are caused by the reduced cohesion of the overheated parts which overlie the center of an irregularly heated piece.

By observing these precautions a piece of steel may always be heated safely, up to a bright yellow heat, when there is much forging to be done on it, and at this heat it will weld well.

The best and most economical of welding

fluxes is clean, crude borax, which should be first melted and then ground to a fine powder. Borax prepared in this way will not froth on the surface of the steel, and one half the usual quantity will do the work as well as the whole quantity unmelted.

After the steel is properly heated, it should be forged to shape as quickly as possible, and just as the red heat is leaving the parts intended for cutting edges, these parts should be refined by rapid light blows, continued until the red disappears.

For the second stage of heating, for hardening, great care should be practised; first, to protect the cutting edges and working parts from heating more rapidly than the body of the piece; next, that the whole part to be hardened be heated uniformly through, without any part becoming visibly hotter than the other. A uniform heat as low as will give the required hardness, is the best for hardening.

Bear in mind that for every variation, which is great enough to be seen, there will result a "variation in grain" which may be seen by breaking the piece; and for every such variation in temperature, there is a very good chance for a crack to be seen. Many a costly tool is ruined by inattention to this point.

The effect of "too high heat" is to open the grain; to make the steel coarse.

The effect of irregular heat is to cause irregular grain, irregular strain and cracks. As soon as the piece is properly heated for hardening, it should be promptly and thoroughly quenched in plenty of the cooling medium, water, brine, or oil, as the case may be.

An abundance of the cooling bath, to do the work quickly and uniformly all over, is very important to good and safe work.

To harden a large piece safely, a running stream should be used. Much of the uneven hardening is caused by the use of too small baths.

For the third stages of heating, to temper, the first important requisite is again "uniformity." The next is time. The more slowly a piece is drawn to its temper, the better and safer is the operation.

When expensive tools, such as taps, rose cutters, etc., are to be made, it is a wise precaution, and one easily taken, to try small pieces of the same steel at different temperatures, so as to find out how low a heat will give the required hardness. The lowest heat is the best for any steel; the test costs nothing, takes very little time and very often saves considerable losses.

ON TEMPER.

The word temper, as used by the steel maker, indicates the amount of carbon in steel; thus, steel of high temper is steel containing much carbon; steel of low temper, is steel containing little carbon; steel of medium temper, is steel containing carbon between these limits, etc., etc. Between the highest and the lowest we have some twenty divisions, each representing a definite content of carbon.

As the temper of steel can only be observed in the ingot, it is not necessary to the needs of the trade to attempt any description of the mode of observation, especially as this is purely a matter of education of the eye, only to be obtained by years of experience.

Likewise, the quality of steel cannot be determined from the appearance of the fracture of a bar as it comes from the hands of the manufacturer.

This appearance is determined, in the main, by the heat at which the bar is finished, and therefore one end of a long bar (and especially of a hammered bar) may show a coarse, and the other end a fine grain, when the whole bar may be well suited for the purpose intended. Two tools properly heated, forged and hardened (one from each end of such a bar) will, if broken, show fractures similar in color and grain.

The act of "tempering" steel is the act of giving to a piece of steel, after it has been shaped, the hardness necessary for the work it has to do. This is done by first hardening the piece, generally a good deal harder than is necessary, and then toughening it by slow heating and gradual softening until it is just right for work.

A piece of steel properly tempered should always be finer in grain than the bar from which it is made. If it is necessary, in order to make the piece as hard as required, to heat it so hot that after being hardened it will be as coarse or coarser in grain than the bar, then the steel itself is of too low temper for the desired work. In a case of this kind, the steel maker should at once be notified of the fact, and could immediately correct the trouble by furnishing higher steel.

Sometimes an effort is made to harden fine steel without removing (by grinding or other method) the scale formed in rolling, hammering or annealing. The result will generally be disappointing, as steel which would harden through such a coating would be of too high temper when the scale was removed.

This surface scale is necessarily of irregular thickness and density, is oxide of iron—not steel—and therefore will not harden, and is to a certain extent a bad conductor of heat. It should therefore be removed in every case to insure the best results. If a great degree of hardness is desired, as in the case of taps and most tools of a complicated form, and it is found that at a moderate heat the tools are too hard and are liable to crack, the smith should first use a lower heat in order to save the tools already made, and then notify the steel maker that his steel is too high, so as to prevent a recurrence of the trouble. In all cases where steel is used in large quantities for the same purpose, as in making of axes, springs, forks, etc., there is very little difficulty about temper, because, after one or two trials, the steelmaker learns what his customer requires, and can always furnish it to him.

In large, general works, however, such as a rolling mill and nail factory, or large machine works, or large railroad shops, both the maker and worker of the steel labor under great disadvantages from want of a mutual understanding.

The steel maker receives his order and fills the sizes, of tempers best adapted to general work, and the smith generally tries to harden all tools at about the same heat. The steel maker is right, because he is afraid to make the steel too high or too low for fear it will not suit, so he gives an average adapted to the size of the bar.

The smith is right, because he is generally the most hurried and crowded man in the establishment. He must forge a tap for this man, a cold nail knife for that one, and a lathe cutter for another, and so on; and each man is in a hurry.

Under these circumstances he cannot be expected to stop and test every piece of steel he uses, and find out exactly at what heat it will harden best and refine properly. He needs steel that will all harden properly at the same heat, and this he generally gets from the general practice among steel makers of making each bar of a certain temper, according to its size. But if it should happen that he were caught with only one bar of say inch and a quarter octagon, and three men should come in a hurry, one for a tap, another for a punch, and another for a chilled rolled plug, he would find it very difficult to make one bar of steel answer for all of these purposes,even if it were of the very best quality. The chances are that he would make one good tool and two bad tools; and when the steel maker came around to inquire, he would find one friend and two enemies, and the smith puzzled and in doubt.

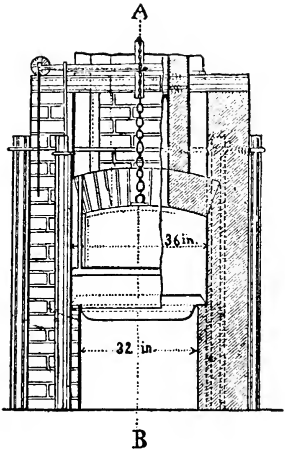
There is a perfectly easy and simple way to avoid all of this trouble, and that is to write after each size the purpose for which it is wanted, as for instance: Track tools,smith tools,lathe tools, taps, dies, cold nail knives, cold nail dies, hot nails, hot or cold punches, shear knives, and so forth. This gives very little trouble in making the order, and it is the greatest relief to the steel maker. It is his delight to get hold of such an order, for he knows that when it is filled he will hardly ever hear a complaint.

Every steel maker worthy of the name knows exactly the temper to provide for any tool, or if it is a new case, one or two trials are enough to inform him, and as he should always have twenty odd tempers on hand, it is just as easy, and far more satisfactory to both parties, to have it made right as to have it made wrong.

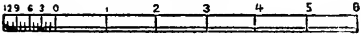
For these reasons we urge all persons to specify the work the steel is to do, then the smith can harden all tools at about the same heat, and he will not be annoyed by complaints, or hints that he does not do his work well.

FURNACES.

We present sketches of a cheap and handy furnace for use in a blacksmith's shop, adapted especially for heating steel, and more particularly for heating steel for hardening. The furnace is so simple that the sketches need no explanation; for binders, ten pieces of old rail about six feet long, with one end set in the ground, and the tops tied by ¾ in. rods are all that is necessary, with a piece of iron about 3x¾ in. running around near the top and set in flush with the bricks. The distinctive features of this furnace are the fire bed and a good damper on the stack. In an experience of many years we have found nothing better than the Tupper grate bar, with half inch openings. These bars set in as shown make a level, permanent bed, and give evenly distributed supply of air to the feed. In such a furnace as this one set of bars will last for years and will remain level.



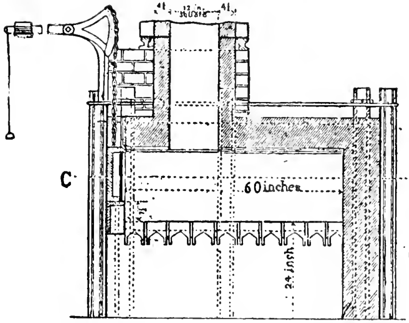
END VIEW

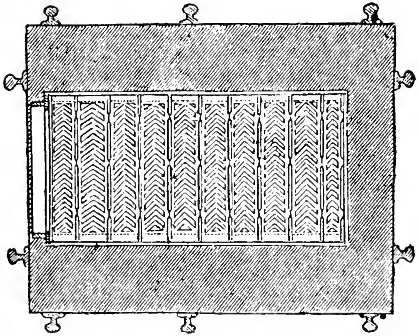


Scale : $\frac{5}{16}$ = 1 foot.

Stack 15' to 20' high.

SECTION: A.B.





While on the subject of grate bars we may as well say that the satisfactory and safe working of this furnace would be entirely defeated by any attempt to use either square wrought iron bars or ordinary cast iron bars. Such bars always warp, get pushed out of place, and allow a rush of air through at one place and no air at another. This causes hot and cold places in the furnace and produces uneven heating, which is the chie source of cracking in hardening; moreover, the air rushing through the large holes will burn the steel. A bar must be used which will remain level and in its place, and the smaller and more numerous the openings are, the better will be the result.

Clean, hard coke is the only fuel for such a furnace and for such work. The furnace should be filled full up to the fore plate; or better, a lit tle higher, with coke in pieces no larger than an ordinary man's fist, but the smaller the better.

When it is used for heating, forging pur poses, the damper may be left high enough to run the furnace as hot as may be required—if ne cessary a welding may be obtained.

When used for hardening, the furnace should be got as hot as needed before the steel is put into it; then when the steel is put in, the dampe should be dropped down tight.

The door, which is 12 inches high and 2 inches wide, should be nicely balanced by a leve and weight, with a rod in a handy place so tha the operator can pull it up easily and turn ove his pieces from time to time, so as to get his hea perfectly uniform.

In the clear gas of a coke fire, the whole in terior of a furnace can be seen easily, and ever piece can be watched as it ought to be. Time, care, wachfulness, and absolute uniformity of heat, are the essentials necessary for success in hardening steel. Every large shop should have such a furnace, and should have one man trained to its use, to do the hardening and tempering for the shop Such a furnace in the hands of a careful man in any railroad shop in the country would pay for itself every year and save the man's wages besides.

The furnace will consume very little coke at any time, and when not in use, with the damper down, it will stay hot a long time and waste the coke but a trifle.

There is no more absurd or wasteful system than that of requiring a smith at his anvil to harden and temper his work. His fire is not fit to heat in, to begin with, and he never has time to do his work properly if it were.

From such a furnace as is here described, we harden all sorts of tools: taps, small dies, large rolls, rotary shear knives, and shear knives as large as five feet long, which is the whole length of the furnace.

The tempered steel which is the best, is that which is the finest in the grain and the strongest.

The best way to test both grain and strength is to hammer out a piece to about $1\frac{1}{2}\text{x}\frac{1}{8}$ in., a foot or so in length, and temper to a high blue or pigeon wing, and when cold to break it off in little pieces with a hand hammer. A little practice will soon enable a man to determine, first, whether he heated his piece to just the right point. Next, when a little experience as to heat has been gained, he will know by the strength and grain whether his steel is really good, or whether it is "dry" and poor.

Finally, The art of working steel can be acquired by intelligent application.

Some will never learn, and others seem to be imbued with the idea that twenty or thirty years practice must necessarily qualify them as experts. In point of fact something new can be learned every day, and he is wise who will lay aside prejudice and change his mind whenever occasion requires it.

THE PROCESS OF MAKING BESSEMER STEEL.

The pig-iron is melted in a cupola, when fusing it is let into a converter. The converter is tilted at a certain angle in order that the molten iron can run into it. When it has taken the required quantity, then the converter is swung up again into a horizontal position, and the converting or blowing begins. For now a tremendous blast of air is forced up into the seething contents of the vessel through openings in it, such a gust of wind as only a set of engines representing the united strength of 5,000 horse power can produce.

I must quote Mr. Bessemer's own description of the process. When the process is brought into full activity small though powerful jets of air spring upwards through the fluid mass. The air expanding in volume divides itself into globules or bursts violently upwards.

Every part of the apparatus trembles under the violent agitation thus produced, a roaring flame rushes from the mouth of the converter and as the process advances changes its viole color to orange and finally to a luminous white flame.

The sparks which at first were large like those of ordinary foundry iron change to small hissing points and these gradually give way to specks of bluish light as the state of malleable iron is approached. After this mighty blowing has been going on for some time, the Spiegeleisen is added to the molten iron and the whole is mixed and combined thoroughly by means of the strong blast.

"Manganese is used now instead of Spiegeleisen." When converted enough the molten iron is poured into the dipper to which is added the Manganese, enough according to what per cent carboned steel is wanted, which mingles with the iron and then poured into moulds, what is called an ingot; which is now in fact Bessemer steel, ready to be rolled into any desired shape or plates, beams, angle iron, etc.

Steel is merely iron treated with carbon in a peculiar way.

Manganese is a mineral and metal of a dusky white or whitish gray color, very hard and difficult to fuse; it never occurs as a material production in a metallic state, the substance usually so called is an oxide of manganese but not pure.

Manganese is largely imported from France, Spain and Portugal. There is some in this country, the largest mine of which is in Virginia.

FORGE FIRES.

The forge fire is one of the most important features in the blacksmith's trade; and therefore more attention should be paid to the forges and the building of forging fires, as is usually done, for if it be true that disasters in welding are in most instances due to improper fires and heating, then it is clear that the fires employed for doing the heating must be responsible in some means for failure in the final process. That many of them as used by the blacksmiths are entirely unfit for the purpose is so well understood as to "go without saying." Their greatest evil is that they are too small. They should be large enough to hold enough fuel that the piece under treatment is well covered with fuel; and the piece will get an even heat.

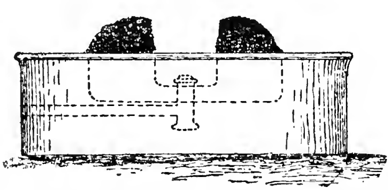


FIG. III.

An open fire, as shown in Figure III, is in very general use, and where it is large enough good results are obtained by giving the piece under treatment sufficient fuel and time to "take" the heat throughout its mass while turning and moving it in the fire from time to time to give it a uniform heat.

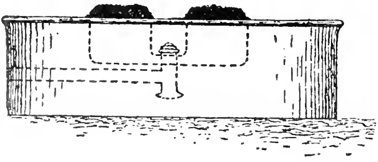


FIG. IV.

But if the fire is too small, as shown in Figure IV, where the coal supports are too low on the forge, and therefore cannot hold coke enough between them to protect a piece under treatment from the blast and slack; in such a fire bad results will follow.

For the smith is tempted, and in fact is obliged to, use the blast immoderately to supplement the inadequate power of the fuel, and a dirty heat is the result. The smith puzzled and a poor job done, which will of course not contribute to the blacksmith's credit.

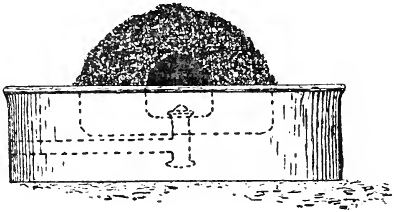


FIG. V.

The best fire made for heavy work is the hollow, as shown in Figure V.

This fire is built by cutting planks according to the length the fire is wanted; put one on each side, as wide apart as required for the work intended, cover the top with another plank, then place damp coal around and over the planks, tamp them down as well as you can. The wall should be at least one foot thick. The thicker the wall the longer the fire will stand. Build the fire between the planks. By the time the planks are burned out the walls are charred enough to be ready for work. Fill up with hard coke before placing the iron in for heating.

This fire is in use in most all prominent railroad shops, and gives the best of satisfaction.

TOOL SMITH'S FIRES.

The tool smith's fire should be built large enough so as to hold sufficient fuel as not to allow any jets of hot blast strike the tools and subject the edges of tools to be burned.

An open fire, as shown in figure III. forge fire, is used with good results, if well supplied with fuel.

A decided improvement in regard to tool fires is shown in Figure VI.

A method of enclosing a fire, as in Figure VI., meeting nearly all requirements. It is practically a small furnace, built upon a forge, its length and arrangement of blast being such as

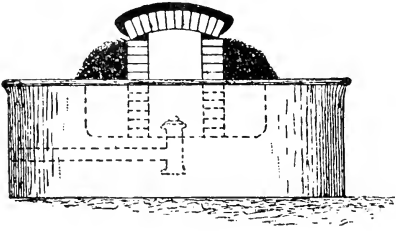


FIGURE VI.

will permit of handling of long taps, reamers, shears, etc., and will stand a long time, and save building a new fire every morning. The fuel used is charcoal or coke, according to the nature of the work.

The hollow fires, as illustrated above, consume less coal than open fires and heat quicker and more thoroughly, because the heat is confined. They require less blast; a decided feature, while the work of handling steel is easier for the smith.

Sketches of cheap and handy furnace, see condensed suggestions for steel workers.

HEATING OF IRON.

Not every smith can make a good clean heat for welding, therefore it is very important that every smith should make himself thoroughly acquainted with this factor in the trade. A man may be ever so clever with the hammer but if he can not make a good heat he is no good behind the anvil.

To work a clean fire, "and keep it clean," is what counts through the day, and is easy on a man. Always keep your fire well supplied with fuel, and never leave it run down or burn low; as soon as the fire becomes low then you have to follow with the iron also, and you get amongst slack and ashes, and that is just what you do not want.

When making heat for welding give your iron time to soak well, have a good supply of coke and have the iron in the center of the fire. (Do not get in the habit of rolling the iron in the fire too much, only enough to get an even heat). When well soaked, increase the blast as the heat comes up. (Too long waiting with the blast is not good, because too much of the oxide gathers on the surface.) Put a hard blast on a few moments before the heat is done, in order to blow all the dirt off and bring the surface to a melting state.

The art and knowledge how to work and turn the iron into the desired shape and form may be considered the trade or profession.

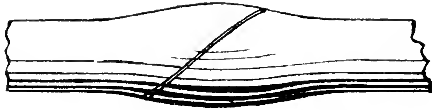


FIG. VII.

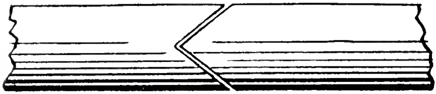


FIG. VIII.

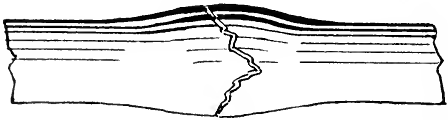


FIG. IX.

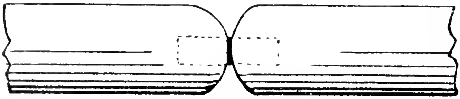


FIG X.

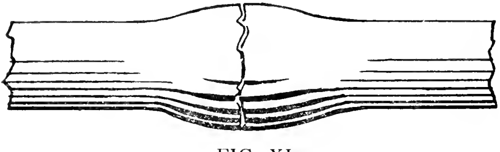


FIG. XI.

FIG. XII.

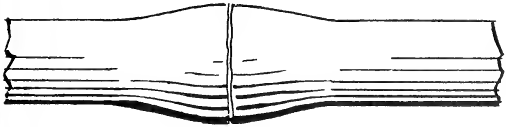


FIG. XIII

The blacksmith trade is different and unlike 'om all other trades. First, it requires physical :rength to perform the work; and, second, the 'ork is so complex in its nature that it takes long time and lots of experience to become a naster in it. Therefore the young beginner hould pay close attention to the workmanship f the iron trade, and faithfully study theoreti-ally as well as practically.

Theory and practice combined in one person 'ill make a thorough tradesman.

WORKING AND WELDING OF IRON.

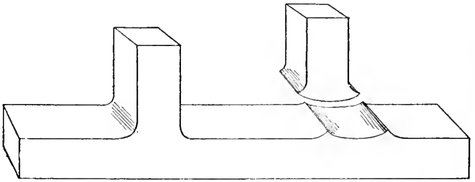
In preparing the iron for welding it should be pset heavy enough before scarfed that when it put together and worked down to the size of ie bar, that it is perfectly solid and show no :arf or marks in the weld and be full sized with ie bar.

Welds are of various kinds. Figure VII is a ommon lap-weld, and does for any ordinary ork. The V weld is made where great strength required, as on crank shafts, rudder posts, car axles, etc. Figure VIII show how the bars are scarfed and prepared before set. The setting is generally done in the fire. The bars are put into the fire as shown in figure VIII, left a little apart, and when the heat is coming up soft enough that the iron becomes cohesive; then the bars are struck together with a dolly bar which is especially made for such purposes. When enough upset it shows as in figure IX; when the heat is ready take it under the steam hammer and work it down; have the right sized swedge at hand, and also round it up under the hammer.

In big shops the swedges are generally in the die of the steam hammer.

In welding very heavy shafts, welds are made quite often as shown in figures X. and XI. Backset the outside or cut it down to assure solid weld in the center. For the convenience of setting the shaft straight a hole is punched into the center and a pin is inserted to hold it in its place. When heat is ready, operate the same as in the first explanation.

In welding mill shafts where a steady strain is on the shaft without a jerk, welds are most genreally set blunt or on a straight cut, as shown in figures XII. and XIII. When upset enough go through same performance as before.



FIGS. XIV. AND XV.

Jump welds, where one bar is jumped on to another one on a right angle, the weld is prepared as shown in figure XV. The piece jumped on should have a good scarf in order to fill up properly, and to catch it well with the filler.

Heat may be made on each piece in a separate fire, or in one fire if the fire is big enough. When heat is made the piece which is jumped on should have as soft a heat as the iron will stand without losing any of its scarf. When heat is ready, and set together, it requires two smiths and four helpers (in heavy work) in order to work the weld successfully. When set, let two helpers strike on the upright piece (with as heavy hammers as they can handle) to set it down solid; have sand at hand and sand it well all around the weld, which will preserve the iron from getting dry and coarse, then each of the smiths take a fuller, one on each side, and fuller down the scarf smooth and level with the bar; throw it on the side, hammer the scarf smooth, so that the weld does not show; if too much stock left cut it away and then finish. When done it will show as in figure XIV.

By working this kind of welds the men must get around lively, it must all be done before the heat gets off. This kind of weld should always be done without making a second heat or a wash over it.

Figure XVI shows a rudder frame in two sections. To make these welds the two sections must be clamped together, which is done by taking four flat bars, or better, angle iron bars which are stronger, long enough to reach over the frame to hold it in its place. Make the weld No. 1 first. Prepare the weld as in figure XVII,

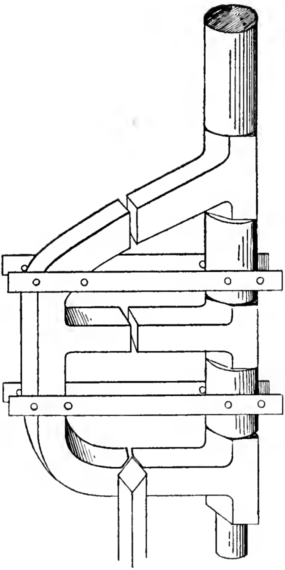


FIG. XVI.

FIG. XVII.

heat the dab in a separate fire and as soft as possible, in order that it well fills up the opening between the two ends; then take the other side in the same way. When No. 1 is finished the one clamp may be removed. Next in order is the weld No. 2, and take No. 3 to last; proceed in the same way as with No. 1.

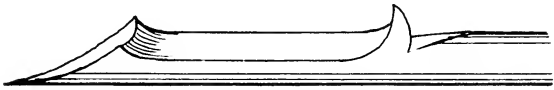


FIG. XVIII.

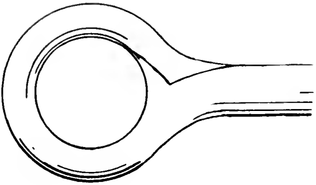


FIG. XIX.

Figure XVIII. shows how to prepare a weld for an eye so as to appear if punched out of a solid. When bent it should appear as in figure XIX. The hole should be made small enough for the drift to press the chip solid in the opening of the neck.

If well done it will appear as nice and smooth as if punched out of a solid piece.

DIES AND TOOLS.

The modern technical work and taste for graceful form of manufactured articles as well as durability, has been gradually forced upon us through constant rivalry and competition.

The manufacturer of the present day is obliged to do his work equal to, if not better, than the next man, or else his goods will be rejected in the market on account of inferior workmanship.

To keep apace with progress, the mechanic is forced in the same way to excel his fellow-craftsmen, or he cannot hold his job. Now the question arises, how can the mechanic attain the desired skill to compete with or excel his rival. Simply by studying and scheming. It cannot be obtained by hard work: one man may work hard at it, using files, chisels, etc., but has not the proper tool to finish the work with, and another man works on the same kind of work, has the necessary tools to do the work with, and what is the result? The result is that the man who is working with tools gets his job done ahead of the other man, and his work looks as if done by a machine, although he may not be as good a mechanic as the other man, and also enjoy the praise of his employer and foreman.

Therefore every smith should partly employ

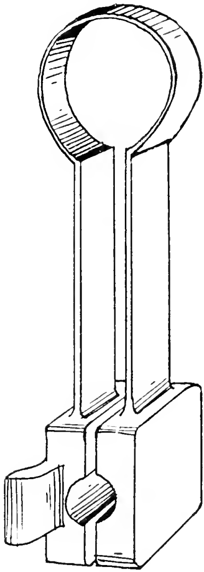


FIG XX.

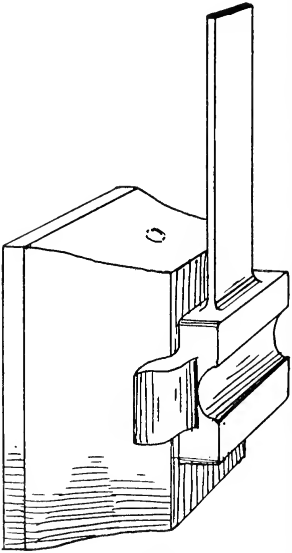


FIG. XXI.

his time to study on tools according to his work.

It is impossible for a man to suggest universal tools. Tools vary as the work varies in different shops.

My aim will not be to give you hundreds of worthless cuts in this issue which would be of no use, but an idea how tools can and should be made, as shown in the following cuts.

To make dies a man should be provided with blocks, as manufactured by the steel manufacturer especially for that purpose. The smith has to forge the block according to what work they are intended, but it is not his duty to sink them, that belongs to the machinist or die sinker, in order to retain the sharp edges and corners. The employer may think that the die becomes too expensive if the machinist has to make them, that they could be done quicker and cheaper by the smith; although it will be the case, but the die is not as good and you may safely say it is of no account, because it is impossible to retain the edges and corners if the block is heated and the form pressed into it under the steam hammer. However there are some tools, such as swedges for round iron and collars, etc., which the smith may make himself, but not as a rule.

Figure XX represents a swedge for the steam hammer; all swedges should be made with laps over the block to hold them in position.

Figure XXI shows the lower half of the swedge in position. In large shops where shafting and car axels are made, the swedges are in the dies of the steam hammer at from one to three swedges in one set of dies.

A swedge for tapering iron should also be made tapering according to the taper required.

Figure XXII represents a hammer die for making the end of a connecting rod. This kind of die can be made in any shape or form re-

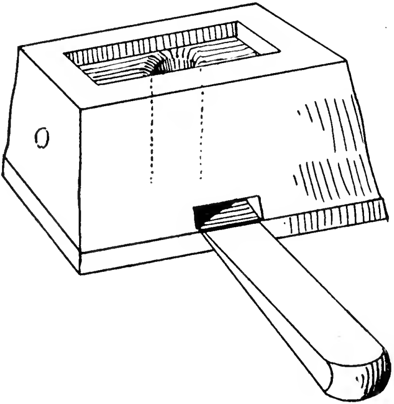
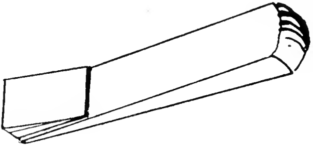


FIG. XXII.

quired; the hole on the side is used to drive th work out; there is no chance to drive it out fron the bottom as it sits in the anvil block of th steam hammer.



FIG, XXIII.

Figure XXIII represents the wedge fo driving it out.

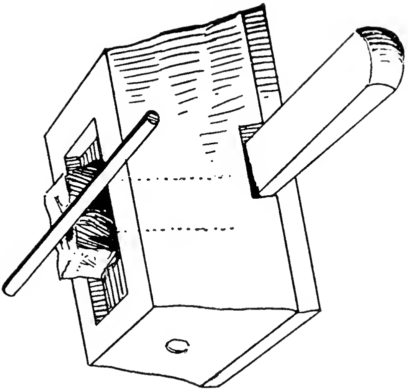


FIG. XXIV.

Figure XXIV represents the iron and the wedge in position ready for work.

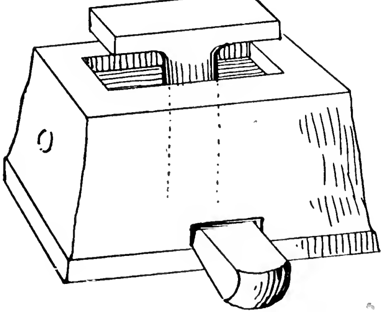


FIG. XXV.

Figure XXV represents the work done and

lifted out of the die. To work in this way and make it out of a solid is always better and stronger, as if welded on.

This kind of a tool is very much in use in blacksmiths' work, not merely for one job, but for a variety of work. It must of course be made according to the size of the work required; for instance, to make a ring with a shank or a jaw with a shank to be welded unto a bar.

Punch a hole into a die block and have the face of it even and not sink it. Spread the ends of the work out long enough according to the size of the ring or jaw, and then bend as required. The neck of such work is always stronger and looks better, and is easier done. All tools for light work of this kind are made of die blocks prepared by the smith and sunk by the machinist or die sinker as stated before.

Figure XXVI represents a tool of uneven surface. It may be used for making braces, or such kind of work with a flat end, either round

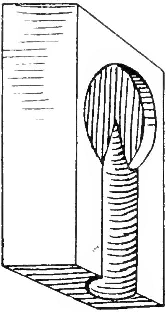


FIG. XXVI.

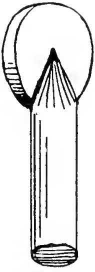


FIG XVII.

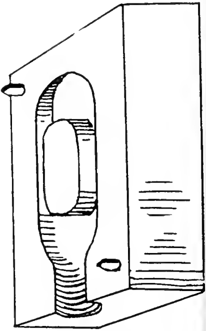


FIG. XXVIII.

or square and with a shank, as the case may be. All of this kind of work belongs to drop forging as shown in Figure XXVII.

Figure XXVIII represents a kind of tool which is often used in railroad work for making coupling rods or link bars and even lighter work where there are many of a kind to make, as coupling rods, etc. There should be also a top tool, made the same as the bottom tool, and the eye pressed half way into each tool and the burr trimmed off. Such a tool must have two pins in order to exactly meet the cut of the tool, as shown in Figure XXVIII.

All such tools with top and bottom are made on moulding principles, as if the work intended to be cut or pressed out by tools is pressed half way into the moulding sand, and then turn the piece over and press the other side into the moulding sand also, and you have a real view of both bottom and top tool.

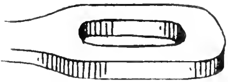


FIG. XXIX.

Figure XXIX shows how a piece of work would appear if it was pressed into the bottom tool only. It would be of double the thickness if a top tool were applied. In preparing the work for tools where there are holes to be pressed out, the hole should be punched before it is put into the tool, and always work the iron with a welding heat in the tool, in order to do perfectly sound work.

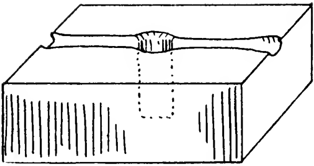


FIG. XXX.

Figure XXX represents a tool with a hole in the center to form a boss on a bar, as shown in Figure XXXI. To prepare the iron for the tool, draw out the ends of a bar heavy enough to make the boss and leave a chunk stand in the center. Make a welding heat on it and place the chunk above the hole in the tool and drive it down with the steam hammer, and it will come out as shown in Figure XXXI.

FIG. XXXI.

I do not deem it necessary to say anything on Tongs, Hammers and other shop tools. They are too well known by every smith, and he must make them as are required for holding the iron. Smiths should, of course, make tick tongs heavy enough that they do not break or come off while working at the steam hammer, else a man may be apt to get hurt. Never work under steam hammers without a span ring on the tongs.

WEIGHTS OF
SQUARE AND ROUND WROUGHT IRON BARS
At 480 Pounds Per Square Inch.

Diameter	SQUARE BARS. Weight of 1 lineal ft. of Iron.	SQUARE BARS. Are in Square Inch.	ROUND BARS. Weight of 1 lineal ft. of Iron	ROUND BARS. Area in Square Inch.
$\frac{1}{16}$	.013	.0039	.010	.0031
$\frac{1}{8}$	.052	.0156	.041	.0123
$\frac{3}{16}$	.117	.0352	.092	0276
$\frac{1}{4}$	.208	.0625	.164	.0491
$\frac{5}{16}$	.326	.0977	.256	.0761
$\frac{3}{8}$	.469	.1406	.368	.1104
$\frac{7}{16}$	.638	.1914	.501	.1503
$\frac{1}{2}$	.833	.2500	.654	.1963
$\frac{9}{16}$	1.055	.3164	.828	.2485
$\frac{5}{8}$	1.302	.3906	1.023	.3068
$\frac{11}{16}$	1.576	.4727	1.237	.3712
$\frac{3}{4}$	1.875	.5625	1.473	.4418
$\frac{13}{16}$	2.201	.6602	1.728	.5185
$\frac{7}{8}$	2.252	.7656	2.004	.6013
$\frac{15}{16}$	2.930	.8789	2.301	.6903
1 inch	3.333	1.0000	2.618	.7854
$\frac{1}{16}$	3.763	1.1289	2.955	.8866
$\frac{1}{8}$	4.219	1.2656	3 313	.9940
$\frac{3}{16}$	4.701	1.4102	3 692	1.1075
$\frac{1}{4}$	5 208	1.5625	4.091	1.2272
$\frac{5}{16}$	5 742	1.7227	4.510	1.3530
$\frac{3}{8}$	6.302	1.8906	4 950	1.4849
$\frac{7}{16}$	6.888	2.0664	5.410	1.6230
$\frac{1}{2}$	7 500	2.2500	5.890	1.7671
$\frac{9}{16}$	8.138	2.4414	6.392	1 9175
$\frac{5}{8}$	8 802	2.6406	6 913	2.0739
$\frac{11}{16}$	9.492	2.8477	7.455	2.2365
$\frac{3}{4}$	10.21	3.0625	8.018	2.4053
$\frac{13}{16}$	10.95	3.2852	8.601	2.5802
$\frac{7}{8}$	11.72	3 5156	9.204	2.7612
$\frac{15}{16}$	12.51	3.7539	9.828	2.9483
2 inch	13.33	4.0000	10.47	3.1416
$\frac{1}{16}$	14.18	4.2539	11 14	3.3410
$\frac{1}{8}$	15.05	4.5756	11.82	3.5466
$\frac{3}{16}$	15.95	4.7852	12.53	3.7583

SQUARE AND ROUND BARS.

(CONTINUED.)

Diameter	SQUARE BARS. Weight of 1 lineal ft. of Iron.	SQUARE BARS. Area in Square Inch.	ROUND BARS. Weight of 1 lineal ft. of Iron.	ROUND BARS. Area in Square Inch.
$\frac{1}{4}$	16.88	5.0625	13.25	3.9761
$\frac{5}{16}$	17.83	5 3477	14.00	4.2000
$\frac{3}{8}$	18.80	5.6406	14.77	4.4301
$\frac{7}{16}$	19.80	5.9414	15.55	4.6664
$\frac{1}{2}$	20,83	6.2500	16.36	4.9087
$\frac{9}{16}$	21.89	6.5664	17.19	5.1572
$\frac{5}{8}$	22.97	6.8906	18.04	5.4119
$\frac{11}{16}$	24 08	7 2227	18.91	5.6727
$\frac{3}{4}$	25.21	7.5625	19.80	5.9396
$\frac{13}{16}$	26.37	7.9102	20.71	6.2126
$\frac{7}{8}$	27.55	8.2656	21.64	6.4918
$\frac{15}{16}$	28.76	8.6289	22.59	6.7771
3 inch	30.00	9.0000	23.56	7.0686
$\frac{1}{16}$	31,26	9.3789	24.55	7,3662
$\frac{1}{8}$	32.55	9.7656	25 57	7.6699
$\frac{3}{16}$	33 87	10.160	26.60	7 9798
$\frac{1}{4}$	35.21	10 563	27.65	8.2958
$\frac{5}{16}$	36.58	10.973	28.73	8.6179
$\frac{3}{8}$	37.97	11.391	29.82	8.9462
$\frac{7}{16}$	39.39	11.816	30.94	9.2806
$\frac{1}{2}$	40.83	12.250	32.07	9.6211
$\frac{9}{16}$	42.30	12.691	33 23	9.9678
$\frac{5}{8}$	43.80	13.141	34.40	10.321
$\frac{11}{16}$	45 33	13.598	35 60	10.680
$\frac{3}{4}$	46.88	14 063	36.82	11.045
$\frac{13}{16}$	48.45	14.535	38 05	11 416
$\frac{7}{8}$	50.05	15.016	39.31	11.793
$\frac{15}{15}$	51 68	15.504	40 59	12.177
4 inch	53 33	16.000	41.89	12.566
$\frac{1}{16}$	55.01	16 504	43.21	12.962
$\frac{1}{8}$	56.72	17 016	44.55	13 364
$\frac{3}{16}$	58.45	17 535	45 91	13 772
$\frac{1}{4}$	60 21	18 063	47.29	14.186
$\frac{5}{16}$	61.99	18.598	48.69	14.607
$\frac{3}{8}$	63.80	19.141	50.11	15.033
$\frac{7}{16}$	65.64	19.691	51.55	15.466

WEIGHT OF SQUARE AND ROUND BARS.

(CONTINUED.)

Diameter	SQUARE BARS. Weight of 1 lineal ft. of Iron.	SQUARE BARS. Area in Square Inch.	ROUND BARS. Weight of 1 lineal ft. of Iron.	ROUND BARS. Area in Square Inch.
$\frac{1}{2}$	67.50	20.250	53.01	15.904
$\frac{9}{16}$	69.39	20 816	54.50	16.349
$\frac{5}{8}$	71.30	21.391	56 00	16.800
$\frac{11}{16}$	73.24	21.973	57.52	17.257
$\frac{3}{4}$	75.21	22.563	59.07	17.721
$\frac{13}{16}$	77.20	23.160	60.63	18.190
$\frac{7}{8}$	79.22	23.766	62.22	18.665
$\frac{15}{16}$	81.26	24.379	63.82	19.147
5 inch	83.33	25.000	65.45	19.635
$\frac{1}{16}$	85.43	25.629	67.10	20.129
$\frac{1}{8}$	87.55	26.266	68.76	20.629
$\frac{3}{16}$	89.70	26.910	70 45	21.135
$\frac{1}{4}$	91.88	27.563	72.16	21.648
$\frac{5}{16}$	94.08	28.223	73.89	22.166
$\frac{3}{8}$	96.30	28.891	75.64	22.691
$\frac{7}{16}$	98.55	29.566	77.40	23.221
$\frac{1}{2}$	100.8	30.250	79.19	23.758
$\frac{9}{16}$	103.1	30.941	81 00	24 301
$\frac{5}{8}$	105.5	31 641	82.83	24.850
$\frac{11}{16}$	107.8	32.348	84 69	25.406
$\frac{3}{4}$	110.2	33.063	86.56	25.967
$\frac{13}{16}$	112.6	33.785	88.45	26.535
$\frac{7}{8}$	115.1	34.516	90.36	27.109
$\frac{15}{16}$	117.5	35.254	92.29	27.688
6 inch	120.0	36.000	94.25	28.274
$\frac{1}{16}$	122.5	36.754	96.22	28.866
$\frac{1}{8}$	125.1	37.516	98.22	29.465
$\frac{3}{16}$	127.6	38.285	100.2	30.069
$\frac{1}{4}$	130.2	39.063	102.3	30.680
$\frac{5}{16}$	132.8	39 848	104.3	31.296
$\frac{3}{8}$	135.5	40.641	106 4	31.919
$\frac{7}{16}$	138.1	41 441	108.5	32.548
$\frac{1}{2}$	140.8	42.250	110.6	33.183
$\frac{9}{16}$	143.6	43.066	112.7	33.824
$\frac{5}{8}$	146.3	43.891	114.9	34.472
$\frac{11}{16}$	149.1	44.723	117.1	35.125

WEIGHT OF SQUARE AND ROUND BARS.
(CONTINUED)

Diameter	SQUARE BARS. Weight of 1 lineal ft. Iron.	SQUARE BARS. Area in Square Inch.	ROUND BARS. Weight of 1 lineal ft. of Iron.	ROUND BARS. Area in Square Inch.
$\frac{3}{4}$	151.9	45.563	119.3	35.785
$\frac{13}{16}$	154.7	46 410	121.5	36.450
$\frac{7}{8}$	157.6	47.266	123.7	37.122
$\frac{15}{16}$	160.4	48.129	126.0	37.800
7 inch	163.3	49.000	128.3	38.485
$\frac{1}{16}$	166.3	49.879	130.6	39 175
$\frac{1}{8}$	169.2	50.766	132.9	39.871
$\frac{3}{16}$	172.2	51.660	135.2	40.574
$\frac{1}{4}$	175.2	52.563	137 6	41.282
$\frac{5}{16}$	178.2	53 473	140.0	41.997
$\frac{3}{8}$	181.3	54.391	142.4	42.718
$\frac{7}{16}$	184.4	55.316	144.8	43.445
$\frac{1}{2}$	187.5	56.250	147.3	44.179
$\frac{9}{16}$	190.6	57.191	149.7	44.918
$\frac{5}{8}$	193 8	58.141	152.2	45.664
$\frac{11}{16}$	197.0	59.098	154.7	46.415
$\frac{3}{4}$	200.2	60.063	157.2	47.173
$\frac{13}{16}$	203.5	61 035	159.8	47.937
$\frac{7}{8}$	206.7	62.016	162.4	48.707
$\frac{15}{16}$	210.0	63 004	164.9	49.483
8 inch.	213.3	64.000	167.6	50.265
$\frac{1}{16}$	216.7	65.004	170.2	51.054
$\frac{1}{8}$	220.1	66.016	172.8	51.849
$\frac{3}{16}$	223.5	67.035	175.5	52.649
$\frac{1}{4}$	226.9	68 063	178.2	53 456
$\frac{5}{16}$	330.3	69.098	180.9	54.269
$\frac{3}{8}$	233.8	70.141	183.6	55.088
$\frac{7}{16}$	237.3	71.191	186.4	55.914
$\frac{1}{2}$	240.8	72.250	189 2	56.745
$\frac{9}{16}$	244.4	73.316	191.9	57.583
$\frac{5}{8}$	248.0	74 391	194.8	58.426
$\frac{11}{16}$	251.6	75.473	197.6	59.276
$\frac{3}{4}$	255 2	76.563	200.4	60.132
$\frac{13}{16}$	158 9	77.660	203.3	60.994
$\frac{7}{8}$	262.6	78.766	206.2	61.862
$\frac{15}{16}$	266.3	79.879	209.1	62.737

WEIGHT OF SQUARE AND ROUND BARS.

(CONTINUED.)

Diameter	SQUARE BARS. Weight of 1 lineal ft. of Iron.	SQUARE BARS. Area in Square Inch.	ROUND BARS. Weight of 1 lineal ft. of Iron.	ROUND BARS. Area in Square Inches.
9 inch	270.0	81.000	212.1	63.617
1/16	273.8	82.129	215 0	64.504
1/8	277 6	83 266	218.0	65.397
3/16	281.4	84.410	221.0	66.296
1/4	285.2	85.563	224.0	67.201
5/16	289 1	86.723	227.0	68.112
3/8	293.0	87.891	230.1	69.029
7/16	296.9	89.066	223.2	69.953
1/2	300.8	90 250	236 3	70.882
9/16	304.8	91.441	239.4	71.818
5/8	308.8	92 641	242.5	72.760
11/16	312.8	93.848	245.7	73.708
3/4	316 9	95.063	248 9	74 662
13/16	321.0	96.285	252.1	75.622
7/8	325.1	97.516	255.3	76.589
15/16	329.2	98 754	258.5	77.561
10 inch	333.3	100.00	261.8	78.540
1/16	337.5	101.25	265.1	79.525
1/8	341.7	102.52	268.4	80.516
3/16	346.0	103.79	271.7	81.513
1/4	350.2	105.06	275.1	82.516
5/16	354.5	106.35	278.4	83 525
3/8	358 8	107.64	281.8	84.441
7/16	363.1	108.94	285.2	85.562
1/2	367 5	110.25	288.6	86.590
9/16	371.9	111.57	292.1	87.624
5/8	376.3	112.89	295.5	88.664
11/16	380.7	114.22	299.0	89.710
3/4	385.2	115.56	302.5	90 763
13/16	389.7	116.91	306.1	91.821
7/8	394 2	118 27	309.6	92.886
15/16	398.8	119.63	313.2	93.956
11 inch	403.3	121.00	316.8	95.033
1/16	407.9	122.38	320.4	96.116
1/8	412.6	123.77	324 0	97.205
3/16	417.2	125.16	327.7	98.301

WEIGHT OF SRUARE AND ROUND BARS,

(CONTINUED.)

Diameter	SQUARE BARS.		ROUND BARS.	
	Weight of 1 lineal ft. of Iron.	Area in Square Inch.	Weight of 1 lineal ft. of Iron.	Area in Square Inch.
$\frac{1}{4}$	421.9	126.56	331.3	99.402
$\frac{5}{16}$	426 6	127.97	335.0	100.51
$\frac{3}{8}$	431.3	129.39	338.7	101.62
$\frac{7}{16}$	436.1	130.82	342.5	102.74
$\frac{1}{2}$	440.8	132.25	346.2	103.87
$\frac{9}{16}$	445 6	133.69	350 0	105.00
$\frac{3}{8}$	450.5	135.14	353.8	106.14
$\frac{11}{16}$	455.3	136.60	357.6	107.28
$\frac{3}{4}$	460.2	138.06	361.4	108.43
$\frac{13}{16}$	465,1	139.54	365.3	109.59
$\frac{7}{8}$	470.1	141.02	369.2	110.75
$\frac{15}{16}$	475.0	142.50	373.1	111.92
12 inch	480.0	144 00	376.9	113.09

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

For Thickness from $\frac{1}{16}$ in to 2 in. and Widths from 1 in, to $12\frac{3}{4}$ in,

Iron weighing 480 lbs. per cubic foot.

Thickness in inches.	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	12
$\frac{1}{16}$	.208	.260	.313	.365	.417	.469	.521	.573	2.50
$\frac{1}{8}$	.417	.521	.625	.729	.833	.938	1.04	1.15	5.00
$\frac{3}{16}$	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	7.50
$\frac{1}{4}$	.833	1.04	1.25	1.46	1 67	1.88	2.08	2.29	10 00
$\frac{5}{16}$	1.04	1.30	1.56	1.82	2.08	2.34	2.60	2.86	12.50
$\frac{3}{8}$	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	15.00
$\frac{7}{16}$	1.46	1.82	2.19	2.55	2.92	3.28	3 65	4.01	17.50
$\frac{1}{2}$	1.67	2.08	2.50	2.92	3.33	3.75	4.17	4.58	20.00
$\frac{9}{16}$	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	22.50
$\frac{5}{8}$	2.08	2.60	3.13	3.65	4.17	4.69	5.21	5.73	25 00
$\frac{11}{16}$	2.29	2.86	3.44	4.01	4.58	5.16	5.73	6.30	27.50
$\frac{3}{4}$	2.50	3.13	3.75	4.38	5.00	5.63	6.25	6.88	30.00
$\frac{13}{16}$	2.71	3.39	4.06	4.74	5.42	6.09	6.77	7.45	32.50
$\frac{7}{8}$	2.92	3.65	4.38	5.10	5.83	6.56	7.29	8.02	35.00
$\frac{15}{16}$	3.13	3.91	4.69	5.47	6.25	7.03	7.81	8.59	37.50
1	3.33	4.17	5.00	5.83	6.67	7.50	8.33	9.17	40.00
$1\frac{1}{16}$	3.54	4.43	5.31	6.20	7.08	7.97	8.85	19.74	42.50
$1\frac{1}{8}$	3.75	4.69	5.63	6.56	7.50	8.44	9.38	10.31	45.00
$1\frac{3}{16}$	3.96	4.95	5.94	6 93	7.92	8.91	9.90	10.89	47.50
$1\frac{1}{4}$	4.17	5.21	6 25	7.29	8 33	9 38	10.42	11.46	50.00
$1\frac{5}{16}$	4.37	5.47	6.56	7.66	8.75	9.84	10.94	12.03	52.50
$1\frac{3}{8}$	4.58	5.73	6.88	8.02	9.17	10.31	11.46	12.60	55.00
$1\frac{7}{16}$	4.79	5.99	7.19	8.39	9.58	10.78	11.98	13.18	57.50
$1\frac{1}{2}$	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	60.00
$1\frac{9}{16}$	5.21	6.51	7.81	9.11	10.42	11.72	13.02	14.32	62.50
$1\frac{5}{8}$	5.42	6.77	8.13	9.48	10.83	12.19	13 54	14.90	65.00
$1\frac{11}{16}$	5.63	7.03	8.44	9.84	11.25	12.66	14.06	15.47	67.50
$1\frac{3}{4}$	5.83	7.29	8.75	10.21	11.67	13.13	14.58	16.04	70.00
$1\frac{13}{16}$	6.04	7.55	9.06	10.57	12.08	13.59	15.10	16.61	72.50
$1\frac{7}{8}$	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	75.00
$1\frac{15}{16}$	6.46	8.07	9.69	11.30	12.92	14.53	16.15	17.76	77.50
2	6.67	8.33	10.00	11.67	13.33	15.00	16.67	18 33	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$
$\frac{1}{16}$	.625	.677	.729	.781	.833	.885	.938	990
$\frac{1}{8}$	1.25	1.35	1.46	1.56	1.67	1.77	1.88	1.98
$\frac{3}{16}$	1.88	2.03	2 19	2.34	2.50	2.66	2.81	2.97
$\frac{1}{4}$	2.50	2.71	2.92	3 13	3.33	3.54	3.75	3 96
$\frac{5}{16}$	3.13	3 39	3.65	3.91	4.17	4.43	4.69	4.95
$\frac{3}{8}$	3.75	4.06	4.38	4.69	5.00	5.31	5.63	5.94
$\frac{7}{16}$	4.38	4.74	5.10	5.47	5.83	6.20	6.56	6.93
$\frac{1}{2}$	5.00	5.42	5.83	6.25	6.67	7.08	7.50	7.92
$\frac{9}{16}$	5.63	6.09	6.56	7.03	7.50	7 97	8.44	8.91
$\frac{5}{8}$	6.25	6.77	7.29	7.81	8.33	8.85	9.38	9.90
$\frac{11}{16}$	6.88	7 45	8.02	8.59	9.17	9.74	10 31	10.89
$\frac{3}{4}$	7.50	8.13	8.75	9.38	10.00	10.63	11.25	11,88
$\frac{13}{16}$	8.13	8.80	9.48	10.16	10.83	11.51	12.19	12.86
$\frac{7}{8}$	8.75	9.48	10.21	10.94	11.67	12.40	13.13	13.85
$\frac{15}{16}$	9.38	10.16	10.94	11.72	12.50	13.28	14.06	14.84
1	10.00	10.83	11.67	12.50	13.33	14.17	15.00	15.83
$1\frac{1}{16}$	10.63	11.51	12.40	13.28	14.17	15 05	15.94	16.82
$1\frac{1}{8}$	11.25	12.19	13.13	14.06	15.00	15.94	16 88	17.81
$1\frac{3}{16}$	11.88	12.86	13.85	14 84	15.83	16.82	17.81	18.80
$1\frac{1}{4}$	12.50	13.54	14.58	15.63	16.67	17.71	18.75	19.79
$1\frac{5}{16}$	13.13	14.22	15.31	16.41	17.50	18.59	19.69	20.78
$1\frac{3}{8}$	13.75	14.90	16.04	17.19	18 33	19.48	20.63	21.77
$1\frac{7}{16}$	14.38	15.57	16.77	17 97	19 17	20.36	21.56	22 76
$1\frac{1}{2}$	15.00	16 25	17.50	18.75	20.00	21.25	22.50	23.75
$1\frac{9}{16}$	15.63	16.93	18.23	19.53	21.83	22.14	23.44	24.74
$1\frac{5}{8}$	16.25	17.60	18.96	20.31	21.67	23.02	24.38	25.73
$1\frac{11}{66}$	16 88	18.25	19.69	21.09	22.50	23.91	25.31	26.72
$1\frac{3}{4}$	17.50	18 96	20.42	21.88	23.33	24.79	26.25	27.71
$1\frac{13}{16}$	18.13	19,64	21.15	22.66	24.17	25 68	27.19	28.70
$1\frac{7}{8}$	18.75	20.31	21.88	23.44	25.00	26 56	28.13	29.69
$1\frac{15}{16}$	19.38	20.99	22.60	24 22	25.83	27.45	29.06	30.68
2	20.00	21.67	23.33	25.00	26.67	28.33	30.00	31.67

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	6	$6\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	11
$\frac{1}{16}$	1.04	1.09	1.15	1.20	1.25	1.30	1.35	1.41	2.50
$\frac{1}{8}$	2.08	2.19	2.29	2.40	2.50	2.60	2.71	2 81	5.00
$\frac{3}{16}$	3.13	3.28	3.44	3.59	3.75	3.90	4.06	4.22	7.50
$\frac{1}{4}$	4.17	4.38	4.58	4.79	5.00	5.21	5.42	5.63	10.00
$\frac{5}{16}$	5.21	5.47	5.73	5.99	6.25	6.51	6.77	7.03	12.50
$\frac{3}{8}$	6.25	6.56	6.88	7.19	7.50	7.81	8.13	8.44	15.00
$\frac{7}{16}$	7.29	7.66	8.02	8.39	8.75	9.11	9.48	9.84	17.50
$\frac{1}{2}$	8.33	8.75	9.17	9.58	10.00	10.42	10.83	11.25	20.00
$\frac{9}{16}$	9.38	9.84	10.31	10.78	11.25	11.72	12.19	12.66	22.50
$\frac{5}{8}$	10.42	10.94	11.46	11.98	12.50	13.02	13.54	14.06	25.00
$\frac{11}{16}$	11.46	12.03	12.60	13.18	13.75	14.32	14.90	15.47	27.50
$\frac{3}{4}$	12.50	13.13	13.75	14.38	15.00	15.63	16.25	16.88	30.00
$\frac{13}{16}$	13 54	14.22	14.90	15.57	16.25	16.93	17.60	18.28	32.50
$\frac{7}{8}$	14.58	15.31	16.04	16.77	17.50	18 23	18.96	19.69	35.00
$\frac{15}{16}$	15.63	16.41	17.19	17.97	18.75	19.53	20.31	21.09	37.50
1	16.67	17.50	18.33	19.17	20.00	20.83	21.67	22.50	40.00
$1\frac{1}{16}$	17.71	18.59	19.48	20 36	21.25	22.14	23.02	23.91	42.50
$1\frac{1}{8}$	18.75	19.69	20 63	21 56	22.50	23.44	24.38	25.31	45.00
$1\frac{3}{16}$	19.79	20.78	21.77	22.76	23.75	24.74	25.73	26.72	47.50
$1\frac{1}{4}$	20.83	21.88	22.92	23.96	25.00	26.04	27.08	28.13	50.00
$1\frac{5}{16}$	21.88	22.97	24.06	25.16	26.25	27.34	28.44	29.53	52.50
$1\frac{3}{8}$	22.92	24.06	25.21	26.35	27.50	28,65	29.79	30.94	55 00
$1\frac{7}{16}$	23.96	25.16	26 35	27.55	28.75	29.95	31.15	32.34	57.50
$1\frac{1}{2}$	25.00	26.25	27.50	28.75	30.00	31.25	32.50	33 75	60.00
$1\frac{9}{16}$	26.04	27.34	28 65	29.95	31 25	32.55	33.85	35.16	62.50
$1\frac{5}{8}$	27 08	28.44	29.79	31.15	32.50	33.85	35.21	36.56	65.00
$1\frac{11}{16}$	28.13	29.63	30.94	32 34	33.75	35.16	36.56	37.97	67,50
$1\frac{3}{4}$	29 17	30.63	32.08	33.54	35.00	36.46	37.92	39.38	70 00
$1\frac{13}{16}$	30.21	31.72	33.23	34 74	36.25	37.76	39.27	40.78	72 50
$1\frac{7}{8}$	31.25	32 81	34.38	35 94	37.50	39.06	40.63	42.19	75.00
$1\frac{15}{16}$	32.29	33.91	35.52	37 14	38.75	40 36	41.98	43.59	77.50
2	33.33	35.00	36.67	38.33	40.00	41 67	43.33	45.00	80.00

WEIGHTS QF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	7	7¼	7½	7¾	8	8¼	8½	8¾	12
1/16	1.46	1.51	1.56	1.61	1.67	1.72	1.77	1.82	2,50
1/8	2.92	3.02	3.13	3.23	3.33	3.34	3.54	3.65	5.00
3/16	4.38	4.53	4.69	4.84	5.00	5.16	5.31	5.47	7.50
1/4	5.83	6 04	6.25	6.46	6.67	6 88	7.08	7.29	10.00
5/16	7.29	7.55	7.81	8.07	8.33	8.59	8.85	9.11	12.50
3/8	8.75	9.06	9.38	9.69	10.00	10.31	10.63	10.94	15.00
7/16	10 21	10.57	10,94	11.30	11.67	12.03	12.40	12.76	17.50
1/2	11.67	12.08	12.50	12,92	13 33	13.75	14.17	14.58	20.00
9/16	13.13	13.59	14.06	14.53	15.00	15.47	15.94	16.41	22.50
5/8	14.58	15.10	15.63	16.15	16.67	17.19	17.71	18.23	25.00
11/16	16.04	16.61	17.19	17.76	18.33	18.91	19.48	20.05	27.50
3/4	17.50	18.13	18 75	19.38	20.00	20.63	21.25	21.88	30.00
13/16	18.96	19.64	20.31	20.99	21.67	22 34	23.02	23.70	32.50
7/8	20.42	21.15	21.88	22 60	23.33	24.06	24.79	25.52	35.00
15/16	21.88	22.66	23.44	24.22	25.00	25.78	26.56	27.34	37.50
1	23.33	24.17	25.00	25.83	26.67	27.50	28.33	29.17	40.00
1 1/16	24.79	25.68	26.56	27.45	28.33	29.22	30.10	30.99	42.50
1 1/8	26.25	27.19	28.13	29.06	30.00	30.94	31.88	32.81	45.00
1 3/16	27.71	28.70	29.69	30.68	31.67	32 66	33,65	34.64	47.50
1 1/4	29.17	30.21	31.25	32.29	33.33	34 38	35.42	36.46	50.00
1 5/16	30.62	31.72	32.81	33.91	35.00	36.09	37.19	38.28	52,50
1 3/8	32.08	33.23	34.38	35 52	36 67	37.81	38.96	40.10	55.00
1 7/16	33.54	34.74	35 94	37.14	38.33	39.53	40.73	41.93	57.50
1 1/2	35.00	36.25	37.50	38.75	40.00	41.25	42.50	43.75	60.00
1 9/16	36.46	37.76	39 06	40.36	41.67	42.97	44 27	45.57	62.50
1 5/8	37.92	39.27	40 63	41.98	43.33	44.69	46.04	47,40	65.00
1 11/16	39.38	40.78	42.19	43 59	45.00	46 51	47 81	49.22	67.50
1 3/4	40.83	42.29	43.75	45.21	46.67	48.13	49.58	51.04	70 00
1 13/16	42.29	43 80	45 31	46.82	48.33	49.84	51.35	52.86	72.50
1 7/8	43.79	45.31	46.88	48.44	50.00	51 56	53.13	54 69	75.00
1 15/16	45.21	46.82	48.44	50.05	51.67	53.28	54.91	56.51	77.50
2	46.67	48.33	50.00	51.67	53.33	55.00	56.67	58.33	80.00

WEIGHTS OF FLAT ROLLED IRON

(CONTINUED.)

Thickness in inches.	9	9¼	9½	9¾	10	10¼	10½	10¾	12
1/16	1.88	1.93	1.98	2.03	2.08	2,14	2.19	2.24	2.50
1/8	3.75	3.85	3.96	4.06	4.17	4.27	4.38	4.48	5.00
3/16	5.63	5.76	5.94	6.09	6.25	6.14	6.56	6.72	7.50
1/4	7.50	7.71	7.92	8.13	8.33	8.54	8.75	8.96	10.00
5/16	9.38	9.64	9.90	10.16	10.42	10.68	10.94	11.20	12.50
3/8	11.25	11.56	11.88	12.19	12.50	12.81	13.13	13.44	15.00
7/16	13.13	13.49	13.85	14.22	14.58	14.95	15.31	15.68	17.50
1/2	15,00	15.42	15.83	16.25	16.67	17.08	17.50	17.92	20.00
9/16	16.88	17.34	17.81	18.28	18.75	19.22	19.69	20.16	22.50
5/8	18.75	19.27	19.79	20.31	20.83	21.35	21.88	22.40	25.00
11/16	20.63	21.20	21.77	22.34	22.92	23.49	24.06	24.66	27.50
3/4	22.50	23.13	23.75	24.38	25.00	25.62	26.25	26.88	30.00
13/16	24.38	25.05	25.73	26.41	27.08	27.76	28.44	29.11	32.50
7/8	26.25	26.98	27.71	28.44	29.17	29.90	30.63	31.35	35.00
15/16	28.13	28.91	29.69	30.47	31.25	32.03	32.81	33.59	37.50
1	30.00	30.83	31.67	32.50	33.33	34.17	35.00	35.83	40.00
1 1/16	31.88	32.76	33.65	34.53	35.42	36.30	37,19	38.07	42.50
1 1/8	33.75	34.69	35.63	36.56	37.50	38.44	39.38	40.31	45.00
1 3/16	35.63	36.61	37.60	38.59	39.58	40.57	41.56	42.55	47.50
1 1/4	37.50	38.54	39.58	40.63	41.67	42.71	43.75	44.79	50.00
1 5/16	39.38	40.47	41.56	42.66	43.75	44.84	45.94	47.03	52.50
1 3/8	41.25	42.40	43.54	44.69	45.83	46.98	48.13	49.27	55.00
1 7/16	43.13	44.32	45.52	46.72	47.92	49.11	50.31	51.51	57.50
1 1/2	45.00	46.25	47.50	48.75	50.00	51.25	52,50	53.75	60.00
1 9/16	46.88	48.18	49.48	50.78	52.08	53.39	54.69	55.99	62.50
1 5/8	48.75	50.10	51.46	52.81	54.17	55.52	56.88	58.23	65.00
1 11/16	50.63	52.03	53.44	54.84	56.25	57.66	59.06	60.47	67.50
1 3/4	52.50	53.96	55.42	56.88	58.33	59.79	61.25	62.71	70.00
1 13/16	54.38	55.89	57.40	58.91	60.42	61.93	63.44	64.95	72.50
1 7/8	56.25	57.81	59.38	60.94	62.50	64.06	65.63	67.19	75.00
1 15/16	58.13	59.74	61.35	62.97	64.58	66.20	67.88	69.43	77.50
2	60.00	61.67	63.33	65.00	66.67	68.33	70.00	71.67	80.00

WEIGHTS OF FLAT ROLLED IRON PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	11	11¼	11½	11¾	12	12¼	12½	12¾
1/16	2.29	2.34	2.40	2.45	2.50	2.55	2.60	2.66
⅛	4.58	4.68	4.79	4.90	5.00	5.10	5.21	5.31
3/16	6.88	7.03	7.19	7.34	7.50	7.66	7.97	7.97
¼	9.17	9.38	9.58	9.79	10.00	10.21	10.42	10.63
5/16	11.46	11.72	11.98	12.24	12.50	12.76	13.02	13.28
⅜	13.75	14.06	14.38	14.69	15.00	15.31	15.63	15.94
7/16	16.04	16.41	16.77	17.14	17.50	17.86	18.23	18.59
½	18.33	18.75	19.17	19.58	20.00	20.42	20.83	21.25
9/16	20.63	21.09	21.56	22.03	22.50	22.97	23.44	23.91
⅝	22.92	23.44	23.96	24.48	25.00	25.52	26.04	26.56
11/16	25.21	25.78	26.35	26.93	27.50	28.07	28.65	29.22
¾	27.50	28.13	28.75	29.38	30.00	30.83	31.25	31.88
13/16	29.79	30.47	31.15	31.82	32.50	33.18	33.85	34.53
⅞	32.08	32.81	33.54	34.27	35.00	35.73	36.46	37.19
15/16	34.38	35.16	35.94	36.72	37.50	38.28	39.06	39.84
1	36.67	37.50	38.33	39.17	40.00	40.83	41.67	42.50
1 1/16	38.96	39.84	40.73	41.61	42.50	43.39	44.27	45.16
1 ⅛	41.25	42.19	43.13	44.06	45.00	45.94	46.88	47.81
1 3/16	43.54	44.53	45.52	46.51	47.50	48.49	49.48	50.47
1 ¼	45.83	46.88	27.92	48.96	50.00	51.04	52.08	53.13
1 5/16	48.13	49.22	50.31	51.41	52.50	53.59	54.69	55.78
1 ⅜	50.42	51.56	52.71	53.85	55.00	56.15	57.29	58.44
1 7/16	52.71	53.91	55.10	56.30	57.50	58.70	59.90	61.09
1 ½	55.00	56.25	57.50	58.75	60.00	61.25	62.50	63.75
1 9/16	57.29	58.59	59.90	61.20	62.50	63.80	65.10	64.41
1 ⅝	59.58	60.94	62.29	63.65	65.00	66.35	67.71	69.06
1 11/16	61.88	63.28	64.69	66.09	67.50	68.91	70.31	71.72
1 ¾	64.17	65.63	67.08	68.54	70.00	71.46	72.92	74.38
1 13/16	66.46	67.97	69.48	70.99	72.50	74.01	75.52	77.03
1 ⅞	68.75	70.31	77.88	73.44	75.00	76.56	78.13	79.69
1 15/16	71.04	72.66	74.27	75.89	77.50	78.11	80.73	82.34
2	73.33	75.00	76.67	78.33	80.00	81.67	83.33	85.00

The weight for 12 in. width on each page to facilitate making the additions necessary to obtain the weights of plates wider than 12 in. Thus, to find the weight of 15¼ × ⅞ add the weights to be found in the same line for 3¼ × ⅞ in. and 12 × ⅞ = 9.48 + 35.00 = 44.48 lbs.

AREAS OF FLAT ROLLED IRON PER LINEAL FOOT.

For Thickness from $\frac{1}{16}$ in. to 2 in. and Widths from 1 in. to $12\frac{3}{4}$ in.

Thickness in inches	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	12
$\frac{1}{16}$	.063	.078	.094	.109	.125	.141	.156	.172	.750
$\frac{1}{8}$	.125	.156	.188	.219	.250	.281	.313	.344	1.50
$\frac{3}{16}$	.188	.234	.281	.328	.375	.422	.469	.516	2.25
$\frac{1}{4}$	.250	.313	.375	.438	.500	.563	.625	.688	3.00
$\frac{5}{16}$	.313	.391	.469	.547	.625	.703	.781	.859	3.75
$\frac{3}{8}$	.375	.469	.563	.656	.750	.844	.938	1.03	4 50
$\frac{7}{16}$	.438	.547	.656	.766	.875	.984	1.09	1.20	5.25
$\frac{1}{2}$	.500	.625	.750	.875	1.00	1.13	1.25	1.38	6.00
$\frac{9}{16}$	.563	.703	.844	.984	1.13	1.27	1.41	1.55	6.75
$\frac{5}{8}$	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	7.50
$\frac{11}{16}$	.688	.859	1.03	1.20	1.38	1.55	1.72	1.89	8.25
$\frac{3}{4}$	.750	.938	1.13	1.31	1.50	1.69	1.88	2.06	9.00
$\frac{13}{16}$	.813	1.02	1.22	1.42	1.63	1.83	2.03	2.23	9.75
$\frac{7}{8}$	.875	1.09	1.31	1.53	1.75	1.97	2.19	2.41	10.50
$\frac{15}{16}$	.938	1.17	1.41	1.64	1.88	2.11	2.34	2.58	11.25
1	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	12.00
$1\frac{1}{16}$	1.06	1.23	1.59	1.86	2.13	2.39	2.66	2.92	12.75
$1\frac{1}{8}$	1.13	1.41	1.69	1.97	2.25	2.53	2.81	3.09	13 50
$1\frac{3}{16}$	1.19	1.48	1.78	2.08	2.38	2.67	2.97	3.27	14.25
$1\frac{1}{4}$	1 25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	15.00
$1\frac{5}{16}$	1.31	1.64	1.97	2.30	2 63	2.95	3.28	3.61	15.75
$1\frac{3}{8}$	1.38	1.72	2.06	2.41	2.75	3.09	3.44	3.78	16.50
$1\frac{7}{16}$	1.44	1.80	2.16	2.52	2.88	3.23	3.59	3.95	17.25
$1\frac{1}{2}$	1.50	1.88	2.25	2.63	3.00	3.38	3 75	4.13	18.00
$1\frac{9}{16}$	1.56	1.95	2 34	2.73	3.13	3.52	3.91	4.30	18.75
$1\frac{5}{8}$	1.63	2.03	2 44	2.84	3.25	3.66	4.06	4.47	19.50
$1\frac{11}{16}$	1.69	2.11	2.53	2.95	3 38	3.80	4.22	4.64	20.25
$1\frac{3}{4}$	1.75	2.19	2 63	3.06	3.50	3.94	4.38	4.81	21.00
$1\frac{13}{16}$	1.81	2.27	2.72	3.17	3.63	4.08	4.53	4.98	21.75
$1\frac{7}{8}$	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	22.50
$1\frac{15}{16}$	1.94	2.42	2.91	3.39	3.88	4.36	4.84	5.33	23.25
2	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	24.00

AREAS OF FLAT ROLLED IRON.

(CONTINUED.)

Thickness in inches.	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	12
$\frac{1}{16}$	.188	.203	.219	.234	.250	.266	.281	.297	.75
$\frac{1}{8}$	.375	.406	.438	.469	.500	.531	.563	.594	1.50
$\frac{3}{16}$	.563	.609	.656	.703	.750	.757	.844	.891	2.25
$\frac{1}{4}$	.750	.813	.875	.938	1.00	1.06	1.13	1.19	3.00
$\frac{5}{16}$	.938	1 02	1.09	1.17	1.25	1.33	1.41	1.48	3.75
$\frac{3}{8}$	1.13	1.22	1.31	1.41	1.50	1.59	1.69	1.78	4.50
$\frac{7}{16}$	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	5.25
$\frac{1}{2}$	1.50	1.63	1.75	1.88	2.00	2.13	2.25	2 38	6.00
$\frac{9}{16}$	1.69	1.83	1.97	2.11	2.25	2.39	2.53	2 67	6.75
$\frac{5}{8}$	1.88	2.03	2.19	2 34	2.50	2.66	2.81	2.97	7.50
$\frac{11}{16}$	2.06	2.23	2.41	2 58	2.75	2.92	3.09	3.27	8.25
$\frac{3}{4}$	2.25	2.44	2.63	2 81	3 00	3.19	3.38	3.56	9.00
$\frac{13}{16}$	2.44	2.64	2.84	3.05	3.25	3.45	3.66	3.86	9.75
$\frac{7}{8}$	2.63	2.84	3.06	3.28	3.50	3.72	3.94	4.16	10.50
$\frac{15}{16}$	2.81	3.05	3 28	3.52	3.75	3.98	4.22	4.45	11.25
1	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	12.00
$1\frac{1}{16}$	3.19	3.45	3.72	3.98	4.25	4.52	4.78	5.05	12.75
$1\frac{1}{8}$	3 38	3.66	3.94	4.22	4 50	4.78	5.06	5.34	13.50
$1\frac{3}{16}$	3.56	3.86	4.16	4.45	4.75	5.05	5.34	5.64	14.25
$1\frac{1}{4}$	3.75	4.06	4.38	4.69	5.00	5.31	5.63	5.94	15.00
$1\frac{5}{16}$	3.94	4 27	4.59	4.92	5.25	5.58	5.91	6.23	15 75
$1\frac{3}{8}$	4.13	4.47	4.81	5.16	5 50	5.84	6 19	6.53	16.50
$1\frac{7}{16}$	4 31	4.67	5.03	5.39	5.75	6.11	6.47	6.83	17.25
$1\frac{1}{2}$	4.50	4.88	5.25	5.63	6 00	6.38	6.75	7.13	18.00
$1\frac{9}{16}$	4.69	5.08	5.47	5.86	6.25	6.64	7.03	7.42	18.75
$1\frac{5}{8}$	4.88	5.28	5.69	6 09	6.50	6.91	7.31	7.72	19.50
$1\frac{11}{16}$	5.06	5.48	5.91	6.33	6.75	7.17	7.59	8 02	20.25
$1\frac{3}{4}$	5.25	5.69	6.13	6 56	7.00	7.44	7.88	8 31	21.00
$1\frac{13}{16}$	5.44	5.89	6.34	6.80	7.25	7.70	8.16	8.61	21.75
$1\frac{7}{8}$	5.63	6.09	6.56	7.03	7.50	7.97	8.44	8.91	22.50
$1\frac{15}{16}$	5.81	6.30	6.78	7.27	7.75	8.23	8.72	9.20	23.25
2	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	24.00

AREAS OF FLAT ROLLED IRON.

(CONTINUED.)

Thickness in inches.	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	6	$6\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	12
$\frac{1}{16}$	.313	.328	.344	.359	.375	.391	.406	.422	.750
$\frac{1}{8}$	.625	.656	688	.719	.750	.781	.813	.844	1 50
$\frac{3}{16}$	.938	.984	1.03	1.08	1.13	1 17	1.22	1.27	2.25
$\frac{1}{4}$	1.25	1.31	1.38	1.44	1.50	1.56	1 63	1.69	3.00
$\frac{5}{16}$	1.56	1.64	1.72	1.80	1.88	1.95	2.03	2.11	3.75
$\frac{3}{8}$	1.88	1,97	2 06	2.16	2.25	2.34	2.44	2.53	4.50
$\frac{7}{16}$	2.19	2.30	2.41	2.52	2 63	2.73	2.84	2.95	5 26
$\frac{1}{2}$	2.50	2.63	2.75	2 88	3.00	3.13	3 25	3.38	6.00
$\frac{9}{16}$	2.81	2,95	3.09	3.23	3.38	3 52	3.66	3.80	6.75
$\frac{5}{8}$	3.13	3.28	3.44	3 59	3.75	3.91	4 06	4.22	7.50
$\frac{11}{16}$	3,44	3.61	3.78	3.95	4.13	4.30	4 47	4.64	8.25
$\frac{3}{4}$	3.75	3.94	4.13	4.31	4.50	4.69	4.88	5.06	9.00
$\frac{13}{16}$	4.06	4.27	4.47	4 67	4.88	5.08	5.28	5.48	9.75
$\frac{7}{8}$	4.38	4,59	4.81	5.03	5.25	5.47	5.69	5.91	10.50
$\frac{15}{16}$	4,69	4.92	5.16	5,39	5,63	5.86	6.09	6.33	11.25
1	5.00	5.25	5.50	5.75	6 00	6.25	6.50	6.75	12.00
$1\frac{1}{16}$	5.31	5.58	5,84	6.11	6.38	6.64	6 91	7.17	12.75
$1\frac{1}{8}$	5.63	5.91	6.19	6.47	6.75	7.03	7.31	7.59	13.50
$1\frac{3}{16}$	5.94	6,23	6 53	6 83	7.13	7.42	7.72	8.02	14.25
$1\frac{1}{4}$	6.25	6.56	6.88	7 19	7.50	7,81	8.13	8,44	15 00
$1\frac{5}{16}$	6.56	6.89	7.22	7.55	7.88	8.20	8.53	8.86	15.75
$1\frac{3}{8}$	6.88	7.22	7 56	7.91	8 25	8.59	8.94	9·28	16.50
$1\frac{7}{16}$	7.19	7.55	7 91	8.27	8.63	8 98	9.34	9.70	17.25
$1\frac{1}{2}$	7,50	7.88	8.25	8.63	9.00	9.38	9.75	10 13	18.00
$1\frac{9}{16}$	7,81	8.20	8.59	8 98	9.38	9 77	10.16	10 55	18 75
$1\frac{5}{8}$	8.13	8.53	8 94	9.34	9 75	10.16	10 56	10.97	19 50
$1\frac{11}{16}$	8.44	8.86	9.28	9.70	10.13	10.55	10.97	11.39	20.25
$1\frac{3}{4}$	8.75	9 19	9 63	10.06	10.50	10.94	11.38	11.81	21.00
$1\frac{13}{16}$	9.06	9.52	9.97	10.42	10.88	11.33	11.78	12 23	21.75
$1\frac{7}{8}$	9.38	9.84	10.31	10.78	11.25	11.72	12.19	12.66	22.50
$1\frac{15}{16}$	9,69	10.17	10.66	11.14	11 63	12.11	12.59	13.08	23.25
2	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	24.00

AREAS OF FLAT ROLLED IRON

(CONTINUED.)

Thickness in inches.	7	7¼	7½	7¾	8	8¼	8½	8¾	12
1/16	.438	.453	.469	.484	.500	.516	.531	.547	.75
1/8	.875	.906	.938	.969	1.00	1.03	1.06	1.09	1.5
3/16	1.31	1.36	1.41	1.45	1.50	1.55	1.59	1.64	2.2
1/4	1.75	1.81	1.88	1.94	2.00	2.06	2.13	2.19	3.0
5/16	2.19	2.27	2.34	2.42	2.50	2.58	2.66	2.73	3.7
3/8	2.63	2.72	2.81	2.91	3.00	3.09	3.19	3.28	4.5
7/16	3.06	3.17	3.28	3.39	3.50	3.61	3.72	3.83	5.2
1/2	3.50	3.63	3.75	3.88	4.00	4.13	4.25	4.38	6.0
9/16	3.94	4.08	4.22	4.36	4.50	4.64	4.78	4.92	6.7
5/8	4.38	4.53	4.69	4.84	5.00	5.16	5.31	5.47	7.5
11/16	4.31	4.98	5.16	5.33	5.50	5.67	5.84	6.02	8.2
3/4	5.25	5.44	5.63	5.81	6.00	6.19	6.38	6.56	9.0
13/16	5.69	5.89	6.09	6.30	6.50	6.70	6.91	7.11	9.7
7/8	6.13	6.34	6.56	6.78	7.00	7.22	7.44	7.66	10.5
15/16	6.56	6.80	7.03	7.27	7.50	7.73	7.97	8.20	11.2
1	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	12.0
1 1/16	7.44	7.70	7.97	8.23	8.50	8.77	9.03	9.30	12.7
1 1/8	7.88	8.16	8.44	8.72	9.00	9.28	9.56	9.84	13.5
1 3/16	8.31	8.61	8.91	9.20	9.50	9.80	10.09	10.39	14.2
1 1/4	8.75	9.06	9.38	9.69	10.00	10.31	10.63	10.94	15.0
1 5/16	9.19	9.52	9.84	10.17	10.50	10.83	11.16	11.48	15.7
1 3/8	9.63	9.97	10.31	10.66	11.00	11.34	11.69	12.03	16.5
1 7/16	10.06	10.42	10.78	11.14	11.50	11.86	12.22	12.58	17.2
1 1/2	10.50	10.88	11.25	11.63	12.00	12.38	12.75	13.13	18.0
1 9/16	10.94	11.33	11.72	12.11	12.50	12.89	13.28	13.67	18.7
1 5/8	11.38	11.78	12.19	12.59	13.00	13.41	13.81	14.22	19.5
1 11/16	11.81	12.23	12.66	13.08	13.50	13.92	14.34	14.77	20.2
1 3/4	12.25	12.69	13.13	13.56	14.00	14.44	14.88	15.31	21.0
1 13/16	12.69	13.14	13.59	14.05	14.50	14.95	15.41	15.86	21.7
1 7/8	13.13	13.59	14.06	14.53	15.00	15.47	15.94	16.41	22.5
1 15/16	13.56	14.05	14.53	15.02	15.50	15.98	16.47	16.95	23.2
2	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	24.0

AREAS OF FLAT ROLLED IRON.

(CONTINUED)

in inches.	9	9¼	9½	9¾	10	10¼	10½	10¾	12
1/16	.563	.578	.594	.609	.625	.641	.656	.672	.750
1/8	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.50
3/16	1.69	1.73	1.78	1.83	1.88	1.92	1.97	2.02	2.25
1/4	2.25	2.31	2.38	2.44	2.50	2.56	2.63	2.69	3.00
5/16	2.81	2.89	2.97	3.05	3.13	3.20	3.28	3.36	3.75
3/8	3.38	3.47	3.56	3.66	3.75	3.84	3.94	4.03	4.50
7/16	3.94	4.05	4.16	4.27	4.38	4.48	4.59	4.70	5.25
1/2	4.50	4.63	4.75	4.88	5.00	5.13	5.25	5.38	6.00
9/16	5.06	5.20	5.34	5.48	5.63	5.77	5.91	6.05	6.75
5/8	5.63	5.78	5.94	6.09	6.25	6.41	6.56	6.72	7.50
11/16	6.19	6.36	6.53	6.70	6.88	7.05	7.22	7.39	8.25
3/4	6.75	6.94	7.13	7.31	7.50	7.69	7.88	8.06	9.00
13/16	7.31	7.52	7.72	7.92	8.13	8.33	8.53	8.73	9.75
7/8	7.88	8.09	8.31	8.53	8.75	8.97	9.19	9.41	10.50
15/16	8.44	8.67	8.91	9.14	9.38	9.61	9.84	10.08	11.25
	9.00	9.25	9.50	9.75	10.00	10.25	10.50	10.75	12.00
1/16	9.56	9.83	10.09	10.36	10.63	10.89	11.16	11.42	12.75
1/8	10.13	10.41	10.69	10.97	11.25	11.53	11.81	12.09	13.50
3/16	10.69	10.98	11.28	11.58	11.88	12.17	12.47	12.77	14.25
1/4	11.25	11.56	11.88	12.19	12.50	12.81	13.13	13.44	15.00
5/16	11.81	12.14	12.47	12.80	13.13	13.45	13.78	14.11	15.75
3/8	12.38	12.72	13.06	13.41	13.75	14.09	14.44	14.78	16.50
7/16	12.94	13.30	13.66	14.02	14.38	14.73	15.09	15.45	17.25
1/2	13.50	13.88	14.25	14.63	15.00	15.38	15.75	16.13	18.00
9/16	14.06	14.45	14.84	15.23	15.63	16.02	16.41	16.80	18.75
5/8	14.63	15.03	15.44	15.84	16.25	16.66	17.06	17.47	19.50
11/16	15.19	15.61	16.03	16.45	16.88	17.30	17.72	18.14	20.25
3/4	15.75	16.19	16.63	17.06	17.50	17.94	18.38	18.81	21.00
13/16	16.31	16.77	17.22	17.67	18.13	18.58	19.03	19.48	21.75
7/8	16.88	17.34	17.81	18.28	18.75	19.22	19.69	20.16	22.50
15/16	17.44	17.92	18.41	18.89	19.38	19.86	20.34	20.83	23.25
	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	24.00

AREA OF FLAT ROLLED IRON.

(CONTINUED.)

Thickness in inches.	11	11¼	11½	11¾	12	12¼	12½	12¾
1/16	.688	.703	.719	.734	.750	.766	.781	.799
1/8	1.38	1.41	1.44	1.47	1.50	1.53	1.56	1.59
3/16	2.06	2.11	2.16	2.20	2.25	2.30	2.34	2.39
1/4	2.75	2.81	2.88	2.94	3.00	3.06	3.13	3.19
5/16	3.44	3.52	3.59	3.67	3.75	3.83	3.91	3.98
3/8	4.13	4.22	4.31	4.41	4.50	4.59	4.69	4.78
7/16	4.81	4.92	5.03	.514	5.25	5.36	5.47	5.58
1/2	5.50	5.63	5.75	5.88	6.00	6.13	6.25	6.38
9/16	6.19	6.33	6.47	6.61	6.75	6.89	7.03	7.17
5/8	6.88	7.03	7.19	7.34	7.50	7.66	7.81	7.97
11/16	6.56	7.73	7.91	8.08	8.25	8.42	8.59	8.77
3/4	8.25	8.44	8.63	8.81	9.00	9.19	9.38	9.56
13/16	8.94	9.14	9.34	9.55	9.75	9.95	10.16	10.35
7/8	9.63	9.84	10.06	10.28	10.50	10.72	10.94	11.16
15/16	10.31	10.55	10.78	11.02	11.25	11.48	11.72	11.95
1	11.00	11.25	11.50	11.75	12.00	12.25	12.50	12.75
1 1/16	11.69	11.95	12.22	12.48	12.75	13.02	13.28	13.55
1 1/8	12.38	12.66	12.94	13.22	13.50	13.78	14.06	14.34
1 3/16	13.06	13.36	13.66	13.95	14.25	14.55	14.84	15.14
1 1/4	13.75	14.06	14.38	14.69	15.00	15.31	15.63	15.94
1 5/16	14.44	14.77	15.09	15.42	15,75	16.08	16.41	16.73
1 3/8	15.13	15.47	15.81	16.16	16.50	16.84	17.19	17.53
1 7/16	15.81	16.17	16.53	16.89	17.25	17.61	17.97	18.33
1 1/2	16.50	16.88	17.25	17.63	18.00	18.38	18.75	19.13
1 9/16	17.19	17.58	17.97	18.36	18.75	19.14	19.53	19.92
1 5/8	17.88	18.28	18.69	19.09	19.50	19.91	20.31	20.72
1 11/16	18.56	18.98	19.41	19.83	20.25	20.67	21.09	21.52
1 3/4	19.25	19.69	20.13	20.56	21.00	21.44	21.88	22.31
1 13/16	19.94	20.39	20.84	21.30	21.75	22.20	22.66	23.11
1 7/8	20.63	21.09	21.56	22.03	22.50	22.97	23.44	23.91
1 15/16	21.31	21.80	22.28	22.77	23.25	23.73	24.22	24.70
2	22.00	22.50	23.00	23.50	24.00	24.50	25.00	25.50

The Areas for 12 inches width are repeated on each page to facilitate making the additions necessary to obtain the areas of plates wider than 12 inches. Thus, to find the area of 15½ × ⅜,

AREAS AND CIRCUMFERENCE OF CIRCLES.

For Diameters from $\frac{1}{10}$ to 100, advancing by Tenths.

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.0					
.1	.31416	.007854	.1	9.7389	7.5477
.2	.62832	.031416	.2	10 0531	8.0425
.3	.94248	.070686	.3	10.3673	8.5530
.4	1.2566	.12566	.4	10.6814	9.0792
.5	1.5708	.19635	.5	10.9956	9.6211
.6	1.8850	.28274	.6	11.3097	10.1788
.7	2.1891	.38485	.7	11.6239	10.7521
.8	2.5133	.50266	.8	11.9381	11.3411
.9	2.8274	.63617	.9	12.2522	11.9459
.0	3.1416	.7854	4.0	12.5664	12.5664
.1	3.4558	.9503	.1	12.8805	13.2025
.2	3.7699	1.1310	.2	13.1947	13.8544
.3	4.0841	1.3273	.3	13.5088	14 5220
.4	4.3982	1.5394	.4	13.8230	15.2053
.5	4.7124	1.7671	.5	14.1372	15 9043
.6	5.0265	2.0106	.6	14.4513	16.6190
.7	5.3107	2.2698	.7	14.7655	17.3494
.8	5.6549	2.5447	.8	15.0796	18.0956
.9	5.9690	2.8353	.9	15.3938	18.8574
2.0	6.3832	3.1416	5.0	15.7080	19.6350
.1	6.5973	3 4636	.1	16.0221	20.4282
.2	6.9115	3.8013	.2	16.2363	21.2372
.3	7.2257	4.1548	.3	16.6504	22.0618
.4	7.5398	4.5239	.4	16.9646	22.9022
.5	7.8540	4 9087	.5	17.2788	23.7583
.6	8.1681	5.3093	.6	17.5929	24.6301
.7	8.4823	5.7256	.7	17.9071	25.5176
.8	8.7965	6.1575	.8	18.2212	26 4208
.9	9.1106	6.6052	.9	18.5354	27 3397
3.0	9.4248	7.0686	6.	18.8496	28.2743

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	19.1637	29 2247	.1	28.5885	65.0388
.2	19.4779	30.1907	.2	28.9027	66.4761
.3	19.7920	31.1725	.3	29.2168	67.9291
.4	20.1062	32.1699	.4	29.5310	69.3978
.5	20.4204	33.1831	.5	29.8451	70.8822
.6	20.7345	34.2119	.6	30.1593	72 3833
.7	21.0487	35.2565	.7	30.4734	73.8981
.8	21.3628	36.3168	.8	30.7876	75.4296
.9	21.6770	37 3928	.9	31.1018	76.9769
7.0	21 9911	38.4845	10.0	31.4159	78.5398
.1	22 3053	39.5919	.1	31.7301	80.1185
.2	22 6195	40.7150	.2	32.0442	81.7128
.3	22.9336	41.8539	.3	32.3584	83.3229
.4	23.2478	43.0084	.4	32.6726	84.9487
.5	23.5619	44.1786	.5	32.9867	86.5901
.6	23.8761	45.6646	.6	33.3009	88.2473
.7	24.1903	46.5663	.7	33.6150	89.9202
.8	24.5044	47 7836	.8	33.9292	91.6088
.9	24.8186	49.0167	.9	34.2434	93 3192
8.0	25.1327	50 2655	11.0	34.5575	95 0332
.1	25.4469	51.5300	.1	34 8717	96.7689
.2	25.7611	52.8102	.2	35.1858	98.5203
.3	26 0752	54.1061	.3	35 5000	100 2875
.4	26.3894	55.4177	.4	35.8142	102.0703
.5	26 7035	56.7450	.5	36.1283	103.8689
.6	27.0177	58 0880	.6	36.4425	105.6832
.7	27.3319	59.4468	.7	36 7556	107,5132
.8	27.6460	60.8212	.8	37.0708	109.3588
.9	27.9602	62.2114	.9	37.3850	111.2202
9.0	28.2743	63.6173	12.0	37.6991	113.0973

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	38.0133	114.9901	.1	47.4380	179.0786
.2	38.3274	116.8987	.2	47.7522	181.4584
.3	38.6416	118 8229	.3	48.0664	183.8536
.4	38 9557	120.7628	.4	48.3805	186.2650
.5	39.2699	122.7185	.5	48.6947	188.6919
.6	39.5841	124.6898	.6	49.0088	191.1345
.7	39.8982	126.6769	.7	49.3230	193.5928
.8	40.2124	128.6796	.8	49.6372	196.0668
.9	40.5265	130.6981	.9	49.9513	198.5565
13.0	40.8407	132.7323	16.0	50.2655	201.0619
.1	41.1549	134.7822	.1	50.5796	203.5831
.2	41 4690	136.8478	.2	50.8938	206 1199
.3	41.7832	138 9291	.3	51.5221	208 6724
.4	42.0973	141.0261	.4	51.8363	211.2407
.5	42.4115	143.1388	.5	52.1504	213.8246
.6	42.7257	145.2672	.6	52.4646	216.4243
.7	43.0398	147.4114	.7	52.7788	219.0397
.8	43.3540	149.5712	.8	53.0929	221.6708
.9	43.6681	151.7468	.9	53.4071	224.3176
14.0	43 9823	153.9380	17.0	53 4071	226.9801
.1	44.2965	156.1450	.1	53.7212	229.6583
.2	44.6106	158 3677	.2	54.0454	232.3522
.3	44.9248	160.6061	.3	54.3496	235.0618
.4	45.2389	162.8602	.4	54 6637	237.7871
.5	45.5531	165.1300	.5	54.9779	240 5282
.6	45.8673	167.4155	.6	55.2920	243.2849
.7	46.1814	169.7167	.7	55.5062	246.0574
.8	46.4956	172.0336	.8	55.9203	248.8456
.9	46.8097	174.3662	.9	56.2345	251.6194
15.0	47.1239	176.7146	18.0	56.5486	254.4690

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	56.8628	257.3043	.1	66.2876	349 6677
.2	57.1770	260.1553	.2	66.6018	352 9894
.3	57.4911	263.0220	.3	66.9159	356.3373
.4	57.8053	365 9044	.4	67.2301	359.6809
.5	58.1195	268.8025	.5	67.5402	363.0509
.6	58.4336	271.7164	.6	67.8584	366.4354
.7	58.7478	274.6459	.7	68.1726	369.8361
.8	59.0619	277.5911	.8	68,4867	373 2526
.9	59.3751	280.5521	.9	68 8009	376.6848
19.0	59.6903	283.5287	22.0	69.1150	380.1327
.1	60.0044	286 5211	.1	69 4292	383.5963
.2	60.3186	289 5292	.2	69.7434	387.0756
.3	60.6327	292 5530	.3	70 0575	390.5707
.4	60.9469	295.5925	.4	70.3717	394.0814
.5	61.2611	298.5477	.5	70.6858	397.6078
.6	61 5752	301.7186	.6	71,0000	401.1500
.7	61.8894	304.8052	.7	71 3142	404.7078
.8	62.2035	307.9074	.8	71.6283	408.2814
.9	62.5177	311.0255	.9	71 9425	411.8707
20.0	62.8319	314.1593	23.0	72.2566	415.4786
.1	63.1460	317.3087	.1	72.5708	419.0963
.2	63.4602	320 4739	.2	72.8849	422.7327
.3	63.7743	323.6547	.3	73.1991	426.3848
.4	64 0885	326.8513	.4	73.5133	430.0526
.5	64.4026	330.0636	.5	73.8274	433.7361
.6	64.7168	333.2916	.6	74.1416	437.4354
.7	65.0310	336.5353	.7	74.4557	441.1503
.8	65 3451	339.7947	.8	74 7099	444.8809
.9	65.6593	343.0698	.9	75.0841	448.6273
12.0	65.9734	346.3606	24.0	75.3982	452.3893

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	75.7124	456.1671	.1	85.1372	576,8043
.2	76.0265	459 9606	.2	85 4513	581.0690
.3	76.3407	463.7698	.3	85.7655	585.3494
.4	76.6549	467 5947	.4	86.0796	589.6455
.5	76.9690	471.4352	.5	86.3938	593.9574
.6	77.2832	475,2916	.6	86.7080	598.2849
.7	77.5973	479.1636	.7	87.0221	602.6282
.8	77.9115	483.0513	.8	87.3363	606.9871
.9	78.2257	486.9547	.9	87.6504	611.3618
25.0	78.5398	490.8739	28.0	87.9646	615.7522
.1	78.8540	494.8087	.1	88.2788	620.1582
.2	79.1681	498.7592	.2	88.5929	624.5800
.3	79.4823	502.7255	.3	88.9071	629.0175
.4	79 7965	506.7075	.4	89.2212	633.4707
.5	80.1106	510.7052	.5	89.5354	637.9397
.6	80.4248	514.7185	.6	89.8495	642.4243
.7	80.7389	518.7476	.7	90.1637	646.9246
.8	81.0531	522.7924	.8	90.4779	651.4407
.9	81.3672	526.8529	.9	90.7920	655.9724
26.0	81.6814	530 9292	29.0	91.1062	660.5199
.1	81.9956	535.0211	.1	91.4203	665.0830
.2	82.3097	539.1287	.2	91.7345	669 6619
.3	82 6239	543.2521	.3	92.0487	674.2565
.4	82.9380	547.3911	.4	92.3628	678.8668
.5	83.2522	551.5459	.5	92 6770	683,4928
.6	83.5664	555.7163	.6	92.9911	688.1345
.7	83.8805	559.9025	.7	93.3053	592.7919
.8	84.1947	564.1044	.8	93.6195	697.4650
.9	84.5088	578.3220	.9	93.9336	702.1538
27.0	84.8230	572.5553	30.0	94.2478	706.8583

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	94.5619	711.5786	.1	103.9867	860.4902
.2	94.8761	716 3145	.2	104.3009	865.6973
.3	95.1903	721.0662	.3	104.6150	870.9202
.4	95.5044	725.8336	.4	104.9292	876.1588
.5	95.8186	730.6167	.5	105.2434	881.4131
.6	96.1327	735.4154	.6	105.5575	886 6831
.7	96.4469	740.2299	.7	105 8717	891.9688
.8	96.7611	745.0601	.8	106.1858	897.2703
.9	97.0752	749.9060	.9	106.5000	902.5874
31.0	97.3894	754.7676	34.0	106.8142	907.9203
.1	97.7035	759.6460	.1	107.1283	913 2688
.2	98.0177	764.5380	.2	107.4425	918.6331
.3	98.3319	769.4467	.3	107.7566	924.0131
.4	98.6460	774.3712	.4	108.0708	929.4088
.5	98.9602	779.3113	.5	108.3849	934.8202
.6	99.2743	784.2672	.6	108.6991	940.2473
.7	99.5885	789.2388	.7	109.0133	945.6901
.8	99.9026	794.2260	.8	109.3274	951.1486
.9	100.2168	799.2290	.9	109.6416	956.6228
32.0	100.5310	804.2477	35.0	109.9557	962.1128
.1	100 8451	809.2821	.1	110.2699	967.6184
.2	101.1593	814.3322	.2	110.5841	973.1397
.3	101.4734	819 3980	.3	110.8982	978.6768
.4	101.7888	824.4796	.4	111 2124	984.2296
.5	102.1018	829.5768	.5	111.5265	989.7980
.6	102.4159	834.6898	.6	111.8407	995 3822
.7	102.7301	839.8185	.7	112.1549	1000.9821
.8	103.0442	844.9628	.8	112.4690	1006.5977
.9	103.3584	850.1229	.9	112.7832	1012,2290
33.0	103.6726	855.2986	36.0	113.0973	1017.8760

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

am.	Circum.	Area.	Diam.	Circum.	Area.
.1	113.4115	1023.5387	.1	122.8363	1200.7246
.2	113.7257	1029.2172	.2	123.1504	1206.8742
.3	114.0398	1034.9113	.3	123.4646	1213.0396
.4	114.3540	1040.6212	.4	123.7788	1219.2207
.5	114.6681	1046.3467	.5	124.0929	1225.4175
.6	114.9823	1052.0880	.6	124.4071	1231.6300
.7	115.2965	1057.8449	.7	124.7212	1237.8582
.8	115.6106	1063 6176	.8	125 0354	1244.1021
.9	115.9248	1069.4060	.9	125.3495	1250.3617
7.0	116.2389	1075.2101	40.0	125.6637	1256.6371
.1	116.5531	1081 0299	.1	125 9779	1262.9281
.2	116.8672	1086.8654	.2	126.2920	1269.2348
.3	117.1814	1092.7166	.3	126.6062	1275.5573
.4	117.4956	1098.5835	.4	126.9203	1281.8955
.5	117.8097	1104.4662	.5	127.2345	1288.2493
6	118.1239	1110.3645	.6	127.5487	1294.6189
.7	118 4380	1116 2786	.7	127.8628	1301.0042
.8	118.7583	1122.2083	.8	128.1770	1307.4052
.9	119.0664	1128.1538	.9	128.4911	1313.8219
8.0	119.3805	1134.1149	41.0	128.8053	1320.2543
.1	119.6947	1140.0918	.1	129.1195	1326.7024
.2	120.0088	1146.0844	.2	129.4336	1333.1663
.3	120.3230	1152.0927	.3	129.7478	1339 6458
.4	120.6372	1158 1167	.4	130.0619	1346.1410
.5	120.9513	1164.1564	.5	130.3761	1352.6520
.6	121.2655	1170.2118	.6	130.6903	1359.1786
.7	121.5796	1176.2830	.7	131.0044	1365.7210
.8	121.8938	1182.3698	.8	131.3186	1372 2791
.9	122.2080	1188.4724	.9	131.6327	1378.8529
9.0	122.5221	1194.5906	42.0	131.9469	1385.4424

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	132.2611	1392.0476	.1	141.6858	1597.5077
.2	132.5752	1398.6685	.2	142.0000	1604.5999
.3	132.8894	1405.3051	.3	142.3142	1611 7077
.4	133.2035	1411.9574	.4	142 6283	1618.8313
.5	133.5177	1418.6254	.5	142.9425	1625.9705
.6	133.8318	1425.7392	.6	143.2566	1633.1255
.7	134.1460	1432.0086	.7	143 5708	1640.2962
.8	134.4602	1438.7238	.8	143.8849	1647.4826
.9	134.7743	1445.4546	.9	144.1991	1654.6847
43.0	135.0885	1452 2012	46.0	144.5133	1661.9025
.1	135.4026	1458.9635	.1	144.8274	1669.1316
.2	135.7168	1465.7415	.2	145.1416	1676.3863
.3	136.0310	1472.5352	.3	145.4557	1683.6502
.4	136.3451	1479.3446	4	145.7699	1690.9308
.5	136.6593	1486.1697	.5	146.0841	1698.2272
.6	136.9734	1493.0105	.6	146 3982	1705.5392
.7	137.2876	1499.8670	.7	146.7124	1712.8670
.8	137.6018	1506.7393	.8	147.0265	1720.2105
.9	137.9159	1513 6272	.9	147.3407	1727.5697
44.0	138.2301	1520.5308	47.0	147.6550	1734.9445
.1	138.5442	1527.4502	.1	147.9690	1742.3351
.2	138 8584	1534.3853	.2	148.2832	1749.7414
.3	139.1726	1541.3360	.3	148.5973	1757,1635
.4	139.4867	1548.3025	.4	148.9115	1764.6012
.5	139.8009	1555.2847	.5	149.2257	1772.0546
.6	140.1153	1562.2826	.6	149 5398	1779.5237
.7	140.4292	1569 2962	.7	149.8540	1787.0086
.3	140.7434	1576.3255	.8	150.1681	1794.5091
.9	141.0575	1583.3706	.9	150.4823	1802.0254
45.0	141.3717	1590.4313	48.0	150.7964	1809.5574

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

m.	Circum.	Area.	Diam.	Circum.	Area.
1	151.1106	1817.1050	.1	160.5354	2050.8395
2	151.4248	1824.6684	.2	160 8495	2058.8742
3	151.7389	1832.2475	.3	161.1637	2066 9245
4	152.0531	1839.8423	.4	161.4779	2074 9905
5	152.3672	1847.4528	.5	161.7920	2083.0723
6	152.6814	1855.0790	.6	162.1062	2091.1697
7	152.9956	1862.7210	.7	162.4203	2099.2829
8	153.3097	1870 3786	.8	162.7345	2107.4118
9	153.6239	1878.0519	.9	163.0487	2115.5563
0	153.9380	1885.7409	52.0	163.3628	2123.7166
1	154 2522	1893.4457	.1	163.6770	2131.8926
2	154 5654	1901.1662	.2	163.9911	2140.0843
3	154.8805	1908.9024	.3	164 3053	2148.2917
4	155.1947	1916.6543	.4	164 6195	2156.5149
5	155.5088	1924.4218	.5	164 9336	2164.7537
6	155.8230	1932.2051	.6	165 2479	2173.0082
7	156.1372	1940.0042	.7	165.5619	2181 2785
8	156 4513	1947 8189	.8	165 8761	2189 5644
9	156 7655	1955.6493	.9	166.1903	2197.8661
0	157.0796	1963.4954	53.0	166 5044	2206.1834
1	157.3938	1971 3572	.1	166 8186	2214.5165
2	157.7080	1979.2348	.2	167.1327	2222.8653
3	158 0221	1987.1280	3	167.4469	2231.2298
4	158.3363	1995.0370	.4	167.7610	2239.6100
5	158.6504	2002.9617	.5	168 0752	2248.0059
6	158 9646	2010.9020	.6	168 3894	2256 4175
7	159.2787	2018.8581	.7	168.7035	2264.8448
8	159.5929	2026.8299	.8	169.0177	2273.2879
9	159.9071	2034 8164	.9	169.3318	2281.7466
0	160.2212	2042 8206	54.0	169.6460	2290.2210

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	169.9609	2298.7112	.1	179.3849	2560.720
.2	170 2743	2307.2171	.2	179.6991	2569.697
.3	170.5885	2315.7386	.3	180.0133	2578 689
.4	170.9026	2324 2759	.4	180.3274	2587.698
.5	171.2168	2332.8289	.5	180.6416	2596.722
.6	171.5310	2341 3976	.6	180.9557	2605 762
.7	171 8451	2349 9820	.7	181.2699	2614 818
.8	172.1593	2358.5821	.8	181.5841	2623.889
.9	172.4735	2367.1979	.9	181.8982	2632.976
55.0	172,7876	2375.8294	58.0	182 2124	2641.079
.1	173.1017	2384.4767	.1	182.5265	2651.197
.2	173.4159	2393.1396	.2	182 8407	2660.332
.3	173.7301	2401.8183	.3	183.1549	2669.482
.4	174.0442	2410.5126	.4	183.4690	2678.647
.5	174.3584	2419.2227	.5	183.7832	2687.828
.6	174.6726	2427 9485	.6	184.0973	2697.025
.7	174.9867	2436.6899	.7	184.4115	2706.238
.8	175.3009	2445.4471	.8	184.7256	2715 467
.9	175.6150	2454.2200	.9	185.0398	2724 711
56.0	175.9292	2463.0086	59.0	185.3540	2733 971
.1	176.2433	2471.8130	.1	185.6681	2743.246
.2	176.5575	2480.6330	.2	185.9823	2752.537
.3	176.8717	2489.4687	.3	186.2964	2761.844
.4	177.1858	2498 3201	.4	186.6106	2771.167
.5	177-5000	2507.1873	.5	186 9248	2780.505
.6	177 8141	2516.0701	.6	187.2389	2789.859
.7	178 1283	2524.9687	.7	187.5531	2799.229
.8	178.4425	2533 8830	.8	187.8672	2808.615
.9	178.7566	2542.8129	.9	188.1814	2808.016
57.0	179.0808	2051.7586	60.0	188.4956	2827.433

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

am.	Circum.	Area.	Diam.	Circum.	Area.
.1	188.8097	2836.8660	.1	198.2345	3127.1492
.2	189.1239	2846.3144	.2	198.5487	3137.0688
.3	189.4380	2855.7784	.3	198.8628	3147.0040
.4	189.7522	2865.2582	.4	199.1770	3156.9550
.5	190.0664	2874.7536	.5	199.4911	3166.9217
.6	190.3805	2884.2648	.6	199.8053	3176.9043
.7	190.6947	2893.7917	.7	200.1195	3186.9023
.8	191.0088	2903.3343	.8	200.4336	3196.9161
.9	191.3230	2912.8926	.9	200.7478	3206.9456
.0	191.6372	2922.4666	64.0	201.0620	3216.9909
.1	191.9513	2932.0563	.1	201.3761	3227.0518
.2	192.2655	2941.6617	.2	201.6902	3237.1285
.3	192.5796	2951.2828	.3	202.0044	3247.2222
.4	192.8938	2960.9197	.4	202.3186	3257.3289
.5	193.2079	2970.5722	.5	202.6327	3267.4527
.6	193.5221	2980.2405	.6	202.9469	3277.5922
.7	193.8363	2989.9244	.7	203.2610	3287.7474
.8	194.1504	2999.6241	.8	203.5752	3297.9183
.9	194.4646	3009.3395	.9	203.8894	3308.1049
2.0	194.7787	3019.0705	65.0	204.2035	3318.3072
.1	195.0929	3028.8173	.1	204.5176	3328.5253
.2	195.4071	3038.5798	.2	204.8318	3338.7590
.3	195.7212	3048.3580	.3	205.1460	3349.0085
.4	196.0354	3058.1520	.4	205.4602	3359.2736
.5	196.3495	3067.9616	.5	205.7743	3369.5545
.6	196.6337	3077.7869	.6	206.0885	3379.8510
.7	196.9779	3087.6279	.7	206.4026	3390.1633
.8	197.2920	3097.4847	.8	206.7168	3400.4913
.9	197.6062	3107.3571	.9	207.3010	3410.8350
3.0	197.9203	3117.2463	66.0	207.3451	3421.1944

AREAS AND CIRCUMFERENCES OF CIRCLES

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	207.6593	3431.5695	.1	217.0841	3750.127
.2	207.9734	3441 9603	.2	217.3982	3760.989
.3	298.2876	3452.3669	.3	217.7124	3771.866
.4	208.6017	3462.7891	.4	218.0265	3782.760
.5	208.9159	3473.2270	.5	218.3407	3793.669
.6	209.2301	3483.6807	.6	218.6548	3804.5944
.7	209.5442	3494.1500	.7	218 9690	3815.535
.8	209 8584	3504 6351	8	219.2832	3826.491
.9	210.1725	3515.1359	.9	219.5973	3837.463
67.0	210.4867	3525.6524	7(.0	219.9115	3848.451
.1	210.8009	3536 1845	.1	220.2256	3859.4544
.2	211.1150	3546.7324	.2	220.5398	3870.473
.3	211.4292	3557.2960	.3	220.8540	3881.5084
.4	211 7433	3567 8754	.4	221.1681	3892.559
.5	212.0575	3578.4704	.5	221.4823	3903.625
.6	212.3717	3589.0811	.6	221.7964	3914.7072
.7	212.6858	3599.7075	.7	222.1106	3925.8049
.8	213.0000	3610 3497	.8	222.4248	3936.9182
.9	213.3141	3621.0075	.9	222.7389	3948.0473
68.0	213 6283	3631.6811	71.0	223.0531	3959.1921
.1	213 9425	3642.3704	.1	223.3672	3970 3526
.2	214.2566	3653.0754	.2	223 6814	3981.5289
.3	214.5708	3663.7960	.3	223.9956	3992.7208
.4	214.8849	3674.5324	.4	224 3097	4003.9284
.5	215.1991	3685.2845	.5	224.6239	4015.1518
.6	215.5133	3696.0523	.6	224.9380	4026.3908
.7	215.8274	3706.8359	.7	225.2522	4037.6456
.8	216.1416	3717.6351	.8	225.5664	4048.9160
.9	216.4556	3728.4500	.9	225.8805	4060.2022
9. 0	216.7699	3739.2807	72.0	226.1947	4071.5041

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	226.5088	4082.8217	.1	235.9336	4429.6535
.2	226.8230	4091.4550	.2	236.2478	4441.4580
.3	227.1371	4105.5040	.3	236.5619	4453.2783
.4	227.4513	4116.8687	.4	236.8761	4465.1142
.5	227.7655	4128.2491	.5	237.1902	4476.9659
.6	228.0796	4139.6452	.6	237.5044	4488.8332
.7	228.3938	4151.0571	.7	237.8186	4500.7163
.8	228.7079	4162.4846	.8	238.1327	4512.6151
.9	229.0221	4173.9279	.9	238.4469	4524.5296
73.0	229.3363	4185.3868	76.0	238.7610	4536.4598
.1	229.6504	4196.8615	.1	239.0752	4548.4057
.2	229.9646	4208.3519	.2	239.3894	4560.3673
.3	230.2787	4219.8579	.3	239.7035	4572.3446
.4	230.5929	4231.3797	.4	240.0177	4584.3377
.5	230.9071	4242.9172	.5	240.3318	4596.3464
.6	231.2212	4254.4704	.6	240.6460	4608.3602
.7	231.5354	4266.0394	.7	240.9602	4620.4110
.8	231.8495	4277.6240	.8	241.2743	4632.4669
.9	232.1637	4289.2243	.9	241.5885	4644.5384
74.0	232.4779	4300.8403	77.0	241.9026	4656.6257
.1	232.7920	4312.4712	.1	242.2116	4668.7287
.2	233.1062	4324.1195	.2	242.5310	4680.8474
.3	233.4203	4335.7827	.3	242.8451	4692.9818
.4	233.7345	4347.4616	.4	243.1592	4705.1319
.5	234.0487	4359.1562	.5	243.4734	4717.2977
.6	234.3628	4370.8664	.6	243.7876	4729.4792
.7	234.6770	4382.5924	.7	244.1017	4741.6765
.8	234.9911	4394.3341	.8	244.4159	4753.8894
.9	235.3053	4406.0916	.9	244.7301	4766.1181
75.0	235.6194	4417.8647	78.0	245.0442	4778.3624

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	245.3584	4790.6225	.1	254.7832	5165.7287
.2	245.6725	4802.8983	.2	255.0973	5178.4757
.3	245.9867	4815.1897	.3	255.4115	5191.2384
.4	246.3009	4827.4969	.4	255.7256	5204.0168
.5	246.6150	4839.8198	.5	256.0398	5216.8110
.6	246.9292	4852.1584	.6	256.3540	5229.6208
.7	247.2433	4864.5128	.7	256.6681	5242.4463
.8	247.5575	4876.8828	.8	256.9823	5255 2876
.9	247.8717	4889.2685	.9	257 2966	5268.1446
79.0	248.1858	4901.6699	82.0	257.6106	5281.0173
.1	248.5000	4914.0871	.1	257.9247	5293.9056
.2	248.8141	4926.5199	.2	258.2389	5306.8097
.3	249.1283	4938 9685	.3	258.5531	5319.7295
.4	249.4425	4951 4328	.4	258.8672	5332.6650
.5	249.7566	4963.9127	.5	259.1814	5345.6162
.6	250.0708	4976.4084	.6	259 4956	5358 5832
.7	250 3850	4988.9198	.7	259.8097	5371.5658
.8	250.6991	5001.4469	.8	260.1239	5384.5641
.9	251.0133	5013.9897	.9	260.4380	5397.5782
80.0	251.3274	5026.5482	83.0	260.7522	5410 6079
.1	251.6416	5039 1225	.1	261.0663	5423 6534
.2	251.9557	5051.7.24	.2	261.3805	5436.7146
.3	252.2699	5064.3180	.3	261 6947	5449.7915
.4	252.5840	5076.9394	.4	262.0088	5462.8840
.5	252 8982	5089 5764	.5	262.3230	5475 9923
.6	253.2124	5102.2292	.6	262 6371	5489 1163
.7	253 5265	5114.8977	.7	262 9513	5502.2561
.8	253.8407	5127 5819	.8	263.2655	5515 4115
.9	254.1548	5140 2818	.9	263.5796	5528.5826
81.0	254.4690	5152.9973	84.0	263.8938	5541.7694

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	264.2079	5554.9720	.1	273.6327	5958 3525
.2	264.5221	5568.1902	.2	273.9469	5972.0420
.3	264.8363	5581 4242	.3	274.2610	5985.7472
.4	265.1514	5594.6739	.4	274,5752	5999.4681
.5	265.4646	5607.9392	.5	274.8894	6013.2047
.6	265.7787	5621.2203	.6	275.2035	6026.9570
.7	266.0929	5634.5171	.7	275.5177	6040.7250
.8	266.4071	5647.8296	.8	275.8318	6054.5088
.9	266.7212	5661.1578	.9	276.1460	6068.3082
85.0	267 0354	5674.5017	88.0	276.4602	6082.1234
.1	267.3495	5687,8614	.1	276.7743	6095.9542
.2	267.6637	5701.2367	.2	277.0885	6109.8008
.3	267.9779	5714.6277	.3	277.4026	6123.6631
.4	268.2920	5728.0345	.4	277.7168	6137.5411
.5	268.6062	5741.4569	.5	278.0309	6151.4348
.6	268.9203	5754.8951	.6	278.3451	6165.3442
.7	269.2345	5768 3490	.7	278.6593	6179.2693
.8	269.5486	5781.8185	.8	278.9740	6193.2101
.9	269.8628	5795.3038	.9	279.2876	6207.1666
86.0	270.1770	5808.8048	89.0	279 6017	6221.1389
.1	270.4911	5822.3215	.1	279.9159	6235.1268
.2	270.8053	5835.8539	.2	280.2301	6249.1304
.3	271.1194	5849.4020	.3	280.5442	6263.1498
.4	271.4336	5862.9659	.4	280.8584	6277.1849
.5	271.7478	5876.5454	.5	281.1725	6291,2356
.6	272.0619	5890.1407	.6	281 4867	6305.3021
.7	272.3761	5903.7516	.7	281.8009	6319 3843
.8	272 6902	5917.3783	.8	282.1150	6333.4822
.9	273.0044	5931.0206	.9	282.4292	6347.5958
87.0	273.3186	5944.6787	90.0	282.7433	6361.7251

AREAS AND CIRCUMFERENCE OF CIRCLES,

(CONTINUED)

Diam.	Circum.	Area.	Diam.	Circum.	Area.
.1	283.0575	6375.8701	.1	292.4823	6807.5250
.2	283.3717	6390.0309	.2	292.7964	6822.1569
.3	283.6858	6404.2073	.3	293.1106	6836.8046
.4	284.0000	6418.3995	.4	293.4248	6851.4680
.5	284.3141	6432.6073	.5	293.7389	6866.1471
.6	284.6283	6446.8309	.6	294.0531	6880.8419
.7	284.9425	6461.0701	.7	294.3672	6895.5524
.8	285.2566	6475.3251	.8	294.6814	6910.2786
.9	285.5708	6489.5958	.9	294.9956	6925.0205
91.0	285.8849	6503.8822	94.0	295.3097	6939.7782
.1	286.1991	6518.1843	.1	295.6239	6954.5515
.2	286.5133	6532.5021	.2	295.9380	6969.3106
.3	286.8274	6546.8356	.3	296.2522	6984.1453
.4	287.1416	6561.1848	.4	296.5663	6998.9658
.5	287.4557	6575.5498	.5	296.8805	7013.8019
.6	287.7699	6589.9304	.6	297.1947	7028.6538
.7	288.0840	6604.3268	.7	297.5088	7043.5214
.8	288.3982	6618.7388	.8	297.8230	7058.4047
.9	288.7124	6633.1666	.9	298.1371	7073.3033
92.0	289.0265	6647.6101	95.0	298.4513	7088.2184
.1	289.3407	6662.0692	.1	298.7655	7103.1488
.2	289.6548	6676.5441	.2	299.0796	7118.1950
.3	289.9690	6691.0347	.3	299.3938	7133.0568
.4	290.2832	6705.5410	.4	299.7079	7148.0343
.5	290.5973	6720.0630	.5	300.0221	7163.0276
.6	290.9115	6734.6008	.6	300.3363	7178.0366
.7	291.2256	6749.1542	.7	300.6504	7193.0612
.8	291.5398	6763.7233	.8	300.9646	7208.1016
.9	291.8540	6778.3082	.9	301.2787	7223.1577
93.0	292.1681	6792.9087	96.	301.5929	7238.2295

AREAS AND CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

am.	Circum.	Area.	Diam.	Circum.	Area.
.1	301.9071	7253.3170	.1	311.3318	7713.2461
.2	302.2212	7268.4202	.2	311.6460	7728.8206
.3	302.5354	7283.5391	.3	311.9602	7744.4107
.4	302.8405	7298.6737	.4	312.2743	7760.0166
.5	303.1637	7313.8240	.5	312.5885	7775.6382
.6	303.4779	7328.9901	.6	342.9026	7791.2754
.7	303.7920	7344.1718	.7	313.2168	7806.9284
.8	304.1062	7359.3693	.8	313.5309	7822.5971
.9	304.4203	7374.5824	.9	313.8451	7838.2815
.0	304.7345	7389.8113	100.0	314.1600	7853.9816
.1	305.0486	7405.0559			
.2	305.3628	7420.3162			
.3	305.6770	7435.5922			
.4	305.9911	7450.8839			
.5	306.3053	7466.1913			
.6	306.6194	7481.5144			
.7	306.9336	7496.8532			
.8	307.2478	7512.2078			
.9	307.5619	7527.5780			
.0	307 8761	7542.9640			
.1	308.1902	7558.3656			
.2	308.5044	7573.7830			
.3	308.8186	7589.2161			
.4	309.1327	7604.6648			
.5	309.4469	7620.1293			
.6	309 7610	7635.6095			
.7	310.0752	7651.1054			
.8	310.3894	7666.6170			
.9	310.7035	7682.1444			
.0	311.0177	7697.6893			

BEARING VALUES OF PINS AT 15.000 LBS. PER SQUARE INCH.

Diam. of Pin. Inch's	Area of Pin in Sq. inches	Bearing Value at 15,000 lbs. Per sq. in.	Diam. of Pin. Inch's	Area of Pin in Sq. inches	Bearing Value at 15,000 lbs Per sq. in
1	.785	11,775	4	12.57	188,550
$1\frac{1}{8}$	.994	14,910	$4\frac{1}{8}$	13.36	200,400
$1\frac{1}{4}$	1.227	18,405	$4\frac{1}{4}$	14.19	212,850
$1\frac{3}{8}$	1.485	22,275	$4\frac{3}{8}$	15.03	225,450
$1\frac{1}{2}$	1.767	26,505	$4\frac{1}{2}$	15.90	238,500
$1\frac{5}{8}$	2.074	31,110	$4\frac{5}{8}$	16.80	252,000
$1\frac{3}{4}$	2.405	36,075	$4\frac{3}{4}$	17.72	265,800
$1\frac{7}{8}$	2.761	41,415	$4\frac{7}{8}$	18.67	280,050
2	3.142	47,130	5	19.64	294,600
$2\frac{1}{8}$	3.547	53,205	$5\frac{1}{8}$	20.63	309,450
$2\frac{1}{4}$	3.976	59,640	$5\frac{1}{4}$	21.65	324,750
$2\frac{3}{8}$	4.430	66,450	$5\frac{3}{8}$	22.69	340,350
$2\frac{1}{2}$	4.909	53,635	$5\frac{1}{2}$	23.76	356,400
$2\frac{5}{8}$	5.412	81,180	$5\frac{5}{8}$	24.85	372,750
$2\frac{3}{4}$	5.940	89,100	$5\frac{3}{4}$	25.97	389,550
$2\frac{7}{8}$	6.492	97,380	$5\frac{7}{8}$	27.11	406,650
3	7.069	106,035	6	28.27	424,050
$3\frac{1}{8}$	7.670	115.050	$6\frac{1}{8}$	29.46	441,900
$3\frac{1}{4}$	8.296	124,440	$6\frac{1}{4}$	30.68	460,200
$3\frac{3}{8}$	8.946	134,190	$6\frac{3}{8}$	31.92	478,800
$3\frac{1}{2}$	9.621	144,315	$6\frac{1}{2}$	33.18	497,700
$3\frac{5}{8}$	10.32	154,800	$6\frac{5}{8}$	34.47	517,050
$3\frac{3}{4}$	11.05	165,750	$6\frac{3}{4}$	35.79	536,850
$3\frac{7}{8}$	11.79	176,850	$6\frac{7}{8}$	37.12	556,800

WEIGHT OF FLAT ROLLED METALS PER SQUARE FOOT.

(From Haswell.)

Thickness in inches.	Wrght. Iron. Pounds.	Cast Iron lbs.	Copper. Pounds.	Lead. Pounds.	Zinc. Pounds	Brass. Pounds.
$\frac{1}{16}$	2.517	2.346	2.89	3.691	2,34	2.685
$\frac{1}{8}$	5.035	4 693	5,781	7.382	4.68	5.35
$\frac{3}{16}$	7.551	7.039	8 672	11.074	7.02	8.025
$\frac{1}{4}$	10.07	9.386	11.562	14.766	9.36	10.7
$\frac{5}{16}$	12.588	11.733	14.453	18.456	11.7	13.375
$\frac{3}{8}$	15.106	14.079	17 344	22.148	14.04	16.05
$\frac{7}{16}$	17 623	16.426	20 234	25.839	16.34	18.725
$\frac{1}{2}$	20.141	18.773	23.125	29 530	18.72	21.4
$\frac{9}{16}$	22 659	21.119	26.016	33.222		24.075
$\frac{5}{8}$	25.176	23.446	28 906	26.913		26.75
$\frac{11}{16}$	27.694	25.812	31.797	40.604		29.425
$\frac{3}{4}$	30.211	28.159	34.688	44 296		32.1
$\frac{13}{16}$	32 729	30.505	37.578	47.987		
$\frac{7}{8}$	35.247	32.852	40.469	51.678		
$\frac{15}{16}$	37.764	35.199	43.359	55.37		
1	40.282	37.545	46.25	59.061		

BREAKING STRAIN OF WROUGHT IRON CHAIN.

The Maximum Breaking Strain is about 9 per cent Less than this Table.

(From Haswell)

Diamater in Inches.	Pounds.	Dinmeter in Inches.	Pounds.
$\frac{3}{16}$	2,464	$\frac{13}{16}$	44,800
$\frac{1}{4}$	3,920	$\frac{7}{8}$	51,520
$\frac{5}{16}$	6,720	$\frac{15}{16}$	58,240
$\frac{3}{8}$	8,960	1	62,720
$\frac{7}{16}$	13,440	$1\frac{1}{8}$	82,880
$\frac{1}{2}$	15,680	$1\frac{3}{8}$	100,800
$\frac{9}{16}$	22,400	$1\frac{1}{2}$	120,960
$\frac{5}{8}$	26,880	$1\frac{3}{4}$	143,360
$\frac{11}{16}$	31,360	$1\frac{5}{8}$	168,000
$\frac{3}{4}$	38,080	$1\frac{3}{4}$	201,580

WEIGHT OF CAST IRON BALLS.

Diam. in Inches.	Volume in Cubic inches.	Weight in Pounds.
1	.5235	.1365
1½	1.7671	.4607
2	4.1887	1.0768
2½	8.1812	2.1328
3	14.1371	3.6855
3½	22.4492	5.8525
4	33.5103	8.7361
4½	47.7129	12.4387
5	65.4498	17.0628
5½	87.1137	22.7206
6	113.0973	29.4845
6½	143.7932	37.4528
7	179.5943	46.8203
7½	220.8932	57.587
8	268.0825	69.8892
8½	321.555	83.8396
9	381.7034	99.5103
9½	448.9204	117.0338
10	523.5987	136.525
11	696.9098	181.7648
12	904.7784	235.8763
13	1150.346	299.623
14	1436.754	374.5629
15	1767.145	460.6959
16	2144.66	559.1142
17	2572.44	670.7168
18	3053.627	796.5825
19	3591.363	936.2708
20	4188.79	1092.02

WEIGHT OF METALS.

Per Cubic Foot and per Cubic Inch.

	Per Cubic foot in lbs.	Per Cubic inches in lbs
Aluminum	162.	.0937
Brass	488.75	.2829
Copper	.67	....
Zinc	.33	....
Brass Wire	524.16	.3033
Copper, cast	547.25	.3179
Copper, plate.	543.625	.3167
Iron, cast.	450.437	.2607
Iron, heavy forging	480.	.2775
Iron, plates	450.	.2604
Iron, wrought bars	486.75	2816
Lead, cast	709.5	.4106
Lead, rolled	711.75	.4119
Mercury, 60°	848.7487	.491174
Steel, plates	490.	.28472
Steel, soft	489.56	.28465
Tin.	455.687	.2637
Zinc, cast	428.812	.2482
Zinc, rolled	449.437	.2601
Gold, cast, pure, 24c	1204.	.6973
Gold, pure, hammered	1217.	.7042
Platinum	1342.	.7766
Silver	655.	.3790
Steel	490.	.2847

Water, pure, at 60° F 62.5
Wax, bees 60.5
Zinc, or Spelter 43.5

WEIGHT OF SUBSTANCES.

Per Cubic Foot.

(From Haswell.)

	Weig in lb
Anthracite, solid	9
Anthracite, broken loose	5
Anthracite, moderately shaken	5
Anthracite, heaped bu , loose	8
Ash, white, dry	3
Asphaltum	8
Brick, pressed	15
Brick, common hard	12
Cement, loose	5
Cement, Portland	9
Cherry, dry	4
Chestnut, dry	4
Clay, dry	12
Coke, loose	6
Coal, bituminous	8
Ebony, dry	7
Elm, dry	3
Flint	16
Glass	15
Granite	17
Gypsum	14
Ice	5
Ivory	11
Lime, in small lumps	5
Marble	16
Oak, live, dry	5
Pine, white	2
Petroleum	5
Rosin	6
Salt, about	4
Slate	17

SHEET STEEL MEASUREMENTS

As per Old Birmingham Guage, in Thousandths of an Inch.

(From Haswell)

No. of Wire Ga'ge	Size of each No. in Dec. Parts of an Inch. Birm. W. G	No. of Wire Ga'ge.	Size of each No. in Dec. Parts of an Inch. Birm. W. G.	No. of Wire Ga'ge.	Size of each No. in Dec. Parts of an Inch. Birm. W. G.
0000	.454	10	.134	23	.025
000	.425	11	.120	24	.022
00	.380	12	.109	25	.020
0	.340	13	.095	26	.018
1	.300	14	.083	27	.016
2	.284	15	.072	28	.014
3	.259	16	.065	29	.013
4	.238	17	.058	30	.012
5	.220	18	.049	31	.010
6	.203	19	.042	32	.009
7	.180	20	.035	33	.008
8	.165	21	.032	34	.007
9	.148	22	.028	35	.005

UPSET SCREW ENDS FOR ROUND AND SQUARE BARS.

Standard Proportions of Keystone Bridge Co.

	ROUND BARS.				SQUARE BARS.			
Diam. of Round or Sq. Bars in inches.	Diam. of Upset Screw End in inches.	Diam. Screw at Root of Thr'd. Inches.	No. Threads per inch.	Per Cent of Ex. of eff'tive area of Screw end of Over-bar.	Diam. of Upset Screw End in inches.	Diam. Screw at Root of Thr'd. Inches.	No. of Threads per inch.	Per cent of Excess of Effective Erea of Screw End Over-bar
1/2	3/4	.620	10	54	3/4	.620	10	21
9/16	3/4	.620	10	21	7/8	.731	9	33
5/8	7/8	.731	9	37	1	.837	8	41
11/16	1	.837	8	48	1	.837	8	17
3/4	1	.837	8	25	1 1/8	.940	7	23
13/16	1 1/8	.940	7	34	1 1/4	1.065	7	35
7/8	1 1/4	1.065	7	48	1 3/8	1.160	6	38
15/16	1 1/4	1.065	7	29	1 3/8	1.160	6	20
1	1 3/8	1.160	6	35	1 1/2	1.284	6	29
1 1/16	1 3/8	1.160	6	19	1 5/8	1.389	5 1/2	34
1 1/8	1 1/2	1.284	6	30	1 5/8	1.389	5 1/2	20
1 3/16	1 1/2	1.284	6	17	1 3/4	1.490	5	24
1 1/4	1 5/8	1.389	5 1/2	23	1 7/8	1.615	5	31
1 5/16	1 3/4	1.490	5	29	1 7/8	1.615	4 1/2	19
1 3/8	1 3/4	1.615	5	18	2	1.712	4 1/2	22
1 7/16	1 7/8	1.712	5	26	2 1/8	1.837	4 1/2	28
1 1/2	2	1.712	4 1/2	30	2 1/8	1.837	4 1/2	18
1 9/16	2	1.837	4 1/2	20	2 1/4	1.962	4 1/2	24
1 5/8	2 1/8	1.837	4 1/2	28	2 3/8	2.087	4 1/2	30
1 11/16	2 1/8	1.962	4 1/2	18	2 3/8	2.087	4	20
1 3/4	2 1/4	1.962	4 1/2	26	2 1/2	2.175	4	21
1 13/16	2 1/4	2.087	4 1/2	17	2 5/8	2.300	4	26
1 7/8	2 3/8	2.175	4 1/2	24	2 5/8	2.300	4	18
1 15/16	2 1/2	2.175	4	26	2 3/4	2.425	4	23
2	2 1/2	2.300	4	18	2 7/8	2.550	4	28
1/16	2 5/8	2.300	4	24	2 7/8	2.550	4	20
1/8	2 5/8	2.375	4	17	3	2.629	3 1/2	20
3/16	2 3/4	2.425	4	23	3 1/8	2.754	3 1/2	24

UPSET SCREW ENDS FOR ROUND AND SQUARE BARS.

Standard Proportions of Keystone Bridge Company.

	ROUND BARS.				SQUARE BARS.			
Diam. of Round or Sq. Bars in inches.	Diam of Upset Screw End in Inches.	Diam. Screw at Root of Thr'd in inches.	No. of Threads per inch.	Per cent of Ex. of eff'tive area of Screw end Over-bar.	Diam. of Upset Screw End in Inches.	Diam. Screw of Root of Thr'd in Inches.	No. of Threads per Inch.	Per cent of Excess of Effective Area of Screw Over-bar.
5/16	2 7/8	2.550	4	22	3 1/4	2.879	3 1/2	22
3/8	3	2.629	3 1/2	23	3 3/8	3.004	3 1/2	26
7/16	3 1/8	2.754	3 1/2	28	3 3/8	3.004	3 1/2	19
1/2	3 1/8	2.754	3 1/2	21	3 1/2	3.100	3 1/4	21
9/16	3 1/4	2.879	3 1/2	26	3 5/8	3.225	3 1/4	24
5/8	3 1/4	2.879	3 1/2	20	3 5/8	3.225	3 1/4	19
11/16	3 3/8	3.004	3 1/2	25	3 3/4	3 317	3	20
3/4	3 3/8	3.004	3 1/2	19	3 7/8	3.442	3	23
13/16	3 1/2	3.100	3 1/4	22	3 7/8	3 442	3	18
7/8	3 5/8	3.225	3 1/4	26	4	3.567	3	21
15/16	3 5/8	3.225	3 1/4	21	4 1/8	3.692	3	24
3	3 3/4	3.317	3	22	4 1/8	3.692	3	19
3 1/8	3 7/8	3.442	3	21	4 3/8	3.923	2 7/8	24
3 1/4	4	3.567	3	20	4 1/4	4.028	2 3/4	21
3 3/8	4 1/8	3.692	3	20	4 5/8	4.153	2 3/4	19
3 1/2	4 1/4	3.798	2 7/8	18				
3 5/8	4 1/2	4.028	2 7/8	23				
3 3/4	4 5/8	4.153	2 3/4	23				
3 7/8	4 3/4	4.255	2 5/8	21				

As upsetting reduces the strength of iron, bars having the same diameter at root of thread as that of the bar, invariably break in the screw end when tested to destruction, without developing the full stregnth of the bar. It is therefore necessary to make up for this loss in strength by an excess of metal in upset screw end over that in the bar The above table is the result of numerous tests on finished bars made at the Keystone Bridge Company's works in Pittsburgh, and gives proportions that will cause the bar to break in the body in preference to the upset end. The screw threads in the above table are the Franklin Institute standard. To make one upset end for 5 inch length of thread allow 6 inches of rod additional.

SIZES AND WEIGHTS OF HOT PRESSED SQUARE NUTS.

The sizes are the usual Manufacturers', not the Franklin Institut Standard. Both weights and sizes are for the unfinished nut. Th weights are calculated, one cubic foot weighing 480 pounds.

Size of Bolt.	Weight of 100 lbs.	Rough Hole.	Thickness of Nut.	Side of Square.	Diagonal.	No. of Nut in 100 lbs
$\frac{1}{4}$	1.5	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{1}{2}$	.71	6800
$\frac{5}{16}$	2.9	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{5}{8}$	.88	3480
$\frac{3}{8}$	4.9	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{3}{4}$	1.06	2050
$\frac{7}{16}$	7.7	$\frac{13}{32}$	$\frac{7}{16}$	$\frac{7}{8}$	1.24	1290
$\frac{1}{2}$	8.6	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{7}{8}$	1.24	1170
$\frac{1}{2}$	11.8	$\frac{7}{16}$	$\frac{1}{2}$	1	1.41	850
$\frac{9}{16}$	16.7	$\frac{1}{2}$	$\frac{9}{16}$	$1\frac{1}{8}$	1.59	600
$\frac{5}{8}$	17.7	$\frac{9}{16}$	$\frac{5}{8}$	$1\frac{1}{8}$	1.59	570
$\frac{5}{8}$	22.8	$\frac{9}{16}$	$\frac{5}{8}$	$1\frac{1}{4}$	1.77	440
$\frac{3}{4}$	32.3	$\frac{21}{32}$	$\frac{3}{4}$	$1\frac{3}{8}$	1.94	310
$\frac{3}{4}$	39.8	$\frac{21}{32}$	$\frac{3}{4}$	$1\frac{1}{2}$	2.12	251
$\frac{7}{8}$	53.	$\frac{25}{32}$	$\frac{7}{8}$	$1\frac{5}{8}$	2.30	190
$\frac{7}{8}$	63.	$\frac{25}{33}$	$\frac{7}{8}$	$1\frac{3}{4}$	2.47	159
1	68.	$\frac{7}{8}$	1	$1\frac{3}{4}$	2.47	146
1	94.	$\frac{7}{8}$	1	2	2.83	106
$1\frac{1}{8}$	103.	$\frac{15}{16}$	$1\frac{1}{8}$	2	2.83	97
$1\frac{1}{8}$	137.	$\frac{15}{16}$	$1\frac{1}{8}$	$2\frac{1}{4}$	3.18	73
$1\frac{1}{4}$	145.	$1\frac{1}{16}$	$1\frac{1}{4}$	$2\frac{1}{4}$	3.18	69
$1\frac{1}{4}$	186.	$1\frac{1}{16}$	$1\frac{1}{4}$	$2\frac{1}{2}$	3.54	54
$1\frac{3}{8}$	247.	$1\frac{3}{16}$	$1\frac{3}{8}$	$2\frac{3}{4}$	3.89	41
$1\frac{1}{2}$	319.	$1\frac{5}{16}$	$1\frac{1}{2}$	3	4.24	31.3
$1\frac{5}{8}$	400.	$1\frac{7}{16}$	$1\frac{5}{8}$	$3\frac{1}{4}$	4.60	24.8
$1\frac{3}{4}$	500.	$1\frac{9}{16}$	$1\frac{3}{4}$	$3\frac{1}{2}$	4.95	19.9
$1\frac{7}{8}$	620.	$1\frac{11}{16}$	$1\frac{7}{8}$	$3\frac{1}{4}$	5.30	16.2
2	750.	$1\frac{13}{16}$	2	4	5.66	13.4
$2\frac{1}{8}$	780.	$1\frac{7}{8}$	$2\frac{1}{8}$	4	5.66	12.8
$2\frac{1}{4}$	930.	2	$2\frac{1}{4}$	$4\frac{1}{4}$	6.01	10.7
$2\frac{3}{8}$	960.	$2\frac{1}{8}$	$2\frac{3}{8}$	$4\frac{1}{4}$	6.01	10.4
$2\frac{1}{2}$	1130.	$2\frac{1}{4}$	$2\frac{1}{2}$	$4\frac{1}{2}$	0.36	8.9
$2\frac{3}{4}$	1370.	$2\frac{7}{16}$	$2\frac{3}{4}$	$4\frac{3}{4}$	6.72	7.3
3	1610.	$2\frac{11}{16}$	3	5	7.07	6.2
$3\frac{1}{4}$	2110.	$2\frac{15}{16}$	$3\frac{1}{4}$	$5\frac{1}{2}$	7.78	4.7
$3\frac{1}{2}$	2750.	$2\frac{1}{8}$	$3\frac{1}{2}$	6	8.49	3.6

SIZES AND WEIGHTS OF HOT PRESSED HEXAGON NUTS.

The sizes are the usual manufacturers'; not the Franklin Institute tandard. Both weights and sizes are for the unfinished nut. The eights are calculated. one cubic foot weighing 480 pounds.

Size of Bolt.	Weight of 100 Nuts.	Rough Hole.	Thickness of Nut.	Short Diameter.	Long Liameter.	No. of Nuts in 100 lbs.
$\frac{1}{4}$	1.3	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{1}{2}$	.58	8000
$\frac{5}{16}$	2 4	$\frac{9}{32}$	$\frac{5}{16}$	$\frac{5}{8}$	.72	4170
$\frac{3}{8}$	4.1	$\frac{11}{32}$	$\frac{3}{8}$	$\frac{3}{4}$	.87	2410
$\frac{7}{16}$	6.8	$\frac{13}{32}$	$\frac{7}{16}$	$\frac{7}{8}$	1.01	1460
$\frac{1}{2}$	7.1	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{7}{8}$	1.01	1410
$\frac{1}{2}$	9.8	$\frac{7}{16}$	$\frac{1}{2}$	1	1.15	1020
$\frac{9}{16}$	14 0	$\frac{1}{2}$	$\frac{9}{16}$	$1\frac{1}{8}$	1 30	710
$\frac{5}{8}$	14.7	$\frac{9}{16}$	$\frac{5}{8}$	$1\frac{1}{8}$	1.30	680
$\frac{5}{8}$	19.1	$\frac{9}{16}$	$\frac{5}{8}$	$1\frac{1}{4}$	1.44	520
$\frac{5}{8}$	22 9	$\frac{9}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$	1.44	440
$\frac{3}{4}$	27.2	$\frac{21}{32}$	$\frac{3}{4}$	$1\frac{3}{8}$	1.59	370
$\frac{3}{4}$	39.	$\frac{21}{33}$	$\frac{7}{8}$	$1\frac{1}{2}$	1.73	256
$\frac{7}{8}$	44.	$\frac{25}{32}$	$\frac{7}{8}$	$1\frac{5}{8}$	1.88	226
$\frac{7}{8}$	50.	$\frac{25}{32}$	1	$1\frac{5}{8}$	1.88	198
1	57.	$\frac{7}{8}$	1	$1\frac{3}{4}$	2.02	176
1	64.	$\frac{7}{8}$	$1\frac{1}{8}$	$1\frac{3}{4}$	2.02	156
$1\frac{1}{8}$	96.	$\frac{15}{16}$	$1\frac{1}{4}$	2	2.31	104
$1\frac{1}{4}$	134.	$1\frac{1}{16}$	$1\frac{3}{8}$	$2\frac{1}{4}$	2.60	75
$1\frac{3}{8}$	180.	$1\frac{3}{16}$	$1\frac{1}{2}$	$2\frac{1}{2}$	2.89	56
$1\frac{1}{2}$	235.	$1\frac{5}{16}$	$1\frac{5}{8}$	$2\frac{3}{4}$	3.18	42
$1\frac{5}{8}$	300.	$1\frac{7}{16}$	$1\frac{3}{4}$	3	3.46	33.4
$1\frac{3}{4}$	370.	$1\frac{9}{16}$	$1\frac{7}{8}$	$3\frac{1}{4}$	3.75	16.7
$1\frac{7}{8}$	460.	$1\frac{11}{16}$	2	$3\frac{1}{2}$	4.04	21.5
2	450.	$1\frac{13}{16}$	2	$3\frac{1}{2}$	4.04	22.4
$2\frac{1}{8}$	560.	$1\frac{7}{8}$	$2\frac{1}{8}$	$3\frac{3}{4}$	4.33	18.0
$2\frac{1}{4}$	560.	2	$2\frac{1}{4}$	$3\frac{3}{4}$	4.33	17.7
$2\frac{3}{8}$	680.	$2\frac{1}{8}$	$2\frac{3}{8}$	4	4.62	14.7
$2\frac{1}{2}$	810.	$2\frac{1}{4}$	$2\frac{1}{2}$	$4\frac{1}{4}$	4.91	12.3
$2\frac{3}{4}$	980.	$2\frac{7}{16}$	$2\frac{3}{4}$	$4\frac{1}{2}$	5.20	10.2
3	1150.	$2\frac{11}{16}$	3	$4\frac{3}{4}$	5.48	8.7
$3\frac{1}{4}$	1340.	$2\frac{15}{16}$	$3\frac{1}{4}$	5	5.77	7.5
$3\frac{1}{2}$	1580.	$3\frac{1}{8}$	$3\frac{1}{2}$	$5\frac{1}{4}$	6.06	6.3

BOLTS, HEADS, NUTS AND THREAD IN PROPORTION.

Unfinished bolt heads and nuts in proportion of same should be one and one-half times the diameter of bolt, to which should be added $\frac{1}{8}$ of an inch. But one and one-half times the diameter does without the addition of $\frac{1}{8}$ of an inch; if not machine finish the $\frac{1}{8}$ inch is calculated for finish.

The depth of head, one half of its width.

The depth of nut same as diameter of bolt.

Screw Threads as determined and recommended by Committee of Franklin Institute of Philadelphia, 1864.

NUMBER OF THREADS PER INCH.

Diam. Screw. Inches.	No. Threads to the inch.	Diam. Screw. Inches.	No. Threads to the inch.	Diam. Screw. Inches.	No. Threads to the inch.	Diam. Screw. Inches.	No. Threads to the inch.
$\frac{1}{4}$	20	1	8	$2\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{3}{4}$
$\frac{5}{16}$	18	$1\frac{1}{8}$	7	$2\frac{1}{2}$	4	$4\frac{3}{4}$	$2\frac{5}{8}$
$\frac{3}{8}$	16	$1\frac{1}{4}$	7	$2\frac{3}{4}$	4	5	$2\frac{1}{2}$
$\frac{7}{16}$	14	$1\frac{3}{8}$	6	3	$3\frac{1}{2}$	$5\frac{1}{4}$	$2\frac{1}{2}$
$\frac{1}{2}$	13	$1\frac{1}{2}$	6	$3\frac{1}{4}$	$3\frac{1}{2}$	$5\frac{1}{2}$	$2\frac{3}{8}$
$\frac{9}{17}$	12	$1\frac{5}{8}$	$5\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$5\frac{3}{4}$	$2\frac{3}{8}$
$\frac{5}{8}$	11	$1\frac{3}{4}$	5	$3\frac{3}{4}$	3	6	$2\frac{1}{4}$
$\frac{3}{4}$	10	$1\frac{7}{8}$	5	4	3		
$\frac{7}{8}$	9	2	$4\frac{1}{2}$	$4\frac{1}{4}$	$2\frac{7}{8}$		

SPIKES, NAILS AND TACKS.

Standard Steel Wire Nails.

Sizes	Length. in Inches	COMMON. Diameter inches.	COMMON. No. per Pound.	FINISHING. Diameter Inches.	FINISHING. No. per Pound.
2 d	1	.0524	1060	.0453	1558
3 d	1¼	.0588	640	.0508	913
4 d	1½	.0720	380	.0508	761
5 d	1¾	.0764	275	.0571	500
6 d	2	.0808	210	.0641	350
7 d	2¼	.0858	160	.0641	315
8 d	2½	.0935	115	.0720	214
9 d	2¾	.0963	93	.0720	195
10 d	3	.1082	77	.0808	137
12 d	3¼	.1144	60	.0808	127
16 d	3½	.1285	48	.0907	90
20 d	4	.1620	31	.1019	62
30 d	4½	.1891	22		
40 d	5	.2043	17		
50 d	5½	.2294	13		
60 d	6	.2576	11		

TACKS.

Title. oz.	Length inch.	No. per Pound.	Title. oz.	Length. Inch.	No. per Pound.
1	$\frac{1}{8}$	16000	4	$\frac{7}{16}$	4000
1½	$\frac{3}{16}$	10666	6	$\frac{9}{16}$	2666
2	$\frac{1}{4}$	8000	8	$\frac{5}{8}$	2000
2½	$\frac{5}{16}$	6400	10	$\frac{11}{16}$	1600
3	$\frac{3}{8}$	5333	12	$\frac{3}{4}$	1333

SPIKES, NAILS AND TACKS.

Length.	STEEL WIRE SPIKES.		COMMON IRON NAILS.		
	Diameter. inches.	No. per pound.	Sizes.	Length.	No. pe pound
3	.1620	41	2d	1	800
3½	.1819	30	3d	1¼	400
4	.2043	23	4d	1½	300
4½	.2294	17	5d	1¾	200
5	.2576	13	6d	2	150
5½	.2893	11	7d	2¼	120
6	.2893	10	8d	2½	85
6⅓	.2249	7½	9d	2¾	75
7	.2249	7	10d	3	60
8	.3648	5	12d	3¼	50
9	.3684	4½	16d	3½	40
			20d	4	20
			30d	4½	16
			40d	5	14
			50d	5½	11
			60d	6	8

TACKS.

Title. oz.	Length. inch.	Number per pound.
14	$\frac{13}{16}$	1143
16	$\frac{7}{8}$	1000
18	$\frac{15}{16}$	888
20	1	800
22	$1\frac{1}{16}$	727
24	$1\frac{1}{8}$	666

WROUGHT SPIKES.

Number to a Keg of 150 Pounds.

Length. inch.	$\frac{1}{4}$ Inch. No.	$\frac{5}{16}$ Inch. No.	$\frac{3}{8}$ Inch. No.	$\frac{1}{4}$ Inch. No.
3	2250	....	....	1161
3½	1890	1208	....	....
4	1650	1135	....	....
4½	1464	1064	... .	....
5	1380	930	742	....
6	1292	868	570	....

Length. Inch.	$\frac{5}{16}$ Inch. No.	$\frac{3}{8}$ Inch. No.	$\frac{7}{16}$ Inch. No.	$\frac{1}{2}$ Inch. No.
7	662	482	445	306
8	635	455	384	256
9	573	424	300	240
10	....	391	270	222
11	....	....	249	203
12	....	....	236	180

WROUGHT IRON STEAM, GAS AND WATER PIPES

Table ot Standard Dimensions

AS MANUFACTURED BY NATIONAL TUBE WORKS CO.

Nominal Internal inches.	Actual External Inches.	Thickness. Inches.	Length of Pipe containing 1 Cubic Foot.	Nom'l Weight per Foot.	No. of Threads per Inch of Screw.
$\frac{1}{8}$	.405	.068	2513.	.241	27
$\frac{1}{4}$	.54	.088	1383.3	.42	18
$\frac{3}{8}$	.675	.091	751.2	.559	18
$\frac{1}{2}$	.84	.109	472.4	.837	14
$\frac{3}{4}$	1.05	.113	270.	1 115	14
1	1.315	.134	166.9	1.668	$11\frac{1}{2}$
$1\frac{1}{4}$	1.66	.14	96.25	2.244	$11\frac{1}{2}$
$1\frac{1}{2}$	1.9	.145	70.66	2.678	$11\frac{1}{2}$
2	2.375	.154	42.91	3.609	$11\frac{1}{2}$
$2\frac{1}{2}$	2.875	.204	30.1	5.739	8
3	3.5	.217	19.5	7.536	8
$3\frac{1}{2}$	4.0	.226	14.57	9.001	8
4	4.5	.237	11.31	10.665	8
$4\frac{1}{2}$	5.	.246	9.02	12.34	8
5	5.63	.259	7.2	14 502	8
6	6.625	.28	4.98	18.762	8
7	7.625	.301	3.72	23.271	8
8	8.625	.322	2 88	28 177	8
9	9.625	344	2 29	33.701	8
10	10 75	.366	1.82	40.065	8

EXPLANATION OF TABLES ON TENSILE STRENGTH.

What size of rod is required to carry a load of 45,000 lbs.; tensile strain 60,000; safe load $\frac{1}{3}$ of strain?

EXAMPLE: 45,000 x 3 = 135,000; divided by 60,000 = 2.25 sq. in., required area. Referring to table of area of square and round bars, we find in area of square 2.25 sq. in. = $1\frac{1}{2}$, answer. Area of round nearest to 2.25 sq. in. is $1\frac{3}{4}$ in. diameter.

How much will $1\frac{1}{4}$ in. rod carry?

Area of $1\frac{1}{4}$ in. round is 1.22 sq. in.

EXAMPLE: 1.22 x 60,000 = 73,200.

ANS.: Safe load $\frac{1}{3}$ of 73,200 = 24.400 lbs.

How much will a 2 inch hook carry?

ANS.: See table on experiments on tensile strength; one square inch will carry about 10,000 lbs.; area of 2 inch round is 3.1416 x 10,000 = 31.416 lbs.

What sized hook will carry 80,000 lbs.?

To find the area, divide the weight what 1 sq. in. carries into the weight to be carried, 10,000 ÷ 80,000 = 8 sq. in., answer.

In area of round bars, column of area and line of $3\frac{1}{4}$ in. is nearest to 8 in. area.

ILLUSTRATION OF TABLES OF WEIGHT OF SQUARE AND ROUND IRON.

What is the weight of a bar of iron $3\frac{3}{8}$ in. round by 12 ft. 4 in. long? In column of weights of round and line of $3\frac{3}{8}$ round, we find 29.82 lbs. per one foot long.

ANSWER: 12 ft. x 29.82 lbs. = 357 84
4 in. is $\frac{1}{3}$ ft. of 29.80 = 9.94
367.78 lbs.

How many feet of $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. square iron will weigh 326 64 lbs.?

ANS.: In column of weight of square and in line of $3\frac{1}{2}$ square we find the weight 40 83 lbs. per one foot long. Divide 40.83 into 326.64 = 8 ft.

ILLUSTRATION OF TABLE OF CIRCUMFERENCE.

How long a bar will be required to make a bend of 3 in. x 3 in. square and 4.5 ft in diamater.

RULE: Add the thickness of the iron to the diameter of the ring required and multiply by 3.1416.

EXAMPLE: 3 in. equals .25 of a foot + 4.5 feet = 4.75

feet. In column of circumference and line of 4.8 ft., which is the nearest to 4.75, we find circumference 18.2212 feet, answer. Allow for weld.

ILLUSTRATION OF TABLE OF AREA.

How many feet of 4 in. round can be made of a bar 8 in. by 8 in. by 2 ft. long?

EXAMPLE: In column of area of square and in line of 8 in. will be found 64 in. area; 64 in. x 12 in. = 778 in. volume x 2 ft. = 1556 in. volume. In column of area of round and line of 4 in. will be found 12.566 in. area; 12.566 in. area x 12 in. = 150.792 in., volume of 1 ft. long 1556 in. ÷ 150.792 in. = 10.31 ft., answer.

How many feet of 6 in. by 6 in. will make a bar 7 in. by 4 in. at one end, and 7 in. by 2 in. at the other end, 12 feet long.

EXAMPLE: 7 in. x 4 in. = 28 in. area at one end, and 7 in. x 2 in. = 14 in area. 28 in. x 14 in. = 42 ÷ 2 = 21 in.; mean area 21 in. x 12 in. = 252 in. volume of 1 ft. long; 252 in. x 12 ft. = 3024 in. volume of the whole bar. In column of area and in line of 6 in. sq. will be found 36 in. area; 36 in. x 12 in. = 432 in. volume of 1 ft. long; 3024 ÷ 432 = 7 ft. Answer.

ILLUSTRATION OF TABLES OF FLAT ROLLED IRON.

What is the weight of a flat rolled bar 5 in x $1\frac{1}{16}$ in. in section?

ANSWER: In the column for 5 in. width, and in the line for $1\frac{1}{16}$ in. thickness, will be found *the value,* 17.71, *which is the weight desired.*

What thickness of $4\frac{1}{2}$ in. bar will be required to give an area of 5.3 square inches.

ANSWER: In the column for $4\frac{1}{2}$ in. width will be found 5.34, which is the area nearest to that required: the corresponding thickness being $1\frac{3}{16}$ in. the bar should be $4\frac{1}{2}$ in. by $1\frac{3}{16}$.

TENSILE STRENGTH OF IRON AND STEEL.

(From Haswell.)

In order to select intelligently the materials for structures and work for industrial purposes, as well as for comparing the values of different materials, it is of great importance to know all their "properties," ultimate strength, limits of elasticity, and ductility expressed in force and dimensions.

Tensile strength is the resistance of the fibers or particles of a body to separation. It is therefore proporuioned to their number or to the area of its transverse sections.

WEIGHT OR POWER REQUIRED TO TEAR ASUNDER ONE SQUARE INCH.

	lbs.
Iron, cast. Low Moor No. 2	14,076
Iron, Clyde No. 1	16,125
Iron, Clyde Nos. 2 and 3	23,468
Iron, Calder No. 1	13,735
Iron, Stirling mean	25,764
Iron, mean of American	31,829
Iron, mean of English	19,484
Iron, green wood, American	45,970
Iron, gun metal, mean	37,232
Iron, wrought iron wire	103,000
Iron, best Swedish bar	72,000
Iron, Russian bar	59,500
Iron, English bar	56,000
Iron, rivets, American	53,300
Iron, bolts, American	52,250
Iron, hammered	53,913
Iron, crank shaft	44,750
Iron, boiler plates, American	48,000 to 62,000
Iron, plates, English mean	51,000
Iron, lengthwise	53,800
Iron, crosswise	48,800
Iron, inferior bar	30,000
Iron, wire, American	73,690
Irod, wire, 16 diam	80,000
Iron, scrap	53,400

Steel, cast, maximum	142,000
Steel, cast, mean	88,657
Steel, cast, blistered soft	133,000
Steel, shear	124,000
Steel, puddled, extreme	173,817
Steel, puddled, lime iron	121,408
Steel, plates, lengthwise	96,300
Steel, plates, crosswise	93,700
Steel, razor	150,000

Lake Superior and Iron Mountain charcoal bloom iron has resisted 90,000 lbs.

Reduced from the experiments of U. S. Ordnance Department, Barton, Rennie, Stevenson, Hodgkinson, Fairbain, Pasley and Hatfield.

Results of Experiments on Tensile Strength of Wrought Iron Tie Rods Common English $1\frac{3}{16}$ Diam.

(From Haswell.)

DESCRIPTION OF CONNECTIONS.

	lbs.
Semi-circular hook fitted to a circular welded eye	14,000
Two semi.circular hooks fitted together	16,220
Right angled hook fitted into a cylindrical eye	27,120
Two links or welded eyes connected together	48,160
Straight rod without any connection	56,000

Iron bars when cold rolled are materially stronger as when only hot rolled, the difference being in some cases as great as 3 to 2.

The tensile strength of steel increases by reheating and rolling up to the second operation, but decreases after that.

Crushing Strengh of Iron as Reduced to a Uniform Measure of 1 Square Inch.

	lbs.
Psrims, American gun metal, cast	174,803
American gun metal, mean	129,000
English Low Moor No. 1	62,450
English Low Moor No. 2	92,330
English Clyde No. 3	106,039
Sterling, mean of all	122,396

Extreme	134,400
Wrought iron, American	127,720
Mean	83,500
English mean from	40,000 to 65,200
Cast steel	295,000

FULCRUM AND LEVER.

Power is a compound of weight or force and velocity; it cannot be increased by mechanical skill or means.

The powers are three in number, viz: Lever, inclined plane, and pulley.

NOTE.—The wheel or axle is a continuous or revolving lever; the wedge a double plane, and the screw a revolving incline plane; levers are straight, bent, curved, single, or double.

To compute the length of a lever, the weight and power being given:

RULE.—Divide the weight by the power and the quotient is the difference of leverage or the distance from the fulcrum at which the power supports the weight.

EXAMPLE.—A weight of 1600 lbs. is to be raised by a power or force of 80 lbs., requires the length of the longest arm of the lever, the shortest being one foot $\frac{1600}{80} = 20$ ft.

To compute the weight that can be raised by a lever, its length, the power, and the position of its fulcrum being given.

RULE.—Multiply the power by its distance from the fulcrum and divide the product by the distance of the weight from the fulcrum:

EXAMPLE.—What weight can be raised by a power of 375 lbs. suspended from end of a lever 8 feet from the fulcrum the distance of the weight from the fulcrum being 2 ft. $\frac{375 \times 8}{2} = 1500$. Ans.

To compute the position of the fulcrum, the weight, power and the lever being given, when the fulcrum is between weight and the power.

RULE: Divide the weight by the power and add (1) one to the quotient and divide the length by the sum thus obtained.

EXAMPLE: A weight of 2,460 lbs. is to be raisec with a lever of 7 ft. long and a power of 300 lbs., a what part of the lever must the fulcrum be placed?

STATEMENT: $\frac{2460}{300} = 8.2 \quad 1 = 9.2$. Reduced tc inches. Solution: 7 ft. = 84 in. ÷ 9.2 ft. = 110 in Answer, $1\frac{13}{42}$ ft.

When the weight is between the fulcrum and th power.

RULE: Divide the length by the quotient of th weight, divided by the power, $\frac{1600}{80} = 20 \div 20 = 1$ ft from the fulcrum.

To compute the length of an arm of the lever tc which is attached, the weight power and length of arn of the lever to which the power is applied being given

RULE: Multiply the power by the length of the arn to which it is applied and divide the product by th weight.

EXAMPLE: A weight of 1,600 suspended from th fulcrum of a lever, is supported by a power of 80 lbs applied at the other end of the arm, 20 ft. in length what is the length of the arm?

SOLUTION: $\frac{80 \times 20}{1600} = 1$ ft. Answer.

To compute the power required to raise a giver weight, the length of the lever and the position of th fulcrum being given.

RULE.—Multiply the weight to be raised by its dis tance from the fulcrum and divide the product by th distance of the power from the fulcrum.

EXAMPLE.—The length of the lever is 10 feet, th weight to be raised 3,000 lbs., and its distance from th fulcrum is 2 ft., what is the power required? $\frac{3000 \times 2}{10 - 2} = \frac{6000}{8} = 750$ lbs.

To compute the length of the arm of the lever tc which the power is applied, the weight, power, and dis tance of the fulcrum being given.

RULE.—Multiply the weight by its distance fron the fulcrum and divide the product by the power.

EPAMPLE.—A weight of 400 lbs. suspendad 1 inches from the fulcrum, is supported by a power o 50 lbs. applied at the other end, what is the length o the arm? $\frac{400 \times 15}{50} = 120$ in.

GENERAL RULE.—The power and distance from th fulcrum is equal to the weight and distance from th fulcrum.

NOTES ON IRON AND STEEL.

1. The average weight of wrought iron is 480 lbs. per cubic foot. A bar 1 inch square and 3 feet long weighs, therefore, exactly 10 lbs. Hence: To find the sectional area, when the weight per foot is given; multiply by $\frac{3}{10}$. To find the weight per foot, when the sectional area is given; multiply by $\frac{10}{3}$.

2. The weight of steel is 2 per cent over that of iron.

3. The elastic limit to extension and compression of wrought iron is very near $\frac{1}{10000}$ per square inch for one ton load of 2240 lbs.

4. Cast iron weighs 450 lbs.

5. Wrought iron, the purest hammered, 489 lbs.

6. Soft forged iron expands about at 100° Fahr. .0007.

7. Cast iron expands about at 100° Fahr. .0006.

8. Wire " " " " .0008.

The melting point of iron and steel is about as follows: Wrought iron, 3,000° Fahrenheit; cast iron, 2,000° Fahrenheit; steel, 2,400° Fahr.; the welding heat, 2,750° Fahr.

MENSURATION.

PRACTICAL RULES.

A surface has two dimensions; length and breadth.

A solid has three dimensions, length, breadth and thickness.

The area of a surface is the number of units of surface which it contains, the unit of surface being a square which has a linear unit for each of its dimensions.

The volume of a solid is the number of units of volume which it contains, the unit of volume being a cube which has a linear unit for each of its three dimensions.

A Circle is a plane figure bounded by a

curved line called the circumference all points of whiah are equally distant from a point within called the center.

A part of the circumference is called an Arc.

A line drawn through the center and terminated by the sircumference is called the "diameter," and half the diameter is called the radius.

RULES.

Circumference of a Circle squals diameter multiplied by 3.1416.

Diameter of Circle equals circumference multiplied by 0.3183.

Side of Square of equal periphery as circle equals diameter multiplied by 0.7854.

Diameter of Circle of equal periphery as square equals side multiplied by 1.2732.

To find surface or area.—Area of a Circle equals square of radius multiplied by 3.1416.

Area of a Sphere equals circumference multiplied by diameter or square of diameter multiplied by 3,1416.

Area of a Cone equals circumference of base multiplied by the slant height or side of cone, halve the product and add it to the area ot the base.

Area of a Triangle equals base multiplied by half perpendicular height.

Area of a Cylinder equals circumference multiplied by height by area of both ends.

To find the volume of solids. Volume of a sphere equals cube of diameter multiplied by 0.5236.

Volume of a Cone equals area of base multiplied by perpendicular height and take one-third of the product.

Volume of a Cylinder equals area of end multipled by length.

Volume of a Prism, right or oblique, equals area of base multiplied by perpendicular height.

PRISMOIDAL FORMULA.

A Prismoid is a solid bounded by by six plane surfaces, only two of which are parallel.

To find the contents of a prismoid, add together the areas of the two parallel surfaces and four times the area of a section taken midway between and parallel to them, and multiply the sum by $\frac{1}{6}$ of the perpendicular distance between the parallel surfaces.

The volume of an irregular body is found by immersing the body in a vessel full of water, remove the body and calculate the amount of water displaced.

TABLE OF DECIMAL EQUIVALENTS

OF

8ths, 16ths, 32nds and 64ths of an Inch, for Use in Connection with Micrometer Calipers.

8ths.

$\frac{1}{8}$ equals .125
$\frac{1}{4}$ equals .25
$\frac{3}{8}$ equals .375
$\frac{1}{2}$ equals .50
$\frac{5}{8}$ equals .625
$\frac{3}{4}$ equals .75
$\frac{7}{8}$ equals .875

16ths.

$\frac{1}{16}$ equals .0625
$\frac{3}{16}$ equals .1875
$\frac{5}{16}$ equals .3125
$\frac{7}{16}$ equals .4375
$\frac{9}{66}$ equals .5625
$\frac{11}{16}$ equals .6875
$\frac{13}{16}$ equals .8125
$\frac{15}{16}$ equals .9375

32nds.

$\frac{1}{32}$ equals .03125
$\frac{8}{32}$ equals .09375
$\frac{5}{32}$ equals .15625
$\frac{7}{32}$ equals .21875
$\frac{9}{32}$ equals .28125
$\frac{11}{32}$ equals .34375
$\frac{13}{32}$ equals .40625
$\frac{15}{32}$ equals .46875
$\frac{17}{32}$ equals .53125
$\frac{19}{32}$ equals .59375
$\frac{21}{32}$ equals .65625
$\frac{23}{32}$ equals .71875
$\frac{25}{32}$ equals .78125
$\frac{27}{32}$ equals .84375
$\frac{29}{32}$ equals .90625
$\frac{31}{32}$ equals .96875

64ths.

$\frac{1}{64}$ equals .015625
$\frac{3}{64}$ equals .046875
$\frac{5}{60}$ equals .078125
$\frac{7}{64}$ equals .109375
$\frac{9}{64}$ equals .140625
$\frac{11}{64}$ equals .171875
$\frac{13}{64}$ equals .202125
$\frac{15}{64}$ equals .234375

64ths

$\frac{17}{64}$ equals .265625
$\frac{19}{64}$ equals .296875
$\frac{21}{64}$ equals .328125
$\frac{23}{64}$ equals .359375
$\frac{25}{64}$ equals .390625
$\frac{27}{64}$ equals .421875
$\frac{29}{64}$ equals .453125
$\frac{31}{64}$ equals .484375
$\frac{33}{64}$ equals .515625
$\frac{35}{64}$ equals .546875
$\frac{37}{64}$ equals .558125
$\frac{39}{64}$ equals .609375
$\frac{41}{64}$ equals .640625
$\frac{43}{64}$ equals .671875
$\frac{45}{64}$ equals .703125
$\frac{47}{64}$ equals .734375
$\frac{49}{64}$ equals .765625
$\frac{51}{64}$ equals .796875
$\frac{53}{64}$ equals .828125
$\frac{55}{64}$ equals .859375
$\frac{57}{64}$ equals .890625
$\frac{59}{64}$ equals .921875
$\frac{61}{64}$ equals .953125
$\frac{63}{64}$ equals .984375

INCHES EXPRESSED IN DECIMAL OF A FOOT.

Inches.	Decimals.	Inches.	Decimals.
1	.083	7	.583
2	.166	8	.667
3	.250	8	.750
4	.333	10	.833
5	.416	11	.916
6	.500	12	1.000

ANGLE IRON RING.

Much has been written on the correct method of ascertaining the length of a bar to make an angle-iron ring of a given diameter, and if you were to examine all the books that profess to give information on the subject you would find that none of them agree on this point; but each of them contains a rule quite different from the other. Many who have not had much experience in this class of work may be puzzled to account for this, as all those books agree upon one rule for finding the length of a bar of either flat, square or round iron to make a ring of any size or given diameter. The reason of this is, no one can lay down a correct rule that would apply to all sizes of angle ironings.

If you were requested to make a ring 2 feet in diameter flange outside; size of iron 3 x 3½ and you found the length of the bar it would take to make it by any given rule, which when bent it came to the exact size; and you also received instruction to make another ring 6 feet in diameter of the same iron, and you ascertained the length of the bar to make the ring by the same rule as you did the small one, you would find when this was bent that the bar in this case was too short to make the ring; "this, I am certain, would be the case," although the same rule was adopted in both instances; and the reason of this is not far to seek.

If you measured the outside flange of the small ring, you would find that by bending the iron it had narrowed to about 2¾ inches, and if you were to measure the outside flange of the large ring you would find it was nearly the same width as the bar was before it was bent.

By this you will see at once that the iron in the large ring had not stretched to the same extent as the iron composing the small ring, because it is nearer a straight line. The mode of bending is also sure to alter the length. If care be taken in getting the bar to a uniform heat in the furnace and then bend it around a block or pins to the diameter required, you will find that it will take a longer bar to make the same sized ring than it would if you heated the bar at a smith's fire in lengths of about a foot at a time, as the iron stretches very much more by the last process.

The only correct method of finding the length of a bar to an angle iron ring of a given diameter is to strike out the full size of the ring on a piece of plate or slab and draw a line across its center; then to find the length of the bar sufficient to make the ring, refer to tables of circumference, or multiply the diameter in inches by 3.1416. Supposing the diameter of the ring to be 3 feet, size of iron $3x3x\frac{1}{2}$, reduce the diameter to inches and multiply thus: 36 in.x3.1416 $=113.0976$; to this add twice the width of the bar, namely, six inches, making a total of 9 feet and $11\frac{1}{10}$ inches; take the bar and cut it that length and mark it with a center punch exactly in the middle; when this is done scarf the end of the bar and bend one-half of it according to the circle previously struck out, and by placing the end on the line that bisects the circle, you will find or see on the opposite side how near the center punch mark comes to the line, if it is over the line toward the straight end of the bar it is a proof that the bar is too long and you must cut donble the length what it is over the center punch mark off of the straight end before bending the other end or other half of the ring.

If the center punch mark does not come to the line then you have cut the bar double that much too short. But this cannot be if you have cut the bar according to the length above named.

If you want to make an angle-iron ring with the flanges inside, get the length of the bar the same as before mentioned, but instead of adding twice the width of the bar deduct once the width of the bar from the length and proceed as before.

It does not require as long a bar of iron to make a **T** iron ring as it does an angle-iron ring, the diameter and thickness being equal, as the former stretches much more than the latter. If you were going to make a **T** iron ring 3 feet in diameter refer to the table of circumference for the length and add twice the width of the rib to the length of the bar and then mark it in the center and bend one half according to the previous instructions on the making of angle iron rings.

If you are going to make any quantity of either **T** iron or **⅃** iron rings, do not cut up your bars of iron until you have bent the half of one, as it will not take you much time in doing it and you can then depend upon getting the correct length, and in the end you will be very much the gainer in time and your employer in material.

The table of rules given you in many books for finding the lengths of T and angle iron rings is only misleading and is not in any case to be depended upon.

ALLOYS AND COMPOSITIONS.

The Following is a List of various Metals for Various Purposes:

METALS.	Copper	Zinc	Tin	Nickel	Lead	Antimony	Bismuth	Iron
Babit Metal....	37	24	21	...	....	....	....	....
Brass, Com'n...	84.3	5.2	10.5	....	....	....	....	....
" " ..	75	25	....	....	....	....	....	....
Math. Instm's..	92.2	....	7 8	...	....	....	....	....
Red Tambac....	88.8	11.2	....	...	....	....	....	....
Wheel Valves..	90	.. .	10	...	....	....	....	....
White..........	10	80	10	...	....	....	....	..
Wire.........	67	33	...	...	....	....	....	....
Brita'nia Met.		....	25	...	....	25	....	....
when fused ad		....	....	...	....	25	25	....
Rronze Red....	86 87	11 1 13	2 9	....	....	....	....	....
" Yellow..	62.2	31.2	1.6	....	....	....	....	....
Gun Metal.....	90 93	....	10 7	....	....	....	....	....
Medals..........	92	....	8	....	....	....	....	....
Statuary	91.4	5.5	4.1	...	...	....	....	....
Chinese Silver*.	65 1	19.3	....	13	....	....	....	....
Church Bells...	80	5.6	10.1	....	4.3	...	....	....
Clock " ..	72	....	26.5	....	....	....	...	1.5
Cocks, Musical Bells. ..	87.5	....	12.5	....	....	....	...	...
Ger. Silver.....	33.3	33.4	....	33 3	....	....	....	....
" " fine..	49.5	24	....	24	....	....	....	2 5
Gongs	81.6	....	18.4	...	....	....	....	...
House Bells....	77	....	23	....	....	....	....	....
Lathe Bushes...	80	....	20	....	....	..	....	....
Mach. Bear'gs..	87.5	....	12.5	...	....	....	....	...
" hard.....	77.4	7	15.6	....	....	....	....	....
Metals that expand in cooling.... ..	....	....	....	....	75	16.7	8.3	....
Pewter, best....	....	...	86	....	....	14	....	....
Printing char...	....	....	....	....	80	20	....	...
Sheet'g Metal..	56	44	....	....	....	....	....	....

ALLOYS AND COMPOSITIONS.

(CONTINUED.)

METALS.	Copper	Zinc	Tin	Nickel	Lead	Antimony	Bismuth	Iron
Speculum M....	66	....	22	....	....	....	....	...
" " ..	50	21	29	....	....	....	....	....
Telescopic Mir'r	66.6	....	33.4	....	....	....	....	....
White Metal....	7·4	7.4	28.4	....	....	56.8	....	....
" " hard..	69.8	25.8	4.4	....	..	....	....	....
Oreide*	73	12.3	....	....	....	...	....	....

*Silver in Chinese Silver, 2.48; Cobolt of Iron in Chinese Silver, 12; Arsenic in Speculum M., 12; Magnesia, 4.4; Cream of Tartar, 6.5; Salimoniac, 2.5; Quick Lime, 1.3.

ALLOYS AND COMPOSITION FOR SOLDERING VARIOUS METALS.

METALS	Copper	Zinc	Tin	Nickel	Lead	Antimony	Bismuth	Silver	Co. of Iron	Iron	Arsenic	Gold	Caicicum
Tin..............	..	..	25	..	75	..	..	..	..	..	..	..	..
"	..	..	58	..	16	..	16	..	..	..	..	..	..
Melts 500° coarse....	..	..	33	..	67	..	..	..	..	..	..	..	..
" 360° ordinary..	..	..	67	..	33	..	..	..	..	..	..	..	..
Spelter, soft	50	50	..	..	..	..	..	..	..	..	..	..	..
" hard	67	33	..	..	..	..	..	..	..	..	..	..	..
Lead..............	..	..	33	..	67	..	..	..	..	..	..	..	..
Steel	13	5	..	..	..	..	..	82	..	...	..	..	..
Brass or Copper.....	50	50	..	..	..	..	..	..	..	..	..	..	..
Fine Brass..........	47	47	..	..	..	..	..	6	..	..	..	..	..
Pewterers or Soft....	..	..	50	..	25	..	25	..	..	..	..	..	..
Gold	4	..	..	..		..	..	7	..	..	..	89	..
" hard.........	66	34	..	..	..	..	..	..	..	..	..	..	..
" soft	..	..	66	..	34	..	..	..	..	..	..	..	..
Silver, hard	20	..	..	..	..	..	..	67	..	..	..	..	21
Pewter	..	..	40	..	20	..	40	..	..	..	..	..	..
Iron.....	66	33	..	..	..	1	..	..	..	..	..	..	..
Copper	..	..	..	..	..	..	..	..	..	..	..	..	..

Tempering Springs.—Fit the springs before tempering; heat them in a furnace to a cherry red and dip them edgeways into a vessel filled with oil; when cooled place the spring over a low fire and leave the remaining oil burn off and cool again in oil. When tempered at a very low heat it is not necessary to let the oil burn off.

Tempering Lathe Tools.—Heat to a cherry red and cool in water; draw temper to a straw color. Lathe tools will stand pretty hard while they are worked at a steady strain.

If lathe tools are made of a good quality of steel they will stand best when tempered in hot water without drawing temper.

Tempering Drills and Chisels.—Heat as usual and cool in pure water, draw temper to a dark blue.

Tempering Cutlery.—Heat to a cherry red (care should be taken not to over heat), and cool in luke warm water; apply tallow or oil and leave it burn off on a low fire; take the hammer handle and scrape across the edge. It is the right temper when the shavings catch fire; cool off at once. Cutlery is also tempered in oil; leave the oil burn off the same as before. It also stands edge at a sky-blue color.

ROCK DRILLS.

To Temper Steam Drills.—When done dressing them leave them cool off before heating them for temper or else they may get hot too far up, which would cause the wings to break.

Build a kind of hollow fire and place the drill in front of it so that the flame of the fire touch the drill at the very end and keep turning the drill and watch the corners, as steam drills are very sensitive and may crack while cooling. Heat to a cherry red. The heat should not show upon the drill any further than three-quarters of an inch, and cool in a lotion of water and salt—one peck of salt to fifty gallons of water. Draw no temper.

Hand Drills.—Hand rock drills are not so sensitive as steam drills are. They should be sharpened and tempered in one heat. Heat to the usual heat, shove them into the salt lotion and leave them there until cold; no temper to be drawn.

A good many tool dressers may be puzzled why water which has been in use for a while for tempering does not temper as hard as fresh water does. It is caused by burning the oxigen out of the water, and it must be replaced by filling up as the lotion evaporates.

To Temper very small Tools and Springs.—Heat at a very low heat, cool by waving the tool or spring in the air, and it will have just the right temper.

Tempering Stone Cutters Tools.—Stone cutter tools should be tempered at a low cherry heat, as they are very thin and cool quick. Draw temper to a light pigeon blue color. To draw temper on tooth chisel have a sponge on a stick and cool the teeth as the temper comes down. When all the teeth have even blue color then cool. Use nothing but pure water.

Tempering a Brick Hammer.—Heat to a cherry red, cool and draw temper to a brown straw color; draw temper on a brick set the same as on a brick hammer.

Tempering a Bush Hammer.—Heat to a cherry red and cool off in pure cold water; draw temper, leave the center teeth a brown purple; as the temper approaches towards the outside teeth leave them get a little softer until the outside row becomes of a dark blue color, then cool. This is the most difficult stone cutter tool to temper. Both ends must be tempered in the same heat. Use the sponge for cooling and guiding the temper.

Tempering Limestone Points and Tooth Axes.—Heat as usual, draw temper between dark and pigeon blue.

Tempering Punches.—Heat to a cherry red and cool in water; rub the surface bright with fine emery paper; draw the temper above the fire to a purple, getting near to dark blue color; the lower end should be a little softer.

Shears are tempered with the same heat, dipped into water edgeways and temper drawn between two hot pieces of iron to the same color as the punch.

Tempering Axes.—Heat the pole of the ax first, then turn and heat the other end and leave the heat approach towards the edge to last, watch the edge carefully and not overheat it; cool in a mild solution of salt water; rub it bright with a rub stone; draw temper to a pigeon blue by placing the ax virtically on the fire with the pole downward and leave the temper come up towards the edge.

Tempering Circular Saws.—Heat the saw to a cherry red, cool in an oil bath; draw temper between two heated plates to a blue color. Circular saws for cutting iron and rail are tempered the same way, but no temper drawn. In most cases the temper is just right.

A very good bath for saws is an equal quantity of oil, beeswax and rosin.

In tempering cross cuts and hand saws the cooling medium is oil, but for the convenience of keeping the blade straight they are cooled between two smooth plates of iron.

SOLUTION FOR TEMPERING.

I.—Saltpeter,	1 oz.
Alum, pulverized,	2 tea spoonfuls.
Salt,	1 tea cup.
Soft water,	2 gallons.

Draw no temper.

II.—Water,	$7\frac{1}{2}$ gallons.
Saltpeter,	5 ounces.
Sal. Ammoniac,	5 "

Draw no temper.

III.—Water,	2 gallons.
Saltpeter,	2 oz.
Alum,	2 oz.
Sal. Ammoniac, pul.,	1 oz.
Salt,	$1\frac{1}{2}$ lbs.

IV.—Water,	2 gallons.
Saltpeter,	$\frac{1}{2}$ oz.
Borax, pulverized,	$\frac{1}{2}$ oz.
Sal. Ammoniac, pul.,	$\frac{1}{2}$ oz.
White Vitriol,	1 oz.
Salt,	$1\frac{1}{2}$ pts.

V.—Put $1\frac{1}{2}$ oz. of corrosive sublimate in 3 quarts of soft water and add one handfull of common salt; dissolve and it is ready for use. This gives toughness and hardness. (Beware, this is poison.)

VI.—Alum,	1 oz.
Saltpeter,	1 oz.
Sal. Ammoniac,	1 oz.
Salt,	$\frac{3}{4}$ lb.
Water,	$1\frac{1}{2}$ gall.

Draw no temper.

MILL PICKS.

VII.—Water,		$1\frac{1}{2}$ gall.
	Ammonia,	$1\frac{1}{2}$ oz.
	White Vitrol,	$1\frac{1}{2}$ oz.
	Sal. Ammoniac,	$1\frac{1}{2}$ oz.
	Alum,	$1\frac{1}{2}$ oz.
	Salt,	3 oz.

and one handful of horse hoof parings.

VIII.—A drill tempered in a solution of chloride of zinc will drill glass.

TEST COLOR FOR TEMPERING.

Says Mr. J. Richards:—Procure eight pieces of cast steel about two inches long by one inch wide and $\frac{3}{8}$ thick, heat them to a high red heat and drop them into a salt bath; leave one without tempering to show the white shade of extreme hardness, and grind off and polish one side of each of the remaining seven pieces; then give them to an experienced tool dresser to be drawn to seven various shades of temper varying from the white piece to the dark blue color of soft steel. On the back of these pieces paste labels describing the technical name of the shades and the general uses to which tools of corresponding hardness are adapted. This will form an interesting collection of specimens, and acsustom the eye to the various tints which will, after some experience, be instantly recognized when seen separately.

To Soften Steel.

One tablespoonful each hydrochloric acid and saltpetre to one gal. of water. Heat the steel and cool in it; then heat again and let get cool.

Cast steel thus treated will weld with sand.

Composition to Toughen Steel.

Resin 2 lbs., tallow 2 lbs., black pitch 1 lb.; melt together and put in the steel when hot.

To Restore Burnt Steel.

Four lbs. of fine white sand pulverized, add ½ lb. of resin, ½ lb. of sal. ammoniac, ¼ lb. copperas, all pulverized; mix well. When the steel is hot sprinkle and let cool. This process will restore any burnt steel.

To Restore Burnt Steel.

Sal Ammoniac,	1 lb.
Borax,	3 lb.
Prussiate of Potash,	½ lb.
Rosin,	2 oz.

Pulverize, add 2 gills each of water and alcohol. Boil to a stiff paste in an iron kettle; the butnt steel is dipped while hot in the composition and hammered slightly.

To Restore Burnt Steel.

Borax,	4½ oz.
Sal. Ammoniac,	12 oz.
Prussiate of Potash,	4½ oz.
Blue clay,	3 oz.
Resin,	⅜ lb.
Water,	½ pint.
Alcohol,	¼ pint.

Simmer over the fire till it dries to a powder. Heat the steel, dip in the powder and hammer.

Polishing Powder for Steel and Metals.

1.—Carbonate magnesia,	5 lbs.
Calcium Carbonate,	5 lbs.
Ferric oxide,	8¾ lbs.

Mix thoroughly.

II.—Carbonate magnesia, 5 lbs.
Elutriated colcothar, 6 oz. 7 drm.

III.—A very useful polishing powder for metals and glass is made of very finely ground glass mixed with a small proportion of dried soda ash.

To Make Iron Take a Bright Polish Like Steel.

Blue vitriol,	1½ oz.
Borax,	1½ oz.
Prussiate of Potash,	1½ oz.
Charcoal,	1½ oz.
Salt,	¾ pt.

Pulverize and dissolve in 1½ qt. of water; heat and cool the iron in this solution.

To Give Iron a Brilliant Luster.

Pulverized arsenious acid,	7½ drm.
Elutriated bloodstone,	7½ oz.
Antimony trechloride,	3¾ oz.

Pour over these materials 5 pints of alcohol, 90 % digest, at a gentle heat, shaking frequently. When iron is polished with this fluid it precipitates upon it a thin film of antimony and arsenic which protects the iron from oxidation and also gives it a fine appearance.

Water Annealing.

First heat the steel to a red heat, let it lie until nearly black hot, then throw into soap suds. Steel treated in this way will be softer than put into ashes.

To Improve Poor Iron.

Dissolve in soft water one and one-half parts of black oxide of manganese, six parts copperas, six parts of common salt; boil until dry, cool and pulverize and mix with nice welding sand; heat the iron and roll in this mixture; work for a time and reheat. This treatment will soon free the iron from all impurities. Good horse nail can be made of poor iron by this process.

MISCELLANEOUS.

Welding Flux.

For Welding Steel.—Sal ammoniac, 1 part; borax, 10 parts; pound together and fuse until clear, and when cool reduce to powder.

Tempering Lotion.

To 2 gals. of rain water take 1 oz. of corrosive sublimate, 1 oz. sal ammoniac, 1 oz. saltpetre, 1½ pints rock salt.

This compound of a Lotion makes the steel almost as hard as a man wants it for any use. It has been used for tempering mill picks and proved very successful.

Another.—125 parts of water by weight, 5 parts sulphuric acid, 13 parts salt, 1 part yellow prussiate of potash. (Recommended by Sparks of Cresent Anvil.)

Another.—Make a dough of 1 part of wheat flour and 2 parts of common salt; put it into a box and leave it dry; reduce it to a powder; when the steel is hot immerse it into the compound and heat it again until it has the right heat for tempering, and cool as usually.

Black Varnish.—Linseed oil varnish 10 parts, powdered umber 2 parts, asphalt powder 2 parts.

Brilliant Black for Metals.—A brilliant black is produced on iron and steel by applying with a fine hair brush, a mixture of turpentine and sulphur boiled together. When the tupentine evaporates there remains on the metal a thin layer of sulphur, which unites closely with the iron when heated for a few moments over a spirit or gas flame. This varnish protects the metals perfectly and is quite durable.

Blueing of Gunbarrels.—Scour the steel with a small quantity of a strong aqueous solution of soda, rinse in water, warm and brush over with a solution of a ¼ oz. of chloride of iron dissolved in 5 oz. of water, and let it dry; then apply in the same manner a solution of one-fifth of of an ounce of pyrogallic acid in one ounce of water; dry and brush. Does not wear well without lacquering.

Malleable or Aluminum Bronze.—By weight .10 aluminum, .90 copper. This composition may be forged either cold or hot. It becomes extremely dense; its tensile strength is 100,000 lbs., when drawn into wire 128,000 and its elasticity one-half that of wrought iron. Specific gravity 7.7.

Specific Gravity.—The specific gravity of any substance is the number found by dividing the weight of substance by the weight of an equal bulk of water. Therefore, the specific gravity of a substance is the number that expresses the weight of a cubic foot of it in pounds.

Weight of water 62.5 lbs. Weight of iron 480 lbs.

Example—$62.5 \div 480 = 7.6$ gravity of iron.

Fresh water weighs 62,37925 per cubic foot.

Note.—But for facility of computation it is reckoned 62.5 or 1000 ounces: Sea water weighs per cubic foot 64.3125.

Annealing Mushet Steel.—Heat the steel to a forging heat, and then put it into a pile of sawdust and keep it well covered; leave it there until cold. It will be soft enough to work it like any other cast steel. When done, heat it and leave it cool off in the usual way.

To Soften Cast Iron.—A pickle of one quart of aqua-fortis and four quarts of water. Immerse the casting and leave it twenty-fours in the solution, when you will find it soft enough to work it.

To Remove Rust on Wrought Iron.—Take one pint of muriatic acid to one quart of water; immerse twenty-four hours. Clean the article with a hot solution of soda of all the grease and oil before immersing. The rust will come off like dirt.—Am. Machinist.

One hundred and thirty-eight bushels charcoal and 430 lbs. of limestone with 2,612 lbs of ore will produce ahout one ton of pig iron.

Painting of Iron.—The iron should be thoroughly cleaned of all rust before applying the paint.

For painting, use one part of verdigris, one part of white lead and three parts of linseed oil; or ½ of verdigris, 1½ of white lead and 2½ of linseed oil. The iron to receive three coats; the first before it is used, the second after the first is thoroughly dry, and the third three days later.

Lacquer for Iron.—A lacquer protecting the iron from rust and presenting a beautiful black appearance is composed of asphalt, pine oil and colophoney.

Tempering Twist Drills and Reamers.—Pack the drills and reamers into an iron sand box and heat slowly cherry red in a furnace or forge fire; dip them vertically into water; brighten the surface and heat the tools evenly till an orange brown color appears on the bright surface.

Acid to Mark Hardened Tools.—Pyroligneous acid four parts, alcohol one part by measure; mix and add one part double aquafortis.

Rate of Wages from $4 to $21 per Week.

DAYS.	$4.00		$4.50		$5.00		$5.50	
	Dols.	Cts.	Dols.	Cts.	Dols.	Cts.	Dols.	Cts.
¼		16½		18¾		20¾		23
½		33¼		37½		41¼		45¾
¾		50		56¼		62½		68¾
1		66½		75		83¼		91½
1¼		83¼		93¾	1	04	1	14½
1½	1	00	1	12½	1	25	1	37½
1¾	1	16½	1	31¼	1	45¾	1	60½
2	1	33¼	1	50	1	66½	1	83¼
2¼	1	50	1	68¾	1	87½	2	06¼
2½	1	66½	1	87½	2	08¼	2	29
2¾	1	83¼	2	06¼	2	29	2	52
3	2	00	2	25	2	50	2	75
3¼	2	16½	2	43¾	2	70¾	2	98
3½	2	33¼	2	62½	2	91¾	3	20¾
3¾	2	50	2	81¼	3	12½	3	43¾
4	2	66½	3	00	3	33¼	3	66½
4¼	2	83¼	3	18¾	3	54¼	3	89½
4½	3	00	3	37½	3	75	4	12½
4¾	3	16½	3	56¼	3	95¾	4	35½
5	3	33¼	3	75	4	16⅓	4	58¼
5½	3	66½	4	12½	4	58¼	5	04
6	4	00	4	50	5	00	5	50
7	4	66½	5	25	5	83¼	6	41½
8	5	33¼	6	00	6	66½	7	33¼
9	6	00	6	75	7	50	8	25
10	6	66½	7	50	8	33¼	9	16½
11	7	33¼	8	25	9	76½	10	08¼
12	8	00	9	00	10	00	11	00
18	12	00	13	50	15	00	16	50
24	16	00	18	00	20	00	22	00
26	17	33¼	19	50	21	66½	23	83¼

Rate of Wages from $4 to $21 per Month.

DAYS.	$6.00 Dols.	$6.00 Cts.	$7.00 Dols.	$7.00 Cts.	$8.00 Dols.	$8.00 Cts.	$9.00 Dols.	$9.00 Cts.
¼		25		29		33¼		37½
½		50		58¼		66½		75
¾		75		87½	1	00	1	12½
1	1	00	1	16½	1	33¼	1	50
1¼	1	25	1	45¾	1	66½	1	87½
1½	1	50	1	75	2	00	2	25
1¾	1	75	2	04	2	33¼	2	62½
2	2	00	2	33¼	2	66½	3	00
2¼	2	25	2	62½	3	00	3	37½
2¾	2	50	2	91½	3	33¼	3	75
2¾	2	75	3	20¾	3	66½	4	12½
3	3	00	3	50	4	00	4	50
2¼	3	25	3	79	4	33¼	4	87¼
3½	3	50	4	08¼	4	66½	5	25
3¾	3	75	4	37½	5	00	5	62½
4	4	00	4	66½	5	33¼	6	00
4¼	4	25	4	95¾	5	66½	6	37½
4½	4	50	5	25	6	00	6	75
4¾	4	75	5	54	6	33¼	7	12½
5	5	00	5	83¼	6	66½	7	50
5½	5	50	6	41½	7	33¼	8	25
6	6	00	7	00	8	00	9	00
7	7	00	8	16½	9	33¼	10	50
8	8	00	9	33¼	10	66½	12	00
9	9	00	10	50	12	00	13	50
10	10	00	11	66½	13	33¼	15	00
11	11	00	12	83¼	14	66½	16	50
12	12	00	14	00	16	00	18	00
18	18	00	21	00	24	00	27	00
24	24	00	28	00	32	00	36	00
26	20	00	30	33¼	34	66½	39	00

Rate of Wages from $4 to $21 per Week.

DAYS.	$10.00		$11.00		$12.00		$13.00	
	Dols.	Cts.	Dols.	Cts.	Dols.	Cts.	Dols.	Cts.
$\frac{1}{4}$		41$\frac{2}{3}$		46		50		54
$\frac{1}{2}$		83$\frac{1}{2}$		91$\frac{2}{3}$	1	00	1	08$\frac{1}{2}$
$\frac{3}{4}$	1	25	1	37$\frac{1}{2}$	1	50	1	62$\frac{1}{2}$
1	1	66$\frac{2}{3}$	1	83$\frac{1}{2}$	2	00	2	16$\frac{1}{2}$
1$\frac{1}{4}$	2	08$\frac{1}{2}$	2	29	2	50	2	71
1$\frac{1}{2}$	2	50	2	75	3	00	3	25
1$\frac{3}{4}$	2	91$\frac{2}{3}$	3	21	3	50	3	79
2	3	33$\frac{1}{2}$	3	66$\frac{2}{3}$	4	00	4	33$\frac{1}{4}$
2$\frac{1}{4}$	3	75	4	12$\frac{1}{2}$	4	50	4	87$\frac{1}{2}$
2$\frac{1}{2}$	4	16$\frac{2}{3}$	4	58$\frac{1}{2}$	5	00	5	41$\frac{2}{3}$
2$\frac{3}{4}$	4	58$\frac{1}{2}$	5	04	5	50	5	96
3	5	00	5	50	6	00	6	50
3$\frac{1}{4}$	5	41$\frac{3}{8}$	5	96	6	50	7	04
3$\frac{1}{2}$	5	83$\frac{1}{2}$	6	41$\frac{2}{3}$	7	00	7	58$\frac{1}{2}$
3$\frac{3}{4}$	6	25	6	87$\frac{1}{2}$	7	50	8	12$\frac{1}{2}$
4	6	66$\frac{2}{3}$	7	33$\frac{1}{2}$	8	00	8	66$\frac{2}{3}$
4$\frac{1}{4}$	7	08$\frac{1}{2}$	7	79	8	50	9	21
4$\frac{1}{2}$	7	50	8	25	9	00	9	75
4$\frac{3}{4}$	7	91$\frac{2}{3}$	8	71	9	50	10	29
5	8	33$\frac{1}{2}$	9	16$\frac{2}{3}$	10	00	10	83$\frac{1}{2}$
5$\frac{1}{2}$	9	16$\frac{2}{3}$	10	08$\frac{1}{2}$	11	00	11	91$\frac{2}{3}$
6	10	00	11	00	12	00	13	00
7	11	66$\frac{2}{3}$	12	83$\frac{1}{2}$	14	00	15	16$\frac{2}{3}$
8	13	33$\frac{1}{2}$	14	66$\frac{2}{3}$	16	00	17	33$\frac{1}{4}$
9	15	00	16	50	18	00	19	50
10	16	66$\frac{2}{3}$	18	33$\frac{1}{2}$	20	00	21	66$\frac{2}{3}$
11	18	33$\frac{1}{2}$	20	16$\frac{2}{3}$	22	00	23	83$\frac{1}{2}$
12	20	00	22	00	24	00	26	00
18	30	00	33	00	36	00	39	00
24	40	00	44	00	48	00	52	00
26	43	33$\frac{1}{2}$	47	66$\frac{2}{3}$	52	00	56	23$\frac{1}{2}$

Rate of Wages from $4 to $21 per Week.

DAYS.	$14.00 Dols.	$14.00 Cts.	$15.00 Dols	$15.00 Cts.	$16.00 Dols.	$16.00 Cts.	$17.00 Dols.	$17.00 Cts.
¼		58½		62½		66⅔		71
½	1	16⅔	1	55	1	33⅓	1	41⅔
¾	1	75	1	87½	2	00	2	12½
1	2	33⅓	2	50	2	66⅔	2	83½
1¼	2	91⅔	3	12½	3	33½	3	54
1½	3	50	3	75	4	00	4	25
1¾	4	08½	4	37½	4	66⅔	4	96
2	4	66½	5	00	5	33½	5	66⅔
2¼	5	25	5	62½	6	00	6	37½
2½	5	83½	6	25	6	66⅔	7	08½
2¾	6	41⅔	6	87½	7	33½	7	79
3	7	00	7	50	8	00	8	50
3¼	7	58½	8	12½	8	66⅔	9	21
3½	8	16⅔	8	75	9	33½	9	91⅔
3¾	8	75	9	37½	10	00	10	62½
4	9	33½	10	00	10	66⅔	11	33½
4¼	9	91⅔	10	62½	11	33½	12	04
4½	10	50	11	25	12	00	12	75
4¾	11	08½	11	87½	12	66⅔	13	46
5	11	66⅔	12	50	13	33½	14	16⅔
5½	12	83½	13	75	14	66⅔	15	58½
6	14	00	15	00	16	00	17	00
7	16	33½	17	50	18	66⅔	19	83½
8	18	66⅔	20	00	21	33½	22	66⅔
9	21	00	22	50	24	00	25	50
10	23	33½	25	00	26	66⅔	28	33½
11	25	66⅔	27	50	29	33½	31	16⅔
12	28	00	30	00	32	00	34	00
18	42	00	45	00	48	00	51	00
24	56	00	60	00	64	00	68	00
26	60	66½	65	00	69	33⅓	73	66⅔

Rate of Wages from $4 to $21 per Week.

DAYS.	$18.00 Dols.	$18.00 Cts.	$19.00 Dols.	$19.00 Cts.	$20.00 Dols.	$20.00 Cts.	$21.00 Dols.	$21.00 Cts.
¼		75		79		83½		87½
½	1	50	1	58½	1	66¾	1	75
¾	2	25	2	37½	2	50	2	62½
1	3	00	3	16½	3	33½	3	50
1¼	3	75	3	96	4	16¾	4	37½
1½	4	50	4	75	5	00	5	25
1¾	5	25	5	54	5	83½	6	12½
2	6	00	6	33½	6	66¾	7	00
2¼	6	75	7	12½	7	50	7	87½
2½	7	50	7	91⅔	8	33½	8	75
2¾	8	25	8	71	9	16¾	9	62½
3	9	00	9	50	10	00	10	50
3¼	9	75	10	29	10	83½	11	37½
3½	10	50	11	08½	11	66¾	12	25
3¾	11	25	11	87½	12	50	13	12½
4	12	00	12	66⅔	13	33½	14	06
4¼	12	75	13	46	14	16⅓	14	87½
4½	13	50	14	25	15	00	15	75
4¾	14	25	15	04	15	83½	16	62½
5	15	00	15	83½	16	66¾	17	50
5½	16	50	17	41⅔	18	33½	19	25
6	18	00	19	00	20	00	21	00
7	21	00	22	16⅔	23	33½	24	50
8	24	00	25	33½	26	66¾	28	00
9	27	00	28	50	30	00	31	50
10	30	00	31	66¾	33	33½	35	00
11	33	00	34	83½	36	66¾	38	00
12	36	00	38	00	40	00	42	00
18	54	00	57	00	60	00	63	00
24	72	00	76	00	80	00	84	00
26	78	00	82	33½	86	66⅔	91	00

Rate of Board by the Week.

Time.		Rate.		Rate.		Rate.		Rate.		Rate.	
Weeks.	Days.	$2 00		$2.25		$2.50		$3.00		$3.50	
	1		29		32		36		43		50
	2		57		64		71		86	1	00
	3		86		96	1	07	1	29	1	50
	4	1	14	1	26	1	43	1	71	2	00
	5	1	43	1	61	1	79	2	14	2	50
	6	1	71	1	93	2	14	2	57	3	00
1	1	2	29	2	57	2	86	3	43	4	00
1	2	2	57	2	89	3	21	3	86	4	50
1	3	2	86	3	21	3	57	4	29	5	00
1	4	3	14	3	54	3	93	4	71	5	50
1	5	3	43	3	86	4	29	5	14	6	00
1	6	3	71	4	18	4	64	5	57	6	50
2		4	00	4	50	5	00	6	00	7	00
2	1	4	29	4	82	5	36	6	43	7	50
2	2	4	57	5	14	5	71	6	86	8	00
2	3	4	86	5	46	6	07	7	29	8	50
2	4	5	14	5	79	6	43	7	71	9	00
2	5	5	43	6	11	6	79	8	14	9	50
2	6	5	71	6	43	7	14	8	57	10	00
3		6	00	6	75	7	50	9	00	10	50
3	1	6	29	7	07	7	86	9	43	11	00
3	2	6	57	7	39	8	21	9	86	11	50
3	3	6	86	7	71	8	57	10	29	12	00
3	4	7	14	8	04	8	93	10	71	12	50
3	5	7	43	8	36	9	29	11	14	13	00
3	6	7	71	8	68	9	64	11	57	13	50
4		8	00	9	00	10	00	12	00	14	00

Rate of Board by the Week.

Time.		Rate.		Rate.		Rate.		Rate.		Rate.	
Weeks.	Days.	$4.00		$4.50		$5.00		$5.50		$6.00	
	1		57		64		71		79		86
	2	1	14	1	29	1	43	1	57	1	71
	3	1	71	1	93	2	14	2	36	2	57
	4	2	29	2	57	2	86	3	14	3	43
	5	2	86	3	21	3	57	3	93	4	29
	6	3	48	3	86	4	29	4	71	5	14
1	1	4	57	5	14	5	71	6	29	6	86
1	2	5	14	5	79	6	43	7	07	7	71
1	3	5	71	6	43	7	14	7	86	8	57
1	4	6	29	7	07	7	86	8	64	9	43
1	5	6	86	7	71	8	57	9	43	10	29
1	6	7	43	8	36	9	29	10	21	11	14
2		8	00	9	00	10	00	11	00	12	00
2	1	8	57	9	64	10	71	11	79	12	86
2	2	9	14	10	29	11	43	12	57	13	71
2	3	9	71	10	93	12	14	13	36	14	57
2	4	10	29	11	67	12	86	14	14	15	43
2	5	10	86	12	21	13	57	14	93	16	29
2	6	11	43	12	86	14	29	15	71	17	14
3		12	00	13	50	15	00	16	50	18	00
3	1	12	57	14	14	15	71	17	29	18	86
3	2	13	14	14	79	16	43	18	07	19	71
3	3	13	71	15	43	17	14	18	86	20	57
3	4	14	29	16	07	17	86	19	64	21	43
3	5	14	86	16	71	18	57	20	43	22	29
3	6	15	43	17	36	19	29	21	21	23	14
4		16	00	18	00	20	00	22	00	24	00

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