PRACTICAL DATA
for the
CYANIDE PLANT

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PRACTICAL DATA
FOR THE
CYANIDE PLANT

BY

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INTRODUCTION

THE inspiration for the publication of this volume was in the realization that, while theory and practice of the cyanide process has been ably explained in the standard works on the subject, no attempt has yet been made to collect the practical data, formulæ, tables, usual methods etc., in one small and convenient volume which might be carried about by the "Man on Shift."

The work is frankly a compilation, with some few diversions from standard practice which long experience has shown to be advisable. It is intended to assist the *shift* man in understanding the basic reasons for the operations he performs every day, and to give him convenient access to the data he may have to use from time to time. The experienced worker also, it is hoped, will find the work a convenience to him on his travels, containing, as it does, matter which could only be had from a number of standard books on the subject aside from his personal notes.

The author fully realizes the deficiencies of the work and requests communications from those who feel inclined to suggest the advisability of additions or improvements.

The author sincerely hopes that the volume may be an aid and a convenience to the "Man on Shift," to whose especial use he has dedicated his work.

H. A. MEGRAW.

SAN LUIS DE LA PAZ, GTO., MEXICO.
July, 1910.

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PRACTICAL DATA FOR THE CYANIDE PLANT

GENERAL

CYANIDING is the term generally applied to the art of extracting metals from their ores by the chemical process, depending upon the chemical solubility of the metals in solutions of the alkaline cyanides. The cyanides generally used are those of sodium or potassium. Cyaniding, in the general use of the term, includes the processes of solution of the metal, its recovery from the solution and its consequent transformation into a form of bullion readily marketable. In dealing with the subject, then, we are to include the methods of dissolving the metal, separating the pregnant solution from the residue of ore, precipitation of the metals from the solution, preparation of the remaining solution for re-use, and the refining of the precipitate.

As it is necessary for an ore to be treated in some way to prepare it for the dissolving process, it might be well to consider what methods are followed to put the ore into the most suitable form for readily giving up its values to the dissolving solution.

CRUSHING AND GRINDING

As the object of cyaniding is to dissolve, as far as possible, all the precious metals in combination or free in the ore, naturally the first step in preparation is to break the ore into such small particles that the dissolving solution will be able to reach and act upon every particle of the metal. These processes of breaking are usually included in the terms crushing and grinding. It is practised to a more or less degree with all kinds of ore, the exact point where it may be left off depending upon the physical and chemical characteristics of each ore to be treated. It will be readily seen that a very open or porous rock will permit solutions to penetrate each atom of rock with less preliminary breaking than an ore which is hard and solid. Instances are on record where a low-grade ore has been treated in percolation tanks after having been broken only by means of a finely set rock crusher to cubes of ½ to ¼ inch in size. The majority of the ores of the precious metals are, however, hard and impenetrable, so that the best results are obtained by very fine subdivision. Grinding and crushing are accomplished by so many mechanical devices that it would be impossible to enumerate them, and the following are mentioned as the most usual methods of practice:

Rock crushers are almost universally used for preliminary breaking. These are, the Blake type, which accomplishes breaking by means of a moving jaw, swung at the top and operated by toggles. This gives a product of varied size, due to the fact that the size of the discharge opening is constantly changing. The Dodge type, similar to the Blake, except that the jaw is swung from the bottom, maintaining a practically constant discharge opening and therefore

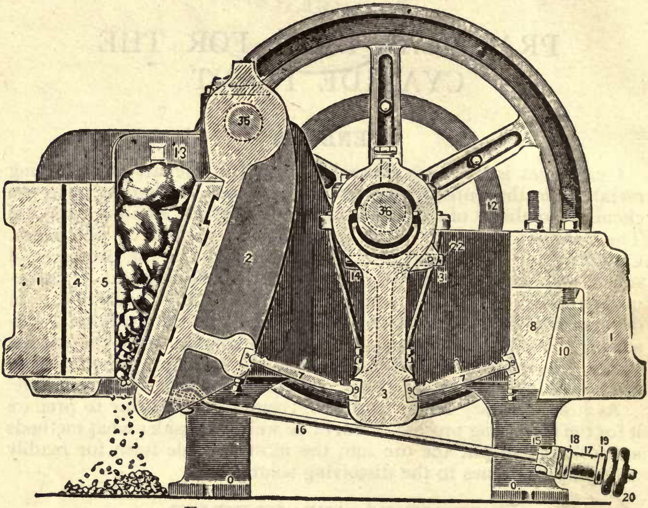


FIG. 1. — Blake Rock Crusher

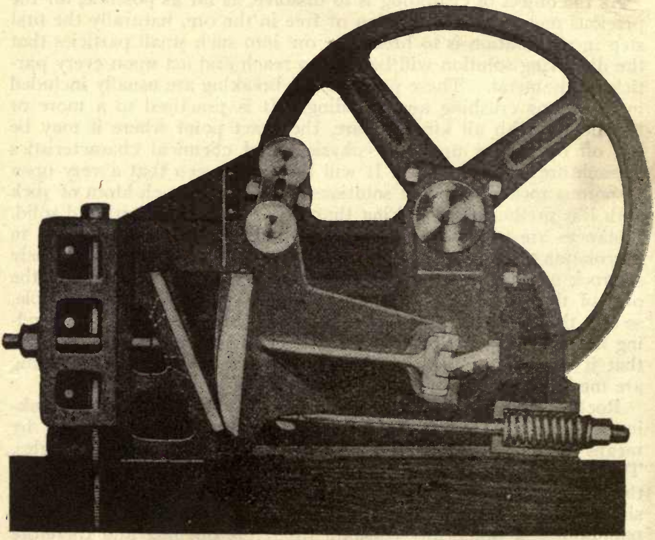


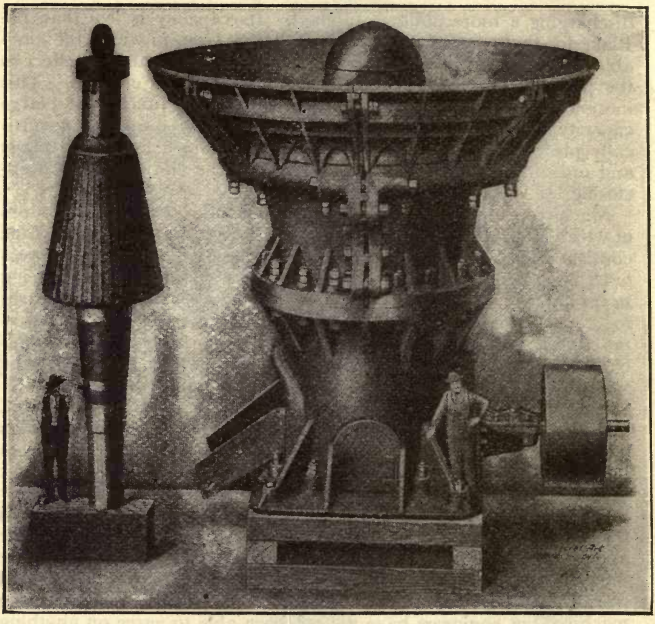
FIG. 2. — Roll Jaw Crusher

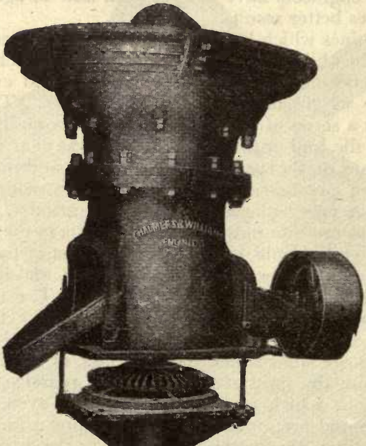
discharging a more uniform product. Its capacity is less than the Blake for that same reason. The Roll Jaw type, in which the movable jaw is convex and rolls through a small arc, similar in effect to the passing of a heavy wheel over the rock to be crushed. This motion gives a constant product with good clearing function and large capacity. The Gyratory type, which grinds by means of a vertically placed, grooved crushing unit revolving in a horizontal plane and crushing rock by compression against the stationary walls enclosing the revolving unit.

Machines of this class are followed by secondary crushing machines of which by far the most popular is the gravity stamp. This machine consists of a vertically placed stem carrying at its lower end a boss head into which the stem is fitted, a shoe of cast iron or steel being in turn fitted into the boss head. This shoe takes the wear of crushing the ore and may be renewed when worn out. The stamp is raised and dropped by means of a double cam fixed to a horizontal revolving shaft. These cams engage a tappet which is keyed to the stamp stem. The stem itself works in guides which keep it in place. Usually five of these stems are grouped together and allowed to fall with their shoe ends enclosed in a box or mortar of cast iron. This mortar also contains the dies upon which the ore is fed and where it is broken by means of the impact of the falling stem with its weight of shoe, boss head, tappet, and the stem itself. Stamps in use now usually weigh from 750 to 1200 lbs., although in some camps it is the tendency to increase the weight up to as much as 1400 lbs. for each stamp. The stamp is one of the original machines designed for the crushing of ores and its form has changed little from the original design. It is generally admitted to be an inefficient and expensive machine, but engineers have not yet been able to agree on anything which promises better results.

Other machines which have been more or less used for the same purpose are the chilian mill, in various forms, which is a roller, or series of rollers, moving on a circular track and crushing ore by means of the weight of the rollers themselves. The Huntington mill, which is a series of rollers revolving horizontally against a vertical track or die, and crushing by virtue of the centrifugal force generated by means of the speed of revolution, in addition to the weight of the crushing members. The Bryan mill is a modified chilian mill and is used in many places as a primary grinder. The machine which seems to promise most beneficial results in the contest against stamps is the chilian mill in some form. Most of the modern forms of this mill are high-speed machines, however, and these are expensive in repairs and not particularly efficient. The slow-speed mill, on the contrary, has many advantages which make it a particularly efficient and economical machine.

In reducing ore still further, fine grinding, or sliming, is becoming more and more the most modern form of practice. With the advent of methods which make it possible and even simple to treat very finely ground ore, or slime, it is becoming an axiom that, "the finer the grinding, the better the result." For fine grinding there seems to be an universal concurrence of opinion in favor of the tube





FIGS. 3 AND 4. — Styles of Gyratory Crusher

mill. This machine is a tube or pipe of plate steel revolving on trunnions or rollers, driven by a proper driving mechanism at a rate of speed depending on conditions. This tube is partly filled with hard pebbles or coarse hard ore, the grinding being performed

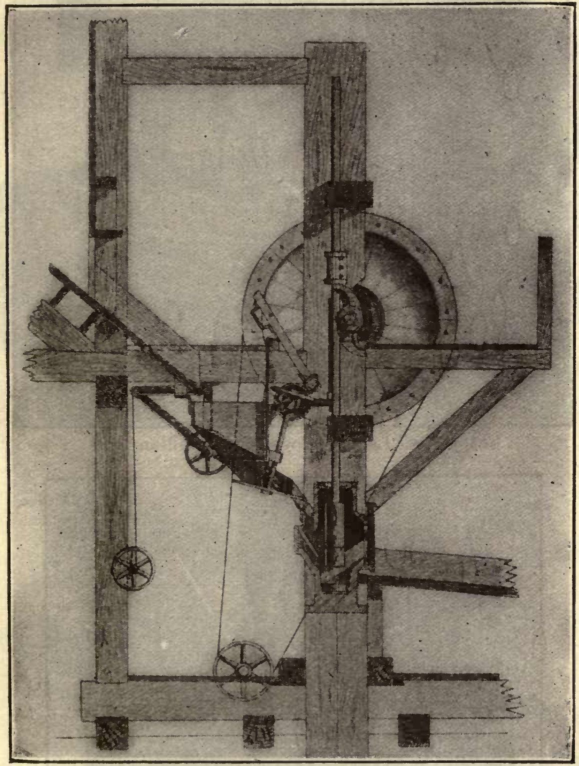


FIG. 5. — Usual Stamp Construction with Suspended Automatic Feeder

by the action of the pebbles against each other, which reduces the pulp fed into the mill, through a hollow bearing, in a very satisfactory manner. It is a prime requisite to keep the wear on the walls of the machine to as low a point as possible, and with this object in view to find a lining medium which will represent as little expense

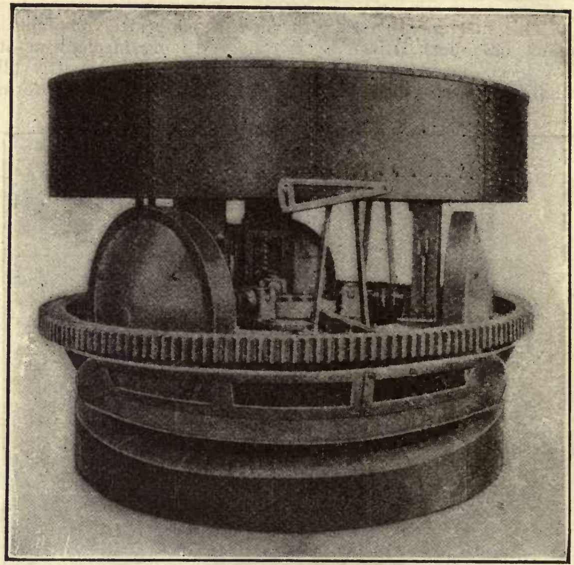


FIG. 6. — "Lane" Slow-Speed Chilian Mill

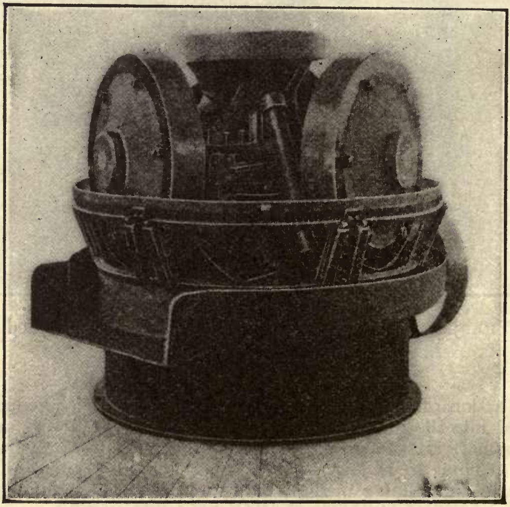
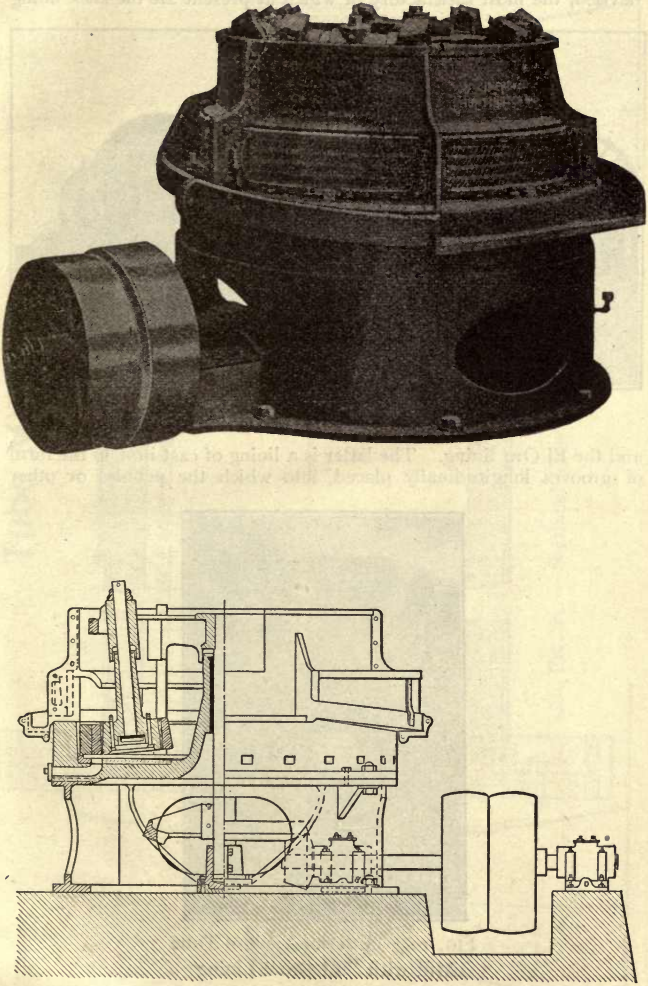


FIG. 7. — High-Speed Chilian Mill



FIGS. 8 AND 9. — Perspective and Sectional View of Huntington Mill

in the form of wear as possible. Many lining mediums have been devised, the most satisfactory of which at present are the silex lining

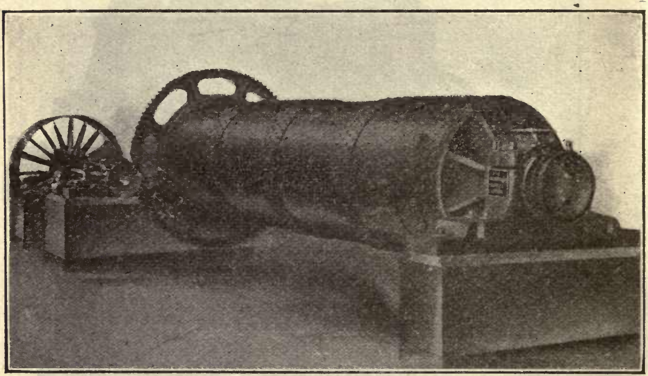


FIG. 10. — View of Center Discharge Tube Mill

and the El Oro lining. The latter is a lining of cast iron in the form of grooves longitudinally placed, into which the pebbles or other

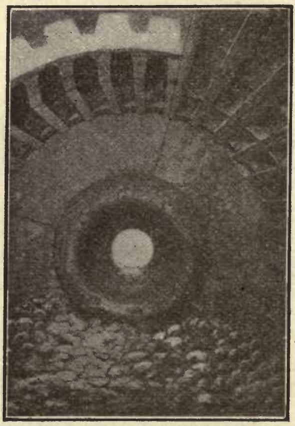


FIG. 12. — Interior View of Tube Mill with "El Oro" Lining

grinding medium become firmly lodged, forming a lining themselves. This lining replaces itself automatically whenever one of the pebbles

Tube Mill

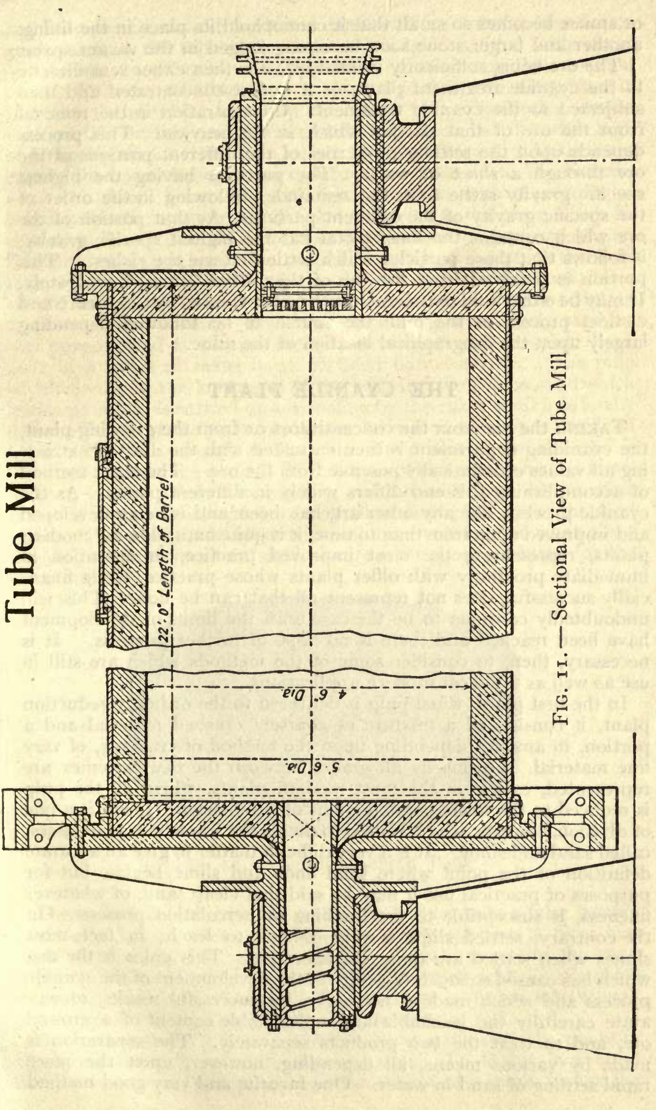


FIG. 11.—Sectional View of Tube Mill

or stones becomes so small that it cannot hold its place in the lining, another and larger stone soon becoming lodged in the vacant space.

The ore being sufficiently subdivided, it is then either sent directly to the cyanide treatment plant, or it is first concentrated and then subjected to the cyanide treatment. Concentration is the removal from the ore of that portion which is the heaviest. This process depends upon the settling properties of the different portions of the ore through a sheet of water. The particles having the highest specific gravity settle first, the remainder following in the order of the specific gravity of the different particles. As that portion of the ore which contains the most metal has the highest specific gravity, it follows that those particles which settle first are the richest. This portion is removed from the run of the mill and treated separately. It may be either sold to the smelting firms or treated by a separate and distinct process at the mill, the course to be followed depending largely upon the geographical location of the mine.

THE CYANIDE PLANT

TAKING the ore from the concentrators or from the grinding plant, the cyaniding department is then entrusted with the duty of extracting all values economically possible from the ore. The exact method of accomplishing this end differs widely in different plants. As the cyanide process, like any other art, has been and is being developed and improved upon from time to time, it is quite natural to see modern plants, representing the most improved practice, in operation in immediate proximity with older plants whose practice, while financially successful, does not represent all that can be done. This will undoubtedly continue to be the case until the limits of development have been reached and there is no hope of further progress. It is necessary, then, to consider some of the methods which are still in use as well as the most modern applications.

In the first place, when pulp is delivered to the ordinary reduction plant, it consists of a mixture of coarsely crushed material and a portion, in amount depending upon the method of crushing, of very fine material. Ordinarily all grades between the two extremes are represented, except in the most modern plants, where all the pulp is reduced to the finest possible point of subdivision. There is a line of division, however, which is used to divide the whole into two classes, called sand and slime. It is a very difficult matter to give an accurate definition of the point where sand ends and slime begins, but for purposes of practical use it may be said that clean sand, of whatever fineness, is susceptible to the leaching or percolation process. On the contrary, settled slime is very difficult to leach; in fact most slimes when settled are quite impenetrable. This point is the one which has caused so much difficulty in the development of the cyanide process and which made it necessary, for successful results, to separate carefully the leachable and unleachable content of a ground ore, and to treat the two products separately. The separation is made by various means, all depending, however, upon the more rapid settling of sand in water. One favorite and very good method has been to use a sand treatment tank with an annular launder or gutter around the top of the tank. This tank is filled with water or solution, according to which is used in crushing, and then the flow of pulp from the grinding plant is allowed to flow into the tank. It is better to introduce the pulp by means of a distributing device such as the Butters and Mein distributor, which has the advantage of filling the tank evenly from center to circumference. As the pulp enters, the sand, being heavier, settles immediately to the bottom, while the slime, being fine and light, overflows with the excess of solution into the annular launder and is carried to the place where its collection is effected. It is best in many cases to perform a preliminary separation upon the pulp before it is delivered to the sand tank. This may be performed by the use of a settling cone, from which most of the slime is overflowed and the sand drawn out of the bottom of the cone. The Dorr classifier is also largely used for this purpose and is a very efficient contrivance. It consists basically of a series of rakes in an inclined bottomed box. The pulp is delivered into the lower end of the box, and the coarse sand which settles promptly is carried up the incline by the rakes until it is finally delivered clear of the pulp into a launder which takes it to the sand plant. The slime overflows from the lower part of the box and is delivered to the slime plant. The motion of the rake, which is intermittent, is very efficient in washing out the main part of the slime from the sand and delivering a fairly clean sand product for the sand plant. The sand tank filled with solution washes out what slime remains, and the resultant sand charge is in good condition for the percolation treatment.

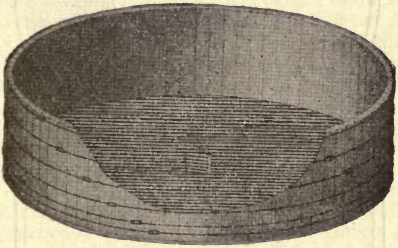
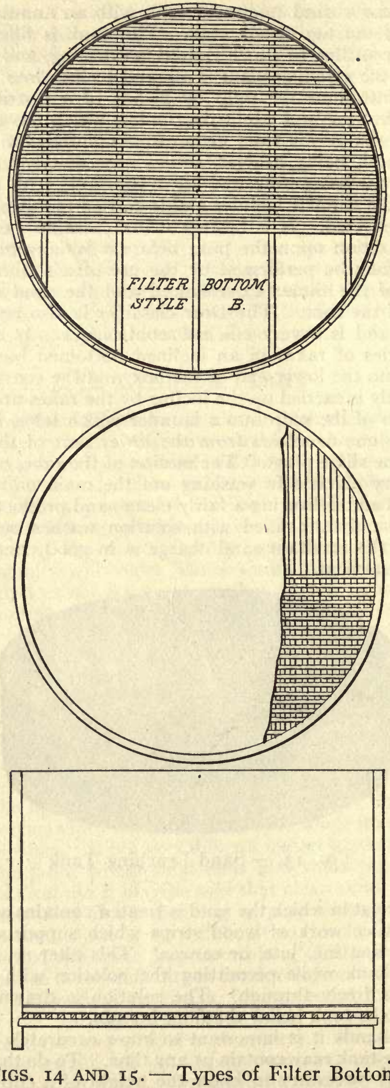


FIG. 13. — Sand Leaching Tank

The tank or vat in which the sand is treated contains a false bottom made of a lattice work of wood strips which supports a filter mat made of coco matting, jute, or canvas. This filter retains the sand charge in the tank while permitting the solution with its dissolved values to pass freely through. The solution is drawn off through pipes fixed in the tank below the filter bottom.

In treating sands it is important to know accurately the quantity of material the tank may contain at any time. To do this, in a round tank, it is only necessary to know the weight of a cubic foot of the



FIGS. 14 AND 15. — Types of Filter Bottoms for Sand Leaching Tanks

sand as laid down in the tank. By deducting from this the moisture contained we have the weight of a cubic foot of dry sand under the conditions obtaining in the tank. In a tank having a known content for each vertical foot (see table, p. 52) the distance of the surface of the sand charge from the top of the tank is measured and deducted from the total content of the tank. It is usually convenient to have a small box made which will hold just one cubic foot. This should be filled with the moist sand as nearly as possible like the sand laid down in the tank. Very often the box can be placed in the tank while it is filling and thus a very fair sample of its density can be obtained. This box is weighed, the moisture in the sample of sand determined, and the weight of both the box and the moisture deducted, thus leaving the weight of one cubic foot of dry sand under the conditions obtaining in the tank. Knowing the cubic content occupied by the sand, the tonnage of the tank follows.

The most approved and efficient method of treating sand is to add the solution in separate baths, the strong solution being added first, and as soon as the leachings show that the maximum strength has been reached throughout the charge, weaker solution is used. This is gradually made weaker and weaker until the last baths are of clear water which displaces the pregnant solution and all dissolved values. Between each bath of solution it is advisable to allow the charge to leach as dry as possible. This permits the passage of air throughout the charge and materially assists the next bath to dissolve further values. In some cases this process is assisted by means of a vacuum pump which draws the air positively through the mass of the charge.

Sand charges, after treatment, are discharged in the most economical way possible under the circumstances. If water is available it is much the cheapest way to thoroughly saturate the charge and then discharge it with water under head from a hose. In this way the tank may be quickly and cheaply emptied. Where water is scarce other methods have to be resorted to. Discharging by hand shoveling is the most expensive way of doing the work, but where the plant is small and water scarce, it must be used. The Blaisdell excavating apparatus for automatically discharging sand tanks is very excellent and closely approaches the cost of hydraulic sluicing, but the machinery is expensive and not applicable to the small plant. The machine is practically a rotary plow with disc cutters suspended by arms fixed to a central revolving shaft. This shaft is lowered as the plow discs cut their way through the charge. The sand is forced toward the center of the tank and discharged through a central opening in the bottom.

SLIMES

THE slime, or very fine, non-leachable portion of the ore is carried to the slime plant where special means are taken to separate it from the superfluous water and collect the thickened slime in charges for treatment. Large cones are often used for dewatering the slime. These cones deliver a product containing from 50 to 75 % water or more, as is considered necessary in treatment. Where crushing is performed in solution it is not necessary to take out such a large percentage of the water or solution, as treatment can be performed in the same solution by adding sufficient cyanide to raise the solution to the strength necessary for proper treatment. Slime is very often collected in the same tank in which treatment is performed. The full stream of pulp is allowed to fall into the tank, generally through a box reaching down into the tank, or behind a baffle board. The current in the tank being very slow, the slime settles to the bottom, clear solution being allowed to overflow from the tank. This clear solution may be, and very often is, returned directly from this point to the crushing plant, where it is used over again. A solution thus used will in time accumulate considerable quantities of dissolved values. To reduce these, the mill solution is at stated intervals passed through the precipitation boxes, thence back again to the crushing plant.

In thus collecting slime in the treatment tanks, a certain proportion must be observed between the flow and the size of the collecting tank; otherwise, if the stream is too great, the overflow will carry more or less of the lighter slime with it. The addition of a proper amount of lime to the solutions current in the mill will give the slime a tendency to settle more rapidly and leave a clearer supernatant solution.

The size of vats or tanks giving a clear overflow when receiving slime pulp is given by Julian and Smart (Cyaniding Gold and Silver Ores), as follows:

Diameter of tank.	Cubic feet of slime pulp delivered per minute.
20 feet	18.
25 "	25.
30 "	34.
35 "	45.5
40 "	60.
45 "	78.
50 "	100.

The treatment of slimes has been developed from a point where it was not possible to treat them at all, many mills having discarded this product for years, to the present-day practice where they are the simplest and most economical form of ore to treat and where results are the best obtainable by practice. The slime after having been collected in a charge of a suitable amount is then treated with cyanide solution of the strength found by experiment to be best adapted to it. As it is imposssible to successfully leach slime, the only remaining way is to keep it in motion during the time when extraction is proceeding. The more thoroughly the charge is kept in agitation, the better will be the final result. At first this agitation was attempted by keeping the charge of slime stirred up with a current of compressed air, the air being directed through a hose and small pipe by a man whose duty it was to see that the slime was kept in continual motion as far as possible. This procedure gave results, but proved to be expensive, and efforts were soon made to keep the charge in motion mechanically. From this was developed the mechanical stirring gear which has been so widely used. This consists of a vertical shaft in the center of the tank carrying horizontal arms near the bottom of the tank, the shaft being revolved by means of gears from a horizontal shaft passing over the line of tanks. This method also gave good results, an improvement on the previous methods. Later a scheme was devised by which the

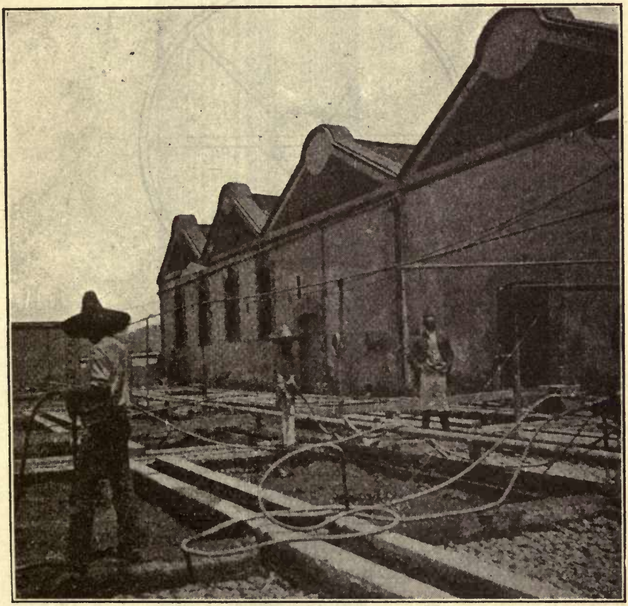


FIG. 16. — Agitating Slime with Compressed Air through Hose

central shaft was made hollow and compressed air was introduced through it to pipes carried by the radial arms, thus adding air agitation and, to a certain degree, oxygen also to the charge. This idea also had merit and was successful. It probably led the way to the most modern practice of to-day, which is the use of the Brown or Pachuca tank. This tank is a tall cylinder having a cone bottom. In the center of the tank is a tube which reaches not quite to the top of the tank, and terminates a short distance from the bottom of the cone. Into the lower end of this tube is introduced a small pipe carrying compressed air. The air introduced at this point lightens the material in the central pipe and causes it to overflow at the top, and consequently drawing in more pulp to replace it at the bottom of the tank. This action is practically that of the air lift. By this system it is possible to keep a charge in thorough motion during the time it is being treated, and the cost is considerably less than that of the most approved mechanical agitators. The angle at the apex of the cone bottom is made as acute as is possible in order to avoid any settling of the charge on the walls of the cone and at the

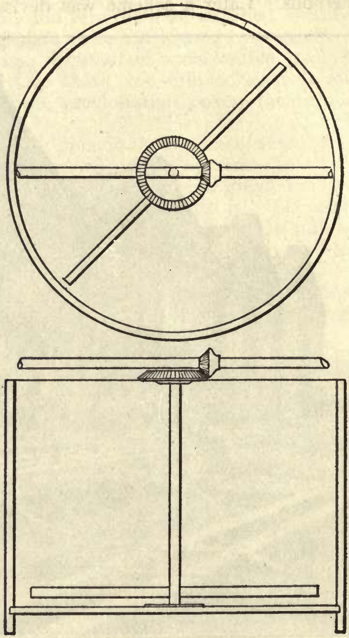


FIG. 17. — Slime Tank with Mechanical Agitator

bottom. It has been suggested that water pipes be installed in the tank at this point, so that, should settling occur for any reason, water can be added under pressure and so loosen the settled charge to such a point that the air lift may begin to work. After the lift is at work it will soon bring into motion any material that may remain settled.

Slimes usually require to be treated with solution of much less strength than sands, as the material is so much more finely divided. In consequence of this fine division also, much less time is necessary

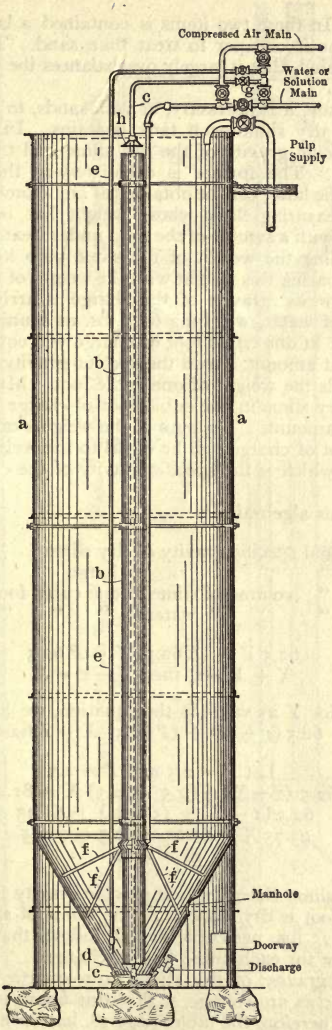


FIG. 18.—"Brown" or "Pachuca" Slime Agitation Tank

for treatment. In these two items is contained a large part of the reason why slime is cheaper to treat than sand. The saving is so great, all considered, that it largely overbalances the increased cost of grinding.

In treating slime, it is necessary, as with sands, to know accurately the quantity of dry slime each tank contains. In calculating this tonnage the specific gravity of the dry slime and that of the charge must be known. The former is calculated in the laboratory by experiment. The latter can be obtained at any moment by the use of a graduated measuring flask whose weight has been determined. Filling the flask with a sample of the pulp under treatment and weighing it, thus finding the weight of the slime pulp itself, without the bottle, and comparing this weight with the weight of the same volume of water, the specific gravity of the charge is arrived at. Taking one cubic foot of water, weighing 62.5 lbs. as a unit, 62.5 times the volume of water in one cubic foot of charge will equal the weight of the water in that amount. And the specific gravity of the dry slime times 62.5 equals the weight of one cubic foot. Multiplying this by the volume of dry slime in one cubic foot of charge gives the weight of slime in this amount. The sum of the weights of water and slime in one cubic foot of charge will be equal to the weight of the charge per cubic foot, which is the specific gravity of the charge multiplied by 62.5.

Expressing this algebraically:

Let E equal specific gravity of dry slime
" P " " " " charge
" X " volume of slime in one cubic foot of charge
" Y " " " water " " " " " "

Then $$62.5\,Y + (E\,62.5)\,X = P\,62.5$$
But $$X + Y = 1, \text{ then } Y - 1 = X$$

Substituting for Y its value in the equation, we have the formula
$$62.5\,(1 - X) + (P\,62.5)\,X = P\,62.5$$

Example, Let $E = 2.5$ and $P = 1.3$
Then $$62.5\,(1 - X) + (2.5 \times 62.5)\,X = 81.25$$
$$62.5\,(1 - X) + 156.25\,X = 81.25$$
$$93.75\,X = 81.25 - 62.5 = 18.75$$
$$\text{or } X = .2$$

So that in a slime charge whose specific gravity is 1.3, two tenths of each cubic foot is dry slime. As dry slime of specific gravity of 2.5 weighs 156.25 lbs. per cubic foot, it follows that there are 31.25 lbs. of dry slime for each cubic foot of charge.

The specific gravity of dry slime from quartz ores will closely approximate 2.5 as an average, so that this figure may have a wide application. Therefore the table, page 58, has been calculated using this figure, for all percentages of dry slime in charge. This table will be found very useful for practical operation, as it makes it the matter of a moment to calculate the tonnage of a charge. Should the specific

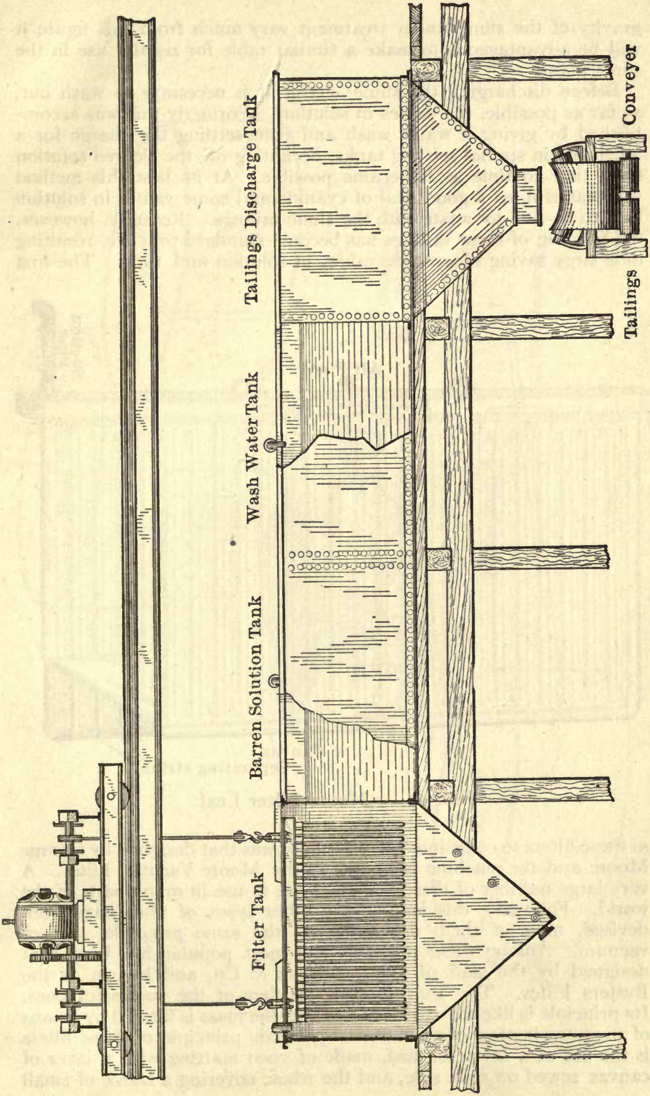


FIG. 19. — Moore Filtration System

gravity of the slime under treatment vary much from this figure it will be advantageous to make a similar table for regular use in the slime plant.

Before discharging the slime charge it is necessary to wash out, as far as possible, the values in solution. Formerly this was accomplished by giving a water wash and then settling the charge for a long time in special settling tanks, decanting off the cleared solution from time to time as it became possible. At its best this method was wasteful, as a good deal of cyanide and some values in solution had to be run to waste with the slime tailings. Recently, however, the filtering of these tailings has become standard practice, resulting in a large saving of cyanide values in solution and time. The first

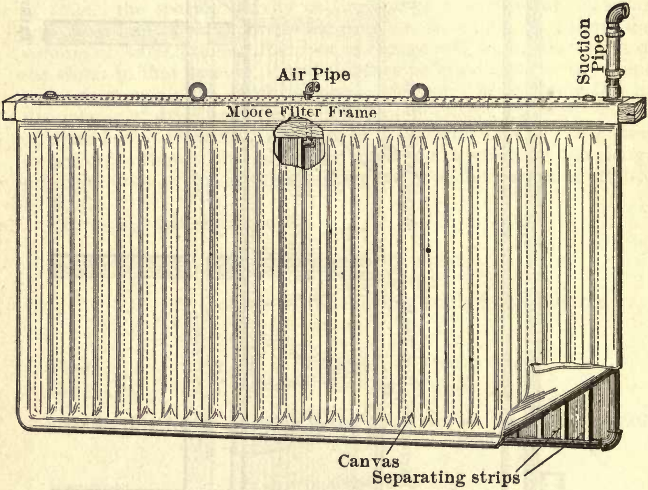


FIG. 20.— Moore Filter Leaf

of these filters to come into successful use was that designed by George Moore and the machine is known as the Moore Vacuum Filter. A very large number of these machines are in use in many parts of the world. Following this lead, many other types of filter have been devised, most of them depending on the same principle, that of vacuum. Among these probably the most popular has been that designed by the staff of Chas. Butters & Co. and known as the Butters Filter. The Burt filter is another of the successful ones. Its principle is like the others except that the mass is filtered by means of pressure instead of vacuum. The basic principle of these filters is the use of a frame or leaf, made of coco matting with a layer of canvas sewed on each side, and the whole covering a frame of small

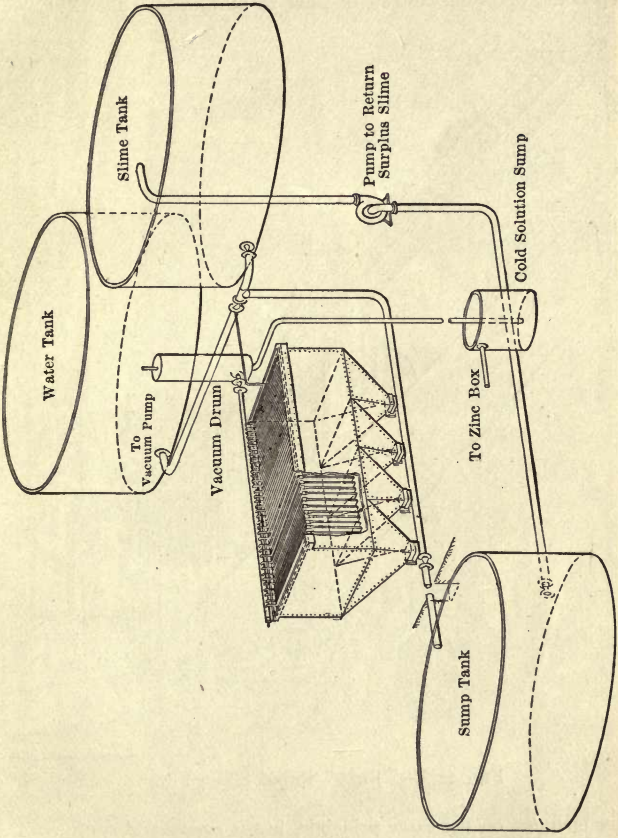


FIG. 21. — Butters' Vacuum Filtration System

iron pipe perforated with small holes. One end of this pipe is connected with a vacuum pump and the frame is immersed in the pulp to be filtered. The vacuum causes the clear solution to be drawn through the mat and the solid slime pulp forms a cake on the outside of the mat. A number of these leaves are used in a unit box or tank, depending upon the amount of slime to be filtered. The Ridgway

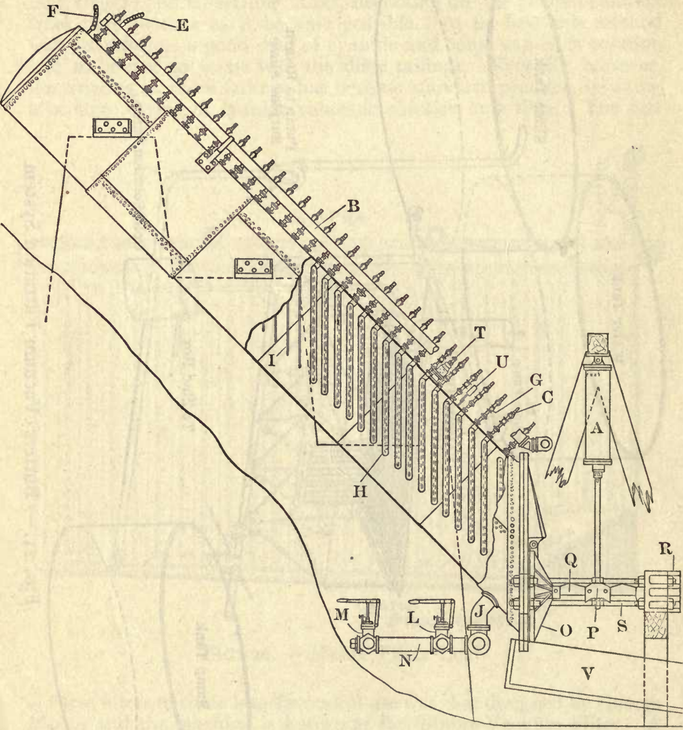


FIG. 22.—"Burt" Rapid Slime Filter

filter operates on the same principle, but is rotary and continuous. It accomplishes good work but is a rather complicated machine. The filter designed by Hunt is a circular rotary continuous machine, using sand as a medium of filtering, thus avoiding the expense of repairing cloths. This machine seems to be a particularly efficient and economical machine and its use may offer advantages over any other type at present in use.

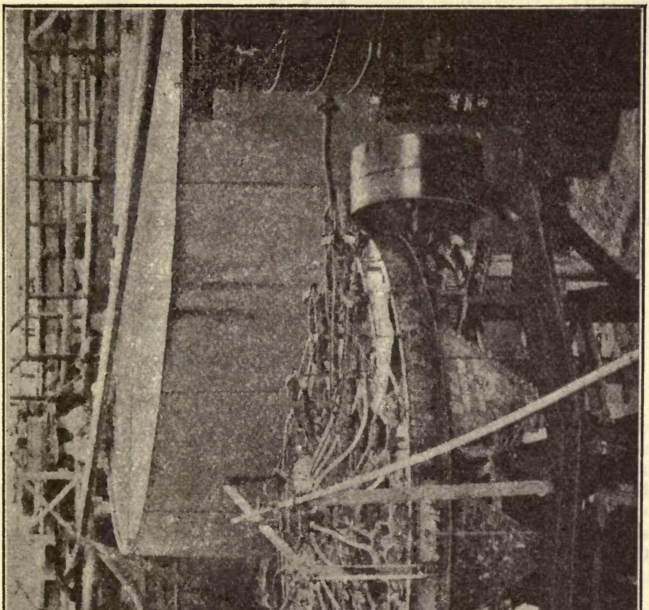


FIG. 23. — Ridgeway Filter in Operation

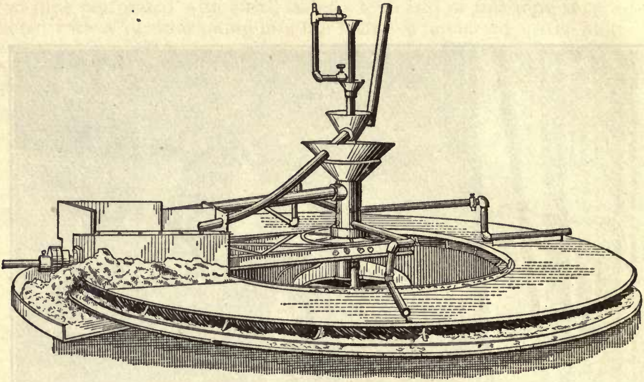


FIG. 24.—Hunt Continuous Slime Filter

The solution from both sand and slime tanks is carried to the precipitation department, where the valuable metal is separated from the solution and collected. Solution from slime treatment, whether the result of settling or filtration, usually has to be further clarified before it is in proper condition to proceed to the precipitation department. This is usually accomplished by passing the solution through sand filters which take out the last trace of slime and send the solution perfectly clear to the precipitators.

PRECIPITATION

THERE are three methods of precipitation in general use at present and most plants have adopted one of these or a combination of two or more of them. The most general way, by far, is precipitation on zinc shavings. By this method the solution is passed through long narrow boxes which are divided off into compartments in such a way that the solution rises through the mass of zinc shavings and flows down between them. In this process the zinc replaces the gold and silver in solution, the latter being precipitated loosely on the zinc in the form of a black slime or sludge. The zinc shavings are supported a few inches from the bottom of the box on a screen which allows the solution to pass freely through while holding the zinc in place. The space below the screens is utilized to allow the settlement of the precipitated slime of gold and silver. A very modern and efficient method of precipitation is that devised by Merrill and in use at the Homestake plant, South Dakota. This process uses zinc fume or dust in place of the shavings. This zinc dust is metallic zinc in the form of an extremely fine powder. On account of the extreme fineness its precipitating action on solutions of gold and silver cyanides is almost instantaneous. Therefore in order that there shall be no re-solution of the precipitated metal, the whole solution is pumped through a filter press at once, where the precipitate and any unused zinc is taken out of the solution immediately. The great advantage of this process is that no zinc boxes are required and the labor of cleaning up is saved. Also it produces, at every clean-up,

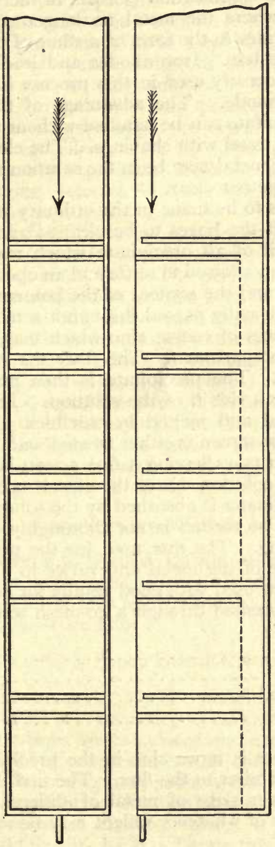


FIG. 25. — Plan and Section of Usual Form of Zinc Precipitation Box

the entire amount of metal which has been recovered. On the contrary, zinc shavings hold a large amount of values which cannot be recovered until the zinc is entirely used up.

The third process now in use is the electrical precipitation process originated by Siemens-Halske of Berlin. This process has been used extensively in South Africa. The idea is simply the precipitation or plating of the metals in solution upon a cathode by means of a current of low density. This process has been modified by the staff of Chas. Butters & Co., by which company the process has been used for years. The modification consists in increasing the current density to a point where the metal no longer plates itself on the cathode, but precipitates in the form of a slime of the metal and falls to the bottom of the box. Iron anodes and lead foil cathodes are used. The current density used in this process is about .3 amperes per square foot of anode. The advantage of this system is that a large bulk of precipitate can be handled without the expense of the consumption of zinc usual with shavings. The electric current also precipitates whatever metal may be in the solution and is not affected by solutions not altogether clear.

When a clean-up is to be made in the ordinary zinc shaving plant, the flow is turned off the boxes to be cleaned and the zinc shaken thoroughly to clear it of all precipitate which may be shaken off. This precipitate is then allowed to settle and an opening in the bottom of the box is opened and the content of the box run to sump. This flow from the box is usually passed through a screen to free the precipitate from any pieces of coarse zinc which may have passed into the bottom of the compartment. The finer the screen the cleaner the resulting bullion. The precipitate is then pumped through a small filter press which rids it of the solution. The cake formed is partially dried, fluxed and melted in crucibles. The broken zinc which is caught on the screen is either treated with acid, and melted, or better, is placed in trays having a fine screen bottom and placed in the flow of strong solution where the zinc is used up and aids in precipitation until it finally is absorbed by the solution.

The precipitate to be melted is not thoroughly dried in order to avoid losses in dusting. The flux used for the precipitate depends entirely on the nature of the metal and varies in different localities. A flux which has been used with good results for gold-silver precipitate which has been washed through a 40-mesh screen is as follows.

Precipitate,	100 %
Borax Glass	10 %
Soda (bicarb.)	5 %
Silica (sand)	2 %

Sometimes where there is more zinc in the precipitate it is well to add a small portion of niter to the flux. The first pourings from the crucibles usually deliver slabs of metal of different sizes and these are remelted into bars of whatever weight may be required.

Solutions

In treating ores by the cyanide process it is necessary to make up solutions of a strength which has been proved most satisfactory. This strength of solution is one by the use of which it has been found that the economical limit of extraction can be reached in a given time.

It is not true that a very strong solution will necessarily be more efficient than a much weaker one. In fact the contrary seems more likely to be true within limits. In treating ores whose values are economically in gold only, it has been the custom to use solutions containing from .02 to .1% KCN. Silver ores require stronger solutions for the reasons that to be workable at all a silver ore must have a much larger weight of metal than a gold ore, and also because the chemical reactions of cyanide solutions with silver require a larger portion of the former to effect solution. The strength to be used depends entirely upon the nature and quantity of the metal contained and also to a great degree upon the other constituents of the ore which may have an effect upon it. The proper solution to be used is determined by experiment before commercial treatment is attempted. Having determined the strength to be used the next step is to make the solutions.

To make a tank full of solution of a determined strength, first find the capacity of the tank in tons of water. Calculate the capacity of each vertical inch of the tank. The per cent to which the solution is to be made up, multiplied by 20 (in a 2000 lb. ton) gives the number of pounds of KCN to be added to each ton of water. Multiplying by the number of tons of water contained in the tank will give the number of pounds of KCN to be added to the tank to make the solution. Expressing this algebraically: Let L equal the number of inches in the tank. Let X equal the strength to be made up and Y equal the present strength of the solution in the tank. Let A equal the number of tons per inch in the tank. Then $X - Y = N$, which is the difference between the actual and required strength and therefore the percentage which is to be added to the solution. Then

$$AL \times 20\,N = \text{lbs. KCN to be added.}$$

When the solution is to be made up with water, $Y = O$.

In computing in metric tons, simply multiply the percentage to be added by the number of tons to be made up. The result is in kilos.

Thus, 1 ton equals 1000 kilos.

$$1000 \times .3\% = 3.000 \text{ kilos KCN to be added.}$$

In using sodium cyanide, NaCN, which is now largely used on the score of economy, it is necessary to calculate its value in terms of KCN, as all percentages are calculated and expressed in terms of the salt originally used. Commercial NaCN contains from 125 to 130% KCN. To find the strength of sodium cyanide in terms of KCN, make up a small quantity of solution of the proportion of 1 gram of the cyanide to 100 cc. of distilled water. If pure KCN were used this solution would be 1% KCN. Titrate this solution with standard silver nitrate ($AgNO_3$) as noted below, and the result will show the strength of the sodium cyanide. From this data it is a simple calculation to find the weight of sodium cyanide to be used to make the solutions in terms of per cent. of KCN.

To test the strength of cyanide solutions, the general method is by titrating with standard silver nitrate solution. This solution is made up of such strength that 1 cc. of the standard nitrate solution represents 1 % KCN. 13.07 grams of pure crystal $AgNO_3$ added to 1 liter of distilled water will give a solution of such strength. Very often in testing weak solutions of cyanide it is convenient to have the standard solution made up to half this strength. In order that the end point of the reaction of the silver nitrate with cyanide solutions may be made clear, an indicator is generally used, consisting of a few drops of a 10% solution of potassium iodide (KI). This renders the precipitate heavier and imparts a yellow opalescent tint which may be readily recognized with practice. In order to familiarize oneself with this color, add two drops of KI solution to 10 cc. of distilled water and then from a burette add a drop of silver nitrate solution. The yellow color will appear immediately. In solutions which have been in use for some time and contain other elements which might mask the reaction it is a good plan to add a liberal quantity of distilled water, say 20 cc. to the 10 cc. of cyanide solution under test. This dilutes the solution to such a point that the reaction may be easily recognized. This test shows the free or available cyanide in the solution. Should it be required to estimate the total cyanide in solution, add 10 cc. of sodium hydrate (NaOH) solution (20 grams to liter) to 50 cc. of solution to be tested and titrate as above.

All cyanide solutions used in treating ores contain a certain amount of lime. This lime is added for two reasons, first, to counteract any acid tendencies in the ore which might consume cyanide, and second to aid settlement of the slime. In silver ores this addition of lime is particularly necessary. The addition of lime, however, is often carried to a point far beyond that necessary and even so far as to become an actual detriment to treatment. The small amount of lime necessary to counteract the acidity of the ore is generally quite sufficient to carry out the settling function satisfactorily. According to experiments made by Sharwood (Jour. Chem. Met. & Min. Soc. S. A.) lime higher than .3 lb. per ton of solution actually retards the solution of gold to a great extent.

To test for the amount of free lime in solution, either oxalic acid or sulphuric acid may be used. The former is made up in a tenth normal solution. Each cc. of this solution used in 50 cc. of the cyanide solution to be tested represents .008 % CaO. This test is to be performed after the titration with silver nitrate in order that the KCN may not be titrated as lime.

In using sulphuric acid for titrating for lime, a tenth normal solution is used. The titration is made in this case after titrating with silver nitrate, as in the case of oxalic acid, 10 cc. of the cyanide solution being used. After the titration with silver nitrate, an excess of potassium ferrocyanide is added, and the titration made with the $\frac{N}{10}$ sulphuric acid. 1 cc. of this solution equals .0112 % CaO.

In the cases of both oxalic and sulphuric acids, an indicator is used to show the point where the solution ceases to be alkaline. The indicator most used is phenol-phthalein, a few drops being added just before titrating. This solution is made by dissolving phenol-phthalein in alcohol to saturation and then adding distilled water until a permanent precipitate is thrown down. In alkaline solutions this indicator has a purple red color. In acid solutions it is colorless.

A normal solution is one of which one liter contains a quantity of the substance, expressed in grams, chemically equivalent to one gram of hydrogen. In cases where the solution is to be made from a salt which contains water of crystallization, the weight of the combined water must be taken into consideration. As in the case of oxalic acid:

$$H_2C_2O_4 + 2H_2O$$

$$\begin{aligned} H_2 &= 2 \\ C_2 &= 24 \\ O_4 &= 64 \\ 2H_2O &= 36 \\ \hline H_2 &= 126 \qquad H = 63 \end{aligned}$$

Thus 63 grams oxalic acid to one liter distilled water makes a normal solution of oxalic acid. In other words, the sum of the atomic weights of the elements comprising the formula of the compound, divided by the number of atoms of hydrogen contained, or to which it is equivalent, is equal to the number of grams of the substance to be added to one liter of water to make a normal solution.

In treating gold ores the reaction taking place between the gold and potassium cyanide is expressed in the equation known as Elsner's equation:

$$4\,Au + 8\,KCN + O = 4\,KAu\,(CN)_2$$

This equation shows the proportion of gold soluble in cyanide solution and also shows the necessity of sufficient oxidation to complete the reaction. In the case of silver the reactions are much more complicated. The oxygen does not play the direct part in the solution of silver as in gold, but the indirect reactions taking place show that the oxygen is quite as necessary, if not more so. The reactions do not take place as promptly as in the case of gold, probably because the silver is always in combination with other elements and the requisites for the completion of the reactions are not at hand to be used promptly. The reactions given for the solution of silver sulphide in cyanide solu tions are given by Sharwood (Min. & Sci. Press, Sept 26, 1908) as follows:

$$96\,KCN + Ag_2S = 2\,KAg\,(CN)_2 + 92\,KCN + K_2S$$

This is in the proportion of 28.9 KCN to 1 Ag and represents the dissolving without oxidation. The K_2S formed in solution is probably changed during slow oxidation to potassium thiocyanate and potassium hydrate,

$$K_2S + KCN + O = KCNS + 2\,KOH$$

It has been shown that if silver sulphide ores are treated with cyanide solutions a soluble double cyanide of the silver with K or Na is formed with K_2S or Na_2S as shown above. Now it is a fact that in the presence of soluble sulphides the silver will not remain completely in solution and extraction will not be good. In order to eliminate these soluble sulphides, a soluble salt of some element whose sulphide is insoluble must be added to the solution. Lead salts are conveniently used and generally in the form of the acetate, although litharge may be used with good effect. The following reactions are given by Caldecott (Jour. Chem. Met. & Min. Soc. S. A., March, 1908) showing the reactions following the use of lead salts:

$$Ag_2S + 4\,NaCN = 2\,NaAg(CN)_2 + Na_2S$$

This reaction showing the formation of sodium sulphide:

$$2\,Na_2S + 2\,O = Na_2S_2O_3 + Na_2O$$
$$Na_2S_2O_3 + Na_2O + 2\,O_2 = 2\,Na_2SO_4$$

and

$$Na_2S + NaCN + O = NaCNS + Na_2O$$

showing the formation of thiocyanate.

The lead acetate added to the solution yields lead oxide, the reactions with which are,

$$Na_2S + PbO = PbS + Na_2O$$

The lead sulphide is insoluble and it is precipitated and removed from the solution. Then follows:

$$PbS + NaCN + O = NaCNS + PbO$$

Here the thiocyanate is again formed in solution, taking the sulphur atoms, and the lead oxide is liberated and is free for further use in repeating the above cycle of reactions. The NaCNS formed is useless for further dissolving. This is one of the reasons for the higher consumption of cyanide when silver is being treated.

In the majority of cases the above reactions are hampered for several reasons, and the dissolving and consequent extraction of the silver values is slow. Probably the large amount of oxygen needed to complete the reactions is not available promptly and the reactions have to proceed with a speed depending upon how fast the requisite oxygen can be supplied.

There are many different expressions of opinion on the subject of the reactions taking place when silver ores are treated, so that the above reactions cannot be offered with absolute certainty of truth, but they do represent the evolved opinions of those most familiar with the situation and who have given it most careful attention and study.

Stoichiometry

WHILE it is not within the scope of this work to go very deeply into chemical science or calculation, at the same time it is a wise plan for every one working with the practice of cyaniding, which depends directly upon chemical knowledge, to know something about the calculations of chemical reactions in order that he may be able to understand the principles governing them and be able to solve a few simple problems which may present themselves at any time.

Stoichiometry is simply the arithmetic of chemistry. Its practice involves only a knowledge of chemical reactions and basic arithmetic. Most of the problems arising can be solved by the rules of simple proportion. A few examples will best show the application and principle of the work.

Calculation of percentage from weight:

Suppose one gram of iron ore is taken for assay. The weight of iron obtained is .02 gram. What is the percentage of iron in the ore?

$$\text{Weight taken} : \text{weight found} :: 100 : X$$
$$1 : .02 :: 100 : X$$
$$X = 2\%$$

Calculation of percentage from chemical formula:

This class of problem is also solved by proportion, using in the first two terms the weights of the constituents in question and in the last two their corresponding percentages.

The formula for silver nitrate is $AgNO_3$. What is the per cent. of silver contained in the compound? Thus using the atomic weights:

$$\text{Weight of compound} : \text{weight of element} :: 100 : X$$
$$170 : 108 :: 100 : X$$
$$X = 63.5\%$$

In the same way the percentage of each constituent may be found. Should it be required to find the weight of silver in a certain known weight of the compound, it is only necessary to multiply the known weight by the percentage found as above. This applies to any chemical compound the formula of which is known. In the same way the percentage of any chemical compound which forms part of another compound may be found. Thus should it be required to find the percentage of CaO in $CaCO_3$ the same rule is followed, using the weight of the compound CaO in the second term of the proportion as shown above.

Calculations for making up and using standard solutions: Let it be required to make a solution of sodium bromide for precipitating silver of such strength that 1 cc. will exactly precipitate 0.01 gram of silver.

From the equation,

$$AgNO_3 + NaBr = AgBr + NaNO_3$$

it is evident that 1 atom of Br precipitates 1 atom of Ag. Hence follows the proportion,

$$108 : 103 :: 0.01 : X$$
$$X = 0.009537$$

This follows from the proportion of the atomic weights of silver and sodium bromide. X in this case is the amount of NaBr to be added to each cc. of the standard solution to be made. Therefore if 1000 cc. or 1 liter of the solution is to be made up, it will require 1000 times X or 9.537 grams NaBr.

A similar calculation is used in making up the solution of silver nitrate with which to titrate the cyanide solutions. Here the ultimate reaction may be expressed as follows:

$$AgNO_3 + 2\,KCN = KAg(CN)_2 + KNO_3$$

Here we wish to make our standard solution of such strength that the silver contained in 1 cc. will be exactly dissolved in a KCN solution, 10 cc. of which will represent .1 % KCN. Therefore first we must find out what weight of KCN is contained in 10 cc. of .1 %. This is readily seen to be .01 gram KCN. One atom of silver nitrate requires two atoms of potassium cyanide, according to the reaction expressed in the equation. Using the atomic weights of the two compounds, we have

$$2\,KCN : AgNO_3$$
$$130 : 170 :: .01 : X$$
$$X = .01307$$

which is the amount of silver nitrate to be added to each cc. of water to make the standard solution, or if 1000 cc. are to be made, 13.07 grams are to be used.

These calculations are about the only ones which will be required in cyaniding work, or will serve as a type for similar calculations which may be required. To those interested in further investigation of the subject, it may be said that any standard work on quantitative analysis will give further details along this line.

Preliminary Experiments on Ores

In order to determine the most efficient methods of procedure in treating by cyanide solutions, it is most important that preliminary experiments be made upon the ore in question. All possible methods should be tried in every possible way, as it is only by careful and repeated tests that conclusions valuable in after practical work can be derived.

Possibly the most important factor in testing work is the selection of the sample upon which the experiments are made. It is absolutely necessary that this sample should represent not only the grade of ore which will be at hand in the completed plant, but it must also represent all the other conditions which will be met with in practice. Its chemical constituents should represent an average of the ore to be treated. It should have neither more nor less of the elements which tend to impede solution and those which tend to assist the operation. In short, unless the sample typifies what may be expected in working practice, the experiments are useless, or worse than useless, misleading. Examples are not lacking of plants built under a misapprehension as to the class of ore available and having to be entirely rebuilt or changed at a great expense when practical work is begun. Therefore it behooves the experimenter to use every possible means to assure himself that the sample upon which he makes his tests is really a true sample in every sense of the word.

The method of taking the sample depends entirely upon the source from which it comes. If one is dealing with a proposition which is milling ore and concentrating or amalgamating, it is then a simple matter to procure an even sample of the material to be experimented upon by sampling the tailings over a period of from one week to three months, taking the samples at regular intervals. In this case it is hardly possible to go astray on the work, providing the mill is treating ore of grade and character which is expected to continue. Where there is no mill and samples have to be taken directly from the mine, it is well to extract a portion of ore from each part of the mine and experiment upon each section separately, except where the ore in the mine is fairly regular, when the samples from different parts of the mine can be put together and thoroughly mixed. The larger the sample, the better and more representative the resultant sample will be. The thoroughly mixed sample, which should contain from five to one hundred tons, according to the size of the mine and the consequent magnitude of the plant, should be reduced to an even size of rock, breaking up all large boulders or rocks. The pile should then be mixed again and reduced, either by taking out one shovel in every five, or better, by cutting the pile in quarters and rejecting half of the sample, opposite quarters, at the first reduction. The sample should then be further reduced in size and the quartering process resorted to again. At this rate, when the sample is reduced to about half a ton, the size of the largest piece should not be over ½″, or such size as will pass through a half-inch ring. When the sample is reduced to a quarter ton the whole should be so crushed to pass through a screen having openings ⅛″ square. At this point the sample can be thoroughly mixed again by shoveling over several times and the sample for test can be extracted. In cases where the plant in view is to be large and important, it is well to install sufficient sampling machinery so that a large tonnage may be crushed, thus securing a sample well representative of all the possibilities to be met with. It is a wise policy to erect a small mill so that experiments may reproduce, as far as possible, results obtained in actual practice. It is true that laboratory results are fairly representative of results which may be obtained on a large scale, probably more so in the cyanide process than in any other mode of reduction, but the character of the sample is the one point where large quantity makes for accuracy.

If it is desired to construct a plant in which the sand and slime is to be treated separately, the sample should be so crushed as to give a part of it in slime and a part in sand. This is a very difficult thing to do on a small scale, and the only way to get a true idea of what crushing will produce is to really crush the ore in the way it is to be done in the future mill, on a smaller scale, of course. If this is not possible, it is well to crush the sample on a bucking board, screening the product after each separate bucking so that the percentage of slime will not be abnormal, as it is likely to be if the whole sample is bucked over until the coarsest particles pass the required screen. After bucking, the whole sample can be separated into sand and slime by passing it through a 200-mesh screen, that part which passes through the screen being held as slime and that which does not pass through the screen being treated as sand.

In making experiments upon the sand, it is well to take out several samples of a weight convenient for test, sizing each sample through a screen of different mesh in order to make experiments upon each grade. For instance, one sample might be passed through a 60-

mesh screen, another through a 40, another through a 30, and another through a 20 mesh. In every case the crushing should be done with all possible care to ensure all the product, as far as possible, being of practically the same screen grade. Experiments may be performed on leaching in an ordinary bell jar, in the bottom of which a filter mat may be arranged by folding a piece of jute or cotton material so as to fill the bottom of the jar and not allow the sand under treatment to pass through. Before attempting to add the cyanide solutions, a test should be made in order to find out the amount of lime necessary in order to neutralize the acid tendencies of the ore. This may be done by adding to the weighed ores in a bottle an equal weight of water in which is dissolved a known weight of lime. Several bottles may be prepared each containing a different quantity of lime. These bottles are shaken up for several hours and allowed to stand for several hours more. At the end of this time they may be tested for the amount of lime still remaining in the solution. Testing all the bottles thus, an idea of the amount of CaO consumed by the ore is readily ascertained. An amount slightly in excess of this should be added to the sands under test. The excess must not be too great, or it will have a deterrent effect upon the extraction of gold. The solutions should not show over 0.3 lb. per ton of solution, after the ore has consumed all it will.

The dry lime is mixed with the sand before treatment in the proportion found necessary, and treatment is then instituted. Each sample for the leaching test should be treated with solution of different strengths in order to find out which is the best adapted for the extraction. Solution should be used eventually which is no stronger than that absolutely necessary for best results. It makes a difference whether the ore contains silver enough to make it commercially important, or whether it is a straight gold ore. In the latter case solution containing .05 to .1 % KCN will probably be strong enough and from two to ten days' treatment will be required, depending upon the value of the ore. When silver is treated, solution of .6 to 1. % KCN will be required and the time will probably be lengthened to from six to twenty days, depending upon the grade of the ore and the combinations in which the silver exists. All strengths of solution should be experimented with and all times between reasonable limits. The first few tests will generally show the limits between which good results can be obtained. After having obtained good results the same experiment under same conditions should be repeated again and again in order to absolutely verify results.

In adding the solution to sands, the first wash should be of strong solution enough to completely cover the charge when it is thoroughly saturated. This solution should be allowed to stand for some time, having the tube leading from the bottom of the bell jar, under the filter mat, closed so that no solution can escape. The solution should be allowed to stand thus for from four to six hours. The tube should then be opened slightly and the solution allowed to run off slowly, so that it will take about ten hours to run off, leaving the charge without any solution which will run off of its own accord. The charge is then allowed to stand in this condition for from four to six hours in order to assist aeration, when another wash of solution should be applied. At this point it is well to mention that better results are obtained in practice in the large tank than can possibly be attained in the laboratory, for the reason that the receding solution in the tank draws after it a volume of air which materially assists the next bath to dissolve further values. The solution draining off from the charge should be tested for KCN and lime and charges of strong solution should be added until the leachings show practically the same strength as the applied solution, showing that no further cyanide consuming effect is to be expected from the ore. Then weaker solution should be added, gradually diminishing in strength until the final wash or two is clear water in order to wash out all dissolved values. The charge should then be taken out of the jar, dried carefully and assayed. The leachings from each test should also be collected and assayed as a check against the tailing assay. In this way, by dint of many careful experiments under different conditions, a very good idea of what may be expected in practice may be determined.

In making the experiments upon the slimes, the amount of lime necessary is determined in the same way. The solutions required in treating slimes will be found to be less than those required in sand, in per cent. KCN, and the time required will be also less, due to the very fine division of the particles of the ore. As slime cannot be leached, agitation must be resorted to. A simple way to make agitation tests is to place the slime with its solution, after having added the necessary lime, in a large bottle and agitate the bottle by fastening it to some moving piece of machinery, such as a slowly revolving wheel or a Wilfley concentrator, or any moving piece in which the speed is not so great that the charge will be held in one place by centrifugal force. The amount of solution necessary for a given amount of ore varies from 3 to 1, to 5 to 1. Experiments should be made with all proportions of solution of all possible strengths and with different times of treatment. In treating slimes it is well to treat with several washes of solution. After the treatment of the first twenty-four hours the solution is tested, the bottle allowed to rest until the slime has settled and the supernatant solution is clear. This is then decanted off and a fresh bath of solution added. The second bath may be decanted off after twelve hours of treatment and a third wash added, to be later decanted again. The number of baths, like the strength of solution, depends upon the character of the ore, and its value, and is only determined by repeated experiment. In agitating the bottle containing the charge, the machine which operates it should be stopped from time to time and the cork removed in order that fresh air may be available. In treating both sand and slime it is important that the solutions be at all times carefully titrated for strength KCN and a calculation made to determine the total consumption of cyanide per ton of ore treated. This is an important point and has large effect upon the total cost of treatment.

The results from the different methods should be all tabulated and compared, checking in each case by assaying the total solution resulting from the treatment.

In cases where the treatment is to be made on slime alone, grinding the whole ore to the point where it can all be treated by agitation, it is only necessary to crush the original sample all to a slime and proceed with treatment as with the slimes above. It is always well to repeat the experiments on a slightly larger scale where it is possible. To this end leaching tanks can be made for treating sands by cutting a barrel in half and putting a filter mat in the bottom of the half. A pipe is fitted in the bottom of the barrel under the filter mat, with a valve by means of which the leaching can be controlled. A small zinc box can be also made if it is desired to experiment with the precipitation, and the leachings from the sands run through the box. With slimes a half barrel can also be used and agitation can be accomplished by a mechanical stirrer or by means of air jets placed in the barrel. A Pachuca tank on a small scale can be very readily made of sheet metal, very light metal will do, and a tank 18″ in diameter and 48″ deep will give very good results.

Only by very careful and conscientious work can dependable results be obtained. In order that results should be of value no pains should be spared to be exact in every operation and to reproduce to the finest possible point conditions which will obtain in actual practice. In very large operations it is an extremely wise plan to build first a small plant in which actual working operations are duplicated. This plant may later become a part or unit in the larger installation, or even if it has to be discarded entirely, it is money well spent in order to be absolutely sure of results.

Trouble

In the regular work of cyaniding, there are liable to occur times when things go wrong and it seems almost impossible to account for the causes of the trouble. In such cases it is a matter of careful study and close application to discover the causes which lead to bad results and, once found, it is comparatively a simple matter to remove the cause of the difficulty. It is a good thing to know some of the things which may happen and which have happened, and thus have a few hints upon which to base observations when things go wrong on the plant.

In the first place it often happens that the slimes will suddenly refuse to settle properly. Of course the first thing to do in such a case is to make sure that the proper quantity of lime has been added regularly. Operatives may happen to omit the regular addition of the lime for a short time and the results will certainly be evident on the plant very quickly. Usually this omission will be accompanied by an abnormal consumption of cyanide, due to not having the required protective alkalinity in the solutions. It is necessary in these cases to be sure the lime is being added regularly. Another cause which may bring about the same result is the use of faulty lime. Cases have occurred where lime has contained large quantities of reducing agents, while the percentage of CaO has remained about normal. Sometimes the amount of reducing agents may be so large that it may render inoperative any alkalinity due to the lime content. A lime may be very easily tested for this condition by making up a solution of cyanide in clear water, testing it, and then adding a small quantity of the lime in question. This is agitated for a few minutes, filtered off and the solution tested again. Any drop in the percentage of cyanide in the solution is then clearly due to the action of the lime. This condition must be at once looked after and the lime discarded.

Other substances than lime have the same coagulating effect upon slimes and may be used to electrolyze them. Of course any of these materials must be used with judgment as there are certain cases in which certain ones may not be safely used. Careful experiment will, however, lead to a correct knowledge of their effects. Julian and Smart (Cyaniding Gold and Silver Ores) give the following table of the relative efficiencies of different chemicals:

Substance.	Quantity required by weight to produce equal effect, or relative efficiency.
Aluminum sulphate	100.
Alum (Potash)	143.
Ferric Iron	223.
Alum (Ammonium)	252.
" (Am. Chrom. Iron.)	295.
Lime	654.
Magnesia	748.
Alum (Pot. Chrom.)	958.
Calcium chloride	1,095.
" carbonate	1,215.
" sulphate	2,870.
Magnesium sulphate	3,460.
Sodium chloride	45,900
" sulphate	61,700.

In cases where the lime is good and the addition to the solution found to be regular, it may be that the ore contains reducing agents which the lime cannot eliminate. In this case it may be easily proved by taking a small portion of the solution from the pulp under examination and acidifying it with a few drops of sulphuric acid and then adding a few drops of potassium permanganate solution from a burette. Should there be no reducing agents present the solution under test will assume the characteristic pink color given by the permanganate, and will hold the color. Should there be reducing agents, however, the color will disappear with the addition of the first drop of permanganate and a brown precipitate may result. A comparison of the quantity of permanganate added before the pink color is constant will give an idea of the quantity of reducing agent present. Reducing agents may be eliminated by oxidation of the pulp. This is accomplished by agitation with air or with chemical oxidizing agents. Probably the most efficient and prompt chemical agent is bleaching powder, or calcium hypochlorite, $Ca(OCl)_2$. A small quantity of this agent added to the pulp will usually be sufficient to thoroughly oxidize any reducing agents present.

In treating accumulated tailings, trouble has been encountered due to small particles of charcoal or partly decomposed organic matter. The former is common in Mexico where charcoal is the universal fuel. Charcoal is an active precipitant and a very poor extraction will be the result where there is an appreciable quantity of this matter in the ore or tailing. It should be carefully screened out before attempting treatment. Organic matter is an active cyanicide and should be eliminated as far as possible. Screening will take out the greater part of the organic matter which is not completely decomposed, the remainder should then be carefully neutralized by the use of chemical. Lime is generally used for the purpose, but bleaching powder may be used with good effect to oxidize the acids formed and render them innocuous.

The use of lime in the cyanide plant is one of the causes of some poor results, the cause for which baffles the mill man. Lime is often used in a most haphazard way, without rhyme or reason, and it is the cause of as much trouble as it is good. The most economical way to use the lime is to make it up by slaking in a small quantity in warm water and feeding the resulting lime water to the solution requiring it. Lime slaked carefully in this way will give 20 % more soluble CaO than when the dry lump, air slaked, is fed directly to cold solution. It is also more effective. A small quantity of lime is usually of a great deal more service than a large quantity. An excess of lime over that necessary to settle slimes is usually waste. Sharwood (Chem. Met. Min. Soc. S. A., April, 1908) shows that lime in solution to a greater extent than 0.3 lb. per ton of solution is decidedly injurious to the extraction of gold. Lime should be used with care and judgment, and usually a series of experiments to determine its best mode of use would be very beneficial. It is even true that some slimes settle better without lime than with it.

Some difficulty in treatment may be found after a plant has been running a long time as a result of foul solutions. In such a case it will probably be found well to precipitate the zinc from the solutions by some one of the methods suggested for the purpose. Orr's method is useful for this purpose. Its principle is the precipitation of the zinc by means of the addition of fused chloride of zinc, thus throwing down the insoluble single cyanide of zinc. This is allowed to settle, the supernatant solution drawn off and allowed to waste if necessary as it contains no cyanide. The precipitate is then dissolved in a solution of an alkaline hydrate and the zinc precipitated from it as sulphide by means of fused sulphide of Na, K, or other alkaline metal. This gives a clear solution with regeneration of the useful cyanide and gets rid of the excess of zinc. The latter may be thrown away or reduced to metal, as seems most economical under the conditions.

The temperature of the pulp has a direct effect upon results. This is due largely to the influence of the viscosity of the solution, which decreases as the temperature increases. In the case of slimes it is true that the greater the proportion of solution to the weight of dry slime treated, the better will be the extraction and general result.

This is, however, a rule that cannot be absolutely applied in every case, for there are instances where it is not true, but in the general run of ores it will be found to apply. It is, of course, impossible to increase the proportion of solution used beyond a certain point which will be found to be the economical limit. And below this limit it is often found that a dilution much less will give results, due to less time of treatment and general convenience, which will be more effective. The amount of dilution had best be determined by careful experiment. The point should be found where the viscosity of the solution will be low enough to allow a thorough mixing of the solution with the ores, so that a particle of cyanide may come in contact with and act upon every particle of metal in the ore. A raise of temperature lowers the viscosity of the solution and allows mixture to take place more freely. This is limited by economy as well as by the point of temperature where the heat will tend to decompose the cyanide, causing an expense greater than the saving attained by higher extraction.

In treating sands by percolation bad results can often be found due to imperfect percolation. In order that leaching results be good it is necessary that the sand should be in a perfectly homogeneous state so that solution will percolate uniformly through the mass. If portions are left which contain more coarse sand than other parts, the main volume of the treating solution will tend to pass through those portions to the detriment of the remaining parts of the tank. Slimes should not be permitted in the sand tank and the sands of whatever fineness should be thoroughly mixed so that percolation will proceed at a perfectly even rate throughout the whole mass in the tank.

In some cases where there is no slime plant, it is desired to add as much slime to the leaching tank as possible. In this case much depends upon the character of the slime. In many cases as much as 10 % of slime can be added to the leaching tank without bad results, provided, however, that the slime is thoroughly mixed with the sand so that the density of the charge may be thoroughly even throughout. The exact quantity of slime which may be mixed with the sand can be determined only by careful experiment, and after ascertaining the quantity which may be used, the greatest care must be taken to assure thorough mixing.

In precipitating on zinc shavings the strength of the solutions precipitated have a good deal to do with the efficiency. Strong solutions give uniformly good results. Very weak solutions do not give such good results and are apt to be erratic. The minimum strength of solution which can be depended upon to give good extraction cannot be stated with any degree of definity, as other circumstances seem to have effects upon it. However, Yates (Jour. Chem. & Met. S. A., Vol. 1, p. 257) gives a minimum of 0.008% KCN, below which uniformly good precipitation cannot be expected. The amount of zinc shavings necessary for correct precipitation varies from ½ to 1½ tons of solution per 24 hours for every cubic foot of zinc shaving. The richer the solution is in metal, the less zinc will be consumed per unit of metal recovered.

In cases where there is much copper in the solution precipitation on zinc will be bad. Copper is likely to precipitate in a solid, firm coating on the zinc, which prevents further action. In such cases the remedy is to use the electrical precipitation process, either wholly or in part. Should the latter mode be preferred, the first compartments may be precipitated by electricity and the remainder by zinc. This process will be effective in removing all the objectional elements from the solution at once.

The use of lead acetate in treating silver ores has the effect of increasing the efficiency of precipitation, but also increases the consumption of zinc. The acetate should not be used beyond the actual amount necessary for proper extraction.

In melting precipitate from the zinc boxes it is well to be perfectly sure in the first place that the flux used is that best suited to the securing of good results. A few sample charges mixed up on a small scale and melted in the assay furnace will settle that question at once. The flux should be such that it will allow the mass to melt readily and promptly and give a good liquid slag free from shots of bullion. A great deal depends upon the furnace in which the melting takes place. It should not be too large, for a large fire requires frequent replenishing with fuel and with each addition the heat is appreciably lowered. The fuel should be added in small quantities frequently rather than large quantities at long intervals. In this way the heat is preserved without great drops in temperature. Before pouring a crucible, whether it contains the slag meltings of bullion only, or bullion for bars, care should be taken that the heat is amply sufficient to maintain the contents of the crucible in a perfectly liquid state for the time necessary to pour the contents into the molds. Bullion which is poured too cold is sure to make an ugly looking bar and the assay at different points will differ widely. A properly poured bar will be perfectly mixed and will have practically the same value at whatever point a sample may be taken.

The slag from the meltings should be saved and when sufficient has been accumulated should be ground fine in the mill or other grinding machine, concentrated and remelted. The concentrates will have to have a special flux while the tailings can be either treated at the plant or shipped to the smelter. After grinding the slag, a large portion of metal shot and pieces from the crucibles will be found in the mortar of the mill in which the grinding has been done. This should be carefully fluxed and melted also. The crucibles in which the melting has been done should be saved and ground up with the slag after they have worn out. Experience has shown that the crucibles are likely to have buttons of metal all through them. The only way to fully recover this material is to grind the crucibles and concentrate and melt the material with the slag.

Data

ALTHOUGH the standard works on chemistry and assaying include many methods for assaying cyanide solutions, it is well to have at hand a method which is reliable and which may be referred to at any time. The following procedure is reliable and seems to be prompt and simple. It was published in the Mining and Scientific Press, June 8, 1907, and is an adaptation of the method of Alfred Chiddey.

Take 292 cc. (10 assay tons) of solution to be assayed in a large beaker; add 5 grams zinc shavings and 40 cc. of a 20 % solution of ordinary commercial lead acetate. Bring to a boil and place in a fume closet or an open window and add 400 cc. commercial HCl. When action nearly ceases, boil again. Pour off the waste solution and squeeze the wad of spongy lead into a cube, place it between filter papers and squeeze it dry by standing on it. By folding the cubes of lead in pieces of lead foil the weight can be increased to about 10 grams each, giving better cupellation and preventing any pieces of lead from being detached from the main bulk, if any moisture happens to be left in the cubes. It has been found that solutions obtained in treating pan amalgamation tailings containing mercury sometimes cause the lead to become too brittle to wad together nicely in a cube, and this has been overcome by using less solution and more lead acetate.

In cases of accidental cyanide poisoning, a remedy has been devised and published in the Queensland Government Mining Journal. The remedy is as follows:

One ounce of 23 % solution of ferrous sulphate, 1 ounce of 5 % solution of caustic potash, 30 grains of powdered magnesium oxide. These ingredients are to be kept separately in sealed tubes which may be broken and the contents mixed at any time they may be needed. It is believed that this mixture will prove an effective antidote if administered at once, but a very few minutes' delay may prove fatal.

The specific gravity of a ground ore, whether sand, slime, or concentrate, may be determined with a fair degree of accuracy by the use of the following formula:

$$\text{Sp. Gr.} = \frac{W}{(W + A) - K}$$

where W is the weight of pulp taken.

A is the weight of the bottle filled with distilled water.

K is the weight of the bottle and pulp with water filled to graduation.

This is performed with a standard graduated flask or bottle of any convenient capacity. The bottle is weighed first with water filled up to the mark of its graduated capacity. The sample of weighed pulp is filled into this bottle when empty, the bottle filled up to the graduation mark with distilled water and the whole weighed again, thus giving the date required in the formula.

New concrete may be made to take a coat of oil paint by first treating it with a 20 % solution of ammonium carbonate, applied with a brush or sprayed. The resulting carbonate of lime formed will dry hard in a short time, and not being hygroscopic, paint may be safely applied to the surface. This information is of use in preparing concrete foundations or floors where it may be considered advisable to apply a coat of paint.

Centrifugal force may be calculated as follows: Multiply the square of the number of revolutions per minute by the diameter of the circle in feet and divide the product by 5217. This is the centrifugal force when the weight of the body is 1. This figure multiplied by the weight of the body is the centrifugal force required.

The weight of 1 cubic foot of gas at any given temperature and pressure is found by first calculating the weight of one cubic foot of dry air at the same temperature and pressure, and then multiplying this weight by the specific gravity of the gas referred to air as a standard.

For calculating the weight of one cubic foot of air at any pressure and temperature,

let W equal the weight required
B " " barometric pressure in inches
t " " temperature in degrees Fahrenheit.

Then:

$$W = \frac{1.3253 \times B}{495\, t}$$

Table, page 52, shows the specific gravity of some gases referred to air as a standard.

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston being the speed), divide the number of gallons by 4, extract the square root, and the result will be the diameter of the pump cylinder in inches.

For calculating the data referring to driving pulleys: To find the speed when the diameter of the driven is given, multiply the diamter of the driver by its revolution per minute and divide the product by the diameter of the driven.

The diameter and revolutions of the driver being given, to find the diameter of the driven to make a given number of revolutions, multiply the diameter of the driver by its revolutions and divide the product by the number of revolutions which the driven is to run.

To ascertain the size of the driver, multiply the diameter of the driven by its number of revolutions and divide the product by the revolutions of the driver. The result is the diameter of the driver.

Fluxes for soldering or welding:

Iron or Steel	Borax or Sal Ammoniac
Tinned Iron	Resin or Chloride of Zinc
Copper and Brass	Sal Ammoniac or Chloride of Zinc
Zinc	Chloride of Zinc
Lead	Tallow or resin
Lead and Tin Pipes	Resin and Sweet Oil

Nitric acid will produce a black spot on steel; the darker the spot the harder the steel. Iron, on the contrary, remains bright under the acid treatment.

To ascertain the horse-power necessary to drive elevators, multiply the number of pounds lifted per minute by the hight of the elevator and divide the product by 33,000. The result will give the theoretical horse-power necessary, to which should be added 50 per cent. for friction losses.

A foot-pound is the work performed in lifting one pound one foot high in one minute.

A horse-power equals 33,000 foot pounds, or the work performed in raising 33,000 lbs. one foot in one minute, or in raising 1 lb. 33,000 feet per minute.

To find the weight of rail required for one mile of track, divide the weight of the rail per yard by 7 and multiply by 11. Thus for 56 lb. rail, $\frac{56}{7} = 8$, $8 \times 11 = 88$ tons for one mile of single track.

Assay ton is the name given to a weight of 29.166 grams, which is $\frac{1}{1000}$ of the number of Troy ounces in one ton of 2000 lbs. If a sample of 1 assay ton is taken for assay and the resultant bead weighed in milligrams, each milligram represents 1 ounce per ton. Should it be required to weigh the pulp in grams, the following principle will be found useful. 29,166 Troy ounces equal one ton. The value of one ounce pure gold is $20.67. Therefore one ton gold has a value of $602,861. If 100 grams are taken for assay and the bead weighed in milligrams, from the proportion

$$1 \text{ mg.} : 100{,}000 \text{ mg.} :: X : \$602{,}861$$

then, X or 1 mg. equals $6.00 per ton.

FORMULAS IN MENSURATION

To find the area of a parallelogram, multiply the length of one side by the perpendicular distance from that side to the one opposite.

To find the diagonal of a square, multiply the length of one side by 1.41421.

To find a square equal to a given circle, multiply the diameter of the circle by .886227. Result is side of required square.

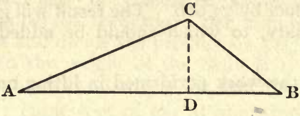
To find the area of a triange, multiply its base by one-half the altitude.

To find the altitude of an equilatrial triangle, multiply length of one side by .866025.

To find area of a triangle, given two sides and included angle. Multiply the two sides together, multiply product by the natural sine of included angle, and divide product by 2.

To find the area of an triangle, given three sides. Add the three sides together, divide the sum by 2. From this half sum subtract each side separately. Multiply the half sum and the three remainders continuously together. Extract the square root of the product.

To find the three angles of a triangle, given its three sides.



Divide the triangle into two right triangles by erecting a perpendicular from its base to the upper angle.

Find length of sides AD and DB by proportion.
$AB : AC + CB :: AC - CB : AD - DB$
thus obtaining the value of $AD - DB$

But $AD + DB$ is known as one side, so that the value of both AD and DB are found.

$$AD = \frac{(AD - DB) + (AD + DB)}{2}$$

and $$DB = AB - AD$$

Then $$\cos A = \frac{AD}{AC} \text{ and } \cos B = \frac{DB}{CB}$$

and angle $C = 180° - (\text{angle } A + \text{angle } B)$.

To find the third side and two angles, given two sides and the included angle. Divide into two right triangles. Find the altitude CD where A is given by formula $\text{Sin } A = \frac{CD}{AC}$, or similarly for B if given. Then find the third side by formula

$$\overline{AC}^2 = \overline{CD}^2 + \overline{AD}^2$$

Then find remaining angles as in preceding formula.

To find two sides, given one side and two adjacent angles. The third angle equals 180° — sum of two given angles. The third angle is opposite the given side. Then
Sin angle opposite given side : given side :: sine of either other given angle : its opposite side.

To find area of a trapezoid, multiply the perpendicular height by half the sum of the two parallel sides.

To find the area of a trapezium. Divide the figure into two triangles. Find the area of each according to formula already given, and add the two areas together.

To find the area of a polygon whose sides are given. Divide into a number of triangles equal to the number of sides by connecting each angle to the centre. Find the area of each triangle and add them together.

To find circumference of a circle, multiply the diameter by 3.1416.

To find the area of a circle, multiply the square of the diameter by .7854. Or multiply the square of the circumference by .07958.

To find the surface of a cube, multiply the area of one side by 6.

To find the surface of a parallelopiped, add together twice the area of the base, twice the area of the side, and twice the area of the end.

To find the cubic contents of a cube or parallelopiped, multiply the area of the base by the perpendicular hight.

To find the contents of a prism, multiply the area of the base by the altitude.

To find the surface of a cylinder, multiply the circumference of the base by the altitude.

To find the contents of a cylinder, multiply the area of the base by the altitude.

To find the surface of a pyramid, multiply the perimeter of the base by half the slant hight and add the area of the base.

To find the contents of a pyramid, multiply the area of the base by one third the altitude.

The last two formulas apply equally to the cone. In this case the perimeter of the base is the same as the circumference of the base.

To find the convex surface of a frustum of a pyramid or cone, multiply half the sum of the perimeters or circumferences of the two bases by the slant hight. To find the entire surface add to this the area of the two bases.

To find the contents of a frustum, add together the sum of the area of the two bases, and the square root of their product, and multiply this result by one third the altitude of the frustum.

Comparison of Value of Silver in Ounces Troy and Kilograms

When Silver is Worth in New York Per Oz.	1 Kilo. is Worth U. S. Currency	When Silver is Worth in New York Per Oz.	1 Kilo. is Worth U. S. Currency	When Silver is Worth in New York Per Oz.	1 Kilo. is Worth U. S. Currency
50 cts.	$16.0750	55 3/4 cts.	$17.9237	61 3/8 cts.	$19.7321
50 1/8	16.1152	55 7/8	17.9639	61 1/2	19.7723
50 1/4	16.1554	56	18.0040	61 5/8	19.8125
50 3/8	16.1956	56 1/8	18.0442	61 3/4	19.8527
50 1/2	16.2358	56 1/4	18.0844	61 7/8	19.8929
50 5/8	16.2760	56 3/8	18.1246	62	19.9330
50 3/4	16.3162	56 1/2	18.1648	62 1/8	19.9732
50 7/8	16.3564	56 5/8	18.2050	62 1/4	20.134
51	16.3965	56 3/4	18.2452	62 3/8	20.0536
51 1/8	16.4367	56 7/8	18.2854	62 1/2	20.0938
51 1/4	16.4769	57	18.3255	62 5/8	20.1340
51 3/8	16.5171	57 1/8	18.3657	62 3/4	20.1742
51 1/2	16.5573	57 1/4	18.4059	62 7/8	20.2144
51 5/8	16.5975	57 3/8	18.4461	63	20.2545
51 3/4	16.6377	57 1/2	18.4863	63 1/8	20.2947
51 7/8	16.6779	57 5/8	18.5265	63 1/4	20.3349
52	16.7180	57 3/4	18.5667	63 3/8	20.3751
52 1/8	16.7582	57 7/8	18.6069	63 1/2	20.4153
52 1/4	16.7984	58	18.6470	63 5/8	20.4455
52 3/8	16.8386	58 1/8	18.6872	63 3/4	20.4957
52 1/2	16.8788	58 1/4	18.7274	63 7/8	20.5359
52 5/8	16.9190	58 3/8	18.7676	64	20.5760
52 3/4	16.9592	58 1/2	18.8078	64 1/8	20.6162
52 7/8	16.9994	58 5/8	18.8480	64 1/4	20.6564
53	17.0395	58 3/4	18.8882	64 3/8	20.6966
53 1/8	17.0797	58 7/8	18.9284	64 1/2	20.7368
53 1/4	17.1199	59	18.9685	64 5/8	20.7770
53 3/8	17.1601	59 1/8	19.0087	64 3/4	20.8172
53 1/2	17.2003	59 1/4	19.0489	64 7/8	20.8574
53 5/8	17.2405	59 3/8	19.0891	65	20.8975
53 3/4	17.2807	59 1/2	19.1293	65 1/8	20.9377
53 7/8	17.3209	59 5/8	19.1695	65 1/4	20.9779
54	17.3610	59 3/4	19.2097	65 3/8	21.0181
54 1/8	17.4012	59 7/8	19.2499	65 1/2	21.0583
54 1/4	17.4414	60	19.2900	65 5/8	21.0985
54 3/8	17.4816	60 1/8	19.3302	65 3/4	21.1387
54 1/2	17.5218	60 1/4	19.3704	65 7/8	21.1789
54 5/8	17.5620	60 3/8	19.4106	66	21.2190
54 3/4	17.6022	60 1/2	19.4508	66 1/8	21.2592
54 7/8	17.6424	60 5/8	19.4910	66 1/4	21.2994
55	17.6825	60 3/4	19.5312	66 3/8	21.3396
55 1/8	17.7227	60 7/8	19.5714	66 1/2	21.3798
55 1/4	17.7629	61	19.6115	66 5/8	21.4200
55 3/8	17.8031	61 1/8	19.6517	66 3/4	21.4602
55 1/2	17.8433	61 1/4	19.6919	66 7/8	21.5004
55 5/8	17.8835				

Comparison of Value of Silver in Ounces Troy and Kilograms

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67 cts.	$21.5405	72¾ cts.	$23.3892	82 cts.	$26.364
67⅛	21.5807	72⅞	23.4294	82¼	26.444
67¼	21.6209	73	23.4695	82½	26.524
67⅜	21.6611	73⅛	23.3097	82¾	26.605
67½	21.7013	73¼	23.5499	83	26.685
67⅝	21.7415	73⅜	23.5901	83¼	26.765
67¾	21.7817	73½	23.6303	83½	26.846
67⅞	21.8219	73⅝	23.6705	83¾	26.926
68	21.8620	73¾	23.7107	84	27.007
67⅛	21.9022	73⅞	23.7509	84¼	27.087
67¼	21.9424	74	23.7910	84½	27.167
68⅜	21.9826	74⅛	23.8315	84¾	27.248
68½	22.0223	74¼	23.8720	85	27.328
68⅝	22.0630	74⅜	23.9120	85¼	27.408
68¾	22.1032	74½	23.9520	85½	27.489
68⅞	22.1434	74⅝	23.9925	85¾	27.569
69	22.1835	74¾	24.0330	86	27.650
69⅛	22.2237	74⅞	24.0730	86¼	27.730
69¼	22.2639	75	24.1130	86½	27.810
69⅜	22.3041	75¼	24.1930	86¾	27.891
69½	22.3443	75½	24.2740	87	27.971
69⅝	22.3845	75¾	24.3540	87¼	28.052
69¾	22.4247	76	24.4350	87½	28.132
69⅞	22.4649	76¼	24.515	87¾	28.212
70	22.5050	76½	24.595	88	28.293
70⅛	22.5452	76¾	24.676	88¼	28.373
70¼	22.5854	77	24.756	88½	28.453
70⅜	22.6256	77¼	24.836	88¾	28.533
70½	22.6658	77½	24.917	89	28.614
70⅝	22.7060	77¾	24.997	89½	28.695
70¾	22.7462	78	25.078	89½	28.775
70⅞	22.7864	78¼	25.158	89¾	28.855
71	22.8265	78½	25.238	90	28.936
71⅛	22.8667	78¾	25.319	90¼	29.016
71¼	22.9069	79	25.399	90½	29.096
71⅜	22.9471	79¼	25.479	90¾	29.177
71½	22.9873	79½	25.560	91	29.257
71⅝	23.0275	79¾	25.640	91½	29.338
71¾	23.0677	80	25.721	91½	29.418
71⅞	23.1079	80¼	25.801	91¾	29.498
72	23.1480	80½	25.881	92	29.579
72⅛	23.1882	80¾	25.962	92¼	29.659
72¼	23.2248	81	26.042	92½	29.739
72⅜	23.2686	81¼	26.122	92¾	29.820
72½	23.3088	81½	26.203		
72⅝	23.3490	81¾	26.283		

Comparison of Value of Silver in Ounces Troy and Kilograms

When Silver is Worth in New York Per Oz.	1 Kilo. is Worth U. S. Currency	When Silver is Worth in New York Per Oz.	1 Kilo. is Worth U. S. Currency	When Silver is Worth in New York Per Oz.	1 Kilo. is Worth U. S. Currency
93 cts.	$29.900	95½ cts.	$30.704	98	31.508
93¼	29.981	95¾	30.784	98¼	31.588
93½	30.061	96	30.865	98½	31.668
93¾	30.141	96¼	30.945	98¾	31.749
94	30.222	96½	31.025	99	31.829
94¼	30.302	96¾	31.106	99¼	31.910
94½	30.382	97	31.186	99½	31.990
94¾	30.463	97¼	31.267	99¾	32.070
95	30.543	97½	31.347	100	32.151
95¼	30.624	97¾	31.427	—	—

Area

1 square millimeter	=	.001550 sq. in.
1 square centimeter	=	.155003 sq. in.
1 square decimeter	=	15.503 sq. in.
1 square meter or centare	=	10.764101 sq. ft.
1 square decameter	=	.024711 acre.
1 hectare	=	2.47110 acres.
1 square kilometer	=	247.110 acres.
1 square myriameter	=	38.61090 sq. miles.

Volume

1 cubic centimeter	=	.0610254 cu. in.
1 centiliter	=	.610254 cu. in.
1 deciliter	=	6.10254 cu. in.
1 liter	=	61.0254 cu. in.
1 decaliter	=	.353156 cu. ft.
1 hectoliter	=	3.53156 cu. ft.
1 kiloliter	=	35.3156 cu. ft.
1 myrialiter	=	353.156 cu. ft.

Abbreviations used in Metric System

milligram	= mg.	cubic centimeter	= cc.	*millimeter	= mm.
centigram	= cg.	centiliter	= cl.	*centimeter	= cm.
decigram	= dg.	deciliter	= dl.	*decimeter	= dm.
gram	= g.	liter	= l.	*meter	= m.
decagram	= Dg.	decaliter	= Dl.	*decameter	= Dm.
hectogram	= Hg.	hectoliter	= Hl.	*hectometer	= Hm.
kilogram	= Kg.	cubic meter	= cm.	*kilometer	= Km.
myriagram	= Mg.	myrialiter	= Me.	*myriameter	= mm.
Quintal	= Q.				

* In measures of area, these abbreviations take the prefix "sq."

WEIGHTS AND MEASURES USUAL IN THE UNITED STATES

Troy Weight

24 grains	=	1 pennyweight (dwt.)
20 pennyweights	=	1 ounce (oz.)
12 ounces	=	1 pound (lb.)

Apothecaries Weight

20 grains	=	1 scruple.
3 scruples	=	1 dram.
8 drams	=	1 ounce.
12 ounces	=	1 pound.

Avoirdupois Weight

27.34375 grains	=	1 dram.
16 drams	=	1 ounce (oz.)
16 ounces	=	1 pound (lb.)
28 pounds	=	1 quarter
4 quarters	=	1 hundredweight (cwt.)
20 hundredweight	=	1 ton.
1 stone	=	14 pounds.
1 quintal	=	100 pounds
1 short ton	=	2000 pounds.
1 long ton	=	2240 pounds.

In Troy, Apothecaries and Avoirdupois weight, the grains are the same.

Length

12 inches	=	1 foot.
3 feet	=	1 yard.
6 feet	=	1 fathom.
66 feet	=	1 chain.
10 chains	=	1 furlong.
8 furlongs	=	1 mile = 5,280 feet.

Area

144 square inches	=	1 square foot.
9 square feet	=	1 square yard.
30¼ square yards	=	1 perch.
40 perches	=	1 rood.
4 roods	=	1 acre.
640 acres	=	1 square mile.

Volume

1728 cubic inches	=	1 cubic foot.
27 cubic feet	=	1 cubic yard.
1 cord of wood	=	128 cubic feet or 8×4×4 feet.

Liquid

4 gills	=	1 pint.
2 pints	=	1 quart.
4 quarts	=	1 gallon.
31½ gallons	=	1 barrel.
63 gallons	=	1 hogshead.
2 hogsheads	=	1 pipe.
2 pipes	=	1 tun.

Dry

2 pints	=	1 quart.
4 quarts	=	1 gallon.
2 gallons	=	1 peck.
4 pecks	=	1 bushel.

Table of Equivalents

1 Marco	=	7.39864 troy ounces.
1 Troy ounce	=	31.10348 grams.
1 Troy ounce	=	430.00000 grains troy.
1 Avoirdupois ounce	=	28.3495 grams.
1000 Kilograms	=	2204.62 pounds avoirdupois.
1 ton avoirdupois	=	907.1849 kilograms.
1 pound avoirdupois	=	453.59242 grams.
1 ton avoirdupois	=	29166.67 Troy ounces.
1 Gram	=	15.43236 grains Troy.

Conversion Table

TO CONVERT	INTO	MULTIPLY BY
Oz. troy per av. ton	Kilos per metric ton	0.034286
Oz. troy	Oz. avoirdupois	1.09714
Oz. troy	Kilograms	0.03110348
Oz. avoirdupois	Oz. troy	0.911457
Lbs. avoirdupois	Kilograms	0.45359243
Metric tons	Av. tons 2000 lbs.	1.10231
Kilos per metric ton	Oz. troy per av. ton	29.166
Kilograms	Lbs. av.	2.20462.
Kilograms	Troy oz.	32.15074
Grams	Troy oz.	0.032150
Tons avoirdupois	Tons metric	.9071849
Tons metric	Tons avoirdupois	1.01231
Millimeters	Inches	0.03937
Centimeters	Inches	0.3937
Meters	Inches	39.37
Meters	Feet	3.281
Meters	Yards	1.094
Kilometers	Miles	.621
Kilometers	Feet	3280.7
Square millimeters	Sq. inches	0.0155
Square centimeters	Sq. inches	0.155
Square meters	Sq. feet	10.764
Square kilometers	Acres	247.1
Hectara	Acres	2.471
Cubic centimeters	Cubic inches	16.383
Cubic centimeters	Fluid drams	3.69
Cubic centimeters	Fluid ounces	29.57
Cubic meters	Cubic feet	35.315
Cubic meters	Cubic yards	1.308
Cubic meters	Gallons	264.2
Liters	Cubic inches	61.022
Liters	Gallons	.2642
Liters	Fluid ounces	33.84

INTERNATIONAL ATOMIC WEIGHTS, 1910

	Symbol	Atomic Weight		Symbol	Atomic Weight
Aluminum	Al	27.1	Molybdenum	Mo	96.0
Antimony	Sb	120.2	Neodymium	Nd	144.3
Argon	A	39.9	Neon	Ne	20.0
Arsenic	As	74.96	Nickel	Ni	58.68
Barium	Ba	137.37	Nitrogen	N	14.01
Bismuth	Bi	208.0	Osmium	Os	190.9
Boron	B	11.0	Oxygen	O	16.00
Bromine	Br	79.92	Palladium	Pd.	106.7
Cadmium	Cd	112.40	Phosphorus	P	31.0
Caesium	Cs	132.81	Platinum	Pt	195.0
Calcium	Ca	40.09	Potassium	K	39.10
Carbon	C	12.00	Praseodymium	Pr	140.6
Cerium	Ce	140.25	Radium	Ra	226.4
Chlorine	Cl	35.46	Rhodium	Rh	102.9
Chromium	Cr	52.0	Rubidium	Rb	85.45
Cobalt	Co	58.97	Ruthenium	Ru	101.7
Columbium	Cb	93.5	Samarium	Sa	150.4
Copper	Cu	63.57	Scandium	Sc	44.1
Dysprosium	Dy	162.5	Selenium	Se	79.2
Erbium	Er	167.4	Silicon	Si	28.3
Europium	Eu	152.0	Silver	Ag	107.88
Fluorine	F	19.0	Sodium	Na	23.00
Gadolinium	Gd	157.3	Strontium	Sr	87.62
Gallium	Ga	69.9	Sulphur	S	32.07
Germanium	Ge	72.5	Tantalum	Ta	181.0
Glucinum	Gl	9.1	Tellurium	Te	127.5
Gold	Au	197.2	Terbium	Tb	159.2
Helium	He	4.0	Thallium	Tl	204.0
Hydrogen	H	1.008	Thorium	Th	232.42
Indium	In	114.8	Thulium	Tm	168.5
Iodine	I	126.92	Tin	Sn	119.0
Iridium	Ir	193.1	Titanium	Ti	48.1
Iron	Fe	55.85	Tungsten	W	184.0
Krypton	Kr	83.0	Uranium	U	238.5
Lanthanum	La	139.0	Vanadium	V	51.2
Lead	Pb	207.10	Xenon	Xe	130.7
Lithium	Li	7.00	Ytterbium (Neoytterbium)	Yb	172.0
Lutecium	Lu	174.0	Yttrium	Yt	89.0
Magnesium	Mg	24.32	Zinc	Zn	65.37
Manganese	Mn	54.93	Zirconium	Zr	90.6
Mercury	Hg	200.0			

* A new element has been reported discovered at the University of Tokio. It has been called nipporium, symbol Np, atomic weight 100. It exists in the rare mineral thorite, in which it occurs as a yellow or red crystal hard enough to cut glass These crystals are a double silicate of nipporium and zirconium.

Specific Gravity of Some Gases

using air as standard

Name of Gas	Symbol	Sp. Gr.
Air	—	1.0000
Carbonic acid	CO^2	1.529
Sulphureted hydrogen	H S	1.9912
Olefiant	C^2H^4	.978
Carbonic oxide	CO	.967
Steam	H^2O	.6235
Marsh gas	CH^4	.559
Oxygen	O	1.1056
Nitrogen	N	.9713
Hydrogen	H	.06926

Capacity of Round Tanks

Diameter in Feet Inside	Contents in Cubic Feet For Each Foot Depth	Capacity in Lbs. Water For Each Foot in Depth
5	19.635	1,227.18
6	28.274	1767.12
7	38.485	2495.31
8	50.266	3141.62
9	63.617	3976.06
10	78.540	4908.75
12	113.100	7068.75
15	176.710	11,044.37
18	254.470	15,904.37
20	314.160	19,635.00
22	380.130	23,758.12
25	490.870	30,679.37
26	530.930	33,232.12
28	615.750	38,484.37
30	706.860	44,178.75
32	804.250	50,265.62
34	907.920	57,045.00
35	962.110	60,131.87
36	1017.880	63,587.50
38	1134.110	70,881.87
40	1256.640	78,540.00
42	1385.440	86,590.00
44	1520.530	95,033.12
45	1590.430	99,401.87
46	1661.900	103,868.75
48	1809.560	113,097.50
50	1963.500	122,718.75

ELECTRO-MOTIVE SERIES OF METALS AND MINERALS IN KCN SOLUTIONS

PROF. S. B. CHRISTY, TRANS. AM. INST. MIN. ENG. SEPT., 1899

	$\frac{M}{1}$ KCN = 6.5% Volts	$\frac{M}{10}$ KCN = 0.65% Volts	$\frac{M}{100}$ KCN = 0.065% Volts	$\frac{M}{1000}$ KCN = 0.0065% Volts
Aluminum........	+ 0.99	+ 0.90	+ 0.76	+ 0.40
Zinc, amalgamated	+ 0.93	+ 0.82	+ 0.70	+ 0.44
Zinc, commercial	Not determined	+ 0.77	+ 0.59	+ 0.39
Copper	+ 0.81	+ 0.62	+ 0.37	+ 0.16
Cadmium	+ 0.61	+ 0.57	+ 0.35	—
Cadmium amalgamated	+ 0.55	+ 0.31	+ 0.19	—
Tin	+ 0.45	+ 0.24	+ 0.17	+ 0.06
Bornite	+ 0.45	+ 0.25	− 0.16	—
Copper, amalgamated	+ 0.39 (?)	+ 0.41	− 0.14 (?)	− 0.12 (?)
Gold............	+ 0.37	+ 0.23	+ 0.09	− 0.38
Silver	+ 0.33	+ 0.15	− 0.05	− 0.36
Copper glance ...	+ 0.29 (?)	+ 0.25	+ 0.05	− 0.44
Lead............	+ 0.13	+ 0.05	+ 0.01	—
Tin, amalgamated	Not determined	+ 0.01	− 0.07	− 0.12
Lead, amalgamated	Not determined	—	− 0.03	—
Quicksilver	− 0.09	+ 0.01	− 0.11	—
Gold, amalgamated	—	—	− 0.13	− 0.26
Antimony	+ 0.06	+ 0.03	− 0.03	—
Arsenic	+ 0.04	− 0.05	− 0.21	—
Bismuth	+0.00	− 0.06	− 0.20	—
Niccolite	− 0.11	− 0.17	− 0.44	—
Iron	− 0.17	− 0.24	− 0.24	—
Chalcopyrite	− 0.20	− 0.34	− 0.44	—
Pyrite	− 0.28	− 0.42	− 0.48	—
Galena	− 0.28	− 0.48	− 0.52	—
Argentite........	− 0.28	− 0.56	− 0.55 (?)	—
Bethierite	− 0.30	− 0.52	− 0.52	—
Speisscobalt.....	− 0.30	− 0.33	− 0.50	—
Magnetopyrite ...	− 0.30	− 0.40	− 0.54	—
Fahlore	− 0.36	− 0.52	− 0.52	—
Arsenopyrite.....	− 0.40	− 0.45	− 0.54	—
Platinum	− 0.40	− 0.46	− 0.50	—
Cuprite	− 0.43	− 0.55	− 0.57	—
Electric light carbon...........	− 0.46	− 0.52 (?)	− 0.57	—
Blende	− 0.48	− 0.52	− 0.55	—
Boulangerite	− 0.50	− 0.55	0.55	—
Bournonite	− 0.50	− 0.55	− 0.56	—
Coke	− 0.52	− 0.52	− 0.42 (?)	—
Ruby Silver ore ..	− 0.54	− 0.53 (?)	− 0.54	—
Stephanite	− 0.54	− 0.55	− 0.52	—
Stibnite	− 0.56	− 0.56	− 0.56	—

Properties of Metals

Metal	Melting Point	Wt. per Cu. In.	Wt. per Cu. Ft.	Tensile Strength	Specific Gravity	Chemical Symbol
Aluminum	1157	.0924	159.63	20,000	2.56	Al.
Antimony	1130	.2424	418.86		6.71	Sb.
Bismuth	505	.354	611.76		9.83	Bi.
Brass, cast	1692	.3029	523.2	24,000	8.393	
Bronze	1692	.319	550.	36,000	8.83	
Chromium	3500	.2457	429.49		6.8	Cr.
Cobalt	2732	.307	530.6		8.5	Co.
Copper	1929	.322	556.	36,000	8.9	Cu.
Gold	1965	.6979	1206.05	20,000	19.32	Au.
Iridium	3992	.8099	1400.		22.42	Ir.
Iron, cast	2700	.26	450.	16,500	7.21	Fe.
Iron, wrought	2920	.278	480.13	50,000	7.7	Fe.
Lead	618	.41	710.	3,000	11.37	Pb.
Manganese	3452	.289	499.4		8.	Mn.
Mercury	— 39	.4909	848.35		13.59	Hg.
Nickel	2700	.3179	549.34		8.8	Ni.
Platinum	3227	.7769	1342.13		21.5	Pt.
Silver	1733	.3805	657.33	40,000	10.53	Ag.
Steel — cast	2450	.28	481.2	50,000	7.81	
Steel — rolled	2600	.2833	489.6	65,000	7.854	
Tin	445	.2634	455.08	4,600	7.29	Sn.
Tungsten	3600	.69	1192.31		19.10	W.
Vanadium	3230	.1987	343.34		5.50	V.
Zinc	779	.245	430.	7,500	6.86	Zn.

Approximate Weight of Castings from Patterns

A Pattern Weighing One Pound Made of	Cast Iron Lbs.	Zinc Lbs.	Copper Lbs.	Yellow Brass Lbs.	Gun Metal Lbs.
Mahogany — Nassau	10.7	10.4	12.8	12.2	12.5
Pine — Red	12.5	12.1	14.9	14.2	14.6
Pine — White	16.7	16.1	19.8	19.0	19.5
Pine — Yellow	14.1	13.6	16.7	16.0	16.5
Oak	9.0	8.6	10.4	10.1	10.9

Tables of KCN Solutions

1 lb. KCN to 1 ton water	....	0.05 per cent.
2 " " " 1 " "	....	0.10 " "
3 " " " 1 " "	....	0.15 " "
4 " " " 1 " "	....	0.20 " "
5 " " " 1 " "	....	0.25 " "
6 " " " 1 " "	....	0.30 " "
7 " " " 1 " "	....	0.35 " "
8 " " " 1 " "	....	0.40 " "
9 " " " 1 " "	....	0.45 " "
10 " " " 1 " "	....	0.50 " "

.5 gram KCN to 1000 cc. water	....	0.05 per cent.
1.0 " " " 1000 " "	....	0.10 " "
1.5 " " " 1000 " "	....	0.15 " "
2.0 " " " 1000 " "	....	0.20 " "
2.5 " " " 1000 " "	....	0.25 " "
3.0 " " " 1000 " "	....	0.30 " "
3.5 " " " 1000 " "	....	0.35 " "
4.0 " " " 1000 " "	....	0.40 " "
4.5 " " " 1000 " "	....	0.45 " "
5.0 " " " 1000 " "	....	0.50 " "

1 gram is to 1000 cc. as kilo is to 1 metric ton. Therefore replacing kilos for grams in above table will give same percentage in 1 metric ton of water.

Rate of Solution of Gold in Slime Pulp of Different Specific Gravity

The following table was worked out by Julian and Smart and published in their work, Cyaniding Gold and Silver ores, from which this was taken.

Ratio of Solution to 1 of Slime by Weight	Rate of Dissolution of Gold
KCN alone	100.
6	58.6
5	56.
4	52.4
3	47.3
2.5	44.3
2.	40.
1.5	34.2
1	20.

Table of Some Common Minerals

Name	Symbol	% Content	Hardness	Average Specific Gravity
Water	H_2O	—	—	1.00
Gold.	Au	—	$2\frac{3}{4}$	19.30
Silver	Ag	—	$2\frac{3}{4}$	10.50
Copper	Cu	—	$2\frac{3}{4}$	8.84
Lead	Pb	—	$1\frac{1}{2}$	11.44
Antimonite	Sb_2S_3	Sb–71.76	$2\frac{1}{2}$	4.57
Valentinite	Sb_2O_3	Sb–83.56	$2\frac{1}{2}$	5.57
Orpiment	AsS_3	As–60.98	$1\frac{3}{4}$	3.45
Realgar	AsS_2	As–70.09	2.0	3.50
Arsenopyrite.	FeSAs	As–46.00	$5\frac{1}{2}$	6.20
Dolomite	$CaMg(CO_3)_2$	CaO–30.43	$3\frac{3}{4}$	2.85
Calcite	$CaCo_3$	CaO–56.00	3	2.65
Gypsum	$CaSO_4$, $2H_2O$	CaO–32.60	2	2.33
Cuprite	Cu_2O	Cu–88.80	$3\frac{3}{4}$	6.00
Chalcocite	Cu_2S	Cu–79.86	$2\frac{3}{4}$	5.65
Tetrahedrite	$Cu_8S_7Sb_2$	Cu–52.08	4.0	4.80
Chalcopyrite.	$CuFeS_2$	Cu–34.59	4.0	4.20
Bornite	Cu_3FeS_3	Cu–55.58	3.0	5.00
Chalcanthite. . . .	$CuSO_4$, $5H_2O$	Cu–25.43	$3\frac{1}{2}$	2.21
Chrysacol	$CuSiO_3$, $2H_2O$	Cu–34.2	$3\frac{1}{2}$	2.20
Malachite	Cu_2CO_4, H_2O	Cu–57.45	$3\frac{1}{2}$	3.85
Azurite	$3Cu_3C_2O_7$, H_2O_7	Cu–55.28	4	3.67
Limonite	$2Fe_2O_3$, $3H_2O$	Fe–48.23	$5\frac{1}{2}$	3.80
Hematite.	$3Fe_2O_3$, H_2O	Fe–67.47	6	4.90
Specularite	Fe_2O_3	Fe–70.	$6\frac{1}{2}$	4.5
Magnetite	Fe_3O_4	Fe–72.41	$5\frac{1}{2}$	5.05
Pyrite	FeS_2	Fe–46.66	6	5.00
Pyrolasite	MnO_2	Mn–63.27	2	4.80
Psilomelane	$BaMn_4O_9$, H_2O	Mn–42.3	$6\frac{1}{2}$	4.20
Psilomelane	$K_2Mn_4O_9$, H_2O	Mn–52.4	$6\frac{1}{2}$	4.20
Cinabarite.	HgS	Hg–86.2	$2\frac{1}{2}$	8.75
Galenite	PbS	Pb–86.62	$2\frac{3}{4}$	7.50
Cerusite	$PbCO_3$	Pb–77.53	$3\frac{1}{4}$	6.00
Anglesite	$PbSO_4$	Pb–68.32	3	6.25
Cerargyrite	AgCl	Ag–75.28	$1\frac{1}{2}$	4.00
Argentite.	Ag_2S	Ag–87.09	$2\frac{1}{2}$	7.30
Pyrargyrite	Ag_3SbS_3	Ag–59.8	$2\frac{1}{2}$	5.80
Stephanite	Ag_5SbS_4	Ag–68.5	$2\frac{1}{2}$	6.27
Cassiterite.	SnO_2	Sn–78.66	$6\frac{1}{2}$	6.75
Blend	ZnS	Zn–67.02	4	4.10
Fluorspar	CaF_2	Ca–51.3	4	3.18
Quartz	SiO_2	—	7	2.65
Barite	$BaSO_4$	BaO–65.7	3	4.51

Decimal Equivalents of Fractions of an Inch. (Advancing by 8ths, 16ths, 32nds and 64ths.)

8ths	32nds	64ths	64ths
1/8 = .125	1/32 = .03125	1/64 = .015625	33/64 = .515625
1/4 = .250	3/32 = .09375	3/64 = .046875	35/64 = .546875
3/8 = .375	5/32 = .15625	5/64 = .078125	37/64 = .578125
1/2 = .500	7/32 = .21875	7/64 = .109375	39/64 = .609375
5/8 = .625	9/32 = .28125	9/64 = .140625	41/64 = .640625
3/4 = .750	11/32 = .34375	11/64 = .171875	43/64 = .671875
7/8 = .875	13/32 = .40625	13/64 = .203125	45/64 = .703125
	15/32 = .46875	15/64 = .234375	47/64 = .734375
16ths.			
1/16 = .0625	17/32 = .53125	17/64 = .265625	49/64 = .765625
3/16 = .1875	19/32 = .59375	19/64 = .296875	51/64 = .796875
5/16 = .3125	21/32 = .65625	21/64 = .328125	53/64 = .828125
7/16 = .4375	23/32 = .71875	23/64 = .359375	55/64 = .859375
9/16 = .5625	25/32 = .78125	25/64 = .390625	57/64 = .890625
11/16 = .6875	27/32 = .84375	27/64 = .421875	59/64 = .921875
13/16 = .8125	29/32 = .90625	29/64 = .453125	61/64 = .953125
15/16 = .9375	31/32 = .96875	31/64 = .484375	63/64 = .984375

Decimal Equivalents of Fractions of an Inch. (Advancing by 64ths.)

1/64 = .015625	17/64 = .265625	33/64 = .515625	49/64 = .765625
1/32 = .03125	9/32 = .28125	17/32 = .53125	25/32 = .78125
3/64 = .046875	19/64 = .296875	35/64 = .546875	51/64 = .796875
1/16 = .0625	5/16 = .3125	9/16 = .5625	13/16 = .8125
5/64 = .078125	21/64 = .328125	37/64 = .578125	53/64 = .828125
3/32 = .09375	11/32 = .34375	19/32 = .59375	27/32 = .84375
7/64 = .109375	23/64 = .359375	39/64 = .609375	55/64 = .859375
1/8 = .125	3/8 = .375	5/8 = .625	7/8 = .875
9/64 = .140625	25/64 = .390625	41/64 = .640625	57/64 = .890625
5/32 = .15625	13/32 = .40625	21/32 = .65625	29/32 = .90625
11/64 = .171875	27/64 = .421875	43/64 = .671875	59/64 = .921875
3/16 = .1875	7/16 = .4375	11/16 = .6875	15/16 = .9375
13/64 = .203125	29/64 = .453125	45/64 = .703125	61/64 = .953125
7/32 = .21875	15/32 = .46875	23/32 = .71875	31/32 = .96875
15/64 = .234375	31/64 = .484375	47/64 = .734375	63/64 = .984375
1/4 = .25	1/2 = .50	3/4 = .75	

Weights and Volumes of Slime Pulp

% Of Dry Slime in Pulp	Specific Gravity of Pulp	U. S. A. Units: Weight of One Cu. Foot of Pulp, Pounds	U. S. A. Units: Cu. Foot of Pulp to One Ton	U. S. A. Units: Cu. Foot of Pulp to One Ton of Dry Slime	Metric Units: Weight of One Cu. Ft. of Pulp, Kilos.	Metric Units: Dry Slime Per Cu. Foot of Pulp, Kilos	% Of Dry Slime in Pulp	Specific Gravity of Pulp	U. S. A. Units: Weight of One Cu. Foot of Pulp, Pounds	U. S. A. Units: Cu. Foot of Pulp to One Ton	U. S. A. Units: Cu. Foot of Pulp to One Ton of Dry Slime	Metric Units: Weight of One Cu. Ft. of Pulp, Kilos	Metric Units: Dry Slime Per Cu. Foot of Pulp, Kilos
0	1.000	62.5	32.00	0	28.3	.00	51	1.440	90.0	22.20	43.5	40.8	20.81
1	1.006	62.8	31.81	3181.0	28.5	.29	52	1.453	90.8	22.01	42.3	41.2	21.42
2	1.012	63.2	31.62	1581.0	28.6	.57	53	1.466	91.6	21.82	41.2	41.5	22.00
3	1.018	63.6	31.42	1047.3	28.8	.86	54	1.479	92.4	21.63	40.1	41.9	22.63
4	1.024	64.0	31.23	780.8	29.0	1.16	55	1.492	93.2	21.44	38.9	42.3	23.28
5	1.030	64.4	31.04	620.8	29.2	1.46	56	1.506	94.0	21.24	37.9	42.6	23.47
6	1.037	64.8	30.85	514.2	29.4	1.76	57	1.519	94.8	21.05	36.9	43.0	24.51
7	1.044	65.2	30.66	438.0	29.6	2.07	58	1.533	95.8	20.86	35.9	43.5	25.23
8	1.050	65.6	30.46	380.7	29.7	2.38	59	1.547	97.0	20.67	35.0	43.9	25.00
9	1.057	66.0	30.27	336.3	29.9	2.69	60	1.562	97.6	20.48	34.1	44.2	26.52
10	1.064	66.4	30.08	300.8	30.1	3.01	61	1.577	98.4	20.28	33.2	44.6	27.21
11	1.071	67.0	29.89	271.7	30.4	3.34	62	1.592	99.4	20.09	32.4	45.1	27.96
12	1.077	67.4	29.70	247.5	30.6	3.67	63	1.607	100.4	19.90	31.6	45.5	28.67
13	1.084	67.8	29.50	226.9	30.7	3.99	64	1.623	101.4	19.71	30.8	46.0	29.44
14	1.092	68.2	29.31	209.4	30.9	4.33	65	1.639	102.4	19.52	30.0	46.4	30.16
15	1.099	68.6	29.12	194.1	31.1	4.67	66	1.655	103.4	19.32	29.2	46.9	30.95
16	1.106	69.2	28.93	180.8	31.3	5.01	67	1.672	104.4	19.13	28.5	47.4	31.76
17	1.113	69.6	28.74	169.0	31.5	5.36	68	1.689	105.4	18.94	27.8	47.8	32.50
18	1.121	70.0	28.54	138.6	31.7	5.71	69	1.706	106.6	18.75	27.1	48.4	33.40
19	1.129	70.6	28.35	149.2	32.0	6.08	70	1.724	107.8	18.55	26.5	48.9	34.23
20	1.136	71.1	28.16	140.8	32.2	6.44	71	1.742	108.8	18.36	25.8	49.4	35.07
21	1.144	71.4	27.97	130.8	32.4	6.80	72	1.760	110.0	18.17	25.2	49.9	35.93
22	1.152	72.0	27.78	126.3	32.6	7.17	73	1.789	111.2	17.98	24.6	50.4	36.79

23	1.160	72.4	27.58	119.9	32.8	7.54	74	1.798	112.4	17.79	24.0	51.0	37.74
24	1.168	73.0	27.39	113.9	33.1	7.94	75	1.818	113.6	17.60	23.5	51.5	38.63
25	1.176	73.4	27.20	108.8	33.3	8.33	76	1.838	114.8	17.40	22.9	52.1	39.60
26	1.184	74.0	27.01	103.9	33.5	8.71	77	1.858	116.0	17.21	22.3	52.6	40.50
27	1.193	74.4	26.81	99.3	33.8	9.13	78	1.879	117.4	17.02	21.8	53.2	41.50
28	1.201	75.0	26.62	95.1	34.0	9.52	79	1.901	118.8	16.83	21.3	53.9	42.58
29	1.210	75.6	26.43	91.1	34.3	9.95	80	1.923	120.2	16.64	20.8	54.5	43.60
30	1.219	76.2	26.24	87.5	34.5	10.35	81	1.945	121.6	16.44	20.3	55.2	44.71
31	1.228	76.8	26.04	84.0	34.8	10.79	82	1.968	123.0	16.25	19.8	55.8	45.76
32	1.237	77.2	25.85	80.8	35.0	11.20	83	1.992	124.4	16.06	19.3	56.4	46.81
33	1.246	77.8	25.66	77.7	35.3	11.65	84	2.016	126.0	15.87	18.9	57.2	47.97
34	1.256	78.4	25.47	74.9	35.6	12.10	85	2.040	127.6	15.68	18.4	57.9	49.21
35	1.265	79.0	25.28	72.2	35.8	12.53	86	2.066	129.0	15.48	18.0	58.5	50.31
36	1.275	79.6	25.08	69.7	36.1	13.00	87	2.092	130.6	15.29	17.6	59.2	51.50
37	1.285	80.2	24.89	67.3	36.4	13.47	88	2.118	132.4	15.10	17.2	60.0	52.80
38	1.295	80.8	24.70	65.0	36.6	13.91	89	2.145	134.0	14.91	16.7	60.8	54.11
39	1.305	81.4	24.51	62.8	36.9	14.39	90	2.173	135.8	14.72	16.3	61.6	55.44
40	1.315	82.2	24.32	60.8	37.3	14.92	91	2.202	137.6	14.52	15.9	62.4	56.78
41	1.326	82.8	24.12	58.8	37.6	15.42	92	2.232	139.4	14.33	15.6	63.2	58.14
42	1.337	83.4	23.93	56.9	37.8	15.88	93	2.262	141.4	14.14	15.2	64.1	59.61
43	1.347	84.2	23.74	55.2	38.2	16.43	94	2.293	143.2	13.90	14.8	65.0	61.10
44	1.358	84.8	23.55	53.5	38.5	16.94	95	2.325	145.2	13.76	14.5	65.9	62.51
45	1.369	85.6	23.36	51.9	38.8	17.46	96	2.358	147.4	13.56	14.1	66.9	64.22
46	1.381	86.2	23.16	50.3	39.1	17.99	97	2.392	149.4	13.37	13.8	67.8	65.77
47	1.392	87.0	22.97	48.9	39.5	18.57	98	2.427	1.516	13.18	13.4	68.8	67.42
48	1.404	87.6	22.78	47.5	39.7	19.06	99	2.463	153.8	12.99	13.1	69.8	69.10
49	1.416	88.4	22.59	46.1	40.0	19.60	100	2.500	156.0	12.80	12.8	70.8	70.80
50	1.429	89.2	22.40	44.8	40.5	20.25							

Comparison of Values of Silver in Ounces and Kilograms

It is often of value for one operating in silver-producing business to know at once the value of a kilogram of silver when the New York quotation is at any stated figure. For that reason the following table has been prepared, showing the value of a kilogram of silver for any quotation in New York between fifty cents and one dollar per Troy ounce. The price from fifty cents to seventy-five cents per ounce has been calculated for every variation of one-eighth cent, and from that point to one dollar for variations of one-quarter cent. This table will be found of value for ascertaining at once the value of a kilogram of silver when the New York quotation is at any point between these two limits. It is more than probable that these limits will cover the probable fluctuations for some time to come.

Sizes and Weights of Wrought Iron Pipe

Nominal Size Inside Diameter	Nominal Weight per Foot	Actual Outside Diameter
Butt Welded		
1/8″	.241 lbs.	.405″
1/4″	.420 "	.540″
3/8″	.559 "	.675″
1/2″	.837 "	.840″
3/4″	1.115 "	1.050″
1″	1.668 "	1.315″
1 1/4″	2.244 "	1.660″
Lap Welded		
1 1/2″	2.678″ "	1.900″
2″	3.609 "	2.375″
2 1/2″	5.739 "	2.875″
3″	7.536 "	3.500″
3 1/2″	9.001 "	4.000″
4″	10.665 "	4.500″
4 1/2″	12.490 "	5.000″
5″	14.502 "	5.563″
6″	18.762 "	6.625″
8″	28.177 "	8.625″
10″	40.065 "	10.750″
12″	48.985 "	12.750″

Specific Gravity of Concentrating Ores and Gangues

LEAD

	Specific Gravity
Galena (lead sulphide)	7.2 to 7.7
Cerussite (lead carbonate)	6.4 to 6.5
Anglesite (lead sulphate)	6.1 to 6.4

COPPER

Melaconite (black copper)	6.2 to 6.3
Cuprite (copper oxide)	5.8 to 6.1
Chalcocite (copper glance)	5.8 to 5.8
Bornite (peacock copper)	4.4 to 5.5
Chalcopyrite (copper pyrite)	4.1 to 4.3
Malachite (copper carbonate)	3.7 to 4.1
Chrysocalla (silicate of copper)	2.0 to 2.2

IRON

Mispickel (iron arsenide)	5.5 to 6.0
Magnetite (iron oxide)	4.9 to 5.2
Pyrite (iron bisulphide)	4.8 to 5.2
Marcastite (iron sulphide)	4.6 to 4.8

ZINC

Smithsonite (zinc carbonate)	4.4 to 4.4
Sphalerite (zinc blende)	3.9 to 4.2
Willemite (zinc silicate)	3.9 to 4.1

GANGUE

Barite (heavy spar)	4.3 to 4.7
Manganese Garnet	4.1 to 4.5
Iron Garnet	3.9 to 4.4
Lime Garnet	3.4 to 3.5
Fluorite (Fluorspar)	3.0 to 3.2
Anhydrite (Gypsum)	2.8 to 2.9
Dolomite (magnesian limestone)	2.8 to 2.9
Quartz	2.5 to 2.8
Calcite (lime carbonate)	2.5 to 2.7
Kaolinite (Kaolin)	2.4 to 2.6

Metallic Contents of Pure Ores

Magnetite (magnetic iron ore) ....Iron, 72.0 per cent.
Hematite (red oxide of iron) ....Iron, 70.0 per cent.
Iron Pyrite ....Iron, 46.6 per cent.
Cuprite (red oxide of copper) ....Copper, 88.8 per cent.
Malachite (green carbonate of copper) . .Copper, 62.0 per cent.
Azurite (blue carbonate of copper) .....Copper, 61.0 per cent.
Bornite (purple or peacock copper) .....Iron, 15 per cent.; Copper, 58.0 per cent.
Chalcopyrite (copper pyrite) ....Iron, 30 per cent.; Copper, 34.0 per cent.
Chalcocite (copper glance)..............Copper, 78.0 per cent.
Galena (lead sulphide) ....Lead, 86.6 per cent.
Cerussite (lead carbonate) ....Lead, 70.0 per cent.
Zinc Blende (zinc sulphide) ....Zinc, 67.0 per cent.

Weights of Flat Steel

PER LINEAL FOOT

Width in Inches	Thickness in Inches											
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
1	.21	.43	.638	.850	1.06	1.28	1.49	1.70	2.12	2.55	2.98	—
1 1/8	.24	.48	.720	.955	1.20	1.43	1.68	1.92	2.39	2.87	3.35	3.88
1 1/4	.27	.53	.797	1.06	1.33	1.59	1.86	2.12	2.65	3.19	3.72	4.25
1 3/8	.30	.59	.875	1.17	1.46	1.76	2.05	2.34	2.92	3.51	4.09	4.68
1 1/2	.32	.64	.957	1.28	1.59	1.92	2.23	2.55	3.19	3.83	4.47	5.10
1 5/8	.35	.69	1.04	1.38	1.73	2.08	2.42	2.77	3.46	4.15	4.84	5.53
1 3/4	.38	.75	1.11	1.49	1.86	2.23	2.60	2.98	3.72	4.47	5.20	5.95
2	.43	.85	1.28	1.70	2.12	2.55	2.98	3.40	4.25	5.10	5.95	6.80
2 1/4	.48	.96	1.44	1.91	2.39	2.87	3.35	3.83	4.78	5.75	6.69	7.65
2 1/2	.53	1.06	1.59	2.12	2.65	3.19	3.72	4.25	5.31	6.38	7.44	8.50
2 3/4	.59	1.17	1.75	2.34	2.92	3.51	4.09	4.67	5.84	7.02	8.18	9.35
3	.64	1.28	1.91	2.55	3.19	3.83	4.46	5.10	6.38	7.65	8.93	10.20
3 1/4	.69	1.38	2.07	2.76	3.45	4.15	4.83	5.53	6.91	8.29	9.67	11.05
3 1/2	.75	1.49	2.23	2.98	3.72	4.47	5.20	5.95	7.44	8.93	10.41	11.90
3 3/4	.80	1.60	2.39	3.19	3.99	4.78	5.58	6.38	7.97	9.57	11.16	12.75
4	.85	1.70	2.55	3.40	4.25	5.10	5.95	6.80	8.50	10.20	11.90	13.60
4 1/2	.96	1.92	2.87	3.83	4.78	5.74	6.70	7.65	9.57	11.48	13.39	15.30
5	1.07	2.13	3.19	4.25	5.31	6.38	7.44	8.50	10.63	12.75	14.87	17.00
5 1/2	1.17	2.34	3.51	4.67	5.84	7.02	8.18	9.35	11.69	14.03	16.36	18.70
6	1.28	2.55	3.83	5.10	6.38	7.65	8.93	10.20	12.75	15.30	17.85	20.40
7	1.49	2.98	4.46	5.95	7.44	8.93	10.41	11.90	14.87	17.85	20.83	23.80
8	1.70	3.40	5.10	6.80	8.50	10.20	11.90	13.60	17.00	20.40	23.80	27.20

WEIGHT AND SPECIFIC GRAVITY OF VARIOUS MATERIALS

Material	Weight per Cubic Feet Average Pounds	Specific Gravity Average
Brick, common	100 to 125	1.6 to 2.
Brick, pressed	134	2.16
Brick, fire	150	2.4
Brickwork, in mortar	110	—
Brickwork, in cement	112	—
Cement, Portland, loose	78	—
Cement, Rosendale, loose	60	—
Clay	119	1.9
Coal, anthracite	93.5	1.5
Coal, bituminous	84	1.35
Coal, cannel	79	1.272
Coke	46	—
Concrete, in cement	137	2.2
Concrete, ordinary	119	1.9
Earth	77 to 125	1.52 to 2.
Galena	—	6.5 to 7.5
Granite, gray	163	2.62
Granite, red	165	2.62
Gypsum	143	2.286
Iron pyrites	—	4.5 to 5.5
Limestone	168	2.7
Lime, quick	53	.843
Marble	168	2.7
Masonry, ashlar	160	—
Masonry, rubble	180	—
Mortar, average	106	1.7
Quartz	165	2.65
Sand, river	117	1.88
Sand, coarse	100	1.611
Sandstone	150	2.4
Silica	—	2.5
Slate, American	175	2.8
Slate, Welsh	180	2.88
Sulphur	125	2.

Weight and Specific Gravity of Liquids

	Specific Gravity	Weight Per Cubic Inch Pounds	Weight Per Gallon Pounds
Water, distilled, 60 degrees Fahrenheit	1.	.036	8.35
Water, sea	1.03	.037	8.55
Water, Dead Sea	1.24	.045	10.4
Acid, Acetic	1.062	.038	8.78
Acid, Nitric	1.217	.044	10.16
Acid, Sulphuric	1.841	.067	15.48
Acid, Muriatic	1.2	.043	9.93
Alcohol, pure	.792	.029	6.7
Alcohol, proof	.916	.033	7.62
Alcohol of commerce	.833	.030	6.93
Oil, Linseed	.940	.034	7.85
Oil, Olive	.915	.033	7.62
Oil, Turpentine	.870	.031	7.16
Oil, whale	.923	.033	7.65
Petroleum	.878	.032	7.39

WEIGHT AND SPECIFIC GRAVITY OF METALS

Metal	Specific Gravity Range According to Several Authorities	Specific Gravity Approx. Mean Value Used in Calculation of Weight	Weight Per Cubic Foot Pounds	Weight Per Cubic Inch Pounds
Aluminum	2.56 to 2.71	2.67	166.5	.0963
Antimony	6.66 to 6.86	6.76	421.6	.2439
Bismuth	9.74 to 9.90	9.82	612.4	.3454
Brass: Copper, Zinc				
80 20	7.8 to 8.6	8.60	536.3	.3103
70 30		8.40	523.8	.3031
60 40		8.36	521.3	.3017
50 50		8.20	511.4	.2959
Bronze: Copper, 95–80; Tin, 5–20	8.25 to 8.96	8.853	552.	.3195
Cadmium	8.6 to 8.7	8.65	539.	.3121
Calcium	1.58	—	—	—
Chromium	5.0	—	—	—
Cobalt	8.5 to 8.6	—	—	—
Gold, pure	19.245 to 19.361	19.258	1200.9	.6949
Copper	8.69 to 8.92	8.853	552.	.3195
Iridium	22.38 to 23.	—	1396.	.8076
Iron, cast	6.85 to 7.48	7.218	450.	.2604
Iron, wrought	7.4 to 7.9	7.70	480.	.2779
Lead	11.07 to 11.44	11.38	709.7	.4106
Manganese	7. to 8.	8.	499.	.2887
Magnesium	1.69 to 1.75	1.75	109.	.0641
Mercury 32°	13.60 to 13.62	13.62	849.3	.4915
Mercury 60	13.58	13.58	846.8	.4900
Mercury 212	13.37 to 13.38	13.38	834.4	.4828
Nickel	8.279 to 8.93	8.8	548.7	.3175
Platinum	20.33 to 22.07	21.5	1347.	.7758
Potassium	0.865	—	—	—
Silver	10.474 to 10.511	10.505	655.1	.3791
Sodium	0.97	—	—	—
Steel	7.69 to 7.932	7.854	489.6	.2834
Tin	7.291 to 7.409	7.350	458.3	.2652
Titanium	5.3	—	—	—
Tungsten	17. to 17.6	—	—	—
Zinc	6.86 to 7.20	7.	436.5	.2526

In the first column of figures the lowest are usually those of cast metals, which are more or less porous; the highest are of metals finely rolled or drawn into wire.

Joists, Scantlings and Timber — Contents in Feet

Size, Inches	Lengths 10	12	14	16	18	20	22	24
1 × 10	8 1/3	10	11 2/3	13 1/3	15	16 2/3	18 1/3	20
1 × 12	10	12	14	16	18	20	22	24
1 × 14	11 2/3	14	16 1/3	18 2/3	21	23 1/3	25 2/3	28
1 × 16	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
1 1/4 × 8	8 1/3	10	11 2/3	13 1/3	15	16 2/3	18 1/3	20
1 1/4 × 10	10 5/12	12 1/2	14 7/12	16 2/3	18 3/4	20 5/8	22 11/12	25
1 1/4 × 12	12 1/2	15	17 1/2	20	22 1/2	25	27 1/2	30
1 1/2 × 6	7 1/2	9	10 1/2	12	13 1/2	15	16 1/2	18
1 1/2 × 8	10	12	14	16	18	20	22	24
1 1/2 × 10	12 1/2	15	17 1/2	20	22 1/2	25	27 1/2	30
1 1/2 × 12	15	18	21	24	27	30	33	36
2 × 4	6 2/3	8	9 1/3	10 2/3	12	13 1/3	14 2/3	16
2 × 6	10	12	14	16	18	20	22	24
2 × 8	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
2 × 10	16 2/3	20	23 1/3	26 2/3	30	33 1/3	36 2/3	40
2 × 12	20	24	28	32	36	40	44	48
2 × 14	23 1/3	28	32 2/3	37 1/3	42	46 2/3	51 1/3	56
2 × 16	26 2/3	32	37 1/2	42 2/3	48	53 1/3	58 2/3	64
2 1/2 × 12	25	30	35	40	45	50	55	60
2 1/2 × 14	29 1/6	35	40 5/6	46 2/3	52 1/2	58 1/3	64 1/6	70
2 1/2 × 16	33 1/3	40	46 2/3	53 1/3	60	66 2/3	73 1/3	80
3 × 6	15	18	21	24	27	30	33	36
3 × 8	20	24	28	32	36	40	44	48
3 × 10	25	30	35	40	45	50	55	60
3 × 12	30	36	42	48	54	60	66	72
3 × 14	35	42	49	56	63	70	77	84
3 × 16	40	48	56	64	72	80	88	96
4 × 4	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
4 × 6	20	24	28	32	36	40	44	48
4 × 8	26 2/3	32	37 1/3	42 2/3	48	53 1/3	58 2/3	64
4 × 10	33 1/3	40	46 2/3	53 1/3	60	66 2/3	73 1/3	80
4 × 12	40	48	56	64	72	80	88	96
4 × 14	46 2/3	56	65 1/3	74 2/3	84	93 1/3	102 2/3	112
6 × 6	30	36	42	48	54	60	66	72
6 × 8	40	48	56	64	72	80	88	96
6 × 10	50	60	70	80	90	100	110	120

JOISTS, SCANTLINGS AND TIMBER — CONTENTS IN FEET — *Continued*

Size, Inches	Lengths							
	10	12	14	16	18	20	22	24
6 × 12	60	72	84	96	108	120	132	144
6 × 14	70	84	98	112	126	140	154	168
6 × 16	80	96	112	128	144	160	176	192
8 × 8	53⅓	64	74⅔	85⅓	96	106⅔	117⅓	128
8 × 10	66⅔	80	93⅓	106⅔	120	133⅓	146⅔	160
8 × 12	80	96	114	128	144	160	176	192
8 × 14	93⅓	112	130⅔	149⅓	168	186⅔	205⅓	224
10 × 10	83⅓	100	116⅔	133⅓	150	166⅔	183⅓	200
10 × 12	100	120	140	160	180	200	220	240
10 × 14	116⅔	140	163⅓	186⅔	210	233⅓	256⅔	280
10 × 16	133⅓	160	186⅔	213⅓	240	266⅔	293⅓	320
12 × 12	120	144	168	192	216	240	264	288
12 × 14	140	168	196	224	252	280	308	336
12 × 16	160	192	224	256	288	320	352	384
14 × 14	163⅓	196	228⅔	261⅓	294	326⅔	359⅓	392
14 × 16	186⅔	224	261⅓	298⅔	336	373⅓	410⅔	448

Table Showing the Relative Volumes of Compressed Air at Various Pressures

Gage Pressure Pounds	Volume of Free Air Corresponding to One Cubic Foot of Air at Given Pressure	Corresponding Volume of One Cubic Foot of Free Air at Given Pressure	Gage Pressure Pounds	Volume of Free Air Corresponding to One Cubic Foot of Air at Given Pressure	Corresponding Volume of One Cubic Foot of Free Air at Given Pressure
0	1.00	1.00	70	5.762	.1735
1	1.068	.9356	75	6.102	.1638
2	1.136	.8802	80	6.442	.1550
3	1.204	.8305	85	6.782	.1474
4	1.273	.7861	90	7.122	.1404
5	1.34	.7462	95	7.462	.1340
10	1.68	.5951	100	7.802	.1281
15	2.02	.4949	110	8.483	.1178
20	2.36	.4236	120	9.170	.1090
25	2.7	.3703	130	9.843	.1016
30	3.04	.3288	140	10.52	.0950
35	3.38	.2957	150	11.20	.0892
40	3.72	.2687	160	11.88	.0841
45	4.06	.2462	170	12.56	.0796
50	4.40	.2272	180	13.24	.0755
55	4.74	.2109	190	13.92	.0712
60	5.08	.1967	200	14.60	.0684
65	5.42	.1844	—	—	—

Table Showing Horse-power Developed

TO COMPRESS 100 CUBIC FEET FREE AIR FROM ATMOSPHERE TO VARIOUS PRESSURES

Gage Pressure Pounds	One-stage Compression D. H. P.	Gage Pressure Pounds	Two-stage Compression D. H. P.	Four-stage Compression D. H. P.
10	3.60	60	11.70	10.80
15	5.03	80	13.70	12.50
20	6.28	100	15.40	14.20
25	7.42	200	21.20	18.75
30	8.47	300	24.50	21.80
35	9.42	400	27.70	24.00
40	10.30	500	29.75	25.90
45	11.14	600	31.70	27.50
50	11.90	700	33.50	28.90
55	12.67	800	34.90	30.00
60	13.41	900	36.30	31.00
70	14.72	1000	37.80	31.80
80	15.94	1200	39.70	33.30
90	17.06	1600	43.00	35.65
100	18.15	2000	45.50	37.80
—	—	2500	—	39.06
—	—	3000	—	40.15

The above table does not take into consideration jacket-cooling or friction of machine. Initial temperature of air at beginning of each compression is 60 degrees.

Circumferences and Areas of Circles.

Diam.	Circum.	Area.	Diam.	Circum.	Area	Diam.	Circu .	Area
1/16	.1963	.00307	8	25.132	50.265	55	172.788	2375.83
1/8	.3927	.01227	9	28.274	63.617	56	175.929	2463.01
3/16	.5890	.02761	10	31.416	78.540	57	179.071	2551.76
1/4	.7854	.04909	11	34.558	95.033	58	182.212	2642.08
5/16	.9817	.07670	12	37.699	113.097	59	185.354	2733.97
3/8	1.1781	.1104	13	40.840	132.732	60	188.496	2827.43
7/16	1.3744	.1503	14	43.982	153.938	61	191.637	2922.47
1/2	1.5708	.1963	15	47.124	176.715	62	194.779	3019.07
9/16	1.7771	.2485	16	50.265	201.062	63	197.920	3117.25
5/8	1.9635	.3068	17	53.407	226.980	64	201.062	3216.99
11/16	2.1598	.3712	18	56.548	254.469	65	204.204	3318.31
3/4	2.3562	.4418	19	59.690	283.529	66	207.345	3421.19
13/16	2.5525	.5185	20	62.832	314.160	67	210.487	3522.66
7/8	2.7489	.6013	21	65.973	346.361	68	213.628	3631.68
15/16	2.9452	.6903	22	69.115	380.133	69	216.770	3739.28
1	3.1416	.7854	23	72.256	415.476	70	219.912	3848.45
1 1/16	3.3379	.8866	24	75.398	452.390	71	223.053	3969.19
1 1/8	3.5343	.9940	25	78.540	490.875	72	226.195	4071.50
1 3/16	3.7306	1.1075	26	81.681	530.930	73	229.336	4185.39
1 1/4	3.9270	1.2271	27	84.823	572.556	74	232.478	4300.84
1 5/16	4.1233	1.3530	28	87.964	615.753	75	235.620	4417.86
1 3/8	4.3197	1.4848	29	91.106	660.521	76	238.761	4536.46
1 7/16	4.5160	1.6229	30	94.248	706.860	77	241.903	4656.63
1 1/2	4.7124	1.7671	31	97.389	754.769	78	245.044	4778.36
1 5/8	5.1051	2.0739	32	100.531	804.249	79	248.186	4901.68
1 3/4	5.4978	2.4052	33	103.672	855.30	80	251.328	5026.55
1 7/8	5.8905	2.7611	34	106.814	907.92	81	254.469	5153-00
2	6.2832	3.1416	35	109.956	962.11	82	257.611	5281.02
2 1/8	6.6759	3.5465	36	113.097	1017.88	83	260.752	5410.61
2 1/4	7.0686	3.9760	37	116.239	1075.21	84	263.894	5541.77
2 3/8	7.4613	4.4302	38	119.380	1134.11	85	267.035	5674.51
2 1/2	7.8540	4.9087	39	122.522	1194.59	86	270.177	5808.80
2 3/4	8.6394	5.9395	40	125.664	1256.64	87	273.319	5944.68
3	9.4248	7.0686	41	128.805	1320.25	88	276.460	6082.12
3 1/4	10.210	8.2957	42	131.947	1385.44	89	279.602	6221.14
3 1/2	10.995	9.6211	43	135.088	1452.20	90	282.744	6361.73
3 3/4	11.781	11.044	44	138.230	1520.53	91	285.885	6503.88
4	12.566	12.566	45	141.372	1590.43	92	289.027	6647.61
4 1/4	13.351	14.186	46	144.513	1661.90	93	292.168	6792.91
4 1/2	14.137	15.904	57	147.655	1734.94	94	295.310	6939.78
4 3/4	14.922	17.720	48	150.796	1908.56	95	298.452	7088.22
5	15.708	19.635	49	153.938	1885.74	96	301.593	7238.23
5 1/4	16.493	21.647	50	157.080	1963.50	97	304.734	7389.81
5 1/2	17.278	23.758	51	160.221	2042.82	98	307.876	7542.96
5 3/4	18.064	25.967	52	163.363	2123.72	99	311.018	7697.69
6	18.849	28.274	53	166.504	2206.18	100	314.159	7853.98
7	21.991	28.484	54	169.646	2290.22	—	—	—

DIMENSIONS IN DECIMAL PARTS OF AN INCH

Number of Gage	American or Brown & Sharpe	Birmingham or Stubs' Iron Wire	Washburn & Moen Mfg. Co.	Trenton Iron Co.	Stubs' Steel Wire	Imperial Wire Gage	U. S. Standard for Plate
000000	......	......	......	......	......	.464	.46875
00000	......	......	......	.450	......	.432	.4375
0000	.46	.454	.3938	.400	......	.400	.40625
000	.40964	.425	.3625	.360	......	.372	.375
00	.3648	.380	.3310	.330	......	.348	.34375
0	.32486	.340	.3065	.305	......	.324	.3125
1	.2893	.300	.2830	.285	.227	.300	.28125
2	.25763	.284	.2625	.265	.219	.276	.265625
3	.22942	.259	.2437	.245	.212	.252	.25
4	.20431	.238	.2253	.225	.207	.232	.234375
5	.18194	.220	.2070	.205	.204	.212	.21875
6	.16202	.203	.1920	.190	.201	.192	.203125
7	.14428	.180	.1770	.175	.199	.176	.1875
8	.12849	.165	.1620	.160	.197	.160	.171875
9	.11443	.148	.1483	.145	.194	.144	.15625
10	.10189	.134	.1350	.130	.191	.128	.140625
11	.090742	.120	.1205	.1175	.188	.116	.125
12	.080808	.109	.1055	.105	.185	.104	.109375
13	.071961	.095	.0915	.0925	.182	.092	.09375
14	.064084	.083	.0800	.080	.180	.080	.078125
15	.057068	.072	.0720	.070	.178	.072	.0703125
16	.05082	.065	.0625	.061	.175	.064	.0625
17	.045257	.058	.0540	.0525	.172	.056	.05625
18	.040303	.049	.0475	.045	.168	.048	.05
19	.03589	.042	.0410	.040	.164	.040	.04375
20	.031961	.035	.0348	.035	.161	.036	.0375
21	.028462	.032	.03175	.031	.157	.032	.034375
22	.025347	.028	.0286	.028	.155	.028	.03125
23	.022571	.025	.0258	.025	.153	.024	.028125
24	.0201	.022	.0230	.0225	.151	.022	.025
25	.0179	.020	.0204	.020	.148	.020	.021875
26	.01594	.018	.0181	.018	.146	.018	.01875
27	.014195	.016	.0173	.017	.143	.0164	.0171875
28	.012641	.014	.0162	.016	.139	.0149	.015625
29	.011257	.013	.0150	.015	.134	.0136	.0140625
30	.010025	.012	.0140	.014	.127	.0124	.0125
31	.008928	.010	.0132	.013	.120	.0116	.0109375
32	.00795	.009	.0128	.012	.115	.0108	.01015625
33	.00708	.008	.0118	.011	.112	.0100	.009375
34	.006304	.007	.0104	.010	.110	.0092	.00859375
35	.005614	.005	.0095	.0095	.108	.0084	.0078125
36	.005	.004	.0090	.009	.106	.0076	.00703125
37	.004453			.0085	.103	.0068	.006640625
38	.003965			.008	.101	.0060	.00625
39	.003531			.0075	.099	.0052	
40	.003144			.007	.097	.0048	

WEIGHTS OF STEEL AND IRON BARS PER LINEAR FOOT

Dia. or Distance Across Flats	Steel — Weight per Foot				Iron — Weight per Foot	
	Round	Square	Hexagon	Octagon	Round	Square
1/16	.010	.013	.012	.011	.010	.013
1/8	.042	.053	.046	.044	.041	.052
3/16	.094	.119	.103	.099	.092	.117
1/4	.167	.212	.185	.177	.164	.208
5/16	.261	.333	.288	.277	.256	.326
3/8	.375	.478	.414	.398	.368	.469
7/16	.511	.651	.564	.542	.501	.638
1/2	.667	.850	.737	.708	.654	.833
9/16	.845	1.076	.932	.896	.828	1.055
5/8	1.043	1.328	1.151	1.107	1.023	1.302
11/16	1.262	1.608	1.393	1.331	1.237	1.576
3/4	1.502	1.913	1.658	1.584	1.473	1.875
13/16	1.763	2.245	1.944	1.860	1.728	2.201
7/8	2.044	2.603	2.256	2.156	2.004	2.552
15/16	2.347	2.989	2.591	2.482	2.301	2.930
1	2.670	3.400	2.947	2.817	2.618	3.333
1 1/16	3.014	3.838	3.327	3.182	2.955	3.763
1 1/8	3.379	4.303	3.730	3.568	3.313	4.219
1 3/16	3.766	4.795	4.156	3.977	3.692	4.701
1 1/4	4.173	5.312	4.605	4.407	4.091	5.208
1 5/16	4.600	5.857	5.077	4.858	4.510	5.742
1 3/8	5.049	6.428	5.571	5.331	4.950	6.302
1 7/16	5.518	7.026	6.091	5.827	5.410	6.888
1 1/2	6.008	7.650	6.631	6.344	5.890	7.500
1 9/16	6.520	8.301	7.195	6.905	6.392	8.138
1 5/8	7.051	8.978	7.776	7.446	6.913	8.802
1 11/16	7.604	9.682	8.392	8.027	7.455	9.492
1 3/4	8.178	10.41	9.025	8.635	8.018	10.21
1 13/16	8.773	11.17	9.682	9.264	8.601	10.95
1 7/8	9.388	11.95	10.36	9.918	9.204	11.72
1 15/16	10.02	12.76	11.06	10.58	9.828	12.51
2	10.68	13.60	11.79	11.28	10.47	13.33
2 1/8	12.06	15.35	13.31	12.71	11.82	15.05
2 1/4	13.52	17.22	14.92	14.24	13.25	16.88
2 3/8	15.07	19.18	16.62	15.88	14.77	18.80
2 1/2	16.69	21.25	18.42	17.65	16.36	20.83
2 5/8	18.40	23.43	20.31	19.45	18.04	22.97
2 3/4	20.20	25.71	22.29	21.28	19.80	25.21
2 7/8	22.07	28.10	24.36	23.28	21.64	27.55
3	24.03	30.60	26.53	25.36	23.56	30.00
3 1/8	26.08	33.20	28.78	27.50	25.57	32.55
3 1/4	28.20	35.92	31.10	29.28	27.65	35.21
3 3/8	30.42	38.78	33.57	32.10	29.82	37.97
3 1/2	32.71	41.65	36.10	34.56	32.07	40.83
3 5/8	35.09	44.68	38.73	37.05	34.40	43.80
3 3/4	37.56	47.82	41.45	39.68	36.82	46.88
3 7/8	40.10	51.05	44.26	42.35	39.31	50.05
4	42.73	54.40	47.16	45.12	41.89	53.33

HORSE-POWER OF BELTING

Horse-power which may be transmitted by open single belts to pulleys running 100 revolutions per minute, the diameters of the driving and driven pulley being equal.

The horse-power of double belts is $\frac{10}{7}$ of that given in the table.

Diam. of Pulley in Ins.	Width of Belt, in Inches												
	2	3	4	5	6	8	10	12	14	16	18	20	22
	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
6	.44	.65	.87	1.09	1.31	—	—	—	—	—	—	—	—
7	.51	.76	1.01	1.27	1.53	—	—	—	—	—	—	—	—
8	.58	.87	1.16	1.45	1.75	—	—	—	—	—	—	—	—
9	.65	.98	1.31	1.64	1.97	—	—	—	—	—	—	—	—
10	.73	1.09	1.45	1.81	2.18	—	—	—	—	—	—	—	—
11	.8	1.2	1.6	2.	2.4	—	—	—	—	—	—	—	—
12	.87	1.31	1.75	2.18	2.62	—	—	—	—	—	—	—	—
13	.95	1.42	1.89	2.36	2.83	—	—	—	—	—	—	—	—
14	1.02	1.52	2.02	2.53	3.05	—	—	—	—	—	—	—	—
15	1.09	1.64	2.19	2.73	3.29	—	—	—	—	—	—	—	—
16	1.16	1.74	2.32	2.91	3.48	—	—	—	—	—	—	—	—
17	1.24	1.85	2.47	3.09	3.7	—	—	—	—	—	—	—	—
18	1.31	1.96	2.62	3.27	3.92	—	—	—	—	—	—	—	—
19	1.39	2.07	2.76	3.45	4.14	—	—	—	—	—	—	—	—
20	1.45	2.18	2.91	3.64	4.36	—	—	—	—	—	—	—	—
21	1.52	2.29	3.05	3.82	4.58	—	—	—	—	—	—	—	—
22	1.6	2.4	3.2	4.	4.8	—	—	—	—	—	—	—	—
23	1.67	2.51	3.35	4.18	5.02	—	—	—	—	—	—	—	—
24	—	—	3.5	4.4	5.2	7.	8.7	10.5	12.2	14.	16.	17.	19.
25	—	—	3.6	4.5	5.5	7.3	9.1	10.9	12.7	14.5	—	—	—
26	—	—	3.8	4.7	5.7	7.6	9.5	11.3	13.2	15.1	—	—	—
27	—	—	3.9	4.9	5.9	7.8	9.8	11.8	13.7	15.6	—	—	—
28	—	—	4.1	5.1	6.1	8.1	10.2	12.2	14.3	16.3	—	—	—
29	—	—	4.2	5.3	6.3	8.4	10.5	12.6	14.8	16.9	—	—	—
30	—	—	4.4	5.4	6.6	8.7	10.9	13.1	15.3	17.4	19.	22.	24.
31	—	—	4.5	5.6	6.8	9.	11.3	13.5	15.8	18.	—	—	—
32	—	—	4.7	5.8	7.	9.3	11.6	14.	16.3	18.6	—	—	—
33	—	—	4.8	6.	7.2	9.6	12.	14.4	16.8	19.2	—	—	—
34	—	—	4.9	6.2	7.4	9.9	12.4	14.8	17.3	19.8	—	—	—
35	—	—	5.1	6.4	7.6	10.2	12.7	15.3	17.9	20.4	—	—	—
36	—	—	5.2	6.5	7.8	10.5	13.1	15.7	18.3	20.9	24.	26.	29.
37	—	—	5.4	6.7	8.1	10.8	13.5	16.2	18.9	21.5	—	—	—
38	—	—	5.5	6.9	8.3	11.0	3.8	16.6	19.3	22.1	25.	28.	30.
39	—	—	5.7	7.1	8.5	11.3	14.2	17.	19.9	22.7	—	—	—
40	—	—	5.8	7.3	8.7	11.6	14.6	17.5	20.4	23.3	26.	29.	32.
42	—	—	6.1	7.6	9.2	12.2	15.3	18.2	21.4	24.3	28.	31.	34.
44	—	—	6.4	8.	9.6	12.8	16.	19.2	22.4	25.6	29.	32.	35.
46	—	—	6.7	8.4	10.	13.4	16.8	20.1	23.4	26.8	—	—	—
48	—	—	7.	8.8	10.4	14.	17.4	21.	24.4	28.	31.	35.	38.
50	—	—	7.2	9.	10.9	14.6	18.2	21.8	25.4	29.	33.	36.	40.
54	—	—	7.8	9.8	11.8	15.6	19.6	23.6	26.4	31.2	35.	39.	43.
60	—	—	8.8	10.8	13.1	17.4	21.8	26.2	30.6	34.8	39.	44.	48.
66	—	—	9.6	12.	14.4	19.2	24.	28.8	33.6	38.4	43.	48.	53.
72	—	—	10.4	13.	15.6	21.	26.2	31.4	36.6	41.8	47.	52.	58.
78	—	—	11.4	14.2	17.	22.6	28.4	34.	39.8	45.4	51.	57.	62.
84	—	—	12.2	15.2	19.4	24.4	30.6	36.4	42.8	48.6	55.	61.	67.

Horse-power of Turned Iron Shafting

As prime mover or head shaft carrying main driving pulley or gear, well supported by bearings

$$\text{Formula: H. P.} = \frac{D^3 \times R}{125}$$

Diam. of Shaft.	Number of Revolutions per Minute										
	60	80	100	125	150	175	200	225	250	275	300
$1\frac{11}{16}$	2.6	3.4	4.3	5.4	6.4	7.5	8.6	9.7	10.7	11.8	12.9
$1\frac{15}{16}$	3.8	5.1	6.4	8.	9.6	11.2	12.8	14.4	16.	17.6	19.2
$2\frac{3}{16}$	5.4	7.3	8.1	10.	12.	14.	16.	18.	20.	22.	24.
$2\frac{7}{16}$	7.5	10.	12.5	15.	18.	22.	25.	28.	31.	34.	37.
$2\frac{11}{16}$	10.	13.	16.	20.	24.	28.	32.	36.	40.	44.	48.
$2\frac{15}{16}$	13.	17.	20.	25.	30.	35.	40.	45.	50.	55.	60.
$3\frac{3}{16}$	16.	22.	27.	34.	40.	47.	54.	61.	67.	74.	81.
$3\frac{7}{16}$	20.	27.	34.	42.	51.	59.	68.	76.	85.	93.	102.
$3\frac{15}{16}$	30.	41.	51.	64.	76.	89.	102.	115.	127.	140.	153.
$4\frac{7}{16}$	43.	58.	72.	90.	108.	126.	144.	162.	180.	198.	216.
$4\frac{15}{16}$	60.	80.	100.	125.	150.	175.	200.	225.	250.	275.	300.
$5\frac{7}{16}$	80.	106.	133.	166.	199.	233.	266.	299.	333.	366.	400.

As second movers or line shafting, bearings 8 feet apart

$$\text{Formula: H. P.} = \frac{D^3 \times R}{90}$$

Diam. of Shaft.	Number of Revolutions per Minute										
	100	125	150	175	200	225	250	275	300	325	350
$1\frac{11}{16}$	6.	7.4	8.9	10.4	11.9	13.4	14.9	16.4	17.9	19.4	20.9
$1\frac{15}{16}$	8.9	11.1	13.3	15.5	17.7	20.	22.2	24.4	26.6	28.8	31.
$2\frac{3}{16}$	12.6	15.8	19.	22.	25.	28.	31.	35.	38.	41.	44.
$2\frac{7}{16}$	17.	21.	26.	30.	34.	39.	43.	47.	52.	56.	60.
$2\frac{11}{16}$	23.	29.	34.	40.	46.	52.	58.	64.	69.	75.	81.
$2\frac{15}{16}$	30.	37.	45.	52.	60.	67.	75.	82.	90.	97.	105.
$3\frac{3}{16}$	38.	47.	57.	66.	76.	85.	95.	104.	114.	123.	133.
$3\frac{7}{16}$	47.	59.	71.	83.	95.	107.	119.	131.	143.	155.	167.
$3\frac{11}{16}$	58.	73.	88.	102.	117.	132.	146.	162.	176.	190.	205.
$3\frac{15}{16}$	71.	89.	107.	125.	142.	160.	178.	196.	213.	231.	249.

Squares, Cubes, Square Roots, Cube Roots, Circumferences and Circular Areas of Nos. from 1 to 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
1	1	1	1.0000	1.0000	3.142	0.7854
2	4	8	1.4142	1.2599	6.283	3.1416
3	9	27	1.7321	1.4422	9.425	7.0686
4	16	64	2.0000	1.5874	12.566	12.5664
5	25	125	2.2361	1.7100	15.708	19.6350
6	36	216	2.4495	1.8171	18.850	28.2743
7	49	343	2.6458	1.9129	21.991	38.4845
8	64	512	2.8284	2.0000	25.133	50.2655
9	81	729	3.0000	2.0801	28.274	63.6173
10	100	1000	3.1623	2.1544	31.416	78.5398
11	121	1331	3.3166	2.2240	34.558	95.033
12	144	1728	3.4641	2.2894	37.699	113.097
13	169	2197	3.6056	2.3513	40.841	132.732
14	196	2744	3.7417	2.4101	43.982	153.938
15	225	3375	3.8730	2.4662	47.124	176.715
16	256	4096	4.0000	2.5198	50.265	201.062
17	289	4913	4.1231	2.5713	53.407	226.980
18	324	5832	4.2426	2.6207	56.549	254.469
19	361	6859	4.3589	2.6684	59.690	283.529
20	400	8000	4.4721	2.7144	62.832	314.159
21	441	9261	4.5826	2.7589	65.973	346.361
22	484	10648	4.6904	2.8020	69.115	380.133
23	529	12167	4.7958	2.8439	72.257	415.476
24	576	13824	4.8990	2.8845	75.398	452.389
25	625	15625	5.0000	2.9240	78.540	490.874
26	676	17576	5.0990	2.9625	81.681	530.929
27	729	19683	5.1962	3.0000	84.823	572.555
28	784	21952	5.2915	3.0366	87.965	615.752
29	·841	24389	5.3852	3.0723	91.106	660.520
30	900	27000	5.4772	3.1072	94.248	706.858
31	961	29791	5.5678	3.1414	90.389	754.768
32	1024	32768	5.6569	3.1748	100.531	804.248
33	1089	35937	5.7446	3.2075	103.673	855.299
34	1156	39304	5.8310	3.2396	106.814	907.920
35	1225	42875	5.9161	3.2711	109.956	962.113
36	1206	46656	6.0000	3.3019	113.097	1017.88
37	1369	50653	6.0828	3.3322	116.239	1075.21
38	1444	54872	6.1644	3.3620	119.381	1134.11
39	1521	59319	6.2450	3.3912	122.522	1194.59
40	1600	64000	6.3246	3.4200	125.660	1256.64

Squares, Cubes, Square Roots, Cube Roots, Circumferences and Circular Areas of Nos. from 1 to 520

No.	Square	Cube	Sq. Root	Cube Root	Circle Circum.	Circle Area
41	1681	68921	6.4031	3.4482	128.81	1320.25
42	1764	74088	6.4807	3.4760	131.95	1385.44
43	1849	79507	6.5574	3.5034	135.09	1452.20
44	1936	85184	6.6332	3.5303	138.23	1520.53
45	2025	91125	6.7082	3.5569	141.37	1590.43
46	2116	97336	6.7823	3.5830	144.51	1661.90
47	2209	103823	6.8557	3.6088	147.65	1734.94
48	2304	110592	6.9282	3.6342	150.80	1809.56
49	2401	117649	7.0000	3.6593	153.94	1885.74
50	2500	125000	7.0711	3.6840	157.08	1963.50
51	2601	132651	7.1414	3.7084	160.22	2042.82
52	2704	140608	7.2111	3.7325	163.36	2123.72
53	2809	148877	7.2801	3.7563	166.50	2206.18
54	2916	157464	7.3485	3.7798	169.65	2290.22
55	3025	166375	7.4162	3.8030	172.79	2375.83
56	3136	175616	7.4833	3.8259	175.93	2463.01
57	3249	185193	7.5498	3.8485	179.07	2551.76
58	3364	195112	7.6158	3.8709	182.21	2642.08
59	3481	205379	7.6811	3.8930	185.35	2733.97
60	3600	216000	7.7460	3.9149	188.50	2827.43
61	3721	226981	7.8102	3.9365	191.64	2922.47
62	3844	238328	7.8740	3.9579	194.78	3019.07
63	3969	250047	7.9373	3.9791	197.92	3117.25
64	4096	262144	8.0000	4.0000	201.06	3216.99
65	4225	274625	8.0623	4.0207	204.20	3318.31
66	4356	287496	8.1240	4.0412	207.35	3421.19
67	4489	300763	8.1854	4.0615	210.49	3525.65
68	4624	314432	8.2462	4.0817	213.63	3631.68
69	4761	328509	8.3066	4.1016	216.77	3739.28
70	4900	343000	8.3666	4.1213	219.91	3848.45
71	5041	357911	8.4261	4.1408	223.05	3959.19
72	5184	373248	8.4853	4.1602	226.19	4071.50
73	5329	389017	8.5440	4.1793	229.34	4185.39
74	5476	405224	8.6023	4.1983	232.48	4300.84
75	5625	421875	8.6603	4.2172	235.62	4417.86
76	5776	438976	8.7178	4.2358	238.76	4536.46
77	5929	456533	8.7750	4.2543	241.90	4656.63
78	6084	474552	8.8318	4.2727	245.04	4778.36
79	6241	493039	8.8882	4.2908	248.19	4901.67
80	6400	512000	8.9443	4.3089	251.33	5026.55

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
81	6561	531441	9.0000	4.3267	254.47	5153.00
82	6724	551368	9.0554	4.3445	257.61	5281.02
83	6889	571787	9.1104	4.3621	260.75	5410.61
84	7056	592704	9.1652	4.3795	263.89	5541.77
85	7225	614125	9.2195	4.3968	267.04	5674.50
86	7396	636056	9.2736	4.4140	270.18	5808.80
87	7569	658503	9.3274	4.4310	273.32	5944.68
88	7744	681472	9.3808	4.4480	276.46	6082.12
89	7921	704969	9.4340	4.4647	279.60	6221.14
90	8100	729000	9.4868	4.4814	282.74	6361.73
91	8281	753571	9.5394	4.4979	285.88	6503.88
92	8464	778688	9.5917	4.5144	289.03	6647.61
93	8649	804357	9.6437	4.5307	292.17	6792.91
94	8836	830584	9.6954	4.5468	295.31	6939.78
95	9025	857375	9.7468	4.5629	298.45	7088.22
96	9216	884736	9.7980	4.5789	301.59	7238.23
97	9409	912673	9.8489	4.5947	304.73	7389.81
98	9604	941192	9.8995	4.6104	307.88	7542.96
99	9801	970299	9.9499	4.6261	311.02	7697.69
100	10000	1000000	10.0000	4.6416	314.16	7853.98
101	10201	1030301	10.0499	4.6570	317.30	8011.85
102	10404	1061208	10.0995	4.6723	320.44	8171.28
103	10609	1092727	10.1489	4.6875	323.58	8332.29
104	10816	1124864	10.1980	4.7027	326.73	8494.87
105	11025	1157625	10.2470	4.7177	329.87	8659.01
106	11236	1191016	10.2956	4.7326	333.01	8824.73
107	11449	1225043	10.3441	4.7475	336.15	8992.02
108	11664	1259712	10.3923	4.7622	339.29	9160.88
109	11881	1295029	10.4403	4.7769	342.43	9331.32
110	12100	1331000	10.4881	4.7914	345.58	9503.32
111	12321	1367631	10.5357	4.8059	348.72	9676.89
112	12544	1404928	10.5830	4.8203	351.86	9852.03
113	12769	1442897	10.6301	4.8346	355.00	10028.7
114	12996	1481544	10.6771	4.8488	358.14	10207.0
115	13225	1520875	10.7238	4.8629	361.28	10386.9
116	13456	1560896	10.7703	4.8770	364.42	10568.3
117	13689	1601613	10.8167	4.8910	367.57	10751.3
118	13924	1643032	10.8628	4.9049	370.71	10935.9
119	14161	1685159	10.9087	4.9187	373.85	11122.0
120	14400	1728000	10.9545	4.9324	376.99	11309.7

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
121	14641	1771561	11.0000	4.9461	380.13	11499.0
122	14884	1815848	11.0454	4.9597	383.27	11689.9
123	15129	1860867	11.0905	4.9732	386.42	11882.3
124	15376	1906624	11.1355	4.9866	389.56	12076.3
125	15625	1953125	11.1803	5.0000	392.70	12271.8
126	15876	2000376	11.2250	5.0133	395.84	12469.0
127	16129	2048383	11.2694	5.0265	398.98	12667.7
128	16384	2097152	11.3137	5.0397	402.12	12868.0
129	16641	2146689	11.3578	5.0528	405.27	13069.8
130	16900	2197000	11.4018	5.0658	408.41	13273.2
131	17161	2248091	11.4455	5.0788	411.55	13478.2
132	17424	2299968	11.4891	5.0916	414.69	13684.8
133	17689	2352637	11.5326	5.1045	417.83	13892.9
134	17956	2406104	11.5758	5.1172	420.97	14102.6
135	18225	2460375	11.6190	5.1299	424.12	14313.9
136	18496	2515456	11.6619	5.1426	427.26	14526.7
137	18769	2571353	11.7047	5.1551	430.40	14741.1
138	19044	2628072	11.7473	5.1676	433.54	14957.1
139	19321	2685619	11.7898	5.1801	436.68	15174.7
140	19600	2744000	11.8322	5.1925	439.82	15393.8
141	19881	2803221	11.8743	5.2048	442.96	15614.5
142	20164	2863288	11.9164	5.2171	446.11	15836.8
143	20449	2924207	11.9583	5.2293	449.25	16060.6
144	20736	2985984	12.0000	5.2415	452.39	16286.0
145	21025	3048625	12.0416	5.2536	455.53	16513.0
146	21316	3112136	12.0830	5.2656	458.67	16741.5
147	21609	3176523	12.1244	5.2776	461.81	16971.7
148	21904	3241792	12.1655	5.2896	464.96	17203.4
149	22201	3307949	12.2066	5.3015	468.10	17436.6
150	22500	3375000	12.2474	5.3133	471.24	17671.5
151	22801	3442951	12.2882	5.3251	474.38	17907.9
152	23104	3511808	12.3288	5.3368	477.52	18145.8
153	23409	3581577	12.3693	5.3485	480.66	18385.4
154	23716	3652264	12.4097	5.3601	483.81	18626.5
155	24025	3723875	12.4499	5.3717	486.95	18869.2
156	24336	3796416	12.4900	5.3832	490.09	19113.4
157	24649	3869893	12.5300	5.3947	493.23	19359.3
158	24964	3944312	12.5698	5.4061	496.37	19606.7
159	25281	4019679	12.6095	5.4175	499.51	19855.7
160	25600	4096000	12.6491	5.4288	502.65	20106.2

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
161	25921	4173281	12.6886	5.4401	505.80	20358.3
162	26244	4251528	12.7279	5.4514	508.94	20612.0
163	26569	4330747	12.7671	5.4626	512.08	20867.2
164	26896	4410944	12.8062	5.4737	515.22	21124.1
165	27225	4492125	12.8452	5.4848	518.36	21382.5
166	27556	4574296	12.8841	5.4959	521.50	21642.4
167	27889	4657463	12.9228	5.5069	524.65	21904.0
168	23224	4741632	12.9615	5.5178	527.79	22167.1
169	28561	4826809	13.0000	5.5288	530.93	22431.8
170	28900	4913000	13.0384	5.5397	534.07	22698.0
171	29241	5000211	13.0767	5.5505	537.21	22965.8
172	29584	5088448	13.1149	5.5613	540.35	23235.2
173	29929	5177717	13.1529	5.5721	543.50	23506.2
174	30276	5268024	13.1909	5.5828	546.64	23778.7
175	30625	5359375	13.2288	5.5934	549.78	24052.8
176	30976	5451776	13.2665	5.6041	552.92	24328.5
177	31329	5545233	13.3041	5.6147	556.06	24605.7
178	31684	5639752	13.3417	5.6252	559.20	24884.6
179	32041	5735339	13.3791	5.6357	562.35	25164.9
180	32400	5832000	13.4164	5.6462	565.49	25446.9
181	32761	5929741	13.4536	5.6567	568.63	25730.4
182	33124	6028568	13.4907	5.6671	571.77	26015.5
183	33489	6128487	13.5277	5.6774	574.91	26302.2
184	33856	6229504	13.5647	5.6877	578.05	26590.4
185	34225	6331625	13.6015	5.6980	581.19	26880.3
186	34596	6434856	13.6382	5.7083	584.34	27171.6
187	34969	6539203	13.6748	5.7185	587.48	27464.6
188	35344	6644672	13.7113	5.7287	590.62	27759.1
189	35721	6751269	13.7477	5.7388	593.76	28055.2
190	36100	6859000	15.7840	5.7489	596.90	28352.9
191	36481	6967871	13.8203	5.7590	600.04	28652.1
192	36864	7077888	13.8564	5.7690	603.19	28952.9
193	37249	7189057	13.8924	5.7790	606.33	29255.3
194	37636	7301384	13.9284	5.7890	609.47	29559.2
195	38025	7414875	13.9642	5.7989	612.61	29864.8
196	38416	7529536	14.0000	5.8088	615.75	30171.9
197	38809	7645373	14.0357	5.8186	618.89	30480.5
198	39204	7762392	14.0712	5.8285	622.04	30790.7
199	39601	7880599	14.1067	5.8383	625.18	31102.6
200	40000	8000000	14.1421	5.8480	628.32	31415.9

Squares, Cubes, Square Roots, Cube Roots, Circumferences and Circular Areas of Nos. from 1 to 520

No.	Square	Cube	Sq. Root	Cube Root	Circle Circum.	Circle Area
201	40401	8120601	14.1774	5.8578	631.46	31730.9
202	40804	8242408	14.2127	5.8675	634.60	32047.4
203	41209	8365427	14.2478	5.8771	637.74	32365.5
204	41616	8489664	14.2829	5.8868	640.89	32685.1
205	42025	8615125	14.3178	5.8964	644.03	33006.4
206	42436	8741816	14.3527	5.9059	647.17	33329.2
207	42849	8869743	14.3875	5.9155	650.31	33653.5
208	43264	8998912	14.4222	5.9250	653.45	33979.5
209	43681	9129329	14.4568	5.9345	656.59	34307.0
210	44100	9261000	14.4914	5.9439	659.73	34636.1
211	44521	9393931	14.5258	5.9533	662.88	34966.7
212	44944	9528128	14.5602	5.9627	666.02	35298.9
213	45369	9663597	14.5945	5.9721	669.16	35632.7
214	45796	9800344	14.6287	5.9814	672.30	35968.1
215	46225	9938375	14.6629	5.9907	675.44	36305.0
216	46656	10077696	14.6969	6.0000	678.58	36643.5
217	47089	10218313	14.7309	6.0092	681.73	36983.6
218	47524	10360232	14.7648	6.0185	684.87	37325.3
219	47961	10503459	14.7986	6.0277	688.01	37668.5
220	48400	10648000	14.8324	6.0368	691.15	38013.3
221	48841	10793861	14.8661	6.0459	694.29	38359.6
222	49284	10941048	14.8997	6.0550	697.43	38707.6
223	49729	11089567	14.9332	6.0641	700.58	39057.1
224	50176	11239424	14.9666	6.0732	703.72	39408.1
225	50625	11390625	15.0000	6.0822	706.86	39760.8
226	51076	11543176	15.0333	6.0912	710.00	40115.0
227	51529	11697083	15.0665	6.1002	713.14	40470.8
228	51984	11852352	15.0997	6.1091	716.28	40828.1
229	52441	12008989	15.1327	6.1180	719.42	41187.1
230	52900	12167000	15.1658	6.1269	722.57	41547.6
231	53361	12326391	15.1987	6.1358	725.71	41909.6
232	53824	12487168	15.2315	6.1446	728.85	42273.3
233	54289	12649337	15.2643	6.1534	731.99	42638.5
234	54756	12812904	15.2971	6.1622	735.13	43005.3
235	55225	12977875	15.3297	6.1710	738.27	43373.6
236	55696	13144256	15.3623	6.1797	741.42	43743.5
237	56169	13312053	15.3948	6.1885	744.56	44115.0
238	56644	13481272	15.4272	6.1972	747.70	44488.1
239	57121	13651919	15.4596	6.2058	750.84	44862.7
240	57600	13824000	15.4919	6.2145	753.98	45238.9

Squares, Cubes, Square Roots, Cube Roots, Circumferences and Circular Areas of Nos. from 1 to 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
241	58081	13997521	15.5242	6.2231	757.12	45616.7
242	58564	14172488	15.5563	6.2317	760.27	45996.1
243	59049	14348907	15.5885	6.2403	763.41	46377.0
244	59536	14526784	15.6205	6.2488	766.55	46759.5
245	60025	14706125	15.6525	6.2573	769.69	47143.5
246	60516	14886936	15.6844	6.2658	772.83	47529.2
247	61009	15069223	15.7162	6.2743	775.97	47916.4
248	61504	15252992	15.7480	6.2828	779.12	48305.1
249	62001	15438249	15.7797	6.2912	782.26	48695.5
250	62500	15625000	15,8114	6.2996	785.40	49087.4
251	63001	15813251	15.8430	6.3080	788.54	49480.9
252	63504	16003008	15.8745	6.3164	791.68	49875.9
253	64009	16194277	15.9060	6.3247	794.82	50272.6
254	64516	16387064	15.9374	6.3330	797.96	50670.7
255	65025	16581375	15.9687	6.3413	801.11	51070.5
256	65536	16777216	16.0000	6.3496	804.25	51471.9
257	66049	16974593	16.0312	6.3579	807.39	51874.8
258	66564	17173512	16.0624	6.3661	810.53	52279.2
259	67081	17373979	16.0935	6.3743	813.67	52685.3
260	67600	17576000	16.1245	6.3825	816.81	53092.9
261	68121	17779581	16.1555	6.3907	819.96	53502.1
262	68644	17984728	16.1864	6.3988	823.10	53912.9
263	69169	18191447	16.2173	6.4070	826.24	54325.2
264	69696	18399744	16.2481	6.4151	829.38	54739.1
265	70225	18609625	16.2788	6.4232	832.52	55154.6
266	70756	18821096	16.3095	6.4312	835.66	55571.6
267	71289	19034163	16.3401	6.4393	838.81	55990.3
268	71824	19248832	16.3707	6.4473	841.95	56410.4
269	72361	19465109	16.4012	6.4553	845.09	56832.2
270	72900	19683000	16.4317	6.4633	848.23	57255.5
271	73441	19902511	16.4621	6.4713	851.37	57680.4
272	73984	20123648	16.4924	6.4792	854.51	58106.9
273	74529	20346417	16.5227	6.4872	857.66	58534.9
274	75076	20570824	16.5529	6.4951	860.80	58964.6
275	75625	20796875	16.5831	6.5030	863.94	59395.7
276	76176	21024576	16.6132	6.5108	867.08	59828.5
277	76729	21253933	16.6433	6.5187	870.22	60262.8
278	77284	21484952	16.6733	6.5265	873.36	60698.7
279	77841	21717639	16.7033	6.5343	876.50	61136.2
280	78400	21952000	16.7332	6.5421	879.65	61575.2

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
281	78961	22188041	16.7631	6.5499	882.79	62015.8
282	79524	22425768	16.7929	6.5577	885.93	62458.0
283	80089	22665187	16.8226	6.5654	889.07	62901.8
284	80656	22906304	16.8523	6.5731	892.21	63347.1
285	81225	23149125	16.8819	6.5808	895.35	63794.0
286	81796	23393656	16.9115	6.5885	898.50	64242.4
287	82369	23639903	16.9411	6.5962	901.64	64692.5
288	82944	23887872	16.9706	6.6039	904.78	65144.1
289	83521	24137569	17.0000	6.6115	907.92	65597.2
290	84100	24389000	17.0294	6.6191	911.06	66052.0
291	84681	24642171	17.0587	6.6267	914.20	66508.3
292	85264	24897088	17.0880	6.6343	917.35	66966.2
293	85849	25153757	17.1172	6.6419	920.49	67425.6
294	86436	25412184	17.1464	6.6494	923.63	67886.7
295	87025	25672375	17.1756	6.6569	926.77	68349.3
296	87616	25934336	17.2047	6.6644	929.91	68813.5
297	88209	26198073	17.2337	6.6719	933.05	69279.2
298	88804	26463592	17.2627	6.6794	936.19	69746.5
299	89401	26730899	17.2916	6.6869	939.34	70215.4
300	90000	27000000	17.3205	6.6943	942.48	70685.8
301	90601	27270901	17.3494	6.7018	945.62	71157.9
302	91204	27543608	17.3781	6.7092	948.76	71631.5
303	91809	27818127	17.4069	6.7166	951.90	72106.6
304	92416	28094464	17.4356	6.7240	955.04	72583.4
305	93025	28372625	17.4642	6.7313	958.19	73061.7
306	93636	28652616	17.4929	6.7387	961.33	73541.5
307	94249	28934443	17.5214	6.7460	964.47	74023.0
308	94864	29218112	17.5499	6.7533	967.61	74506.0
309	95481	29503629	17.5784	6.7606	970.75	74990.6
310	96100	29791000	17.6068	6.7679	973.89	75476.8
311	96721	30080231	17.6352	6.7752	977.04	75964.5
312	97344	30371328	17.6635	6.7824	980.18	76453.8
313	97969	30664297	17.6918	6.7897	983.32	76944.7
314	98596	30959144	17.7200	6.7969	986.46	77437.1
315	99225	31255875	17.7482	6.8041	989.60	77931.1
316	99856	31554496	17.7764	6.8113	992.74	78426.7
317	100489	31855013	17.8045	6.8185	995.88	78923.9
318	101124	32157432	17.8326	6.8256	999.03	79422.6
319	101761	32461759	17.8606	6.8328	1002.20	79922.9
320	102400	32768000	17.8885	6.8399	1005.30	80424.8

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
321	103041	33076161	17.9165	6.8470	1008.5	80928.2
322	103684	33386248	17.9444	6.8541	1011.6	81433.2
323	104329	33698267	17.9722	6.8612	1014.7	81939.8
324	104976	34012224	18.0000	6.8683	1017.9	82448.0
325	105625	34328125	18.0278	6.8753	1021.0	82957.7
326	106276	34645976	18.0555	6.8824	1024.2	83469.0
327	106929	34965783	18.0831	6.8894	1027.3	83981.8
328	107584	35287552	18.1108	6.8964	1030.4	84496.3
329	108241	35611289	18.1384	6.9034	1033.6	85012.3
330	108900	35937000	18.1659	6.9104	1036.7	85529.9
331	109561	36264691	18.1934	6.9174	1039.9	86049.0
332	110224	36594368	18.2209	6.9244	1043.0	86569.7
333	110889	36926037	18.2483	6.9313	1046.2	87092.0
334	111556	37259704	18.2757	6.9382	1049.3	87615.9
335	112225	37595375	18.3030	6.9451	1052.4	88141.3
336	112896	37933056	18.3303	6.9521	1055.6	88668.3
337	113569	38272753	18.3576	6.9589	1058.7	89196.9
338	114244	38614472	18.3848	6.9658	1061.9	89727.0
339	114921	38958219	18.4120	6.9727	1065.0	90258.7
340	115600	39304000	18.4391	6.9795	1068.1	90792.0
341	116281	39651821	18.4662	6.9864	1071.3	91326.9
342	116964	40001688	18.4932	6.9932	1074.4	91863.3
343	117649	40353607	18.5203	7.0000	1077.6	92401.3
344	118336	40707584	18.5472	7.0068	1080.7	92940.9
345	119025	41063625	18.5742	7.0136	1083.8	93482.0
346	119716	41421736	18.6011	7.0203	1087.0	94024.7
347	120409	41781923	18.6279	7.0271	1090.1	94569.0
348	121104	42144192	18.6548	7.0338	1093.3	95114.9
349	121801	42508549	18.6815	7.0406	1096.4	95662.3
350	122500	42875000	18.7083	7.0473	1099.6	96211.3
351	123201	43243551	18.7350	7.0540	1102.7	96761.8
352	123904	43614208	18.7617	7.0607	1105.8	97314.0
353	124609	43986977	18.7883	7.0674	1109.0	97867.7
354	125316	44361864	18.8149	7.0740	1112.1	98423.0
355	126025	44738875	18.8414	7.0807	1115.3	98979.8
356	126736	45118016	18.8680	7.0873	1118.4	99538.2
357	127449	45499293	18.8944	7.0940	1121.5	100098
358	128164	45882712	18.9209	7.1006	1124.7	100660
359	128881	46268279	18.9473	7.1072	1127.8	101223
360	129600	46656000	18.9737	7.1138	1131.0	101788

Squares, Cubes, Square Roots, Cube Roots, Circumferences and Circular Areas of Nos. from 1 to 520

No.	Square	Cube	Sq. Root	Cube Root	Circle Circum.	Circle Area
361	130321	47045881	19.0000	7.1204	1134.1	102354
362	131044	47437928	19.0263	7.1269	1137.3	102922
363	131769	47832147	19.0526	7.1335	1140.4	103491
364	132496	48228544	19.0788	7.1400	1143.5	104062
365	133225	48627125	19.1050	7.1466	1146.7	104635
366	133956	49027896	19.1311	7.1531	1149.8	105209
367	134689	49430863	19.1572	7.1596	1153.0	105785
368	135424	49836032	19.1833	7.1661	1156.1	106362
369	136161	50243409	19.2094	7.1726	1159.2	106941
370	136900	50653000	19.2354	7.1791	1162.4	107521
371	137641	51064811	19.2614	7.1855	1165.5	108103
372	138384	51478848	19.2873	7.1920	1168.7	108687
373	139129	51895117	19.3132	7.1984	1171.8	109272
374	139876	52313624	19.3391	7.2048	1175.0	109858
375	140625	52734375	19.3649	7.2112	1178.1	110447
376	141376	53157376	19.3907	7.2177	1181.2	111036
377	142129	53582633	19.4165	7.2240	1184.4	111628
378	142884	54010152	19.4422	7.2304	1187.5	112221
379	143641	54439939	19.4679	7.2368	1190.7	112815
380	144400	54872000	19.4936	7.2432	1193.8	113411
381	145161	55306341	19.5192	7.2495	1196.9	114009
382	145924	55742968	19.5448	7.2558	1200.1	114608
383	146689	56181887	19.5704	7.2622	1203.2	115209
384	147456	56623104	19.5959	7.2685	1206.4	115812
385	148225	57066625	19.6214	7.2748	1209.5	116416
386	148996	57512456	19.6469	7.2811	1212.7	117021
387	149769	57960603	19.6723	7.2874	1215.8	117628
388	150544	58411072	19.6977	7.2936	1218.9	118237
389	151321	58863869	19.7231	7.2999	1222.1	118847
390	152100	59319000	19.7484	7.3061	1225.2	119459
391	152881	59776471	19.7737	7.3124	1228.4	120072
392	153664	60236288	19.7990	7.3186	1231.5	120687
393	154449	60698457	19.8242	7.3248	1234.6	121304
394	155236	61162984	19.8494	7.3310	1237.8	121922
395	156025	61629875	19.8746	7.3372	1240.9	122542
396	156816	62099136	19.8997	7.3434	1244.1	123163
397	157609	62570773	19.9249	7.3496	1247.2	123786
398	158404	63044792	19.9499	7.3558	1250.4	124410
399	159201	63521199	19.9750	7.3619	1253.5	125036
400	160000	64000000	20.0000	7.3684	1256.6	125664

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES, AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
401	160801	64481201	20.0250	7.3742	1259.8	126293
402	161604	64964808	20.0499	7.3803	1262.9	126923
403	162409	65450827	20.0749	7.3864	1266.1	127556
404	163216	65939264	20.0998	7.3925	1269.2	128190
405	164025	66430125	20.1246	7.3986	1272.3	128825
406	164836	66923416	20.1494	7.4047	1275.5	129462
407	165649	67419143	20.1742	7.4108	1278.6	130100
408	166464	67917312	20.1990	7.4169	1281.8	130741
409	167281	68417929	20.2237	7.4229	1284.9	131382
410	168100	68921000	20.2485	7.4290	1288.1	132025
411	168921	69426531	20.2731	7.4350	1291.2	132670
412	169744	69934528	20.2978	7.4410	1294.3	133317
413	170569	70444997	20.3224	7.4470	1297.5	133965
414	171396	70957944	20.3470	7.4530	1300.6	134614
415	172225	71473375	20.3715	7.4590	1303.8	135265
416	173056	71991296	20.3961	7.4650	1306.9	135918
417	173889	72511713	20.4206	7.4710	1310.0	136572
418	174724	73034632	20.4450	7.4770	1313.2	137228
419	175561	73560059	20.4695	7.4829	1316.3	137885
420	176400	74088000	20.4939	7.4889	1319.5	138544
421	177241	74618461	20.5183	7.4948	1322.6	139205
422	178084	75151448	20.5426	7.5007	1325.8	139867
423	178929	75686967	20.5670	7.5067	1328.9	140531
424	179776	76225024	20.5913	7.5126	1332.0	141196
425	180625	76765625	20.6155	7.5185	1335.2	141863
426	181476	77308776	20.6398	7.5244	1338.3	142531
427	182329	77854483	20.6640	7.5302	1341.5	143201
428	183184	78402752	20.6882	7.5361	1344.6	143872
429	184041	78953589	20.7123	7.5420	1347.7	144545
430	184900	79507000	20.7364	7.5478	1350.9	145220
431	185761	80062991	20.7605	7.5537	1354.0	145896
432	186624	80621568	20.7846	7.5595	1357.2	146574
433	187489	81182737	20.8087	7.5654	1360.3	147254
434	188356	81746504	20.8327	7.5712	1363.5	147934
435	189225	82312875	20.8567	7.5770	1366.6	148617
436	190096	82881856	20.8806	7.5828	1369.7	149301
437	190969	83453453	20.9045	7.5886	1372.9	149987
438	191844	84027672	20.9284	7.5944	1376.0	150674
439	192721	84604519	20.9523	7.6001	1379.2	151363
440	193600	85184000	20.9762	7.6059	1382.3	152053

Squares, Cubes, Square Roots, Cube Roots, Circumferences and Circular Areas of Nos. from 1 to 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
441	194481	85766121	21.0000	7.6117	1385.4	152745
442	195364	86350888	21.0238	7.6174	1388.6	153439
443	196249	86938307	21.0476	7.6232	1391.7	154134
444	197136	87528384	21.0713	7.6289	1394.9	154830
445	198025	88121125	21.0950	7.6346	1398.0	155528
446	198916	88716536	21.1187	7.6403	1401.2	156228
447	199809	89314623	21.1424	7.6460	1404.3	156930
448	200704	89915392	21.1660	7.6517	1407.4	157633
449	201601	90518849	21.1896	7.6574	1410.6	158337
450	202500	91125000	21.2132	7.6631	1413.7	159043
451	203401	91733851	21.2368	7.6688	1416.9	159751
452	204304	92345408	21.2603	7.6744	1420.0	160460
453	205209	92959677	21.2838	7.6801	1423.1	161171
454	206116	93576664	21.3073	7.6857	1426.3	161883
455	207025	94196375	21.3307	7.6914	1429.4	162597
456	207936	94818816	21.3542	7.6970	1432.6	163313
457	208849	95443993	21.3776	7.7026	1435.7	164030
458	209764	96071912	21.4009	7.7082	1438.9	164748
459	210681	96702579	21.4243	7.7138	1442.0	165468
460	211600	97336000	21.4476	7.7194	1445.1	166190
461	212521	97972181	21.4709	7.7250	1448.3	166914
462	213444	98611128	21.4942	7.7306	1451.4	167639
463	214369	99252847	21.5174	7.7362	1454.6	168365
464	215296	99897344	21.5407	7.7418	1457.7	169093
465	216225	100544625	21.5639	7.7473	1460.8	169823
466	217156	101194696	21.5870	7.7529	1464.0	170554
467	218089	101847563	21.6102	7.7584	1467.1	171287
468	219024	102503232	21.6333	7.7639	1470.3	172021
469	219961	103161709	21.6564	7.7695	1473.4	172757
470	220900	103823000	21.6795	7.7750	1476.5	173494
471	221841	104487111	21.7025	7.7805	1479.7	174234
472	222784	105154048	21.7256	7.7860	1482.8	174974
473	223729	105823817	21.7486	7.7915	1486.0	175716
474	224676	106496424	21.7715	7.7970	1489.1	176460
475	225625	107171875	21.7945	7.8025	1492.3	177205
476	226576	107850176	21.8174	7.8079	1495.4	177952
477	227529	108531333	21.8403	7.8134	1498.5	178701
478	228484	109215352	21.8632	7.8188	1501.7	179451
479	229441	109902239	21.8861	7.8243	1504.8	180203
480	230400	110592000	21.9089	7.8297	1508.0	180956

SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, CIRCUMFERENCES AND CIRCULAR AREAS OF NOS. FROM 1 TO 520

No.	Square	Cube	Sq. Root	Cube Root	Circle	
					Circum.	Area
481	231361	111284641	21.9317	7.8352	1511.1	181711
482	232324	111980168	21.9545	7.8406	1514.3	182467
483	233289	112678587	21.9773	7.8460	1517.4	183225
484	234256	113379904	22.0000	7.8514	1520.5	183984
485	235225	114084125	22.0227	7.8568	1523.7	184745
486	236196	114791256	22.0454	7.8622	1526.8	185508
487	237169	115501303	22.0681	7.8676	1530.0	186272
488	238144	116214272	22.0907	7.8730	1533.1	187038
489	239121	116930169	22.1133	7.8784	1536.2	187805
490	240100	117649000	22.1359	7.8837	1539.4	188574
491	241081	118370771	22.1585	7.8891	1542.5	189345
492	242064	119095488	22.1811	7.8944	1545.7	190117
493	243049	119823157	22.2036	7.8998	1548.8	190890
494	244036	120553784	22.2261	7.9051	1551.9	191665
495	245025	121287375	22.2486	7.9105	1555.1	192442
496	246016	122023936	22.2711	7.9158	1558.2	193221
497	247009	122763473	22.2935	7.9211	1561.4	194000
498	248004	123505992	22.3159	7.9264	1564.5	194782
499	249001	124251499	22.3383	7.9317	1567.7	195565
500	250000	125000000	22.3607	7.9370	1570.8	196350
501	251001	125751501	22.3830	7.9423	1573.9	197136
502	252004	126506008	22.4054	7.9476	1577.1	197923
503	253009	127263527	22.4277	7.9528	1580.2	198713
504	254016	128024064	22.4499	7.9581	1583.4	199504
505	255025	128787625	22.4722	7.9634	1586.5	200296
506	256036	129554216	22.4944	7.9686	1589.7	201090
507	257049	130323843	22.5167	7.9739	1592.8	201886
508	258064	131096512	22.5389	7.9791	1595.9	202683
509	259081	131872229	22.5610	7.9843	1599.1	203482
510	260100	132651000	22.5832	7.9896	1602.2	204282
511	261121	133432831	22.6053	7.9948	1605.4	205084
512	262144	134217728	22.6274	8.0000	1608.5	205887
513	263169	135005697	22.6495	8.0052	1611.6	206692
514	264196	135796744	22.6716	8.0104	1614.8	207499
515	265225	136590875	22.6936	8.0156	1617.9	208307
516	266256	137388096	22.7156	8.0208	1621.1	209117
517	267289	138188413	22.7376	8.0260	1624.2	209928
518	268324	138991832	22.7596	8.0311	1627.3	210741
519	269361	139798359	22.7816	8.0363	1630.5	211556
520	270400	140608000	22.8035	8.0415	1633.6	212372

2 SINE AND COSINE FUNCTIONS.

Deg.	Sine. 0′	10′	20′	30′	40′	50′	60′	Deg.
0	0.00000	0.00291	0.00582	0.00873	0.01164	0.01454	0.01745	89
1	0.01745	0.02036	0.02327	0.02618	0.02908	0.03199	0.03490	88
2	0.03490	0.03781	0.04071	0.04362	0.04653	0.04943	0.05234	87
3	0.05234	0.05524	0.05814	0.06105	0.06395	0.06685	0.06976	86
4	0.06976	0.07266	0.07556	0.07846	0.08136	0.08426	0.08716	85
5	0.08716	0.09005	0.09295	0.09585	0.09874	0.10164	0.10453	84
6	0.10453	0.10742	0.11031	0.11320	0.11609	0.11898	0.12187	83
7	0.12187	0.12476	0.12764	0.13053	0.13341	0.13629	0.13917	82
8	0.13917	0.14205	0.14493	0.14781	0.15069	0.15356	0.15643	81
9	0.15643	0.15931	0.16218	0.16505	0.16792	0.17078	0.17365	80
10	0.17365	0.17651	0.17937	0.18224	0.18509	0.18795	0.19081	79
11	0.19081	0.19366	0.19652	0.19937	0.20222	0.20507	0.20791	78
12	0.20791	0.21076	0.21360	0.21644	0.21928	0.22212	0.22495	77
13	0.22495	0.22778	0.23062	0.23345	0.23627	0.23910	0.24192	76
14	0.24192	0.24474	0.24756	0.25038	0.25320	0.25601	0.25882	75
15	0.25882	0.26163	0.26443	0.26724	0.27004	0.27284	0.27564	74
16	0.27564	0.27843	0.28123	0.28402	0.28680	0.28959	0.29237	73
17	0.29237	0.29515	0.29793	0.30071	0.30348	0.30625	0.30902	72
18	0.30902	0.31178	0.31454	0.31730	0.32006	0.32282	0.32557	71
19	0.32557	0.32832	0.33106	0.33381	0.33655	0.33929	0.34202	70
20	0.34202	0.34475	0.34748	0.35021	0.35293	0.35565	0.35837	69
21	0.35837	0.36108	0.36379	0.36650	0.36921	0.37191	0.37461	68
22	0.37461	0.37730	0.37999	0.38268	0.38537	0.38805	0.39073	67
23	0.39073	0.39341	0.39608	0.39875	0.40142	0.40408	0.40674	66
24	0.40674	0.40939	0.41204	0.41469	0.41734	0.41998	0.42262	65
25	0.42262	0.42525	0.42788	0.43051	0.43313	0.43575	0.43837	64
26	0.43837	0.44098	0.44359	0.44620	0.44880	0.45140	0.45399	63
27	0.45399	0.45658	0.45917	0.46175	0.46433	0.46690	0.46947	62
28	0.46947	0.47204	0.47460	0.47716	0.47971	0.48226	0.48481	61
29	0.48481	0.48735	0.48989	0.49242	0.49495	0.49748	0.50000	60
30	0.50000	0.50252	0.50503	0.50754	0.51004	0.51254	0.51504	59
31	0.51504	0.51753	0.52002	0.52250	0.52498	0.52745	0.52992	58
32	0.52992	0.53238	0.53484	0.53730	0.53975	0.54220	0.54464	57
33	0.54464	0.54708	0.54951	0.55194	0.55436	0.55678	0.55919	56
34	0.55919	0.56160	0.56401	0.56641	0.56880	0.57119	0.57358	55
35	0.57358	0.57596	0.57833	0.58070	0.58307	0.58543	0.58779	54
36	0.58779	0.59014	0.59248	0.59482	0.59716	0.59949	0.60182	53
37	0.60182	0.60414	0.60645	0.60876	0.61107	0.61337	0.61566	52
38	0.61566	0.61795	0.62024	0.62251	0.62479	0.62706	0.62932	51
39	0.62932	0.63158	0.63383	0.63608	0.63832	0.64056	0.64279	50
40	0.64279	0.64501	0.64723	0.64945	0.65166	0.65386	0.65606	49
41	0.65606	0.65825	0.66044	0.66262	0.66480	0.66697	0.66913	48
42	0.66913	0.67129	0.67344	0.67559	0.67773	0.67987	0.68200	47
43	0.68200	0.68412	0.68624	0.68835	0.69046	0.69256	0.69466	46
44	0.69466	0.69675	0.69883	0.70091	0.70298	0.70505	0.70711	45
	60′	50′	40′	30′	20′	10′	0′	
	Cosine.							

Cosine.

Deg.	0′	10′	20′	30′	40′	50′	60′	Deg.
0	1.00000	1.00000	0.99998	0.99996	0.99993	0.99989	0.99985	89
1	0.99985	0.99979	0.99973	0.99966	0.99958	0.99949	0.99939	88
2	0.99939	0.99929	0.99917	0.99905	0.99892	0.99878	0.99863	87
3	0.99863	0.99847	0.99831	0.99813	0.99795	0.99776	0.99756	86
4	0.99756	0.99736	0.99714	0.99692	0.99668	0.99644	0.99619	85
5	0.99619	0.99594	0.99567	0.99540	0.99511	0.99482	0.99452	84
6	0.99452	0.99421	0.99390	0.99357	0.99324	0.99290	0.99255	83
7	0.99255	0.99219	0.99182	0.99144	0.99106	0.99067	0.99027	82
8	0.99027	0.98986	0.98944	0.98902	0.98858	0.98814	0.98769	81
9	0.98769	0.98723	0.98676	0.98629	0.98580	0.98531	0.98481	80
10	0.98481	0.98430	0.98378	0.98325	0.98272	0.98218	0.98163	79
11	0.98163	0.98107	0.98050	0.97992	0.97934	0.97875	0.97815	78
12	0.97815	0.97754	0.97692	0.97630	0.97566	0.97502	0.97437	77
13	0.97437	0.97371	0.97304	0.97237	0.97169	0.97100	0.97030	76
14	0.97030	0.96959	0.96887	0.96815	0.96742	0.96667	0.96593	75
15	0.96593	0.96517	0.96440	0.96363	0.96285	0.96206	0.96126	74
16	0.96126	0.96046	0.95964	0.95882	0.95799	0.95715	0.95630	73
17	0.95630	0.95545	0.95459	0.95372	0.95284	0.95195	0.95106	72
18	0.95106	0.95015	0.94924	0.94832	0.94740	0.94646	0.94552	71
19	0.94552	0.94457	0.94361	0.94264	0.94167	0.94068	0.93969	70
20	0.93969	0.93869	0.93769	0.93667	0.93565	0.93462	0.93358	69
21	0.93358	0.93253	0.93148	0.93042	0.92935	0.92827	0.92718	68
22	0.92718	0.92609	0.92499	0.92388	0.92276	0.92164	0.92050	67
23	0.92050	0.91936	0.91822	0.91706	0.91590	0.91472	0.91355	66
24	0.91355	0.91236	0.91116	0.90996	0.90875	0.90753	0.90631	65
25	0.90631	0.90507	0.90383	0.90259	0.90133	0.90007	0.89879	64
26	0.89879	0.89752	0.89623	0.89493	0.89363	0.89232	0.89101	63
27	0.89101	0.88968	0.88835	0.88701	0.88566	0.88431	0.88295	62
28	0.88295	0.88158	0.88020	0.87882	0.87743	0.87603	0.87462	61
29	0.87462	0.87321	0.87178	0.87036	0.86892	0.86748	0.86603	60
30	0.86603	0.86457	0.86310	0.86163	0.86015	0.85866	0.85717	59
31	0.85717	0.85567	0.85416	0.85264	0.85112	0.84959	0.84805	58
32	0.84805	0.84650	0.84495	0.84339	0.84182	0.84025	0.83867	57
33	0.83867	0.83708	0.83549	0.83389	0.83228	0.83066	0.82904	56
34	0.82904	0.82741	0.82577	0.82413	0.82248	0.82082	0.81915	55
35	0.81915	0.81748	0.81580	0.81412	0.81242	0.81072	0.80902	54
36	0.80902	0.80730	0.80558	0.80386	0.80212	0.80038	0.79864	53
37	0.79864	0.79688	0.79512	0.79335	0.79158	0.78980	0.78801	52
38	0.78801	0.78622	0.78442	0.78261	0.78079	0.77897	0.77715	51
39	0.77715	0.77531	0.77347	0.77162	0.76977	0.76791	0.76604	50
40	0.76604	0.76417	0.76229	0.76041	0.75851	0.75661	0.75471	49
41	0.75471	0.75280	0.75088	0.74896	0.74703	0.74509	0.74314	48
42	0.74314	0.74120	0.73924	0.73728	0.73531	0.73333	0.73135	47
43	0.73135	0.72937	0.72737	0.72537	0.72337	0.72136	0.71934	46
44	0.71934	0.71732	0.71529	0.71325	0.71121	0.70916	0.70711	45
	60′	50′	40′	30′	20′	10′	0′	

Sine

3. TANGENT AND COTANGENT FUNCTIONS.

Tangent.

Deg.	0′	10′	20′	30′	40′	50′	60′	Deg.
0	0.00000	0.00291	0.00582	0.00873	0.01164	0.01455	0.01746	89
1	0.01746	0.02036	0.02328	0.02619	0.02910	0.03201	0.03492	88
2	0.03492	0.03783	0.04075	0.04366	0.04658	0.04949	0.05241	87
3	0.05241	0.05533	0.05824	0.06116	0.06408	0.06700	0.06993	86
4	0.06993	0.07285	0.07578	0.07870	0.08163	0.08456	0.08749	85
5	0.08749	0.09042	0.09335	0.09629	0.09923	0.10216	0.10510	84
6	0.10510	0.10805	0.11099	0.11394	0.11688	0.11983	0.12278	83
7	0.12278	0.12574	0.12869	0.13165	0.13461	0.13758	0.14054	82
8	0.14054	0.14351	0.14648	0.14945	0.15243	0.15540	0.15838	81
9	0.15838	0.16137	0.16435	0.16734	0.17033	0.17333	0.17633	80
10	0.17633	0.17933	0.18233	0.18534	0.18835	0.19136	0.19438	79
11	0.19438	0.19740	0.20042	0.20345	0.20648	0.20952	0.21256	78
12	0.21256	0.21560	0.21864	0.22169	0.22475	0.22781	0.23087	77
13	0.23087	0.23393	0.23700	0.24008	0.24316	0.24624	0.24933	76
14	0.24933	0.25242	0.25552	0.25862	0.26172	0.26483	0.26795	75
15	0.26795	0.27107	0.27419	0.27732	0.28046	0.28360	0.28675	74
16	0.28675	0.28990	0.29305	0.29621	0.29938	0.30255	0.30573	73
17	0.30573	0.30891	0.31210	0.31530	0.31850	0.32171	0.32492	72
18	0.32492	0.32814	0.33136	0.33460	0.33783	0.34108	0.34433	71
19	0.34433	0.34758	0.35085	0.35412	0.35740	0.36068	0.36397	70
20	0.36397	0.36727	0.37057	0.37388	0.37720	0.38053	0.38386	69
21	0.38386	0.38721	0.39055	0.39391	0.39727	0.40065	0.40403	68
22	0.40403	0.40741	0.41081	0.41421	0.41763	0.42105	0.42447	67
23	0.42447	0.42791	0.43136	0.43481	0.43828	0.44175	0.44523	66
24	0.44523	0.44872	0.45222	0.45573	0.45924	0.46277	0.46631	65
25	0.46631	0.46985	0.47341	0.47698	0.48055	0.48414	0.48773	64
26	0.48773	0.49134	0.49495	0.49858	0.50222	0.50587	0.50953	63
27	0.50953	0.51320	0.51688	0.52057	0.52427	0.52798	0.53171	62
28	0.53171	0.53545	0.53920	0.54296	0.54673	0.55051	0.55431	61
29	0.55431	0.55812	0.56194	0.56577	0.56962	0.57348	0.57735	60
30	0.57735	0.58124	0.58513	0.58905	0.59297	0.59691	0.60086	59
31	0.60086	0.60483	0.60881	0.61280	0.61681	0.62083	0.62487	58
32	0.62487	0.62892	0.63299	0.63707	0.64117	0.64528	0.64941	57
33	0.64941	0.65355	0.65771	0.66189	0.66608	0.67028	0.67451	56
34	0.67451	0.67875	0.68301	0.68728	0.69157	0.69588	0.70021	55
35	0.70021	0.70455	0.70891	0.71329	0.71769	0.72211	0.72654	54
36	0.72654	0.73100	0.73547	0.73996	0.74447	0.74900	0.75355	53
37	0.75355	0.75812	0.76272	0.76733	0.77196	0.77661	0.78129	52
38	0.78129	0.78598	0.79070	0.79544	0.80020	0.80498	0.80978	51
39	0.80978	0.81461	0.81946	0.82434	0.82923	0.83415	0.83910	50
40	0.83910	0.84407	0.84906	0.85408	0.85912	0.86419	0.86929	49
41	0.86929	0.87441	0.87955	0.88473	0.88992	0.89515	0.90040	48
42	0.90040	0.90569	0.91099	0.91633	0.92170	0.92709	0.93252	47
43	0.93252	0.93797	0.94345	0.94896	0.95451	0.96008	0.96569	46
44	0.96569	0.97133	0.97700	0.98270	0.98843	0.99420	1.00000	45
	60′	50′	40′	30′	20′	10′	0′	

Cotangent.

Cotangent.

Deg	0′	10′	20′	30′	40′	50′	60′	Deg
0	00	343.77371	171.88540	114.58865	85.93979	68.75009	57.28996	89
1	57.28996	49.10388	42.96408	38.18846	34.36777	31.24158	28.63625	88
2	28.63625	26.43160	24.54176	22.90377	21.47040	20.20555	19.08114	87
3	19.08114	18.07498	17.16934	16.34986	15.60478	14.92442	14.30067	86
4	14.30067	13.72674	13.19688	12.70621	12.25051	11.82617	11.43005	85
5	11.43005	11.05943	10.71191	10.38540	10.07803	9.78817	9.51436	84
6	9.51436	9.25530	9.00983	8.77689	8.55555	8.34496	8.14435	83
7	8.14435	7.95302	7.77035	7.59575	7.42871	7.26873	7.11537	82
8	7.11537	6.96823	6.82694	6.69116	6.56055	6.43484	6.31375	81
9	6.31375	6.19703	6.08444	5.97576	5.87080	5.76937	5.67128	80
10	5.67128	5.57638	5.48451	5.39552	5.30928	5.22566	5.14455	79
11	5.14455	5.06584	4.98940	4.91516	4.84300	4.77286	4.70463	78
12	4.70463	4.63825	4.57363	4.51071	4.44942	4.38969	4.33148	77
13	4.33148	4.27471	4.21933	4.16530	4.11256	4.06107	4.01078	76
14	4.01078	3.96165	3.91364	3.86671	3.82083	3.77595	3.73205	75
15	3.73205	3.68909	3.64705	3.60588	3.56577	3.52609	3.48741	74
16	3.48741	3.44951	3.41236	3.37594	3.34023	3.30521	3.27085	73
17	3.27085	3.23714	3.20406	3.17159	3.13972	3.10842	3.07768	72
18	3.07768	3.04749	3.01783	2.98869	2.96004	2.93189	2.90421	71
19	2.90421	2.87700	2.85023	2.82391	2.79802	2.77254	2.74748	70
20	2.74748	2.72281	2.69853	2.67462	2.65109	2.62791	2.60509	69
21	2.60509	2.58261	2.56046	2.53865	2.51715	2.49597	2.47509	68
22	2.47509	2.45451	2.43422	2.41421	2.39449	2.37504	2.35585	67
23	2.35585	2.33693	2.31826	2.29984	2.28167	2.26374	2.24604	66
24	2.24604	2.22857	2.21132	2.19430	2.17749	2.16090	2.14451	65
25	2.14451	2.12832	2.11233	2.09654	2.08094	2.06553	2.05030	64
26	2.05030	2.03526	2.02039	2.00569	1.99116	1.97680	1.96261	63
27	1.96261	1.94858	1.93470	1.92098	1.90741	1.89400	1.88073	62
28	1.88073	1.86760	1.85462	1.84177	1.82906	1.81649	1.80405	61
29	1.80405	1.79174	1.77955	1.76749	1.75556	1.74375	1.73205	60
30	1.73205	1.72047	1.70901	1.69766	1.68643	1.67530	1.66428	59
31	1.66428	1.65337	1.64256	1.63185	1.62125	1.61074	1.60033	58
32	1.60033	1.59002	1.57981	1.56969	1.55966	1.54972	1.53987	57
33	1.53987	1.53010	1.52043	1.50184	1.50133	1.49190	1.48256	56
34	1.48256	1.47330	1.46411	1.45501	1.44598	1.43703	1.42815	55
35	1.42815	1.41934	1.41061	1.40195	1.39336	1.38484	1.37638	54
36	1.37638	1.36800	1.35968	1.35142	1.34323	1.33511	1.32704	53
37	1.32704	1.31904	1.31110	1.30323	1.29541	1.28764	1.27994	52
38	1.27994	1.27230	1.26471	1.25717	1.24969	1.24227	1.23490	51
39	1.23490	1.22758	1.22031	1.21310	1.20593	1.19882	1.19175	50
40	1.19175	1.18474	1.17777	1.17085	1.16398	1.15715	1.15037	49
41	1.15037	1.14363	1.13694	1.13029	1.12369	1.11713	1.11061	48
42	1.11061	1.10414	1.09770	1.09131	1.08496	1.07864	1.07237	47
43	1.07237	1.06613	1.05994	1.05378	1.04766	1.04158	1.03553	46
44	1.03553	1.02952	1.02355	1.01761	1.01170	1.00583	1.00000	45
	60′	50′	40′	30′	20′	10′	0′	

Tangent.

4. Common Logarithms.

N	0	1	2	3	4	5	6	7	8	9
10	00,000	00,432	00 860	01,284	01,703	02,119	02,531	02,938	03,342	03,743
11	04,139	04,532	04,922	05,308	05,690	06,070	06,446	06,819	07,188	07,555
12	07,918	08,279	08,636	08,991	09,342	09,691	10,037	10,380	10,721	11,059
13	11,394	11,727	12,057	12,385	12,710	13,033	13,354	13,672	13,988	14,301
14	14,613	14,922	15,229	15,534	15,836	16,137	16,435	16,732	17,026	17,319
15	17,609	17,897	18,184	18,469	18,752	19,033	19,312	19,590	19,866	20,140
16	20,412	20,683	20,952	21,219	21,484	21,748	22,011	22,272	22,531	22,789
17	23,045	23,300	23,553	23,805	24,055	24,304	24,551	24,797	25,042	25,285
18	25,527	25,768	26,007	26,245	26,482	26,717	26,951	27,184	27,416	27,646
19	27,875	28,103	28,330	28,556	28,780	29,003	29,226	29,447	29,667	29,885
20	30,103	30,320	30,535	30,750	30,963	31,175	31,387	31,597	31,806	32,015
21	32,222	32,428	32,634	32,838	33,041	33,244	33,445	33,646	33,846	34,044
22	34,242	34,439	34,635	34,830	35,025	35,218	35,411	35,603	35,793	35,984
23	36,173	36,361	36,549	36,736	36,922	37,107	37,291	37,475	37,658	37,840
24	38,021	38,202	38,382	38,561	38,739	38,917	39,094	39,270	39,445	39,620
25	39,794	39,967	40,140	40,312	40,483	40,654	40,824	40,993	41,162	41,330
26	41,497	41,664	41,830	41,996	42,160	42,325	42,488	42,651	42,813	42,975
27	43,136	43,297	43,457	43,616	43,775	43,933	44,091	44,248	44,404	44,560
28	44,716	44,871	45,025	45,179	45,332	45,484	45,637	45,788	45,939	46,090
29	46,240	46,389	46,538	46,687	46,835	46,982	47,129	47,276	47,422	47,567
30	47,712	47,857	48,001	48,144	48,287	48,430	48,572	48,714	48,855	48,996
31	49,136	49 276	49,415	49,554	49,693	49,831	49,969	50,106	50,243	50,379
32	50,515	50,651	50,786	50,920	51,055	51,188	51,322	51.455	51,587	51,720
33	51,851	51,983	52,114	52,244	52,375	52,504	52,634	52,763	52,892	53,020
34	53,148	53,275	53,403	53,529	53.656	53 782	53,908	54,033	54,158	54,283
35	54,407	54,531	54.654	54,777	54,900	55,023	55,145	55,267	55,388	55,509
36	55,630	55,751	55,871	55,991	56,110	56,229	56,348	56,467	56,585	56,703
37	56,820	56,937	57,054	57,171	57,287	57,403	57,519	57,634	57,749	57,864
38	57,978	58,092	58,206	58,320	58,433	58,546	58,659	58,771	58,883	58,995
39	59,106	59,218	59,329	59,439	59,550	59,660	59,770	59,879	59,988	60,097
40	60,206	60,314	60,423	60,531	60,638	60,746	60,853	60,959	61,066	61,172
41	61,278	61,384	61,490	61,595	61,700	61.805	61,909	62,014	62,118	62,221
42	62 325	62,428	62,531	62,634	62,737	62.839	62,941	63,043	63,144	63,246
43	63.347	63,448	63,548	63,649	63,749	63,849	63,949	64,048	64,147	64,246
44	64,345	64,444	64,542	64,640	64,738	64,836	64,933	65,031	65,128	65,225
45	65,321	65 418	65,514	65,610	65,706	65,801	65.896	65,992	66,087	66,181
46	66,276	66,370	66,464	66,558	66,652	66,745	66,839	66,932	67,025	67,117
47	67 210	67,302	67,394	67,486	67,578	67,669	67,761	67,852	67,943	68,034
48	68,124	68,215	68,305	68,395	68,485	68,574	68,664	68,753	68,842	68,931
49	69,020	69,108	69,197	69,285	69,373	69,461	69,548	69,636	69,723	69,810
50	69,897	69,984	70,070	70,157	70,243	70,329	70,415	70,501	70,586	70,672
51	70,757	70,842	70,927	71,012	71,096	71,181	71,265	71,349	71,433	71,517
52	71,600	71,684	71,767	71,850	71,933	72,016	72,099	72,181	72,263	72,346
53	72,428	72,509	72,591	72,673	72,754	72,835	72,916	72.997	73,078	73,159
54	73,239	73,320	73,400	73,480	73,560	73,640	73,719	73,799	73.878	73,957

4. Common Logarithms.—(*Concluded*).

N	0	1	2	3	4	5	6	7	8	9
55	74,036	74,115	74,194	74,273	74,351	74,429	74,507	74,586	74,663	74,741
56	74,819	74,896	74,974	75,051	75,128	75,205	75,282	75,358	75,435	75,511
57	75,587	75,664	75,740	75,815	75,891	75,967	76,042	76,118	76,193	76,268
58	76,343	76,418	76,492	76,567	76,641	76,716	76,790	76,864	76,938	77,012
59	77,085	77,159	77,232	77,305	77,379	77,452	77,525	77,597	77,670	77,743
60	77,815	77,887	77,960	78,032	78,104	78,176	78,247	78,319	78,390	78,462
61	78,533	78,604	78,675	78,746	78,817	78,888	78,958	79,029	79,099	79,169
62	79,239	79,309	79,379	79,449	79,518	79,588	79,657	79,727	79,796	79,865
63	79,934	80,003	80,072	80,140	80,209	80,277	80,346	80,414	80,482	80,550
64	80,618	80,686	80,754	80,821	80,889	80,956	81,023	81,090	81,158	81,224
65	81,291	81,358	81,425	81,491	81,558	81,624	81,690	81,757	81,823	81,889
66	81,954	82,020	82,086	82,151	82,217	82,282	82,347	82,413	82,478	82,543
67	82,607	82,672	82,737	82,802	82,866	82,930	82,995	83,059	83,123	83,187
68	83,251	83,315	83,378	83,442	83,506	83,569	83,632	83,696	83,759	83,822
69	83,885	83,948	84,011	84,073	84,136	84,198	84,261	84,323	84,386	84,448
70	84,510	84,572	84,634	84,696	84,757	84,819	84,880	84,942	85,003	85,065
71	85,126	85,187	85,248	85,309	85,370	85,431	85,491	85,552	85,612	85,673
72	85,733	85,794	85,854	85,914	85,974	86,034	86,094	86,153	86,213	86,273
73	86,332	86,392	86,451	86,510	86,570	86,629	86,688	86,747	86,806	86,864
74	86,923	86,982	87,040	87,099	87,157	87,216	87,274	87,332	87,390	87,448
75	87,506	87,564	87,622	87,679	87,737	87,795	87,852	87,910	87,967	88,024
76	88,081	88,138	88,195	88,252	88,309	88,366	88,423	88,480	88,536	88,593
77	88,649	88,705	88,762	88,818	88,874	88,930	88,986	89,042	89,098	89,154
78	89,209	89,265	89,321	89,376	89,432	89,487	89,542	89,597	89,653	89,708
79	89,763	89,818	89,873	89,927	89,982	90,037	90,091	90,146	90,200	90,255
80	90,309	90,363	90,417	90,472	90,526	90,580	90,634	90,687	90,741	90,795
81	90,849	90,902	90,956	91,009	91,062	91,116	91,169	91,222	91,275	91,328
82	91,381	91,434	91,487	91,540	91,593	91,645	91,698	91,751	91,803	91,855
83	91,908	91,960	92,012	92,065	92,117	92,169	92,221	92,273	92,324	92,376
84	92,428	92,480	92,531	92,583	92,634	92,686	92,737	92,788	92,840	92,891
85	92,942	92,993	93,044	93,095	93,146	93,197	93,247	93,298	93,349	93,399
86	93,450	93,500	93,551	93,601	93,651	93,702	93,752	93,802	93,852	93,902
87	93,952	94,002	94,052	94,101	94,151	94,201	94,250	94,300	94,349	94,399
88	94,448	94,498	94,547	94,596	94,645	94,694	94,743	94,792	94,841	94,890
89	94,939	94,988	95,036	95,085	95,134	95,182	95,231	95,279	95,328	95,376
90	95,424	95,472	95,521	95,569	95,617	95,665	95,713	95,761	95,809	95,856
91	95,904	95,952	95,999	96,047	96,095	96,142	96,190	96,237	96,284	96,332
92	96,379	96,426	96,473	96,520	96,567	96,614	96,661	96,708	96,775	96,802
93	96,848	96,895	96,942	96,988	97,035	97,081	97,128	97,174	97,220	97,267
94	97,313	97,359	97,405	97,451	97,497	97,543	97,589	97,635	97,681	97,727
95	97,772	97,818	97,864	97,909	97,955	98,000	98.046	98,091	98,137	98,182
96	98,227	98,272	98,318	98,363	98,408	98,453	98,498	98,543	98,588	98,632
97	98,677	98,722	98,767	98,811	98,856	98,900	98,945	98,989	99,034	99,078
98	99,123	99,167	99,211	99,255	99,300	99,344	99,388	99,432	99,476	99,520
99	99,564	99,607	99,651	99,695	99,739	99,782	99,826	99,870	99,913	99,957