WOOD PIPE

CATALOG NUMBER 19

FEDERAL PIPE AND TANK COMPANY

6851 EAST MARGINAL WAY, SEATTLE, WASHINGTON, U.S.A.

CONTENTS OF SECTIONS

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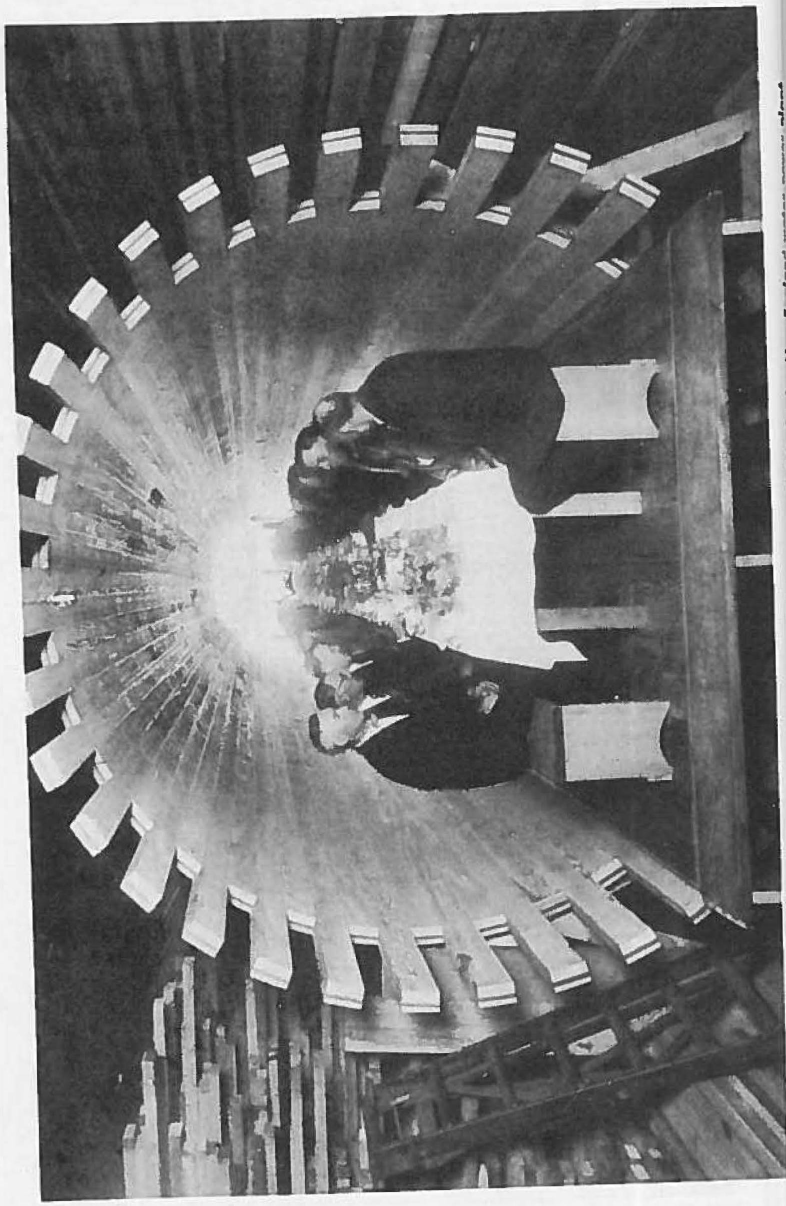


INTRODUCTION

THIS CATALOG has been prepared to explain and illustrate the products manufactured by this company, and to provide a handbook covering the principal information required by the users of these products. Our constant endeavor has been to present dependable, complete and readily usable information. We have attempted to bring the story of wood pipe and allied products up to date, and to indicate the improvements in specifications, design and construction which have resulted in a greatly increased value for a wide range of uses. We believe that it is to the best interests of our customers, and in turn to ourselves, that this be presented in a conservative manner, and we have endeavored to use only simple words and plain language with the constant thought of avoiding misleading expressions and extravagant claims.

After an examination of the many illustrations of Federal installations, it will be readily understood why this company takes a pardonable pride in its outstanding position in the industry. It will also be apparent that Federal is equipped to handle the largest and most unusual installations of Wood Pipe, Wood Tanks, Wood Flumes, etc. Our ability to meet any requirements in our field is based on the solid foundation of a management and personnel having a minimum of twenty-one years experience in design, manufacture and installation. It is particularly worthy of note that the Superintendents and "key" men employed in our factory have been making Wood Pipe for from seventeen to twenty-eight years. The ability and experience of such an organization is reflected in the high quality of Federal products.

This company offers the services of competent engineers of many years experience in the specialized field of design, manufacture and use of our products. We have frequently been able to offer a satisfactory solution for unusual problems, and are pleased to furnish such services. We wish to call particular attention to the fact that, in offering such engineering advice, it is not our intention to interfere with or usurp the work of practicing engineers, and our advice to those contemplating a project of any magnitude would be that they employ a competent engineer. It is, however, only natural that we feel especially qualified to answer questions concerning Wood Pipe, Flumes and Tanks.

While considerable information has been included in this catalog which will be found useful and convenient for the engineer, space would not permit including specific answers to all questions which may arise, and engineers are invited to consult with us regarding specifications or details of design.

Every precaution has been taken to assure the accuracy of data presented, but the possibility of error is recognized, and we assume no responsibility for the results of any errors.

Parallel Lines of 48" Pipe

SECTION I

DESCRIPTIVE AND GENERAL INFORMATION

FEDERAL PRODUCTS

DOUGLAS FIR — Untreated and Creosoted

FEDERAL WIRE-WOUND PIPE — Untreated and Creosoted
Sizes 2" to 24" diameter—Heads up to 400 feet
This pipe is made up complete at the factory in random lengths from 6 feet to 20 feet long. It is installed by simply driving these lengths together.

FEDERAL CREOSOTED IRRIGATION, DRAINAGE AND SEWER PIPE — Wire-wound
Sizes 3" to 12" diameter—40 foot head
This is a creosoted wire-wound pipe, designed for low head service.

FEDERAL CREOSOTED CULVERT PIPE
Sizes 6" to 24"—Wire-wound
This is a thick shell, creosoted, wire-wound pipe, made especially for culverts. Larger sizes made in the continuous stave type.

FEDERAL CONTINUOUS STAVE PIPE — Untreated and Creosoted
Sizes 4" to 16 feet diameter—Heads up to 400 feet maximum (less for the larger sizes).
This pipe is shipped knocked down and installed in place. As a rule, we enter into contracts which include installation.

FEDERAL CREOSOTED WOOD FLUME
Sizes 18" to 16 feet diameter
These flumes are built to a semi-circle, plus a depth equal to 1/12 of the diameter. Like continuous stave pipe, these flumes are erected in place.

FEDERAL TANKS — Untreated and Creosoted
Sizes of Circular Tanks—3 feet diameter by 3 feet high up to 60 feet diameter by 40 feet high, with capacities from 100 gallons to 700,000 gallons. Tanks are furnished knocked down or erected in place, including tower which may be required.
Sizes of Rectangular Tanks—Rectangular tanks are built to order to required dimensions.

FEDERAL CEDAR STEAM PIPE CASING — "Steam Log"
Sizes 3" to 27" diameter
This casing is furnished in heavy or extra heavy shell, and with or without tin and asbestos lining. It provides an unusually efficient insulation for underground steam lines.

GATE VALVES, AIR VALVES, CAST IRON AND STEEL FITTINGS, and all the various appurtenances required in connection with the installation of our products for any purpose.

USE OF FEDERAL PRODUCTS

Federal Products—Pipe, Flume, Tanks—are being used by the following for one or more of the purposes listed:

BY:

Private Water Companies
Irrigation Districts
Hydro-Electric Plants
Central Heating Plants
Bridge and Building Contractors
Sugar Beet Plants
Meat Packing Plants
Vinegar Plants

Cities	Fisheries	Gravel Plants	Pulp Mills
Towns	Golf Courses	Oil Companies	Breweries
Water Districts	Estates	Tanneries	Wineries
Farms	Road Districts	Smelters	Laundries
School Districts	Logging Camps	Nurseries	Hotels
Railroads	Sawmills	Steel Plants	

U. S. Government Bureaus (Reclamation, Indian Service, Forest Service, and other Departments).
State Departments (Institutions, Fisheries, Schools).
Mines (coal, iron, gold, silver, molybdenum, and others).
Various Industrial Plants and Individuals.

FOR:

Domestic Water Supply
Sanitary Sewers, including Outfalls
Domestic Water Distribution
Fire Protection
Storage Tanks
Factory Service
Concrete Forms

Irrigation	Surge Tanks	Storm Sewers	Drainage
Water Power	Culverts	Sluicing	Insulation

TO DELIVER OR CONTAIN:

Sluiced Material	Acid Solutions	Pulp (with water)	
Mine Tailings	Fresh Water	*Beer	*Sulphur
Sewage	Salt Water	*Wine	*Cement
Vinegar	Hot Water	*Fuel Oil	(*—*Tanks only*)

AND PLACED:

Under ground—in mines	Buried—in trenches	On towers
Cradled in the ground	Under water	Above ground
Suspended from ceilings	On high trestles	On buildings

LOCATED IN:

Arizona	Michigan	North Dakota	Vermont
California	Montana	Ohio	Washington
Colorado	Nebraska	Oregon	Wisconsin
Connecticut	Nevada	Pennsylvania	Wyoming
Florida	New Hampshire	South Dakota	Alaska
Idaho	New Jersey	Tennessee	Canada
Louisiana	New Mexico	Texas	Mexico
Maine	New York	Utah	Philippine Islands
Massachusetts	North Carolina		

INQUIRE ABOUT FEDERAL PRODUCTS FOR YOUR REQUIREMENTS

Douglas Fir Timber

DOUGLAS FIR

(Pseudotsuga Taxifolia)

Douglas Fir (coast type) is used almost exclusively by this company and it is, accordingly, appropriate to include a description of this remarkable timber and to explain the excellent characteristics which make it particularly desirable for our purposes.

Name and Locale

The name "Douglas Fir" was selected in honor of David Douglas, a Scotch botanist, who introduced the seed of the fir tree in Europe in 1827. The same timber is sometimes referred to as "Washington Fir," or "Oregon Pine." Some scattering stands of small timber, which are properly designated as "Inland type," are found in the inland areas of the Pacific Northwest and Canada; but the coast type, with which we are here concerned, grows in great abundance west of the Cascade range in British Columbia, Washington and northern Oregon.

Size and Strength

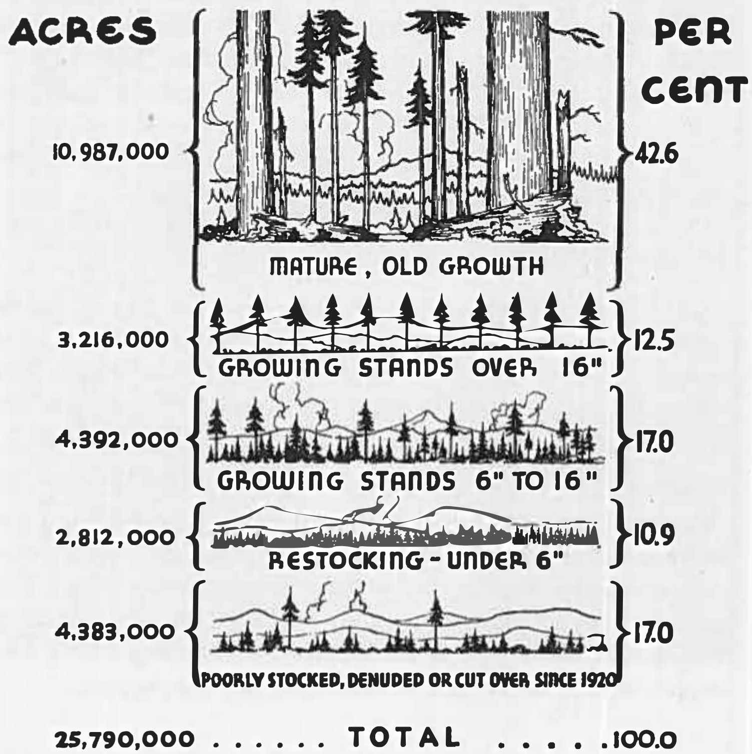
Douglas Fir trees grow to immense size. The tallest tree on record is 380 feet in height; and, on occasions, diameters have been found as great as 15 feet, measured at breast height. It is not exceptional to find entire forests averaging more than 200 feet in height and 5 feet in diameter.

Douglas Fir timber has long been recognized for its quality of exceptional strength. It has been, and is being, widely used for heavy construction and also provides an excellent material for such purposes as flooring and interior finishing of buildings. The quality of strength is a requisite for timber to be used in making first quality wood pipe, and Douglas Fir rates highest, in this respect, of any timber used commercially for this purpose.

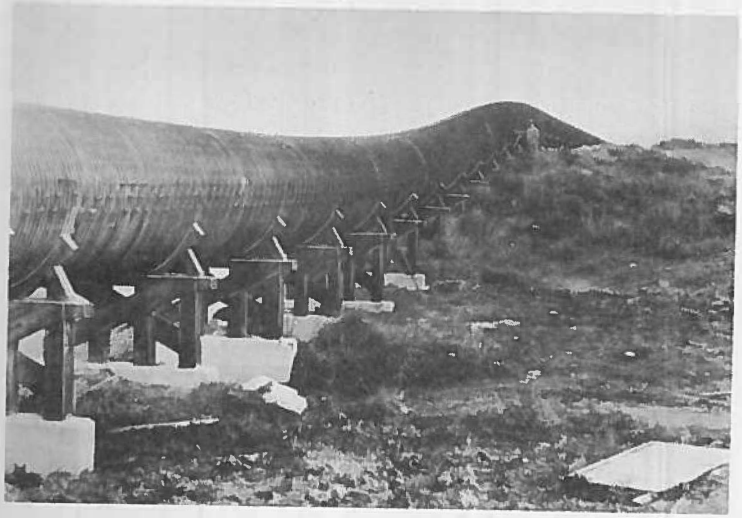
Abundance

The "Wood Handbook," published in 1935 by the U. S. Forest Service, contains the following statement: "The existing stand of merchantable Douglas Fir is larger than that of any other species." The rules for grading pipe stave stock, and other grades, are now more rigid than formerly, but an unlimited quantity meeting present specifications may be readily obtained. This abundance of high grade Douglas Fir is in sharp contrast to the situation confronting other species which have been, or are being, used in the manufacture of Wood Pipe.

TIMBER TYPES in the DOUGLAS FIR REGION



Laying FEDERAL Wire-Wound Pipe Distribution System



A Six-Foot FEDERAL Creosoted Pumping Line on a sharp vertical curve

Laying FEDERAL Wire-Wound Wood Pipe in residential district

Loading Trucks with FEDERAL 18-inch pipe, for 16-mile City Supply Line

DESCRIPTION OF FEDERAL PRODUCTS

DOUGLAS FIR—Untreated and Creosoted

Federal Wire-Wound Wood Pipe

This is made in the sizes of 2″, 3″, 4″, 5″, 6″, and then in 2″ intervals up to 24″ diameter. The finished thickness of staves varies from 1″, for 2″ pipe, up to 1⅜″ for 24″ pipe; and for the larger sizes this thickness depends to some extent upon the head for which the pipe is designed. In past years, sapwood was permitted in untreated pipe, but Federal Untreated Wood Pipe is now made using only 100% heart stock. Special galvanized steel pipe winding wire is wrapped around the barrel of the pipe at the factory and this is spaced from a maximum of 3″, for low head service, down to a minimum of about ½″, as required for heads up to 400 feet, and occasionally, even closer spacing for higher heads.

The various types of couplings are illustrated on Page 68, and pipe is furnished complete with these couplings. All coupling ends of pipe sections are given a creosote application, and wood collar couplings are creosoted by the pressure and vacuum process. This preservative treatment of collars was adopted during comparatively recent years and adds greatly to the life of wire-wound pipe.

Untreated wire-wound pipe is provided with a heavy asphaltum coating, but for severe soil conditions the galvanized wire may be given the additional protection of a burlap wrap, saturated with a protective coating. Burlap is better adapted for use with wood pipe than other kinds of wrapping material, because it will fit closely over the wire. This protection has proven to be very effective, even for brackish soil conditions. For pipe lines to handle strong acids—such as may be found in pulp mill operations—copper wire, and occasionally stainless steel wire, may be applied.

Standard cast iron fittings and gate valves, for use with wire-wound pipe, are illustrated in Section IV. Welded steel fittings are suitable for certain conditions, and the prices are attractive for the larger sizes.

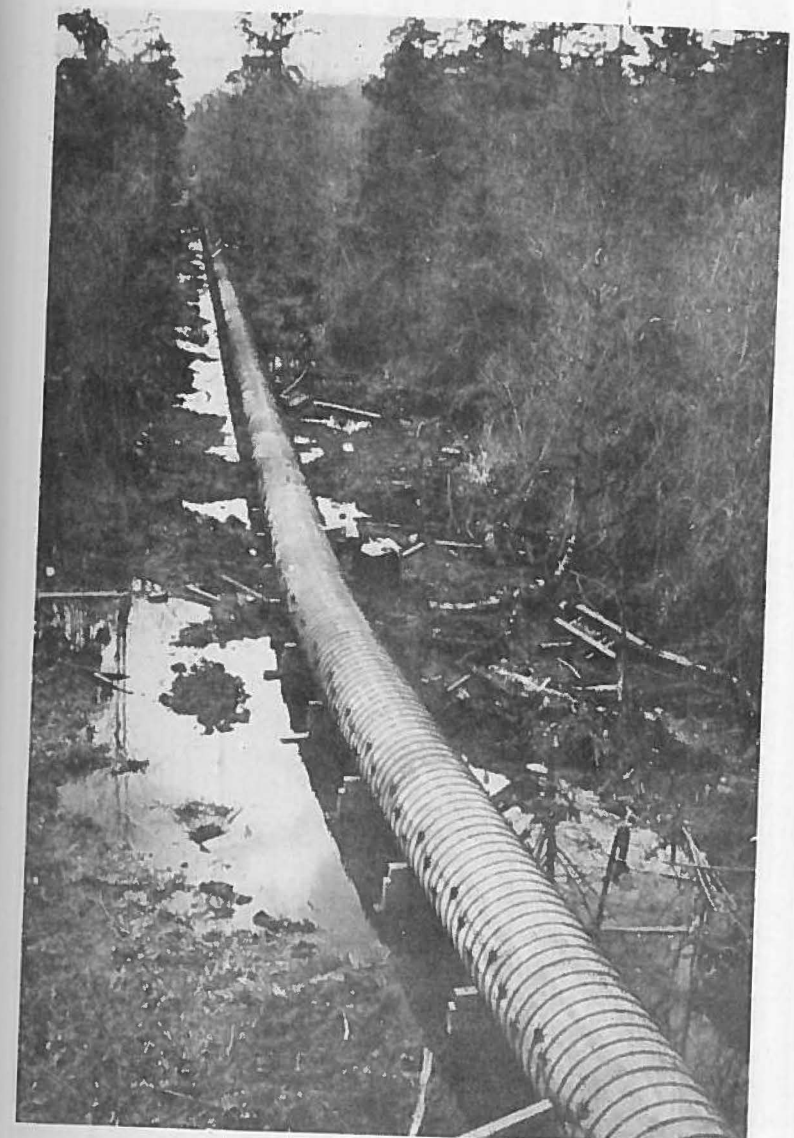
Federal wire-wound pipe is furnished complete, ready to install by simply driving the lengths together in place. It is light to handle, and the cost of laying is very low. This may be done by almost anyone who follows instructions and uses reasonable judgment, but the cost of an experienced foreman is a good investment for large jobs.

Trenches should be dug to accurate grade and alignment. If the alignment is good, the width of trench need be only a few inches more than the outside diameter of the pipe. The depth of trench should provide for at least one foot, and preferably eighteen inches, cover in mild climates; and the pipe should be placed below the frost line in cold climates. Wood pipe is not seriously damaged by slight freezing, but severe and continued freezing should be avoided. Numerous wire-wound lines have been placed above ground on timber or concrete supports. Untreated pipe should not be cradled in the earth, but creosoted pipe may very properly be only partially buried.

Pressure creosoted wire-wound pipe is furnished for use under conditions where insufficient or intermittent water saturation makes this preservation advisable. This is further explained on Page 39, under "Untreated or Creosoted Pipe."

Federal Creosoted Irrigation, Drainage and Sewer Pipe is of the wire-wound type, but of somewhat lighter construction, being designed for the low operating pressures which predominate for such service.

Federal Creosoted Culvert Pipe is also of the wire-wound type in the smaller sizes, but has a thick shell to provide adequate strength for deep backfill and heavy external loads.



54" FEDERAL Creosoted Fir Pulp Mill Supply Line

FEDERAL Power Plant Penstocks showing second of Twin Lines under construction

FEDERAL 6½-foot diameter Creosoted Fir City Supply Line

Federal Continuous Stave Wood Pipe

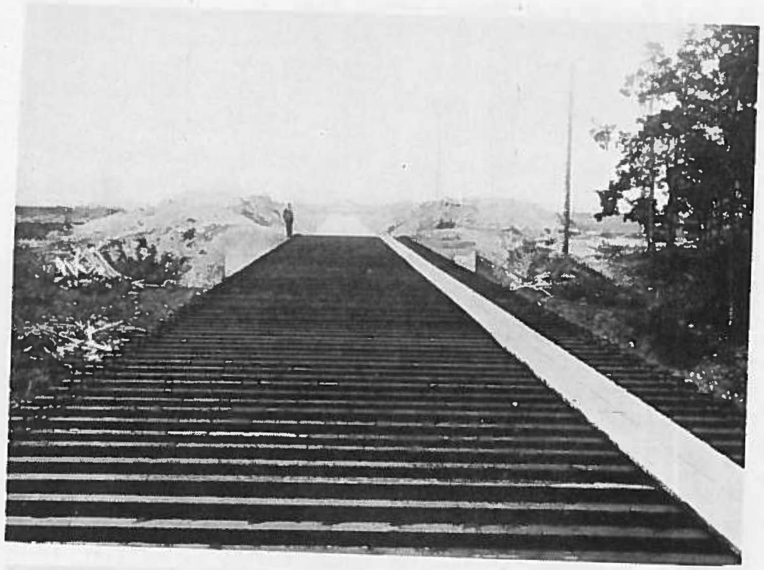
This is the "big brother" of wire-wound pipe, but differs greatly in that it is not shipped from the factory in the form of completely assembled lengths of pipe, but is shipped knocked down, ready to be built in place. This results in reduced freight and hauling costs, particularly if shipment is to be made to distant points, and this type of pipe has an outstanding advantage over any other kind of pipe if the final location is difficult of access. If necessary, men can carry the individual pieces required for the construction of even the largest sizes of continuous stave pipe.

As a rule, diameters range from two feet, up to the present maximum of 17½ feet. This type of pipe has been made by us in sizes as small as four-inch diameter, but sizes smaller than 16″ have, as a rule, only a specialized application for industrial service.

The finished thickness of staves varies, in general, from 1 7/16″ for 16″, up to 2½″ for six-foot pipe, and up to 4½″ for the largest sizes. Steel band diameters range from 7/16″ up to 1″, and these are spaced on the pipe in accordance with the operating head—usually in ten-foot intervals of head throughout the length of the line.

In erecting this type of pipe, stave ends are staggered (see illustrations) and the customary joints for connecting ends of staves are illustrated on Page 78. The modern and finest type of joint is provided by using malleable iron castings. These are almost invariably recommended for use in connection with creosoted continuous stave pipe.

Cast iron, or welded steel fittings are used in connection with continuous stave pipe. Such fittings are shown on Page 87 and elsewhere. Generally, steel fittings are made to the same outside diameter as the inside diameter of the wood pipe and the staves are banded tightly to the steel with a gasket between the fitting and the staves.



Looking along top of FEDERAL 16-foot diameter Creosoted Flume—believed to be largest flume of this type constructed to date.

Side view of 16-foot Flume, showing creosoted cradles and sub-structure.

Continuous stave pipe may be placed underground, or supported in timber cradles resting on timber or concrete footings. Concrete or steel cradles are sometimes used. See Pages 88 to 92 for illustrations of the most commonly used types of cradles.

The Federal Pipe and Tank Company usually enters into contracts for continuous stave pipe erected in place in a trench, or on supports, provided by the owner or general contractor. There can be no question but that this procedure serves the best interests of both the purchaser and ourselves, if the installation is of reasonable magnitude. Short continuous stave pipe lines may be constructed in a creditable manner by persons without previous experience. Instructions for erection are presented in Section II.

Continuous stave pipe is used for a wide range of purposes. See Page 39 for an explanation of the conditions indicating the advisability of selecting Untreated or Creosoted pipe.

Federal Creosoted Wood Flume

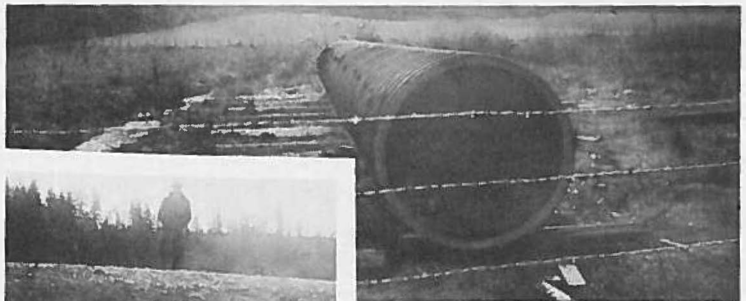
Semi-circular flume is similar to continuous stave pipe, in that it is shipped knocked down and erected in place. It is actually built to a little more than a semi-circle, having an additional depth of one inch for each foot of internal diameter.

FEDERAL 4-foot Creosoted Flume

84" Flume to 84" Pipe, and reducing to 66" Pipe

Flumes have been constructed from 18" to 16 feet in diameter, and as large as 20 feet diameter is practicable. The finished thickness of staves varies from 1½" to 2⅝", and the diameter of steel bands from 7/16" to ¾". The ends of bands pass through spreaders placed across the top of the flume. Cradles are spaced eight feet apart along the flume (closer for the largest sizes), and quotations include spreaders and cradles (without sills), unless otherwise specified. Sills are ordinarily not included, because it is frequently logical to consider these as being part of the sub-structure. The staves are invariably pressure-creosoted and spreaders and cradles are usually treated in the same manner. Cradle support must be provided to a point well up on the sides of a flume, and the design of Federal Flume cradles provides such adequate support. Federal Flumes are generally installed under contracts including erection on owner's foundation.

Semi-circular Stave Flumes are exceptionally strong, as is evidenced by the fact that in some instances falling rocks have removed one or two cradle supports without causing failure of the structure. These flumes are extremely durable. Some kinds of flume require painting every year or two, but this rather expensive and troublesome maintenance is not necessary for Federal Creosoted Wood Flumes.



60 Feet of 48" Culvert, assembled on bank and rolled into stream

Same 48" Culvert under new highway fill

Federal Creosoted Wood Culverts

Federal Culverts are manufactured in the wire-wound type of construction for sizes up to 24" diameter, and in the continuous stave type for larger sizes. Staves are furnished somewhat thicker than for water pipe. A heavy pressure-Creosote treatment is applied, assuring long life.

These culverts are comparatively light in weight, resulting in low hauling costs. They are easily installed by the same simple methods used for Federal Wood Pipe. They have ample strength to withstand the loads to which culverts are subjected, and this strength is combined with flexibility so that the culverts will adjust themselves to considerable movement of the surrounding earth without being damaged.

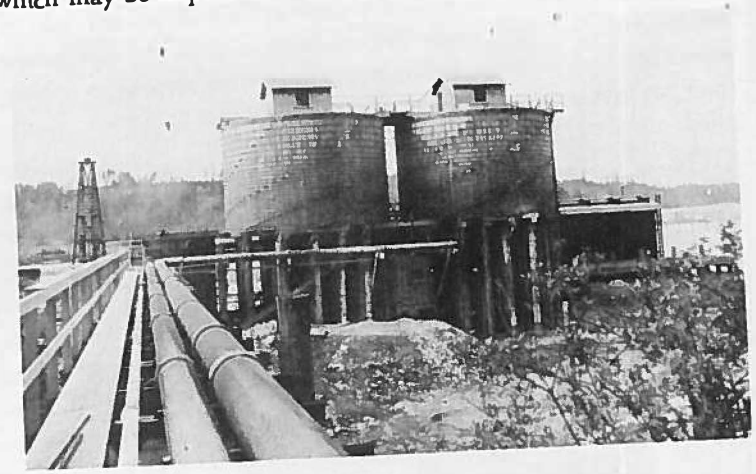
24" Creosoted Wood Culvert

Federal Tanks

Federal Tanks are made in many different sizes, with capacities ranging from 100 to 700,000 gallons. They are furnished both Untreated and Pressure-Creosoted. Open Top tanks are frequently used; but headed tanks, or tanks with covers, are provided for many purposes. Circular construction is most common, and this shape results in the lowest cost per gallon of storage; but rectangular tanks are manufactured on special order.

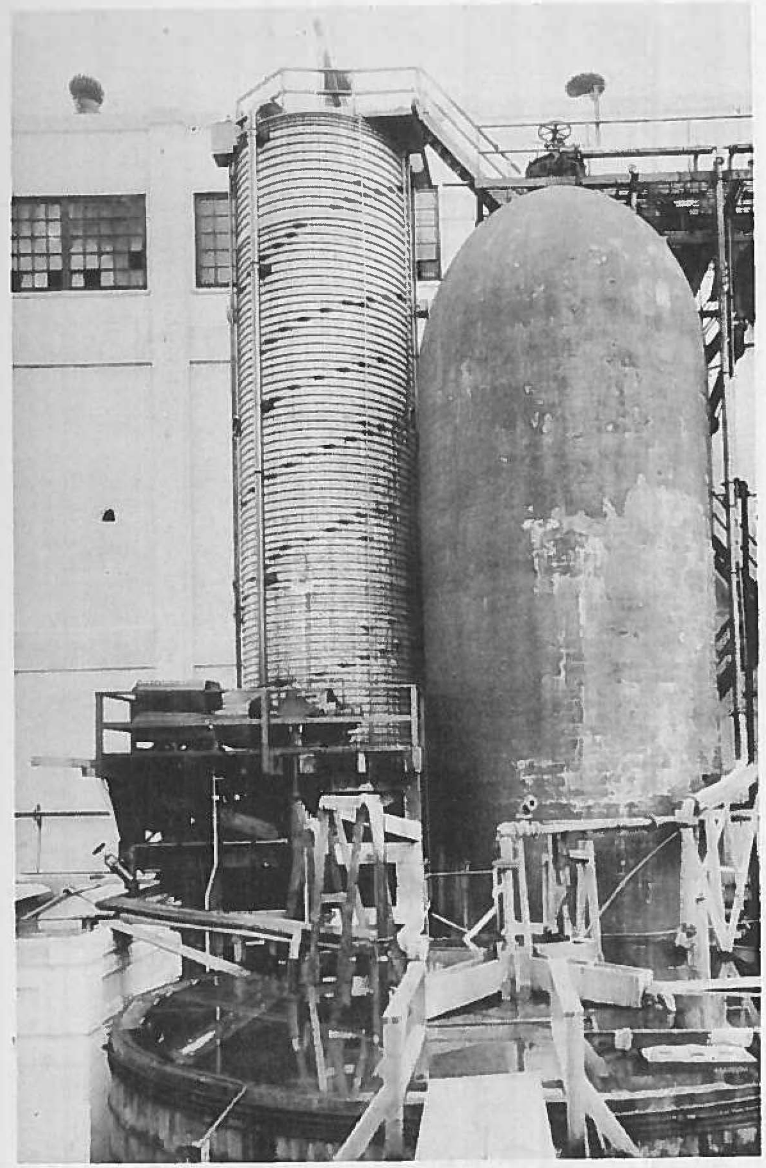
Many circular tanks, in sizes up to 100,000 gallons capacity, are shipped knocked down and assembled in place by purchasers.

Complete directions for erection are presented in this book — beginning on Page 113. Federal also contracts to furnish and erect tanks in place, including timber towers and appurtenances which may be required.

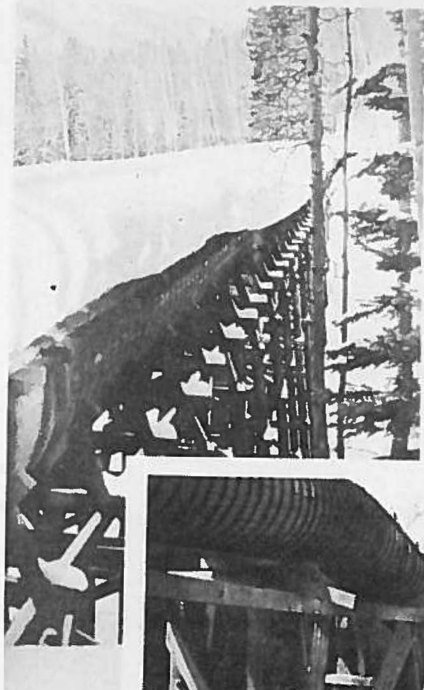


33' x 20' Headed Tanks with 10" and 14" FEDERAL Wire-Wound Pipe.

50,000 Gallon Creosoted Tank for City Water Supply, first constructed in Seattle in 1918. No longer needed at original location after 1936, and tank was then dismantled and re-constructed in new location as shown.



10' x 42' Wood Stave Acid Tank



TOP: 78" undermined for 100-foot span, but carried full load for some time.

LEFT: 10-foot Creosoted Flume with 6-foot overhanging snow load—far in excess of design for such a load.

BELOW: Trestle failure under 95 feet of 36" pipe, resulting in 25-foot sag. Service continued one month at 30 pounds internal water pressure.

FEDERAL WOOD PIPE PROVIDES TRUE ECONOMY

A number of different factors enter into the determination of the true economic value of a pipe line. If the following points are carefully considered, it will be evident that there are excellent reasons why many purchasers throughout the country recognize the outstanding economy of installing Federal Wood Pipe.

First Cost

Low first cost does not in itself signify economic value, but a saving in capital investment commands attention. With few exceptions, Federal Wood Pipe can be installed, in place, at a decided saving in cost.

Obsolescence

Not all pipe lines become obsolete, but many do because of the necessity for increased capacity, or there may be occasion for entirely discontinuing service. Highways, city streets, bridges, buildings and many other structures have in the past become obsolete and this is also true of pipe lines. Such obsolescence will continue to occur in the future, and the useful service life of many pipe lines will be determined by the number of years until they become inadequate or no longer required. Obsolescence may not be anticipated, but this factor should be considered hand in hand with first cost.

Capacity

Pipe lines are installed to deliver water or other liquids and any increased ability to perform this function results in an increased value. In the final analysis, it is not the size of pipe which is really important, but rather what it will do. A reasonable instance is that a 34″ wood pipe may have a capacity equal to, or greater than, a 36″ pipe made from other material. As a result there is either a reduced first cost for 34″ wood pipe, or 36″ wood pipe has an added value because of the additional water delivered. This will produce added power in the case of a hydro-electric plant, or the reduction in friction head for pumping a given quantity of water will decrease power costs. This added value is constant throughout the years, as Federal Wood Pipe is not subject to increased friction created by tuberculation and corrosion. This is in sharp contrast with the rapidly reducing capacity of many other kinds of pipe, some of which are affected as much as 25% in twenty years.

Dependability

Federal Wood Pipe will withstand severe strains and shocks. To illustrate, let us quote from a user having a long wood pipe line in a locality subject to earth disturbances. *"The ground settled under the pipe in three different places. In the worst place, this caused the pipe to drop down three feet and two feet out of line. It pulled over 300 joints and some of them opened up as much as half an inch, but the line did not go out of service and did not have to be shut off for repairs."* Compare this with the disastrous failures of rigid types of pipe which have caused extensive damage. Another example of dependability is illustrated by the picture on Page 34, showing a 78″ continuous stave pipe undermined by flood conditions for a span of 100 feet and with no resulting interruption of service. Extreme conditions will, of course, damage wood pipe, but there is seldom abrupt failure.

Life

The number of years service to be obtained from a pipe is certainly an important factor in the determination of economic value. Untreated wood pipe, installed under favorable conditions, has served for so many years that it may be classed as practically permanent. Under normal conditions it has given service from 25 to 40 years. Creosoted wood pipe will serve not less than 35 years under any conditions within reason, and may frequently be expected to last from 50 to 60 years.

Annual Cost

Annual cost is determined by analyzing all of the above factors, allowing for the cost of replacement at the end of estimated life, and dividing by the number of years service. It is not by any

means always correct to assume that the pipe which has the longest estimated life will also have the lowest annual cost. The amount of money saved if wood pipe is purchased, placed at interest, will accumulate, to provide for reconstruction well within the life of wood pipe. Each dollar saved in first cost, placed at compound interest, will accumulate to the amount indicated by the following table:

RATE OF INTEREST

Years	4%	4½%	5%	6%
10	1.480	1.552	1.628	1.790
15	1.800	1.935	2.079	2.396
20	2.191	2.411	2.653	3.207
25	2.665	3.005	3.386	4.291
30	3.243	3.745	4.321	5.743
35	3.946	4.667	5.516	7.686
40	4.801	5.816	7.039	10.285
45	5.841	7.248	8.985	13.764
50	7.106	9.032	11.467	18.420

From the above it will be noted, for instance, that $1000.00 saved now will amount to $3,386.00 in 25 years, at 5% compound interest. These figures have an important bearing in comparing annual costs. Let us assume the following:

Pipe A .... 50 years estimated life
Pipe B .... 25 years estimated life
Pipe A—10,000 lin. ft. @ $5.00—$50,000.00
Pipe B—10,000 lin. ft. @ $3.00—$30,000.00

Obviously, $30,000 must be available at the end of 25 years to replace Pipe B so that it may serve for a total of 50 years. Say the interest rate is 5%. From the above table $30,000 ÷ 3.386 = $8860. which must be invested now to equal $30,000. in 25 years. Adding this to $30,000. equals $38,860., and the annual cost is determined as follows:

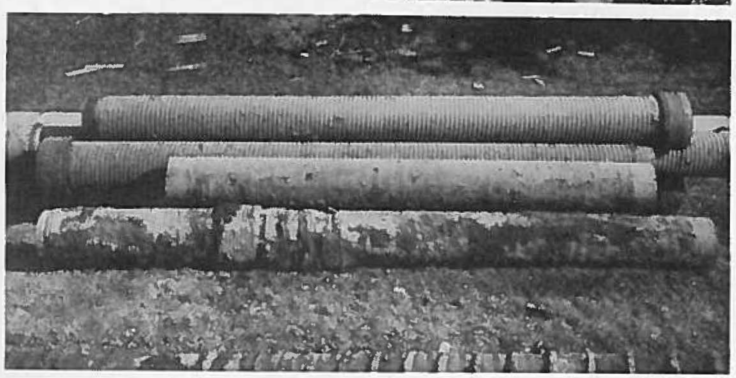
	Present Cost		Estimated Cost		Annual Cost
Pipe A	$50,000.00	÷	50 years	=	$1000.00
Pipe B	$38,860.00	÷	50 years	=	$ 777.00

These figures establish a substantial saving in present outlay and annual cost, plus the advantage of making changes to meet new requirements at the end of a 25 year period.

12" originally installed 1913, relaid 1933; picture taken 1941.

FEDERAL Untreated Town Supply Line. Original untreated wood pipe served 24 years, despite unstable support.

8" Untreated Wood Pipe installed in 1900 (in foreground) served until 1939 and was replaced with FEDERAL Untreated Pipe (in background) — 90 pound service pressure.



UNTREATED OR CREOSOTED PIPE

The question may arise as to whether Untreated or Creosoted Wood Pipe should be installed. We would be pleased to offer recommendations for any specific conditions, but the following general explanation indicates the outstanding factors entering into the selection of one or the other. It is principally a matter of service life and requires a proper consideration of the conditions which prevail.

Untreated, Coated Wood Pipe

This type is used to a considerably greater extent than Creosoted Pipe. A satisfactory service life depends upon reasonable preservation resulting from practically constant water saturation, in addition to the preservative qualities of resin in the wood. Internal pressures of 20 pounds per square inch (approximately 50-foot head), and up, provide saturation to the required extent. Soil which is water-saturated practically all of the time will also provide this saturation for the wood, even though internal water pressure is lower than 20 pounds.

For border-line situations, where reasonable saturation may be doubtful, the question becomes a matter of economics. Conditions must be most unfavorable if a life of at least 20 years may not be reasonably expected. Even so, in many instances the requirements for a period longer than 20 to 25 years may not be anticipated with any degree of accuracy, with the result that probable obsolescence should be the deciding factor, and sound business judgment will frequently establish the advantage of a minimum initial investment.

Creosoted Wood Pipe

Should be used for conditions which do not meet those presented above as favorable for untreated pipe, if the moderate additional investment for a practically permanent installation appears to be justified, taking into consideration the probable number of years which will elapse before the pipe line becomes obsolete.

Low-pressure sections of a pipe line may very properly consist of Creosoted pipe, and the balance may be Untreated, and we have made numerous such installations, notably for city supply lines. Creosoted pipe may be, and has been, extensively used for entire domestic water supply lines, and only a reasonable period of flushing is necessary to remove taste. The installation of Creosoted pipe is not recommended, as a general rule, for domestic water distribution lines in which the water may stand more or less stationary for long periods.

There are some exceptions, but Creosoted pipe should usually be purchased for irrigation lines, sewers, culverts and similar purposes, featuring extended periods of non-use or operation only partly filled with water. Semi-circular flumes are almost invariably creosoted. Creosoted pipe should be installed in localities where termites are prevalent, if the service conditions are such that these insects may attack. Extra-heavy creosote treatment is necessary to protect against toredos and similar marine life.

THE LIFE OF UNTREATED PIPE

It will be noted that the specifications for Untreated Wood Pipe (Nos. 10 and 15) as presented herein, provide for 100% heart stock. Douglas Fir is a resinous wood and the heart stock contains the maximum content of this natural preservative. It is well known that with complete, constant saturation the life of wood is practically indefinite, and in addition to the preservation of resin provided by nature, many pipe lines are further preserved by an adequate degree of water saturation resulting from moderate or high internal water pressure.

Wood Collar Couplings are specified to be creosote-treated, even though the pipe itself is Untreated. The location of these couplings on the pipe does not permit appreciable water saturation from internal pressure, and accordingly preservation is supplied by the pressure-creosoting process.

The standards for stave stock are higher than ever before in the history of the industry. The quality of zinc-coated wire is superior to much of that formerly used. Details of design have been improved with the passing years. Greater emphasis has been placed on fine workmanship, and in many respects there has been a marked advancement in the many phases of the manufacture of wood pipe.

All of the above are only natural developments of our many years of experience, and the accumulated experience of our predecessors. The result is, a modern wood pipe of finer quality and a product which is far more durable than that made years ago. Present improved quality cannot be questioned, particularly with respect to those most important factors of All Heart Stock and Creosoted Collars, and yet, even the Untreated Douglas Fir pipe as made in the past has established an excellent record for long life.

The following, taken from a Consulting Engineer's report to a private corporation, tells a story of past performance and is a fair analysis of anticipated service:

> *"I was told that the main was laid over thirty years ago and that the pipe was second-hand when installed.*
>
> *"The kind of pipe to be used in case of renewal was discussed by us during our trip. I agree with you that, all things considered, Wood Stave Outside Treated (Untreated-Coated) Pipe is advisable. The first cost of the pipe, the labor of moving it to the line and of laying is considerably less than for other types, while the life is sufficiently long—say thirty years or more—that at the end of its life conditions at the plant may be entirely different from what they are now, and a new arrangement of the water supply may be required."*

The life of Untreated-Coated Douglas Fir Wood Pipe, as formerly made, has been from 25 to 40 years, with the exception of the failure of occasional sap staves and untreated collars. The modern product will have an equal, or even longer life, depending on service conditions. On this basis, it offers exceptional value as a conduit for a large percentage of pipe requirements.

THE LIFE OF CREOSOTED PIPE

Engineers and the heads of many industries are familiar with the long life records of creosoted timber serving under various conditions, and these need no further proof of its durability. Instances may be cited of satisfactory service up to 50 years for structures installed under unfavorable conditions, but we will here confine our statements to actual installations of wood pipe, only.

In 1902 a 12-inch creosoted fir pipe 1000 feet long was placed in service at Everett, Washington. This pipe line gave complete satisfaction, in spite of unfavorable soil conditions. The record shows that not one cent was spent for repairs or maintenance. It was used in connection with a steam power plant, and because of extensive alterations in the power equipment about 1930, the pipe line was no longer required. Non-use produced conditions more unfavorable for long life than existed during service, but this line was examined in 1935 and found to be entirely sound.

In 1910 a fifty-inch creosoted fir pipe about 1000 feet long was erected at Burbank, Washington. This pipe delivered water for irrigation and was installed in light, sandy soil, only partially buried in a trench, and operated only about three-fourths filled with water for six months out of each year. It is doubtful if any combination of conditions could be found anywhere which would provide a more severe test. Inspections have included a careful examination of the most vital portion of the pipe just below the ground line, but there is absolutely no evidence of decay. (See photos, Page 44.)

Beginning in 1916, a large irrigation district started a program of installing creosoted wood pipe where pipe lines were required in their system. They have continued to use creosoted wood pipe and say now, "*We have more than $200,000 invested in this type of construction, and the annual maintenance cost on our pipe lines has averaged less than $500 per year.*" They have no indication of deterioration, and only one-quarter of one percent annual maintenance cost. Naturally they are fully satisfied.

In 1918 a 50,000-gallon creosoted wood tank was installed in Seattle. This served until 1936, when it was no longer required. It was taken down and erected near Grand Coulee Dam, in eastern Washington. After 18 years, the original owner received a fair value for a tank which he purchased at a comparatively low price, and the new owner obtained a tank which was apparently just as good as new. Every piece was examined when the tank was dismantled. None of these gave any evidence of deterioration and all were used in rebuilding the tank. See Page 32 for a picture of this tank in its new location.

In 1918 a 60-inch creosoted wood outfall sewer was installed in Seattle. This was placed above ground on piling, and at that time it was thought that the line might not be required after a few years. In 1937 this line was dismantled and rebuilt in a trench in the same location. The most rigid inspection did not disclose any sign of decay, and the cost of reconstruction was amply justified by the apparent certainty of at least 25 years additional service.

Other creosoted wood pipe lines could be cited, particularly since the pressure-creosoting process came into general use for wood pipe in 1918, but the above are typical examples. Creosoted staves may be expected to last at least 35 years under any conditions within reason, and 50 to 60 years may frequently be expected.

34" Creosoted Irrigation Pumping Line

50" Creosoted Irrigation Line installed in 1912, partially buried, and operated without internal water pressure.

Same 50" Creosoted Pipe dismantled and reconstructed in 1939—100% sound.

THE CREOSOTE TREATMENT OF WOOD PIPE

Untreated wood stave pipe should be selected for many conditions of service, but for others, creosote treatment is recommended. It is generally recognized that completely saturated wood staves are repellant to decay and will remain in excellent condition for many years. This has been demonstrated in many cases by city water systems, power plant pipe lines and other installations that are continuously filled with water under pressure. However, in some localities soil conditions are unfavorable for lines even under constant pressure. In other structures such as culverts, storm and sanitary sewers, flumes and low pressure irrigation systems with intermittent use, the staves are not continuously saturated and consequently other means of preservation are desirable. Wood pipe under these conditions, or subject to the attack of termites and marine borers, is adequately protected if impregnated with creosote under pressure.

The proper and efficient treatment of Douglas fir pipe staves should satisfy the following conditions:

1. To protect the staves adequately from decay, termites or marine borers as conditions of installation indicate.
2. To apply the treatment by methods that will avoid stave distortion in the process.
3. The treatment must be such as not to affect water flowing through the pipe from the standpoints of taste, health and germination of seeds.
4. The treated staves must retain their original strength and elasticity.
5. The treatment must be such as to leave the staves clean and dry and in condition for assembling into pipe.

Coal Tar Creosote

Coal tar creosote is the most effective commercial wood preservative known today, and has been successfully used for more than a century.

The name "creosote" was originally applied to a product of wood tar made from beech and other hardwoods by destructive distillation. The word "creosote" as applied to the wood preservative, however, is confined strictly to a derivative of coal tar. Coal tar creosote is an amber, black or brownish oil, heavier than water, with a characteristic burnt or antiseptic odor. It is defined by the American Wood Preservers' Association as a "distillate of coal tar produced by high temperature carbonization of

60" Creosoted Wood Outfall Sewer installed above ground in 1918.

Same 60" Creosoted Sewer dismantled in 1937 and rebuilt in trench at same location—100% Sound.

bituminous coal; it consists principally of liquid and solid aromatic hydrocarbons, and contains appreciable quantities of tar acids and tar bases; it is heavier than water, and has a continuous boiling range of at least 125° C., beginning at about 200° C."

Specifications for coal tar creosote have been developed by the American Wood Preservers' Association, American Railway Engineering Association, American Society for Testing Materials, Federal Government and others, to establish trade standards and to prevent adulteration.

The outstanding advantages of coal tar creosote are:

1. Its high toxicity to wood destroying organisms of all kinds.
2. Resistance to leaching.
3. Low volatility.
4. Ease of application.
5. General availability.
6. Permanence.

Fabrication

Prior to delivery to the creosoting plant the staves are kiln dried, milled to pattern with all four sides planed to exact dimensions for a watertight fit including convex and concave surfaces and beveled edges with bead and groove as required, and graded in accordance with the requirements of the purchaser's specification. This assures a uniform product properly seasoned and fabricated and practically eliminates shrinkage, checking, swelling or warping during the preservative treating process.

Incising An Aid to Uniform Penetration

Incising is a development in the preparation of Douglas fir and other species of lumber which are to be given preservative treatment. It is accomplished by the separation of the outer fibers at regular intervals by knifelike teeth to facilitate penetration and uniform distribution of the preservative. "Incising" is a coined word, descriptive of the operation, which is based on the principle that a preservative will move lengthwise of wood fibers much more readily than across the grain. This relationship may be in a ratio as high as 25 to 1. The incisor teeth open the grain from the surface, at regular intervals, to a predetermined depth, so that the preservative can flow longitudinally from one incision to another. The incising process is a Pacific Coast development started in 1915. Staves are incised mechanically as they pass through the moulder by means of suitable equipment.

Effect of incising in the strength of lumber has been carefully studied by the Pacific Coast timber treating plants, railroads and other large users of pressure creosoted Douglas fir. The results of exhaustive tests made by producers and users have been remarkably consistent. These tests indicate that the effective strength of timber is reduced, on an average, less than three percent by incising. On the other hand the penetration and distribution of preservative are much more uniform which offset many times the slight decrease in structural strength.

Pressure Treating Process

Numerous superficial methods of applying preservatives to Douglas fir lumber are available. The most common of these are brush and spray treatments, steeping, hot and cold bath, and diffusion process. All are indifferent treatments and fail to penetrate the timber sufficiently to provide adequate protection for a long period. The best that can be accomplished by any of these methods is a thin paint coat. The pressure process, on the other hand, under definite control diffuses the preservative deeply into the wood to a predetermined penetration governed by the quantity of preservative specified. The preservative treatment of timber with creosote applied by the pressure method has been successfully used for over a century.

The method of treating Douglas fir staves with creosote oil, by the pressure process, is described as follows:

1. Upon arrival at the treating plant the completely fabricated staves are loaded in tram cars and made into retort charges of similar dimensions. The charge is then drawn into the treating cylinder or retort and the door is closed and sealed. The battery of retorts generally range in size from 6′ to 8′ in diameter by 125′ to 135′ in length.

2. The initial treating step is to introduce creosote into the retort at a temperature of about 170° F. completely surrounding the charge of staves; steam is then applied to the heating coils in the bottom of the retort and the temperature raised gradually to approximately 190° F. A vacuum of 20″ or more is applied to lower the boiling point of the free moisture in the staves. This operation, requiring about 3 to 4 hours, has the two-fold purpose of warming and reducing the moisture absorbed subsequent to kiln drying, which makes the staves more receptive to treatment.

3. Following the warming period the empty-cell or Rueping process is applied. The creosote is speedily withdrawn from the retort and an air pressure of 25 to 50 pounds per square inch is applied to the staves for one hour which compresses the confined air in the wood. The retort is then refilled with creosote without releasing the air pressure and oil pressure is applied at about 190° F. and 125 pounds per square inch until the required penetration and absorption of creosote in the staves is obtained, allowance being made for rebound of excess creosote. Upon releasing the pressure the air confined in the wood expands forcing out the surplus creosote from the wood cells. As a further cleaning process the temperature of the oil surrounding the staves is raised for a short period causing it to be less viscous. The oil is then withdrawn from the retort and a final vacuum applied to leave the staves free from surface oil. The time consumed for the total cycle is about twelve hours. The oil retained in the individual charge is determined by measuring tank gauges or scales.

This treatment results in clean dry staves, free from contamination of dirt or dripping creosote with adequate penetration of the preservative and protection from wood destroying organisms.

For most purposes, staves are given what is termed an eight pound treatment. This means that an average of eight pounds (approximately one gallon) of creosote remains in the staves per cubic foot of timber placed in the retort. Before treatment, the dry staves wiegh an average of 34½ pounds per cubic foot and an eight pound treatment increases this 23.2%, or approximately one-fourth. Ten and twelve pound treatments are sometimes applied for certain severe service conditions. Fourteen or sixteen pound treatment should be employed to provide protection against marine borers.

SECTION II

SPECIFICATIONS AND CONSTRUCTION DETAILS

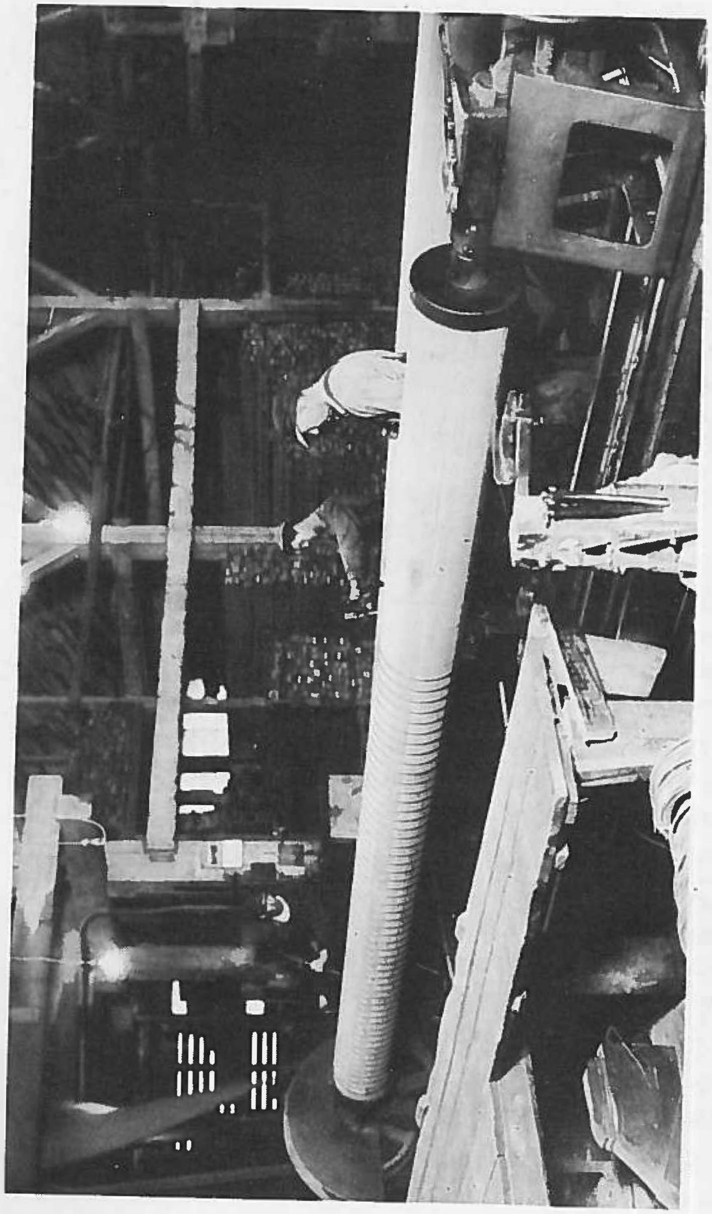
The Specifications presented in this section provide for high quality products for the most common purposes and for average conditions. Special purposes or unusual conditions may call for modification of certain sections, or possibly a completely revised specification. Our experience covers a wide range of uses for our products and we would be pleased to submit specifications for unusual requirements.

Construction Details presented in this section are intended only to illustrate what is typical for various sizes and for a reasonable range of application.

The above statements are made because we know that there is some reason to be concerned about the improper application of general specifications. It is hoped, however, that the information contained in this section will serve a useful purpose, and will help to acquaint our customers with materials and construction details.

Federal is constantly striving to make changes which will result in increased value, and accordingly reserves the right to make revisions in specifications, without notice.

Specifications for Federal products which are not presented in this section, will be furnished on request.



Wrapping galvanized wire on pipe in our factory.

SPECIFICATION NO. 10
January, 1942

GENERAL SPECIFICATIONS FOR WIRE-WOUND DOUGLAS FIR WOOD STAVE PIPE

Sizes 2 to 24 Inches Inclusive

Important Note:

This is a general specification covering various types of Wire-Wound Wood Pipe. If used by reference to above specification number, or incorporated into other specifications, the following information must be supplied.

1. *Head of Pipe.*
2. *Type of Coupling (if different than shown by table, or if alternate Metal Collar Couplings).*
3. *Kind of Pipe desired—*
   - *(a) Untreated Coated*
   - *(b) Creosoted Uncoated*
   - *(c) Creosoted Coated*

STANDARD UNTREATED PIPE

Staves

Staves shall be made from 100% heart stock Douglas Fir timber, grown in the North Pacific Coast region, which shall be sound and free from all imperfections that might impair its strength or durability, or affect its water tightness when used in pipe. Pitch seams, not extending more than one-quarter of the way through the piece, or more than four inches long, will be allowed. Cross grain shall be limited to an angle of not more than one inch in eight inches of stave length. Small, tight, sound knots, not over one-half inch in diameter, not penetrating through the thickness of the piece, will be allowed.

All timber must be thoroughly seasoned, either by air or kiln drying, before being milled into staves. Staves shall be dressed on both sides to true circles of the inside and outside diameters of the pipe. The edges of the staves shall be dressed to conform to the radial lines of the pipe, one edge to be provided with a bead, and the other edge to be provided with a corresponding groove. All staves shall be of uniform thickness and width, and the finished thickness shall be as provided in the table which is included in these Specifications.

The staves shall be the full length of the pipe section in which they are used, and the pipe may be made in random lengths from six to twenty feet, but the average length shall not be less than twelve feet. Short lengths, which may be required for sharp curvature, shall not be considered in determining the average length of pipe sections furnished.

Wire

The pipe shall be wrapped with pure zinc-coated (such as "Bethanized"), or heavily galvanized, medium steel special pipe winding wire, having a minimum of 0.50 ounces of zinc per square foot of wire surface. The wire shall have a tensile strength of from 58,000 to 68,000 pounds per square inch of cross-section. The wire shall be capable of being bent cold around a diameter equal to the diameter of the piece tested, without any fracture.

The size and spacing of banding wire shall be adjusted for a working stress not to exceed 15,000 pounds per square inch of cross-section of the wire, based on the internal pressure created by the head for which the pipe is designed. The spacing of wire shall in no instance be such as to develop a band bearing in excess of 800 pounds per square inch, assuming a width equal to the radius of the wire in contact with the staves.

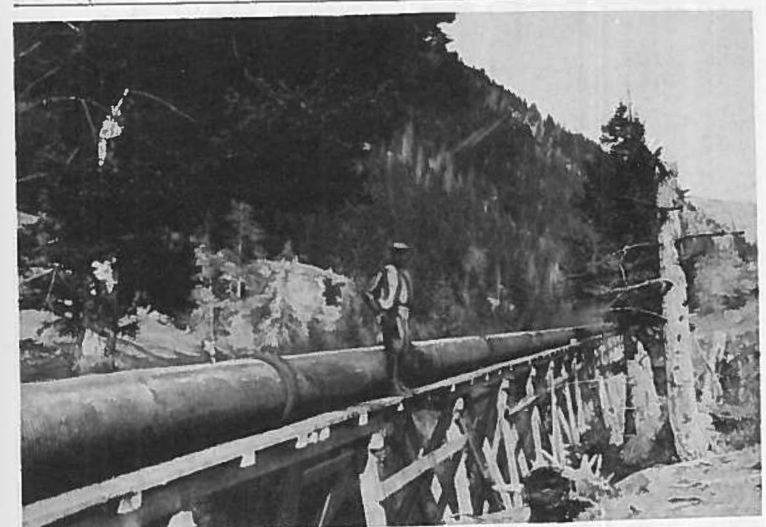
Dimensions of Staves—Size and Spacing of Wire

These dimensions shall be as provided in the following table. The size of wire shall be in accordance with the American Steel and Wire Gage, and the spacing of wire shall be in inches, measured from center to center along the pipe.

SHELL THICKNESS & WIRE SPACING

Table No. 4

Size Pipe	Shell	Gage Wire	Wire Spacing in Inches							
			50	100	150	200	250	300	350	400
2"	1"	#8	3	2¼	1⅝	1¼	1⅛	1	13/16	¾
3"	1"	#8	3	2¼	1⅝	1 3/16	1	13/16	11/16	⅝
4"	1 1/16"	#8	3	2¼	1½	1⅛	⅞	¾	⅝	9/16
5"	1 1/16"	#8	3	2⅛	1⅜	1 1/16	13/16	11/16	9/16	½
6"	1⅛"	#6	3	2 7/16	1⅝	1 3/16	15/16	13/16	11/16	9/16
8"	1⅛"	#6	3	2¼	1½	1⅛	⅞	¾	⅝	9/16
10"	1⅛"	#4	3	2¼	1½	1¼	1			
10"	1¼"	#4						⅞	¾	⅝
12"	1 3/16"	#4	3	2⅛	1⅝	1⅛	15/16			
12"	1¼"	#4						¾	⅝	9/16
14"	1 3/16"	#4	3	2						
14"	1 3/16"	#2			1¾	1⅜	1 1/16	⅞	¾	⅝
14"	1¼"	#2								
16"	1¼"	#2	3	2¼	1 9/16	1 3/16				9/16
16"	1 5/16"	#2					13/16	¾	11/16	
18"	1¼"	#2	3	2 1/16	1⅜	1 1/16		11/16	9/16	½
18"	1 5/16"	#2					13/16			
20"	1 5/16"	#2	3	1⅞	1¼	15/16		⅝	½	7/16
20"	1⅜"	#2					¾			
22"	1 5/16"	#2	3	1 11/16	1⅛					
22"	1⅝"	#2				13/16	11/16	9/16	9/16	½
22"	1⅜"	#1								
24"	1 5/16"	#2	3	1 9/16	1					
24"	1⅜"	#2				¾	⅝	½		
24"	1⅝"	#1							½	7/16



20" Untreated Pipe

Couplings

Unless otherwise specified, various sizes and heads of pipe shall be furnished with the type of couplings indicated by the following table:

TYPE OF COUPLING

Table No. 5

Size Pipe	HEADS							
	50	100	150	200	250	300	350	400
2″	I.J.	I.J.	I.J.	I.J.	I.J.	6″WWC	6″WWC	6″WWC
3″	″	″	″	″	6″WWC	″	″	″
4″	″	″	″	6″WWC	″	″	″	″
5″	″	″	6″WWC	″	″	″	″	″
6″	″	″	″	″	″	″	″	″
8″	″	″	″	″	″	″	8″WWC	8″WWC
10″	″	″	″	″	″	8″WWC	″	″
12″	″	″	″	″	8″WWC	″	″	″
14″	″	R.I.J.	8″WWC	8″WWC	″	″	″	″
16″	R.I.J.	″	8″IBC	8″IBC	8″IBC	8″IBC	8″IBC	8″IBC
18″	″	″	″	″	″	″	″	″
20″	″	″	″	″	″	″	″	″
22″	″	″	″	″	″	″	″	″
24″	″	″	″	″	″	″	″	″

Abbreviations:
I.J. Inserted Joint.
R.I.J. Reinforced Inserted Joint.
6″WWC Creosoted Wire-Wound Collar, 6″ long.
8″WWC Creosoted Wire-Wound Collar, 8″ long.
8″IBC Creosoted Individual Banded Collar, 8″ long.
2–M Double Metal Collar.
(Alternate for 6″WWC, 8″WWC or 8″IBC).

If pipe having collar couplings is specifically called for, the sizes and heads of pipe shown in the above table as being furnished with I.J. and R.I.J. couplings shall be furnished with 6″ WWC where I.J. is shown by the table, and 8″ IBC where R.I.J. is shown by the table.

Inserted Joint and Reinforced Inserted Joint Couplings

These couplings shall be made by milling a tenon on one end of a section of pipe and a corresponding mortise on the other end. These ends shall be so milled as to make a snug driving fit when laying pipe. The length of tenons — and corresponding mortises—shall be 2½ inches for pipe 8 inches and smaller; 3 inches for pipe 10 to 20 inches, inclusive; and 4 inches for 22 and 24 inch pipe. Tenons and mortises shall be preserved by painting with creosote oil.

Inserted Joint pipe shall have not less than three wraps of wire close together over the mortise.

Reinforced Inserted Joint pipe shall be provided with round steel bands to be cinched down on the mortise, one band to be furnished with each joint for 50-foot head pipe, and two bands for 100-foot head pipe. The bands shall be 7/16 inches in diameter for sizes of pipe from 16 to 22 inches, inclusive; and ½-inch diameter for 24-inch pipe.

These bands shall have cold-rolled threads, with a hexagonal nut and plate washer at one end, and a standard button head at the other end.

Bands shall comply with Colorado Fuel and Iron Specifications, and they shall be given an asphaltum coating after fabrication. The ends of bands shall be connected by means of malleable iron pipe shoes.

Creosoted Wood Collar Couplings

These couplings shall consist of wood collars fitting snugly over smoothly turned tenons on the ends of pipe sections. The collar staves shall be preserved by the 8-pound pressure and vacuum creosoting process; the grade of creosote and the method of application to comply with the specifications of the American Wood Preservers' Association. The tenons shall be preserved by painting with creosote oil. The length of the wood collars shall be as shown in Table No. 5 indicating Types of Couplings.

The spacing of wire on the Wire-Wound Collars, and the spacing of bands on the Individual Banded Collars shall be such as to provide strength at least 50% in excess of the wire wrapping of the pipe with which they are used. The ends of the wire on Wire-Wound Collars shall be securely fastened in the same manner as provided for pipe sections.

Bands and shoes for Individual Banded Collars shall be the same as specified for use with R.I.J. couplings.

Double Seal Metal Collar Couplings

(Alternate for Creosoted Wood Collar Couplings)

Collars shall be made of mild steel having an ultimate tensile strength of not less than 50,000 pounds per square inch. Both the inner and outer rings shall be butt-welded in such a manner that the strength of the welds shall be not less than eighty per cent of the rated strength of the metal.

Collars for two-inch pipe shall consist of one outside ring, only. Collars for pipe three inches to twenty-four inches in diameter shall consist of two metal rings—an inner compression ring one-eighth inch thickness by two inches width, and an outer ring varying in thickness and width in accordance with the dimensions given in the table which follows. The diameters of the finished rings shall not vary more than 1/64-inch from the size specified. The welds shall be finished in such a manner that the outside surface of the inner ring and the inside surface of the outer ring shall be reasonably smooth.

Table No. 6

Size Pipe	INNER RING		OUTER RING	
	Size	Inside Diameter	Size	Inside Diameter
2"	....	....	1/8"x4"	3¾"
3"	1/8"x2"	3"	1/8"x4"	4¾"
4"	1/8"x2"	4"	1/8"x4"	5¾"
5"	1/8"x2"	5"	3/16"x4"	6¾"
6"	1/8"x2"	6"	3/16"x4"	8"
8"	1/8"x2"	8"	3/16"x4"	10"
10"	1/8"x2"	10"	3/16"x4"	12"
12"	1/8"x2"	12"	3/16"x5"	14"
14"	1/8"x2"	14"	3/16"x5"	16"
16"	1/8"x2"	16"	3/16"x5"	18"
18"	1/8"x2"	18"	3/16"x5"	20"
20"	1/8"x2"	20"	3/16"x5"	22"
22"	1/8"x2"	22"	3/16"x5"	24"
24"	1/8"x2"	24"	3/16"x5"	26"

Rings shall be thoroughly painted or dipped to provide a protective coating. The paint used shall be of such a consistency that the rings will receive a tough, slightly elastic coating which will not run nor chip under ordinary ranges of temperature. "Carbon Elastic" paint, as manufactured by the American Tar Company, or its equivalent, shall be acceptable.

The ends of pipe sections shall be provided with smoothly turned tenons, and the metal rings shall fit these tenons snugly. The tenons shall be painted with creosote oil before the rings are placed on the pipe sections.

Manufacture

Pipe shall be manufactured on machines especially designed for this purpose, using the most modern methods in all respects. Wire wrapping shall be applied at the proper tension so that it will be slightly embedded in the staves. At least three wraps of the wire shall be laid tightly together at each end of pipe sections. Wrapping shall be started by bending and stapling the end of the wire so that three or more wraps shall lay over it. Wrapping shall be completed at the other end of the pipe section by laying three wraps in a steel clip designed for this purpose, and the end of the wire shall be bent back over the clip after it is closed, and this end shall be stapled to the pipe. The wire wrapping shall be stapled along the pipe, staples being placed not to exceed eighteen inches apart, and located spirally around the pipe. The ends of pipe sections shall be smoothly turned to produce couplings having a snug fit.

Coating

The outside of the pipe shall be given a coating of hot coal tar and pitch, or asphaltum. The coating material shall adhere closely to the outside of the pipe and to the wire, and shall not flow nor become brittle under ordinary ranges of temperature. The outside of tenons shall be wrapped with paper during this dipping process. After dipping, and while the coating is still soft, the pipe shall be rolled in fine sawdust.

STANDARD CREOSOTED PIPE

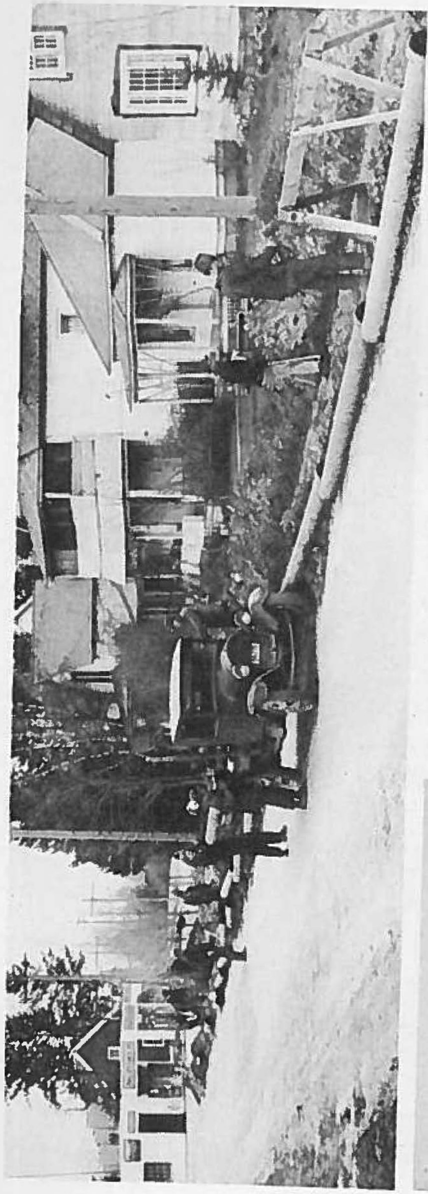
Creosoted Wire-Wound Wood Stave Pipe shall comply with the above Specifications, except that sapwood shall be no defect. After being milled, staves shall be pressure-creosoted in accordance with the specifications of the American Wood Preservers' Association, this treatment to result in the retention of an average of not less than 8 pounds of creosote per cubic foot of wood treated. Unless a coating is particularly specified, Creosoted Wood Pipe shall be furnished without the outside coating which is provided for Untreated Pipe.

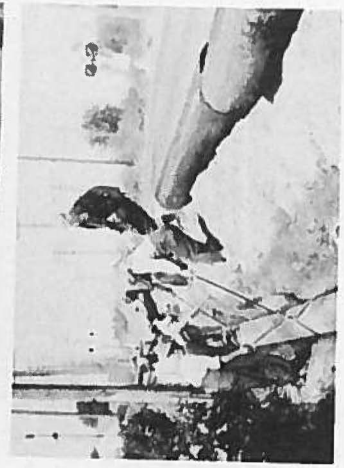
CAST IRON FITTINGS

Unless otherwise provided, bends, tees, crosses, wyes, reducers, saddles, adaptors, and other fittings for use with wire-wound wood pipe, shall be Gray Iron castings. These shall be especially designed for use with wood pipe, and all outlets for connection with wood pipe shall be provided with smooth, truly circular hub ends. Outlets for connection with threaded steel pipe shall be tapped for U. S. Standard steel pipe threads. Flanged outlets shall be 125 pound American Standard, faced and drilled.

The thickness of walls shall provide adequate strength for the design head of the pipe with which the fittings are to be used. The method of manufacture and quality of castings shall be in accordance with, or superior to, that provided by Federal Specifications QQI - 652 for Gray Iron Castings having 20,000 pounds minimum tensile strength. The castings shall be of uniform quality, free from blow holes, porosity, hard spots, shrinkage defects, cracks and other injurious defects. They shall be smooth and well cleaned before inspection, by sand-blasting, tumbling, pickling or other approved processes.

Laying 6" Wire-Wound Pipe





Getting ready to lay FEDERAL 16" City Distribution Pipe.

Driving 14" Creosoted Irrigation Pipe

Installing 6" FEDERAL Untreated City Supply Line along Highway.

SPECIFICATION NO. 10A

January, 1942

SPECIFICATIONS FOR INSTALLING WIRE-WOUND WOOD STAVE PIPE

Handling and Distribution

Pipe shall be carefully handled at all times when it is being unloaded, hauled and distributed along the line of installation. The pipe shall not be handled with sharp pointed tongs or other similar equipment which would damage the coating or the staves. Particular care must be taken to avoid damage to the tenons and couplings at the ends of pipe sections.

Pipe shall be distributed along the line with the coupling or mortise ends forward in the direction which the pipe is to be laid. If it is distributed prior to trenching, it shall be placed far enough from the location of the trench so that it will not be damaged by machinery or covered with earth.

Preparation of Trench

The trench shall be finished to true grade and alignment. The width of the trench at the bottom shall be at least nine inches greater than the outside diameter of the pipe. The bottom of the trench shall be free from large rocks or other obstructions which would result in the weight of the pipe being concentrated at certain points. Particular care shall be taken in this respect in the case of pipe larger than twelve-inch diameter.

Laying Pipe

Pipe sections shall be lowered into the trench with reasonable care, ropes being used for the larger sizes. Pipe shall be laid with the coupling or mortise ends of sections pointing forward in the direction of laying. The driving plug shall fit the end of the pipe properly so that it will have a uniform bearing against the stave ends, and it shall be held firmly against the pipe when driving. Care should be taken in inserting the tenon, to see that it is started around the entire circumference, and the pipe section shall first be driven lightly until it is apparent that a properly fitted connection is being made, and then driven until it comes up tight against the shoulder of the section previously laid. Curves shall be made by driving the pipe sections on straight, or nearly so, and then springing into place. If necessary, short sections of pipe shall be used for making sharp curvature, and the pipe shall be properly braced or blocked to prevent movement when it is placed under pressure. Elbows and other fittings shall be blocked in the same manner.

Pipe may be cut to special lengths and damaged ends may be repaired by cutting and milling joints in the field. Before the wire wrapping is cut, it shall be stapled three or four times back of the point where it is to be cut. Just back of the re-milled end, the wire shall have at least three wraps tight together, and securely stapled. The tenon end shall be milled accurately to size and finished with a wood rasp.

Soap, or other similar lubricants, may be applied to tenons to permit easier driving of pipe; but, aside from milling the ends of special pieces referred to in the preceding paragraph, the tenon ends of pipe sections shall not be changed from factory milling without the full approval of the manufacturer. If such alterations are permitted, they shall be performed in accordance with the manufacturer's instructions.

Priming and Testing

Unless otherwise provided, priming and testing pipe shall be a part of the pipe installation; and water for the test, at the required pressure is to be furnished by the purchaser.

Water shall be admitted to the line gradually, as soon as possible after the pipe is laid, and time shall be allowed for the necessary taking-up of pipe and couplings before the pipe is subjected to the full pressure. After the line is under approximately full pressure, no caulking shall be permitted until ample time has been allowed for swelling. This time may be as much as three days for untreated pipe, and eight days for creosoted pipe.

Pipe shall be tested to operating pressure within the limits at any location of not less than 90% of the operating pressure, and not more than 110% of the head for which the pipe is banded. All running leaks which appear under this test shall be repaired to the satisfaction of the Engineer or the Purchaser. The test pressure shall be maintained thereafter for a period of 24 hours; or a shorter period, if satisfactory to the Engineer or Purchaser.

Backfilling

Prior to testing, sufficient backfill may be placed around the pipe between couplings to prevent movement during the test. Couplings shall be left uncovered until testing is completed, with the exception that pipe may be entirely covered at road crossings or similar locations.

The pipe shall be backfilled with material excavated from the trench, using the cleanest soil and clay available and that containing the least organic matter, to cover the pipe. Backfill shall be tamped underneath the pipe to the width of the inside diameter of the pipe for sizes fourteen-inch and smaller, and up to the horizontal diameter for sizes sixteen-inch and larger. After the pipe is covered with fine material, the balance of the backfill may be placed by a "bulldozer" or similar equipment.

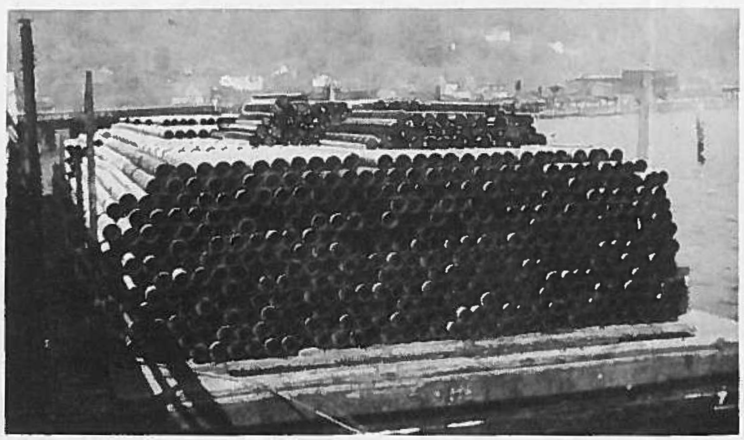
Installing 16" City Supply Line

SPECIFICATION NO. 13

SPECIFICATIONS FOR BURLAP WRAP ON WIRE-WOUND WOOD STAVE PIPE

(NOTE: *Burlap wrapping is an extra, not furnished under the preceding standard specifications. See Page 23 regarding conditions for which it should be specified.*)

The outside of the pipe shall be covered with one thickness of burlap weighing one-half pound per square yard. The burlap shall be cut into strips approximately ten inches wide and wrapped spirally on the pipe, with edges lapped at least one inch. Prior to the application of burlap, the outside of the pipe shall be dipped in hot coal tar and pitch, or asphaltum, and after burlap is applied the pipe shall receive another coating of the same material, which shall thoroughly saturate the burlap. While the coating is still hot, the pipe shall be rolled in sawdust to facilitate handling. Wire-wound couplings shall be wrapped in the same manner as the pipe sections, but individual banded couplings shall be furnished without burlap covering.

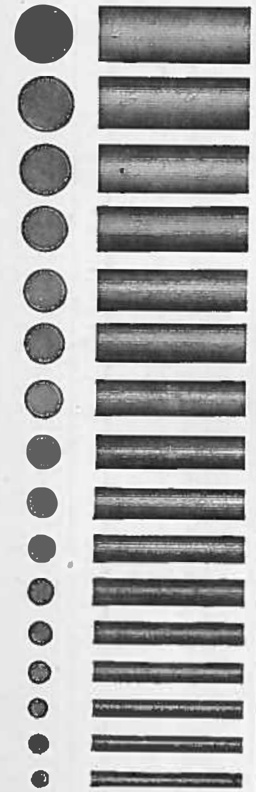


Seven miles of FEDERAL 6" Sewer Pipe loaded on scow at our factory.

PIPE WINDING WIRE TABLE

Table No. 7

Full Sizes of Plain Wire



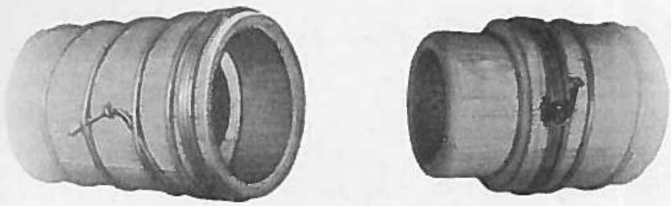
Steel Wire Gage* No.	Sizes of Wire: Com'on Fr'ct'ns	Sizes of Wire: Decimally	Pounds per Foot	Feet to Pound
1		.2830	.2136	4.681
	9/32	.28125	.211	
2		.2625	.1838	5.441
	¼	.250	.1667	
3		.2437	.1584	6.313
4		.2253	.1354	7.386
	7/32	.21875	.1276	
5		.2070	.1143	8.750
6		.1920	.0983	10.17
	3/16	.1875	.0937	
7		.1770	.0835	11.97
8		.1620	.070	14.29
	5/32	.15625	.0651	
9		.1483	.0586	17.05
10		.1350	.0486	20.57
	⅛	.1250	.0416	
11		.1205	.0387	25.82
12		.1055	.0296	33.69
	3/32	.09375	.0234	
13		.0915	.0223	44.78
14		.0800	.0170	58.58
15		.0720	.0138	72.32
16	1/16	.0625	.0104	95.98

* Formerly American Steel & Wire Gage

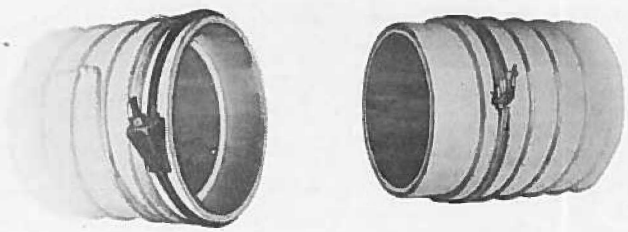
FEDERAL 16" Wire-Wound Pipe

FEDERAL COUPLINGS

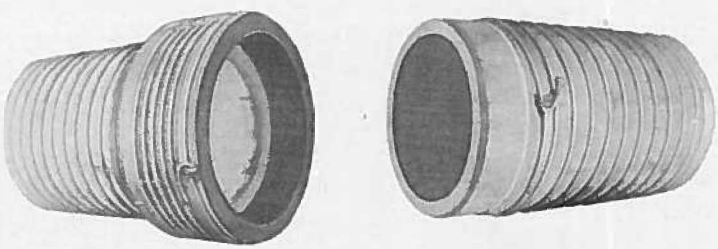
Five standard types of Couplings are used on Federal Wire-Wound Pipe, as follows:



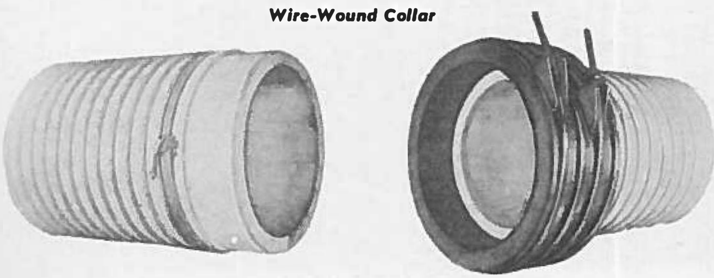
Inserted Joint



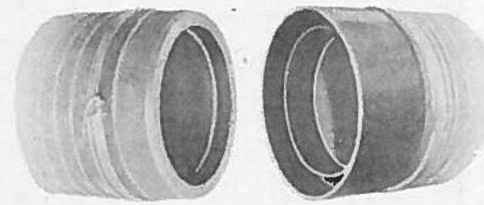
Reinforced Inserted Joint



Wire-Wound Collar



Individual Banded Collar



Double Seal Metal Collar

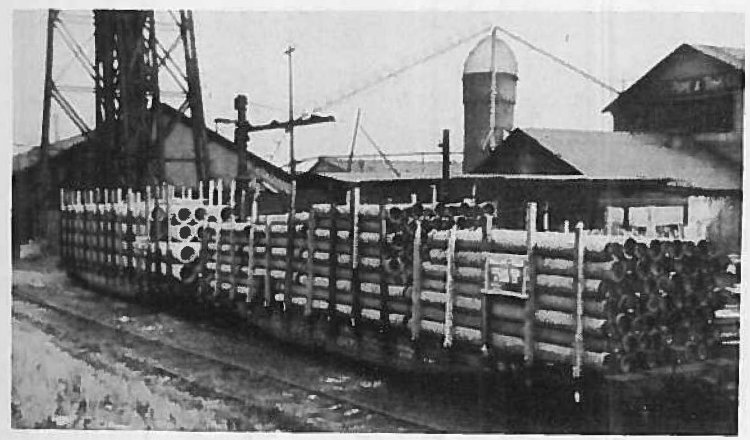
I.J.—Inserted Joint Couplings are least expensive and are suitable for sizes up to 12″, operating under low pressure.

R.I.J.—Reinforced Inserted Joint Couplings are suitable for larger sizes (14″ to 24″) operating under low pressure.

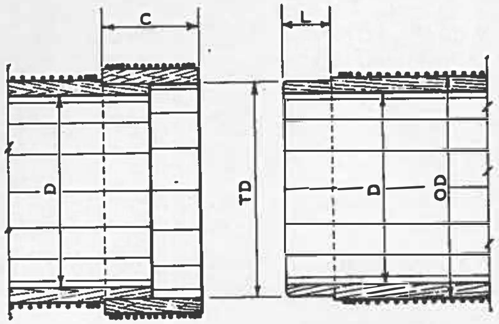
W.W.C.—Wire-Wound Creosoted Wood Collar Couplings are used with sizes up to 16″, for high or low pressure.

I.B.C.—Individual Banded Creosoted Wood Collar Couplings are the equivalent of Wire-Wound Collars for sizes 18″ to 24″.

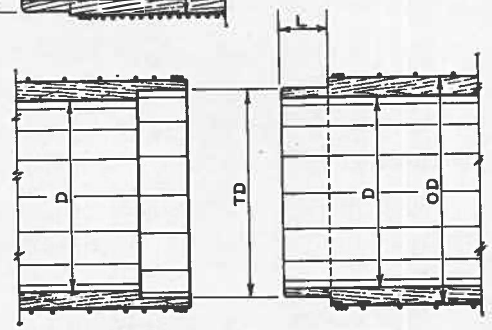
2M—Double Seal Metal Collar Couplings are furnished as an alternate for W.W.C. or I.B.C. couplings, at the same price. The inside rings are 1/8″ thick for all sizes. The outside rings are 1/8″ thick for sizes up to 4″ and 3/16″ thick for larger sizes.



Carloads 18″ and 8″ Wire-Wound Pipe



Creosoted Wood Collar Coupling (W.W.C. or I. B.)



Inserted Joint Coupling (I. J. or R. I. J.)

Mortise *Tenon*

COUPLING DIMENSIONS

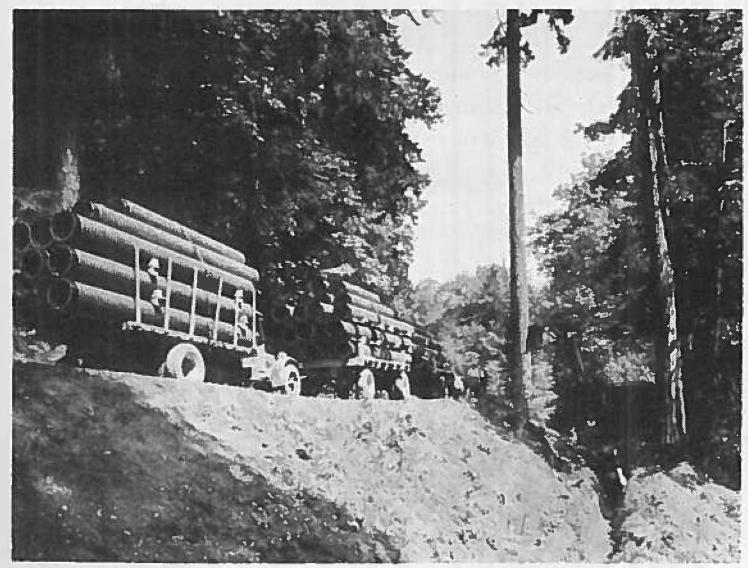
Table No. 8

Size of Pipe	O. D. of Pipe	Creosoted Wood Collar Pipe: Length of Tenon	Creosoted Wood Collar Pipe: Diameter of Tenon	Inserted Joint Pipe: Length of Tenon	Inserted Joint Pipe: Diameter of Tenon	Inserted Joint Pipe: Inside of Mortise
D	OD	L	TD	L	TD	TD
2"	4"	3"	3¾"	2½"	3 3/16"	3⅛"
3"	5"	3"	4¾"	2½"	4 3/16"	4⅛"
4"	6⅛"	3"	5¾"	2½"	5¼"	5 3/16"
5"	7⅛"	3"	6¾"	2½"	6¼"	6 3/16"
6"	8¼"	3"	8"	2½"	7¼"	7 3/16"
8"	10¼"	3"	10"	2½"	9¼"	9 3/16"
10"	10¼"–10½"	3"	12"	3"	11⅜"	11 5/16"
12"	14⅜"–14½"	3"	14"	3"	13⅜"	13 5/16"
14"	16⅜"–16½"	4"	16"	3"	15½"	15 7/16"
16"	18½"–18⅝"	4"	18"	3"	17½"	17 7/16"
18"	20½"–20⅝"	4"	20"	3"	19½"	19 7/16"
20"	22⅝"–22¾"	4"	22"	4"	21½"	21 7/16"
22"	24⅝"–24¾"	4"	24"	4"	23½"	23 7/16"
24"	26⅝"–26¾"	4"	26"	4"	25½"	25 7/16"

Cast Iron Fittings are made to provide a driving fit for L and TD of Collar Pipe as listed in table. If Inserted Joint or Double Seal Metal Collar Couplings are to be furnished, special pieces of pipe, with one end milled for fitting, will be furnished without extra charge. In the case of Inserted Joint pipe, the order should specify whether a fitting tenon is to replace the I.J. tenon or I.J. mortise; or a sketch should be included showing the relative location of fittings, and the point at which pipe laying is to be started. Driving plugs are placed in the mortise end when laying pipe. It is not necessary, however, for Inserted Joint tenons to point in the same direction as the flow of water which is to pass through the pipe.

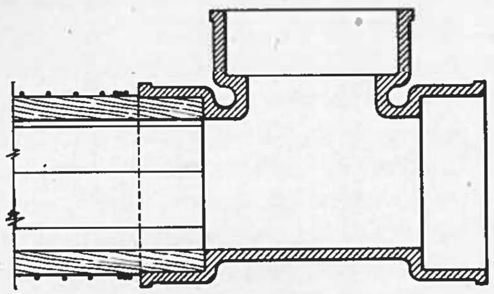
Table No. 4 indicates heads at which O.D. changes for sizes 10″ and larger.

See Table No. 6 regarding tenons for Double Seal Metal Collar Couplings. L is one-half length of outside steel ring (2″ for sizes 10″ and smaller, and 2½″ for sizes 12″ and larger).



Truckloads for 18″ Creosoted City Supply Line

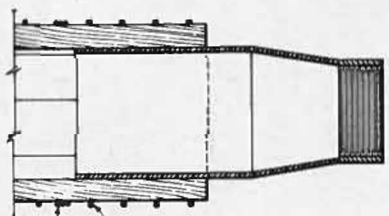
FITTINGS FOR WIRE-WOUND WOOD PIPE



Typical Cast Iron Wood Pipe Fitting

Cast Iron

Cast Iron Fittings, such as Bends, Tees, Crosses, Reducers, Adapters, etc., are used almost exclusively with wire-wound pipe. The tenons, as milled for creosoted wood collar couplings, are a driving fit for hub ends of fittings, and this connection becomes even tighter as the wood swells. A typical connection is here illustrated and pictures of the most common fittings are presented in Section IV. FEDERAL has the necessary pattern equipment so that almost any combination of outlets for various sizes of wood pipe can be furnished. Certain outlets, as may be specified, can be made for connection with flanged, threaded or other common types of pipe.



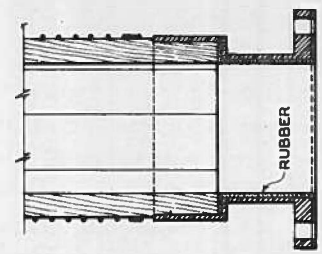
Typical Welded Steel Wood Pipe Fitting

Welded Steel

Welded steel fittings are ordinarily made to the same outside diameter as the inside diameter of the pipe with which they are to be used. The ends of steel fittings must be smooth outside for

several inches, or more, to permit making a connection by banding the pipe staves against the steel nipple; threaded steel bands with shoes being used for this purpose. Steel Saddles are an exception, as these are banded against the outside of the staves, with a sheet rubber gasket being used to obtain a tight connection. Any combination of sizes can be furnished in welded steel fittings, with any of the outlets flanged, threaded, or otherwise. Standard pipe couplings or nipples are welded in place as required for threaded connections.

Welded steel fittings as described, or similar, are used extensively with continuous stave wood pipe, but to a considerable extent have only a rather special application for wire-wound pipe, particularly for industrial lines. They can be provided with a vulcanized rubber lining of the same quality as the rubber used for truck tires. Rubber lined steel fittings are recommended for use with wood pipe lines which are to handle acid solutions or highly abrasive materials.



Typical Hub End Welded Steel Fitting, shown with rubber lining

Hub end welded steel fittings, with a rubber lining, are particularly suitable for use with pipe for operating heads in excess of about 300 feet, if acid solutions or abrasive materials are to be handled. Steel fittings (not rubber lined) without hub ends are sometimes made to the required inside diameter so that the ends may be driven over wood pipe tenons. This is common practice for fittings to be used with Creosoted Irrigation, Drainage and Sewer Pipe, but this kind of fitting is seldom used with other types of wood pipe.

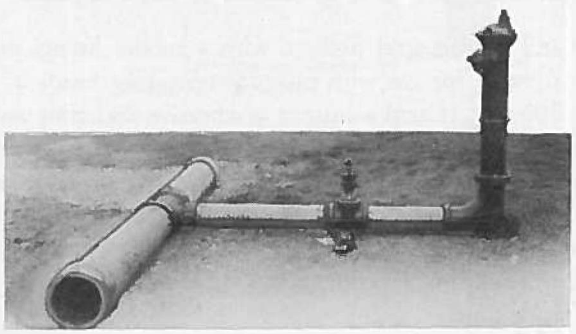
Wood Reducers

Tapered wood pipe reducers, from about 8 feet to 20 feet long, can be furnished. These provide a long, smooth transition between two sizes of pipe. The ends are made with couplings matching those of the pipe with which the tapered section is to be used. Such tapered pieces of wire-wound wood pipe are rather costly to manufacture, and accordingly, cast iron reducers should ordinarily be used and are entirely suitable for most purposes.

Service Connections

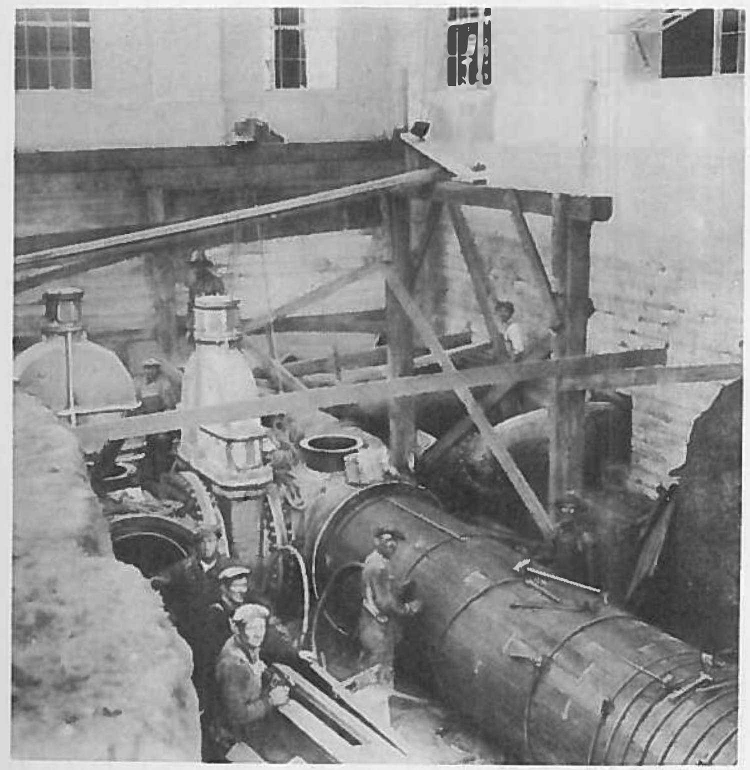
Brass Tapping Nipples and Corporation Cocks are illustrated in Section IV, adjacent to list prices for these items. A rather coarse thread with considerable taper is provided at one end, and connection is made by screwing this into a hole bored into the wood pipe. The hole should be of the proper size to make a tight fit, but not so small as to cause tearing of the wood. It is desirable to try a hole bored into a board to determine the correct setting of an expansion bit. Wire wrapping on the pipe may be driven a little to each side of the original location to make room for placing these brass connections.

Exceptionally large sizes have been used with reasonably satisfactory results, but in general we recommend not larger than one-inch to be installed in wood pipe up to 8″ diameter, and 1½″ maximum for pipe 10″ and larger. Two-inch may be used in pipe 18″ diameter and up, for low operating heads, if not subjected to appreciable vibration. Cast iron tees or saddles with threaded outlets should be employed for any larger service connections.



Fire Hydrants

A typical hydrant connection is illustrated. This shows 4″ wood pipe nipples between the tee and the auxilliary valve and between this valve and the hydrant. The tee as shown, known as a hydrant tee, is provided with lugs for convenience in attaching shackle rods. Standard hydrants, of the type illustrated, are also available with 6″ hub end connections and with flanged connections.

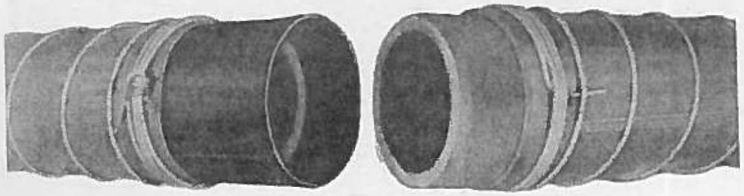


Completing Construction Twin Lines 48″ Pipe and Showing Gate Valve Connections

36" Creosoted Sewer Pipe at large sewage disposal plant.

21" Creosoted Sewer Pipe

Low Head Creosoted Irrigation Pipe



SPECIFICATION No. 14

FEDERAL CREOSOTED IRRIGATION, DRAINAGE and SEWER PIPE

(For Low Head Service)

Staves

Staves shall be manufactured from sound live Douglas Fir lumber, sapwood not restricted, but free from any imperfections that would tend to lessen the life of the pipe. Finished thickness of staves is 11/16 inches.

Creosote Treatment

After being milled, staves shall be given an eight pound treatment of high grade creosote oil as prescribed by the American Wood Preserving Association, which provides for an average of eight pounds of oil for each cubic foot of wood treated.

Wire

Staves are to be wrapped with special heavy galvanized wire having not less than .50 ounces zinc coating per square foot of wire surface. Table for spacing is given below. The wire shall have a tensile strength of from 58,000 to 68,000 pounds per square inch of cross section of wire.

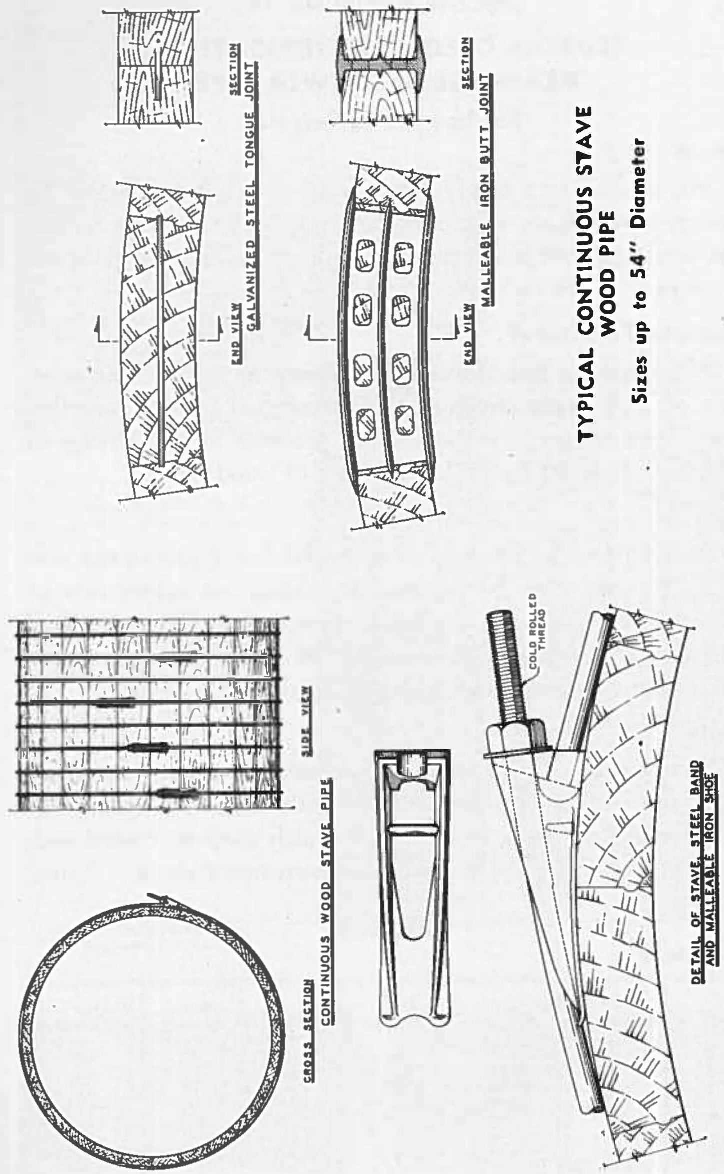
Joints

Each length of pipe shall have tenons turned on each end. Each joint of pipe shall be provided with one metal collar four inches in length, made of 1/8" steel; which shall be coated with specially prepared paint to withstand corrosion from soil action.

DETAILS

Table No. 9

Size	Head	Collar	Shell Thickness	Wire	Wire Spacing	Weight Lbs. Per 100 Ft.
3"	40'	Steel	11/16"	#8	3"	292
4"	40'	Steel	11/16"	#8	3"	370
5"	40'	Steel	11/16"	#8	3"	471
6"	40'	Steel	11/16"	#8	3"	552
8"	40'	Steel	11/16"	#8	3"	715
10"	40'	Steel	11/16"	#6	3"	916
12"	40'	Steel	11/16"	#6	3"	1086



TYPICAL CONTINUOUS STAVE WOOD PIPE
Sizes up to 54" Diameter

SPECIFICATION No. 15
January, 1942

GENERAL SPECIFICATIONS FOR CONTINUOUS STAVE DOUGLAS FIR WOOD PIPE
Sizes 4" to 120" Inclusive

(Specifications for larger sizes will be furnished on application)

Important Note:

This is a General Specification, and may require modification for special conditions. If used by reference to above specification number, or if incorporated into other specifications, the following information must be supplied—

1. *Stave thickness (if different than shown by table).*
2. *Kind of pipe desired—Untreated or Creosoted.*
3. *Joints—Steel Tongues or Malleable Iron Butt Joints.*
4. *Quantities under various heads (usually in 10-foot variations).*

STANDARD UNTREATED CONTINUOUS STAVE PIPE

Type of Pipe

The pipe shall be of the type known as Continuous Stave Pipe, which is erected in place. It shall be made of Douglas Fir staves, banded together by means of mild steel bands, and shall comply with the following detailed specifications:

Staves

Staves shall be made from 100% heart stock Douglas Fir timber, grown in the North Pacific Coast region, and shall be sound and free from all imperfections which might impair its strength or durability, or affect its water-tightness when used in pipe. Pitch seams, not extending more than one-quarter of the way through the piece, or more than four inches long, will be allowed. Cross grain shall be limited to an angle of not more than one inch in eight inches of stave length. Small, tight, sound knots, not over one-half inch in diameter, not penetrating through the thickness of the piece, will be allowed.

All timber must be thoroughly seasoned, either by air or kiln drying, before being milled into staves. Staves shall be dressed on both sides to true circles of the inside and outside diameters of the pipe. The edges of the staves shall be dressed to conform to the radial lines of the pipe, one edge to be provided with a bead, and the other edge to be provided with a corresponding groove. All staves shall be of uniform thickness and width, and the finished thickness shall be as provided in Table No. 10.

The ends of staves shall be cut off square and shall be slotted to receive the steel tongues which connect the ends of staves. The slots shall be in the same location in all stave ends, and shall be so that the tongue will fit snugly. The depth of the slot shall be one-half the width of the tongue.

The minimum length, and the average length of staves shall not be less than provided in the following table:

Stock Size Inches	Minimum Length	Average Length
2x4	7½′	12′
2x6	7½′	13′
2½x6 and larger	9½′	15′

Tongues

The tongues shall be cut from not lighter than 12 gauge mild steel, and shall be galvanized. The tongues shall be 1½ inches wide, and of such length so that after the pipe is cinched they will penetrate slightly into the adjoining staves, thereby making a water-tight joint.

Malleable Joints

(Alternate for Galvanized Steel Tongues)

If this type of joint is particularly specified, the butt joints of staves shall be connected by means of malleable iron castings of the Kelsey type. The joint shall be long enough to overlap the adjoining staves and shall have a straight or curved central tongue which shall penetrate into the abutting staves and the adjoining staves, forming a water-tight joint. Joints shall be coated, as provided for shoes. If this type of joint is furnished, additional bands to provide 6 inch spacing at butt joints shall not be required.

A TABLE SHOWING MAXIMUM HEADS FOR STANDARD FINISHED THICKNESS OF STAVES

For Douglas Fir Continuous Stave Pipe

Table No. 10

Diameter of Pipe	Standard Finished Thickness of Staves									
	1¼″	1⅜″	1 7/16″	1½″	1⅝″	2″	2⅛″	2½″	2⅝″	3⅝″
4″	400									
6″	400									
8″	400									
10″		400								
12″		400								
14″		400								
16″			400							
18″			370							
20″			330							
22″			300							
24″				290		380				
26″				270		360				
28″				250		330				
30″				230		310				
32″				220		290				
34″				210		280				
36″					210		270			
38″					200		260			
40″					190		250			
42″					180		230			
44″					170		220			
46″					160		210			
48″					150		200			
50″					150		190			
52″					140		190			
54″					140		180	220		310
56″							180	210		300
58″							170	200		290
60″							160	190	210	280
66″								180	190	260
72″								160	170	240
78″								150	160	220
84″									150	200

90″ to 120″ (3⅝ shell for heads ranging to 140′, and thicker for higher heads.)

NOTE: *The above stave thicknesses are subject to change for certain conditions; but, unless otherwise specified, staves are to be finished to the thickness indicated by this table.*

Bands

The bands shall be round mild steel rods, having an ultimate tensile strength of from 55,000 to 65,000 pounds per square inch of cross-section. Bands shall be made with button heads and cold-rolled threads, with hexagonal nuts and plate washers. They shall comply in all respects with the Colorado Fuel and Iron Company's specifications for pipe bands, except that the threads shall not be less than 6 inches long, and the bands shall be furnished with an asphaltum coating as provided therein.

One-piece bands shall be furnished for sizes of pipe up to, and including, 54 inch diameter; and two-piece bands shall be furnished for pipe larger than 54 inch.

One-piece bands shall have a button head at one end, and shall be threaded at the other end; requiring one shoe for each band when placed on the pipe. Two-piece bands shall be made with one section having button heads at each end, and one section having threads at each end; requiring two shoes for each band when placed on the pipe.

Bands shall be bent to fit the outside diameter of the pipe and such bending shall be done prior to application of the asphalt coating.

Band Spacing

The spacing of bands shall be adjusted so that the working stress of the steel will not exceed 15,000 pounds per square inch—equivalent to a factor of safety of four, based on an ultimate strength of 60,000 pounds. The spacing of bands shall in no instance be such as to develop a band bearing in excess of 800 pounds per square inch, assuming a width equal to the radius of the band in contact with the staves. The maximum spacing of bands shall be 10 inches, center to center. Spacing of bands shall not exceed 6 inches at butt joints of staves, if the pipe is constructed with steel tongues.

Shoes

The shoes to connect the ends of the bands shall be of malleable cast iron, and shall be of such design and strength as to develop the ultimate strength of the band with which they are used. They shall fit the outer surface of the pipe and shall have sufficient bearing surface to prevent injurious indentation of the wood. They shall be coated by dipping in asphaltum before shipment.

Erection

The ends of adjoining staves shall break joint at not less than 18 inches. Staves shall be laid and driven in such a manner as to avoid any tendency to cause wind or twist in the pipe, and the required alignment and grade shall be maintained. Staves shall be well driven to produce tight butt joints; driving bars, or other suitable means being used to avoid marring or otherwise damaging the staves in driving. In rounding out the pipe, care shall be exercised to avoid damage by chisels, mauls or other tools. The pipe shall be rounded out to produce smooth inner and outer surfaces. Bands shall be accurately spaced and placed perpendicular to the axis of the pipe. Shoes shall be placed so as to cover longitudinal joints between staves, and bear equally on two staves as nearly as practicable. They shall be placed alternately on opposite sides of the pipe so as to be out of line, and cover successively at least two seams on each side in a uniform manner. Bands shall be hammered during the process of cinching. All metal work shall be handled with reasonable care so as to avoid injuring the coating. In hammering shoes into place, they shall be struck in such a manner as to avoid deformation or injury. After erection, all metal work shall be retouched—where abraded—with a suitable paint.

Backfilling

Before the pipe is filled with water, any blocking used under the pipe for building shall be removed in order that the pipe may have a uniform support for its full length. If located in a trench, the pipe shall be backfilled and tamped to the horizontal diameter with material excavated from the trench, using the cleanest soil and clay available and that containing the least organic matter. Following the test, pipe shall be covered with the same grade of selected material, and the balance of the backfill may be placed by a "bulldozer" or similar equipment.

Testing

Unless otherwise provided, the price for pipe erected in place shall include the cost of priming and testing. Water for this purpose is to be furnished at the required pressure by the purchaser. Whenever possible, water shall be admitted to the line gradually, allowing time for the swelling of the staves before full pressure is applied. The pipe shall be tested to full operating pressure, and any running leaks appearing under such pressure shall be closed.

Cradles

If timber cradles are specified, they shall be constructed from sound Douglas Fir, free from twist, large knots, or wind shake. The milling shall be done in such a manner as to provide true joints and as nearly perfect bearing surfaces as possible.

Detailed dimensions of cradles shall be as shown by drawings. The circumferential bearing surface may vary, depending on the size of pipe and the thickness of the staves. Unless otherwise provided, this shall be approximately 120 degrees; in no case shall it be less than 90 degrees. Unless specified otherwise, cradles shall be spaced 10 feet, center to center, along the pipe.

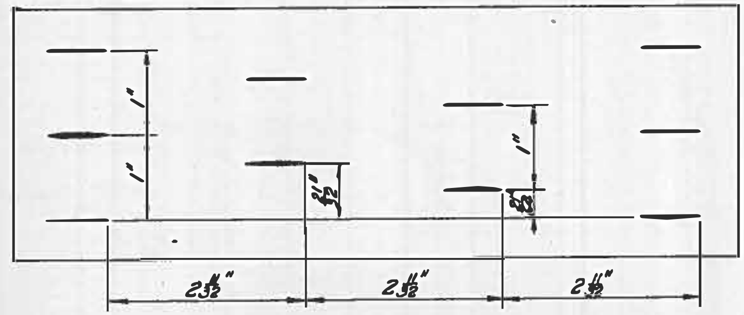
For that portion of the pipe line where the space between bands is less than the thickness of the cradles, the cradles shall be grooved for the bands so that the weight of the pipe shall be supported by the staves. Cradles need not be so grooved if the band spacing is such that three or more bands will rest in each cradle.

If creosoted cradles are specified, treatment shall be in accordance with that provided for staves, except that timber shall not be dried prior to treatment. The sills and mud sills are to be incised, but the pieces making up the cradle proper are not to be incised, unless it is so specified. In such instances, however, the curved and other band-sawed surfaces are not to be incised.

The erection of cradles shall be performed in a workmanlike manner, and the various parts shall be carefully assembled and securely spiked or doweled together. Placing of mud sills and sills to grade and alignment shall not be considered to be a part of cradle erection.

STANDARD CREOSOTED CONTINUOUS STAVE PIPE

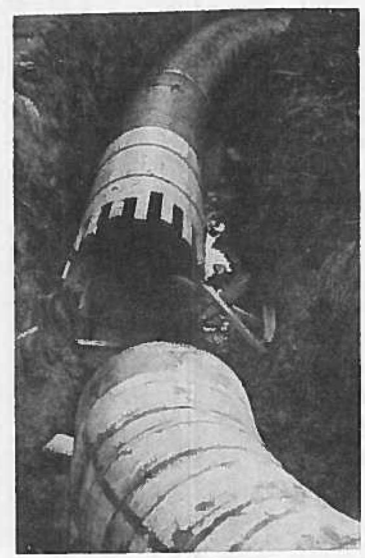
Creosoted Continuous Stave Pipe shall comply with the specifications for Untreated Continuous Stave Pipe, except that sapwood shall be no defect. After being milled to pattern, unless otherwise provided, the inside and outside surfaces of staves shall be incised. The depth of incisions shall be a maximum of one-half inch, and the pattern of the incisions shall be approximately as here indicated.



TOOTH ARRANGEMENT FOR DOUGLAS FIR TIMBER INCISOR

Staves shall be pressure-creosoted in accordance with the Specifications of the American Wood Preservers' Association—this treatment to result in the retention of an average of not less than 8 pounds of creosote oil per cubic foot of wood treated.

Creosoted staves shall not be sawn off during the erection of pipe, except when such cutting is absolutely necessary. All such cut ends shall be thoroughly painted with creosote oil.



Welded Steel Bend

WEIGHT OF UNTREATED DOUGLAS FIR STAVES ONLY IN POUNDS PER 100 LINEAL FEET OF PIPE

Table No. 12

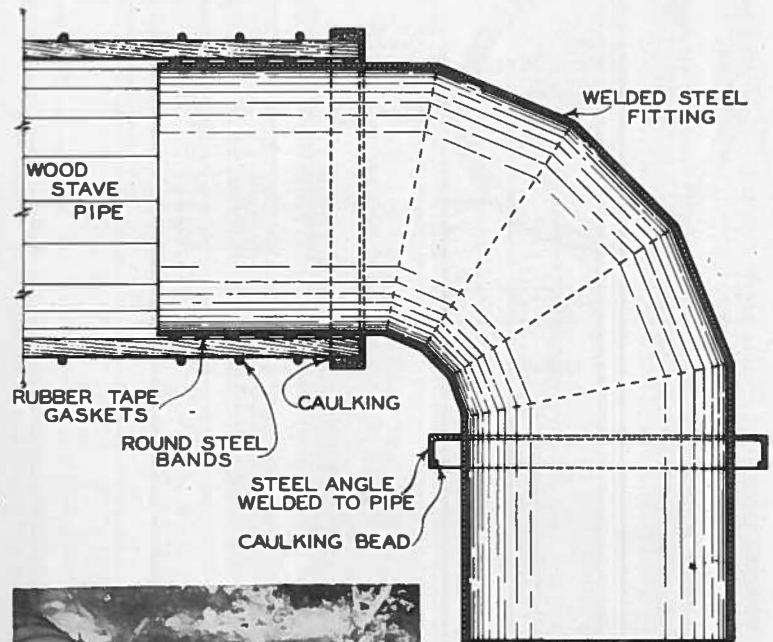
Diameter of Pipe	Standard Finished Thickness of Staves									
	1¼″	1⅜″	1 7/16″	1½″	1⅝″	2″	2½″	2½″	2⅝″	3⅝″
4″	495									
6″	684									
8″	873									
10″		1180								
12″		1386								
14″		1595								
16″			1890							
18″			2110							
20″			2324							
22″			2540							
24″				2884		3920				
26″				3110		4220				
28″				3337		4525				
30″				3563		4825				
32″				3789		5130				
34″				4015		5430				
36″					4610		6110			
38″					4855		6430			
40″					5100		6750			
42″					5350		7070			
44″					5590		7390			
46″					5835		7710			
48″					6080		8035			
50″					6325		8360			
52″					6570		8675			
54″					6815		8995	10650		15750
56″							9315	11030		16310
58″							9640	11400		16850
60″							9955	11780	12400	17400
66″								12915	13580	19030
72″								14045	14770	20670
78″								15175	15960	22320
84″								16305	17150	23980
90″								17450	18335	25600
96″										27250
102″										28900
108″										30550
114″										32200
120″										33800
132″										37100
144″										40400

(Basis 0.02 lbs. per Cubic Inch)

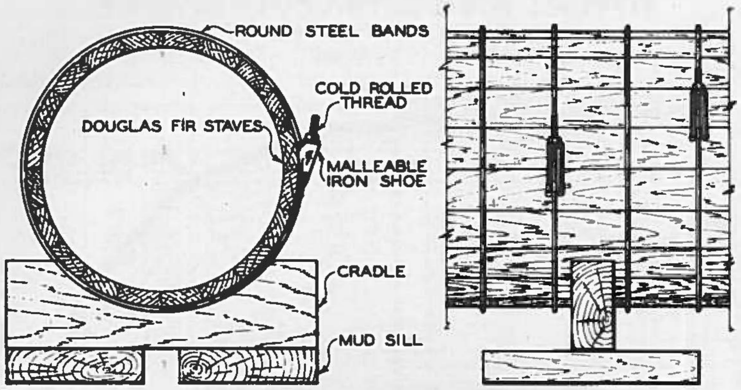
To determine the approximate weight of Pressure-Creosoted Staves, add the following percentages to the Untreated weight shown by this table:—

Treatment	Add Per Cent
8 lbs.	25
10 lbs.	30
12 lbs.	36
14 lbs.	41
16 lbs.	47

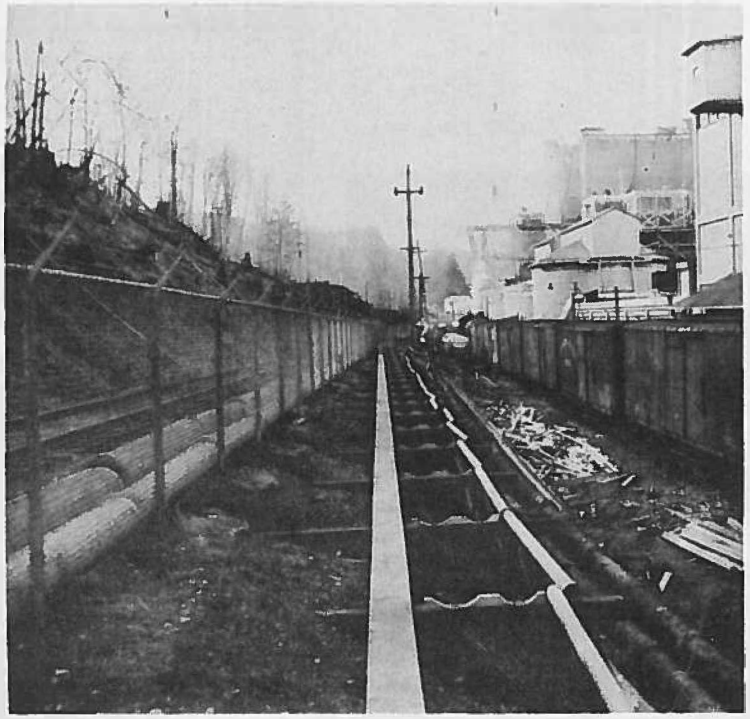
FITTINGS FOR CONTINUOUS STAVE PIPE



Welded Steel Bend with Caulking Hub

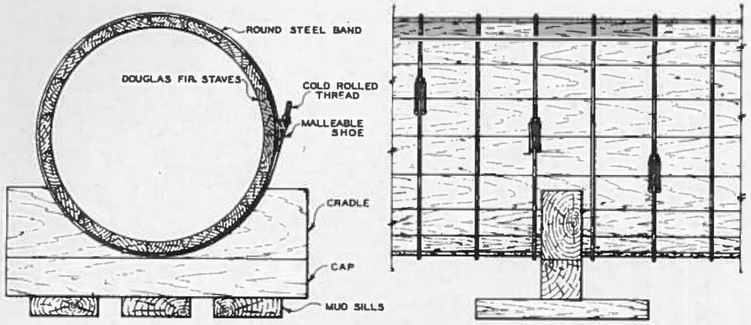


Typical Cradle for 24" diameter, and smaller

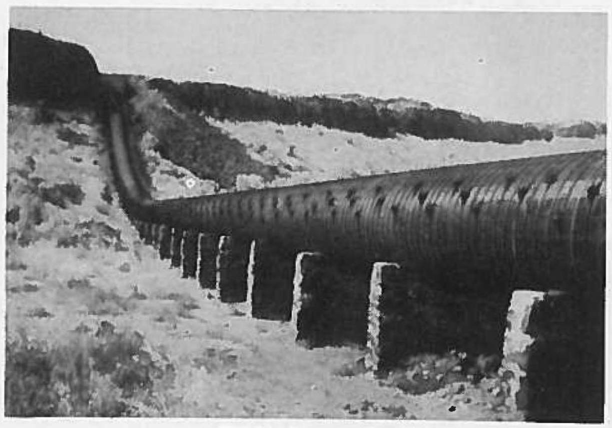


Cradles for 10" and 14" Wire-Wound Pipe

Wire-Wound Pipe Installed in Cradles shown on previous page

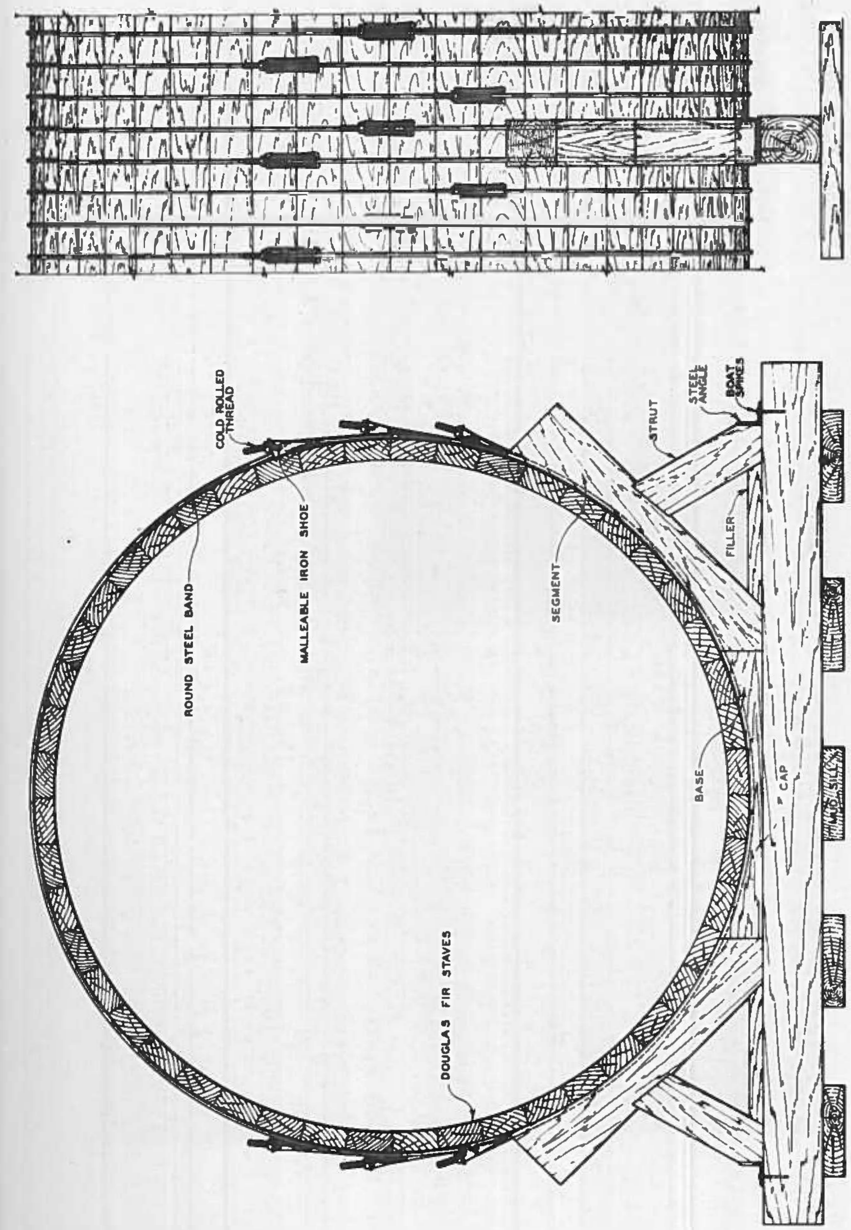


Typical Cradle for 24" to 36" diameter

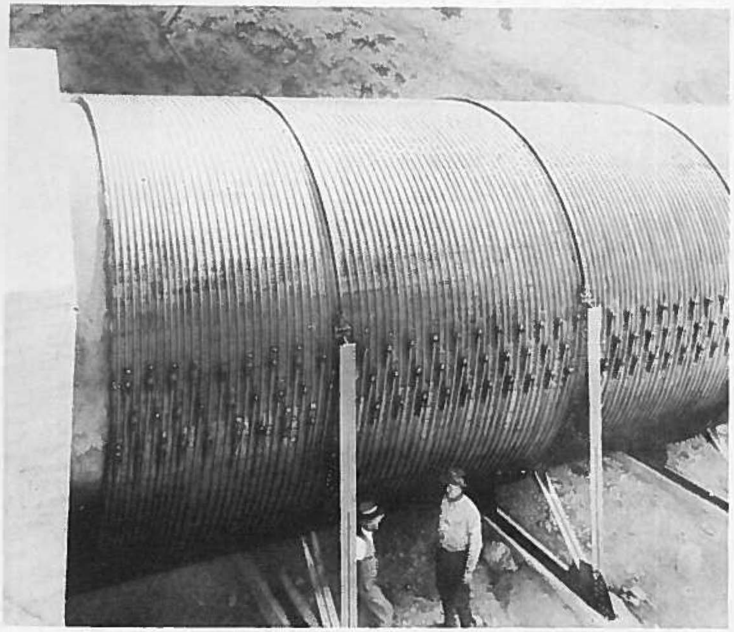


Rubble Masonry Cradles

Reinforced Concrete Cradles

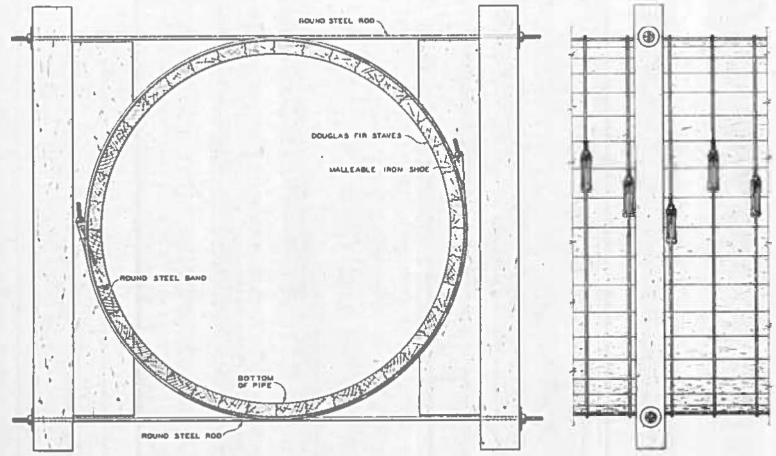


TYPICAL CRADLE FOR SIZES UP TO ABOUT 10-FEET DIAMETER



Steel Cradles

Concrete Cradles



Typical Buckstay Cradle for large diameter pipe, which is to be subjected to extremely heavy backfill.

Buckstay Cradles

Typical View of Continuous Stave Pipe Erection, showing a 52" creosoted City Supply Line.

Starting construction of a 48" Wood Pipe for Water Power—pipe to be built in each direction.

Banding crew working on 54" Creosoted Pulp Mill and City Supply Line. Opening in distance was "buckled in" later.

INSTRUCTIONS No. 15-A

January, 1942

INSTRUCTIONS FOR MATERIAL DISTRIBUTION AND ERECTION OF CONTINUOUS STAVE WOOD PIPE

Unloading Cars

The material consists of staves, tongues or joints, bands and shoes.

Usually the best time to sort staves as to length is when unloading cars. Arrange the space available to make separate piles of staves varying not more than one foot in length. Consider all staves from 11 to 12 feet in length as 12-foot staves, and all from 12 to 13 feet in length as 13-foot staves, etc. It is convenient to place a chute out of the car door with lengths marked on each side, beginning with Zero at the bottom of the chute. DO NOT permit ends of staves to be damaged due to bumping lower end of chute. It is decidedly worth while to sort staves carefully as to length, and good sorting will save time when erecting pipe. Make the piles neat and substantial. Sloppy, haphazard piling means damage to edges or ends of staves, which results in considerable loss and extra labor when building, to say nothing of an inferior pipe when finally erected.

Bead on Staves

The staves are usually milled with a bead on one edge, and a corresponding groove on the other edge. It will become apparent as soon as pipe erection is started that lumber must be distributed along the line of erection with the beads all on one side, assuming that the staves are all piled the same side up.

Say, the pipe line runs East and West and the staves are distributed all with the convex side up. Then the beads should all be on the South side of the piles, or all on the North side. Any staves piled otherwise will have to be turned, end for end, before being placed in the pipe. A stave placed in the pipe wrong with respect to the bead causes additional labor, so this should be watched closely.

The best time to place all staves the same, with respect to bead and groove, is when unloading cars and sorting as to lengths. It may be done when loading trucks or when placing staves along the line of erection. It SHOULD NOT be left to be done when building pipe.

Bands, Shoes and Tongues

The bands are ordinarily shipped in bundles of 10 or 15, which can be hauled directly to the line of erection and distributed approximately as required per 100 feet of pipe. Do not overlook the fact that tongues and shoes are easily lost, particularly the small metal tongues, and these should be left in the original bundles or containers.

Hauling Staves

(In order to simplify the explanation, these directions from this point apply particularly to 36″ pipe, using 22 staves to the circle. They would apply for other pipe sizes by keeping in mind the number of staves required to the circle for the particular size under consideration.)

In the first place, DO NOT PERMIT staves to be damaged while hauling, OR AT ANY OTHER TIME. Do not let chains cut into the edges, and don't handle with picaroons.

Staves are to be distributed along the line of erection in sets placed practically end to end, each set containing 22 staves of the same foot length, as explained above. Keep this in mind and load wagons or trucks in sets.

Building

Obtain or make a semi-circular outside form. This can best be made of 1½″ iron pipe, which should be bent to shape on a circle having the same diameter as the outside of the pipe. For a 36″ pipe with 1½″ shell, the outside form should be bent on a 39-inch diameter.

A semi-circular inside form is required to support the top of the pipe while building. This can be made of lumber, with a vertical post and a small base to support it. For 36″ pipe it should be 35″ in diameter.

Instructions have been given above to distribute staves in sets of even length. This is correct, except for the first set erected. Half of the staves for the first set should be two to three feet longer than the other half; that is, provided erection is begun, as it usually is, either at one end or the other of the completed pipe.

For pipe having an odd number of staves to the circle—for instance, 30-inch pipe with 19 staves—it is necessary to place one extra-long stave (about two or three feet longer than the other long ones) in the first set erected. This long stave may well be placed at the bottom of the pipe, and carried along in this position as subsequent sets are placed.

Place the staves in the outside form, alternating a long one and a short one so as to break joints two to three feet. It is suggested that the seam between the two bottom staves be located exactly at the bottom of the pipe. The importance of this is to furnish a gauge for the eye to assist in preventing the starting of a "wind" in the staves as erection is continued. Place about half of the staves, and then set in the inside form and complete the circle. Then place three or four bands around the pipe, cinch them fairly tight, and the forms can be removed.

This first set is usually the most difficult to build. An additional inside and outside form, even if only roughly shaped, will help and it may be necessary to temporarily lengthen the first few bands placed.

Now move the outside form up near the farther end of the next set of staves to be placed and repeat the process, placing the metal tongues in the slots provided to connect the ends of staves. A light wooden maul may be used to tap the staves *carefully* into position. For this second set, and for all of the following sets, use 22 staves, all of practically the same length so as to continue the same break in joints started on the first set.

After the third set of staves is placed, and about four bands to each set have been placed on the pipe, drive on the ends of the last set to tighten the butt joints. This requires a driving bar of 2x4 (or larger, for thick staves), about 5 feet long, preferably of hardwood, and an iron maul. DON'T strike the ends of the staves with the maul directly.

Wind

Some care must be taken to avoid any "wind" in the staves. This will develop if the first staves driven up for each set are always on the same side of the pipe. Alternate the side of pipe on which the first staves are driven up, and "wind" will seldom occur. If, however, the staves do tend to turn to the right, for instance, drive the staves on the left side first.

If the pipe is to be curved, move the end to the required position before starting to drive up staves. Don't attempt to build pipe on a curve—build it straight, and then throw in the curve before driving up staves or cinching bands to any extent. If the pipe is built on a steep hill, it will be found best to begin erection at the bottom of the hill.

Banding

Band spacing will be variable depending on operating head, but unless otherwise specified, bands have been furnished to be spaced 10″ apart. After building several sections of pipe with the bands placed at random, go back over it and place bands 10″ apart, moving the bands originally placed as you come to them.

If steel tongues are being used, sufficient bands will be furnished so that they can be spaced closer together at butt-joints of staves, so that it will not be more than 6″ from any butt-joint to the nearest band. If the lumber is sorted as carefully as above outlined, there will be enough bands for this 6″ butt-joint spacing, but this is ONE of the reasons for sorting stave lengths carefully. These extra bands are not placed at butt-joints of staves, if malleable iron butt joints are being used.

In placing bands, it is best for one man to stand on each side of the pipe, spring the band open and shove the button head under the pipe. Since adjoining bands should have the shoes on opposite sides of the pipe, shove one band under from one side of the pipe, and the next one from the opposite side.

It adds greatly to the appearance of the pipe, and something to its quality, if shoes are staggered uniformly on each side of the pipe. Shoes should always be placed small end down, and should as nearly as possible straddle the seams between staves. Place one over the first seam below the center, the next one on the same side of the pipe over the center seam, and third one over the first seam above the center. Go back to the first seam below the center for the fourth shoe (this puts it on a level with the first shoe), and repeat the uniform staggering. Aside from improving the appearance of the pipe, the practical object of this uniform staggering is to distribute the slightly unequal pressure caused by the shoes.

Cinching

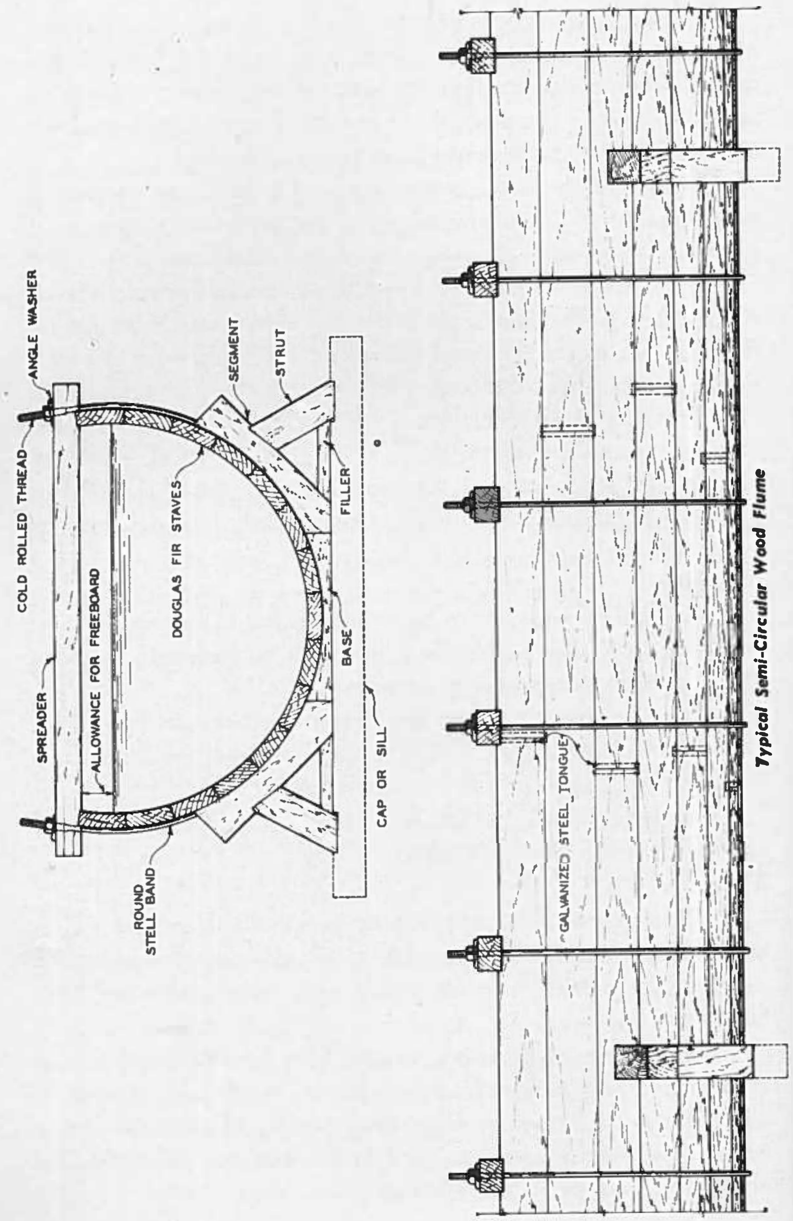
Finally, the bands are to be cinched tight. Go along the pipe from band to band, preferably with a man on each side, cinching about as tight as reasonably possible with a 12″ or 14″ wrench. Then start over again at the same point, and repeat the process until there is no slack left with a reasonable strain on the wrench. Hammer the bands around the pipe while cinching.

The bands should be cinched tight, but judgment must be exercised. Don't crush the staves.

Testing

Fill the pipe with water as slowly as reasonably possible. Give small leaks plenty of time to take up—2 to 3 days for untreated pipe, and 6 to 8 days for creosoted pipe, which takes up more slowly.

NOTE: *These erection instructions have been included herein, principally for guidance in the erection of small lots of continuous stave pipe. Please see Page 29 regarding the advisability of entering into a contract for pipe erected in place by Federal, if a reasonable quantity is involved.*



Typical Semi-Circular Wood Flume

SPECIFICATION No. 16

January, 1942

FEDERAL CREOSOTED DOUGLAS FIR CONTINUOUS STAVE FLUME

General

Flumes shall be constructed to a semi-circle, plus a depth above the horizontal center line to the underside of the spreader, equal to 1/12 of the flume diameter. Unless otherwise specified, material to be furnished shall consist of creosoted Douglas Fir staves, galvanized steel tongues, steel bands, cast iron angle washers, creosoted spreaders dapped for staves and bored for bands, and creosoted cradles, exclusive of sill (or cap). Flume material is to be shipped knocked down.

Staves

Staves and creosote treatment of same shall be furnished in compliance with the specifications for continuous stave pipe. The top edge of the top staves, which are to be placed in contact with the dap cut into the underside of the spreaders, shall be finished smooth (without bead or groove).

Tongues

Tongues shall be furnished in compliance with the specifications for tongues for continuous stave pipe.

Bands

Steel bands shall comply with the specifications for bands for continuous stave pipe. Each end of the bands shall have a standard cold-rolled thread, hex nut and washer.

Washers

Angle washers shall be of cast iron, not less than three inches square at the base, and shall have the proper angle to provide an even bearing for the band nut. They shall be coated, as provided for bands.

Spreaders

Spreaders shall be made from Select Merch. Grade Douglas Fir, S1S1E, to not more than ¼ inch less than the nominal dimension, and shall not be kiln dried. Spreaders shall be cut to the required length, dapped for staves and bored for bands, after which they shall be creosoted, as provided for staves.

Cradles

Cradles (and sills, if included) shall be made from Select Common grade Douglas Fir, S4S, not kiln dried. Pieces shall be accurately framed to fit the circle of the flume and so that they will fit together properly when assembled. After framing, they shall be creosoted as provided for staves.

Erection

Erection shall be performed in a manner corresponding to that provided for continuous stave pipe.

Dimensions

The dimensions of the various parts shall be as set forth in the following tabulation. Detailed dimensions of cradles (which can be indicated only by drawings) shall be Federal standard, or equal.

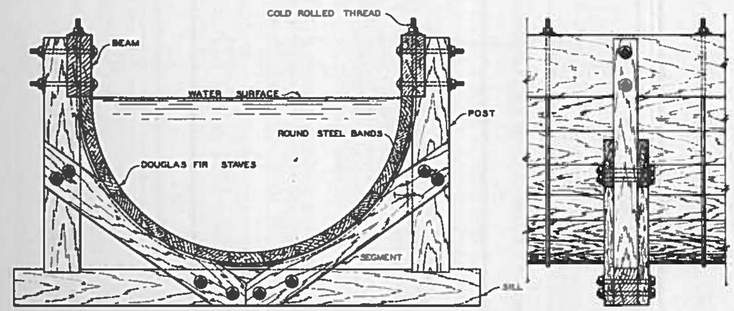
DETAILED DIMENSIONS OF FEDERAL CREOSOTED WOOD FLUMES

Table No. 13

		STAVES		BANDS		SPREADERS		CRADLES (Spaced 8')		SILL (if included)	
I. D. Feet	I. D. Inches	Stock	Thickness Inches	Diameter Inches	Spacing C. to C. In.	Size	Length	Type	Stock	Size	Length
2	24	2x4	1½	7/16	24	2x4	2'- 8"	Block	3x8	4x4	4'-0"
2½	30	"	"	"	"	"	3'- 4"	"	3x10	"	4'-0"
3	36	2x6	"	½	"	3x4	3'-10"	Built Up	3"	"	5'-0"
3½	42	"	"	"	"	"	4'- 3"	"	"	"	5'-0"
4	48	"	1⅝	"	"	"	4'-10"	"	"	4x6	6'-0"
4½	54	"	"	"	"	"	5'- 4"	"	"	"	6'-0"
5	60	"	"	"	19.2	"	6'- 0"	"	"	"	7'-0"
5½	66	"	"	"	"	"	6'- 5"	"	"	6x6	8'-0"
6	72	"	"	"	"	"	7'- 0"	"	"	"	8'-0"
6½	78	"	"	"	"	"	7'- 6"	"	"	"	9'-0"
7	84	"	"	"	16	4x4	8'- 0"	"	"	"	9'-0"
7½	90	"	"	"	"	"	8'- 6"	"	"	"	10'-0"
8	96	"	"	"	"	"	9'- 0"	"	4"	6x8	12'-0"
8½	102	"	"	"	"	"	9'- 6"	"	"	"	12'-0"
9	108	"	"	"	"	"	10'- 0"	"	"	"	14'-0"
9½	114	"	"	"	"	"	10'- 6"	"	"	"	14'-0"
10	120	"	1¾	"	"	"	11'- 0"	"	6"	6x10	15'-0"
11	132	"	"	"	"	4x6	12'- 0"	"	"	"	16'-0"
12	144	"	"	"	"	"	13'- 0"	"	"	"	18'-0"

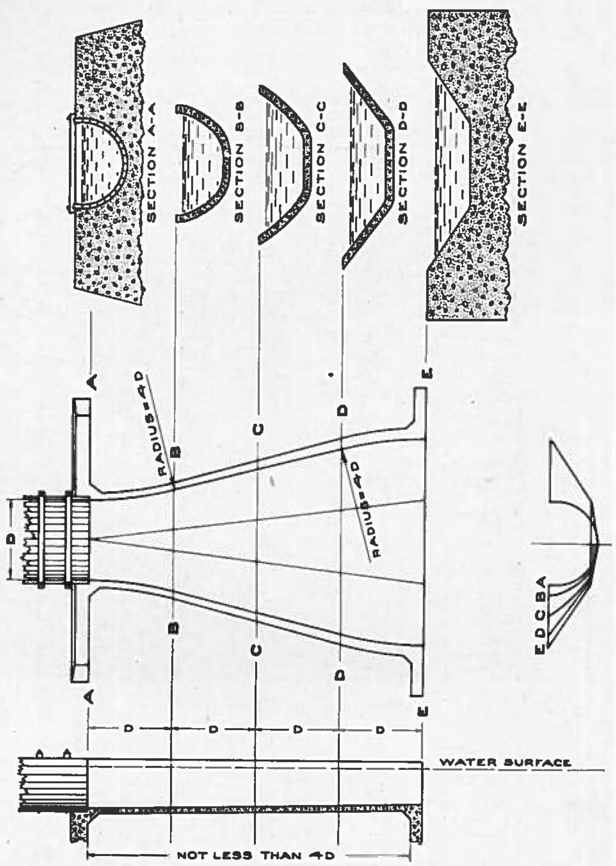
Note—Federal constructs larger; and also smaller flumes, than listed above.

Warped Canal to Flume Intake



Special Design Open-Top Flume, for moderate sizes serving under unusual conditions.

TYPICAL DESIGN OF FLUME INTAKE

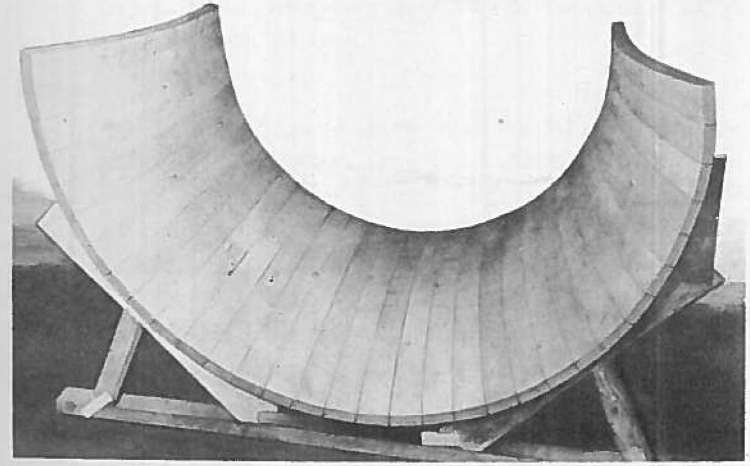


The above is a sketch of an approved design which can readily be adapted to any size of flume or ditch. It is especially drawn with the object in view of reducing as far as possible the loss in head due to the transition from the cross section of the ditch to that of the flume.

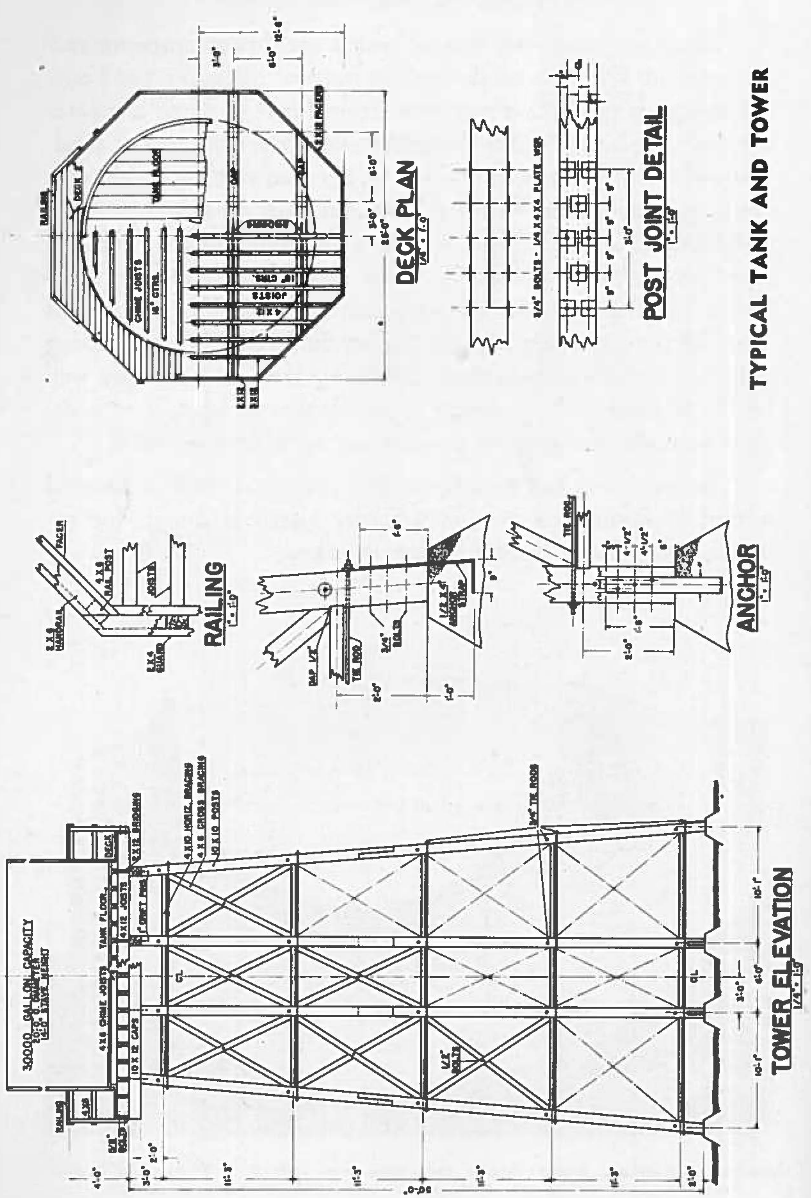
TYPICAL FLUME INTAKES

Flumes are frequently located with a canal both upstream and downstream. For such conditions the purpose of intake (and outlet) design is to effect a transition from canal to flume cross-section with the least possible disturbance and resulting loss of head. The rather long, warped intake is well suited to such conditions. For high velocities the top of the warped walls should slope down toward the mouth of flume. It is also relatively easy to furnish a taper section for the first 10 to 20 feet of semi-circular wood flume, and this will provide additional freeboard to correspond with the sloping water surface during the period of accelerating velocity. The outlet structure, delivering into a canal, may well be of the same general design as the intake; at least, if it is desired to make the greatest possible saving in loss of head.

The modified bell-mouth intake, combined with a tapered section of flume, is a very satisfactory alternate design for entrance into a flume from a stream or lake.



Modified Bell-Mouth Flume Intake for connection with 8' x 7' tapered Flume Reducer. (Temporarily set-up in our plant prior to creosote treatment.)



SPECIFICATION No. 17

January, 1942

GENERAL SPECIFICATIONS FOR FEDERAL DOUGLAS FIR WOOD STAVE WATER TANKS

General

Tanks shall be circular in shape, with vertical sides and a flat bottom, and shall be banded with steel rods spaced as required to withstand the static water pressure. Tanks shall be furnished to the outside diameter and outside height (stave length) specified, and shall have the nominal capacity indicated. Unless otherwise specified, tanks are to be furnished knocked down, ready to be assembled on a complete foundation structure furnished by others. (See Tank Price List for tank sizes.)

Lumber

Lumber for staves and bottom shall be Douglas Fir Tank Stock, complying with the West Coast Lumbermen's Association Specification No. 294, Booklet No. 11. Staves and bottom shall be entirely free from sap wood and shall contain no imperfections which will impair the strength or durability of the piece or affect the water-tightness of the tank.

Staves

The finished thickness of staves shall be 3/8″ less than the nominal thickness of the stock used. For instance, 2″ stock shall be finished 1 5/8″ thick. The finished length of staves shall be one inch shorter than the nominal length. Edges shall be milled to radial lines and dressed smooth. Inner and outer surfaces shall be milled to the true periphery of the tank. For tanks 14 feet, or over, in diameter, and 12 feet, or over, in height, sufficient bilge staves shall be furnished to withstand the compression of the bands where they are closely spaced for some distance above the tank floor. The maximum width of these bilge staves shall be located 30% of the stave length above the bottom end, at which point the bilge staves shall be about 1/4″ wider than at either end.

The staves shall be crozed near the bottom end to form a recess to fit the beveled edges of the tank bottom. The chime, or that portion of the stave extending below the croze, shall not be less than 3½" for tanks made from 2" stock, 4" for tanks made from 3" stock, and 5½" for all heavier stock.

Bottoms

The bottom planks shall be finished to the same thickness as the staves. They shall be smoothly planed on all surfaces. The width of bottom planks may vary from 6" to 12" (most frequently 8" to 10").

Bottoms shall be cut to a true circle of the required diameter. The edges shall be beveled to fit into the croze of the staves. This bevel may be on the bottom surface only, or both top and bottom surfaces may be beveled for connection with a croze of corresponding double taper.

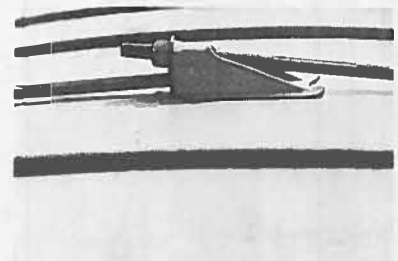
Bottom planks for tanks 30 feet or less in diameter shall be furnished in one piece, but for larger tanks the bottom planks over 30 feet long may be spliced. The abutting ends of such bottom planks shall be cut square and slotted ¾" deep across the middle and connected by means of ⅛" x 1½" galvanized steel tongues, which are to fit snugly into the slots. The tongues shall be long enough to penetrate about 1/16" into the planks at each side of the splice. Splices in adjacent bottom planks shall be at least two feet apart.

Bottom planks shall be doweled together. The wooden dowel pins are to be placed exactly in the center of the edges of planks, and the holes for these pins are to be of the proper diameter and bored vertically to the surface. Dowel pins shall be spaced not over 4 feet apart for bottoms less than 2 inches in thickness, and not over 5 feet apart for bottoms of greater thickness. Dowel pins shall also be placed not to exceed 12 inches from splice joints.

Bands

The tank shall be banded with mild steel rods, the size of which may range from ½" to 1" diameter, depending on the size of the tank. The steel used shall have an ultimate tensile

strength of 55,000 to 65,000 pounds per square inch, and the spacing of bands on the tank shall be adjusted so that the working stress on the steel will not exceed 15,000 pounds per square inch when the tank is filled with water. In addition to this, there shall be at least one band to be placed around the bottom of the tank opposite the lower edge of the croze. A complete band may consist of two or more sections, the ends of which are to be connected by means of malleable iron lugs. One end of each band section shall have a button head, and the other end shall have not less than 6 inches of U. S. Standard cold-rolled threads with a hexagon nut. Bands shall be coated with asphaltum after fabrication.



Tank Lug

Lugs

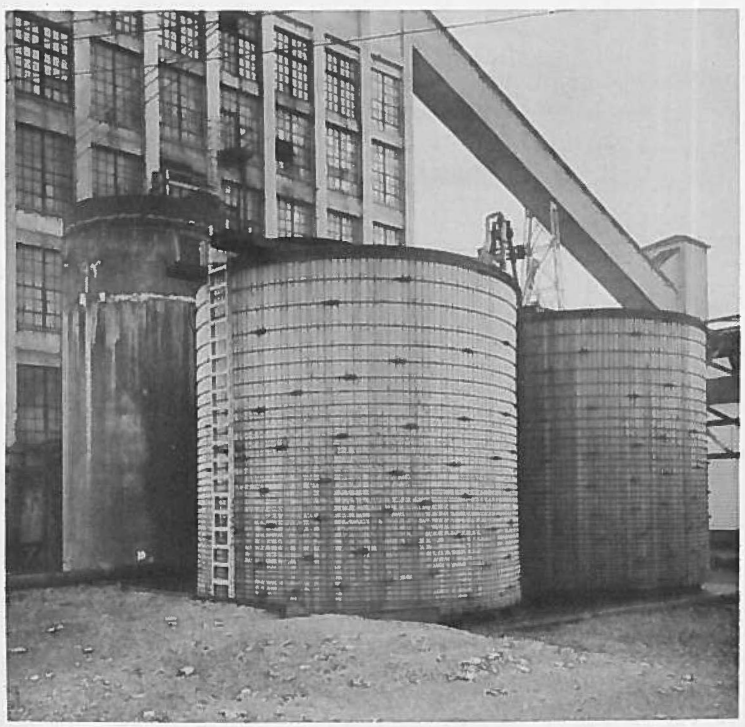
The ends of band sections shall be connected by means of malleable iron lugs. These shall be stronger than the band with which they are used. They shall have sufficient bearing area in contact with the staves to prevent any appreciable indentation. The lugs shall be smooth, sound castings, true to pattern and free from injurious flaws or cracks.

NOTE: *The above specification applies for the most commonly used types of ordinary water tanks, and is suitable for tanks to serve under a wide range of conditions. The following are among the many ordinary and special purposes for which tanks are used, for which a modified specification might be desirable or necessary:*

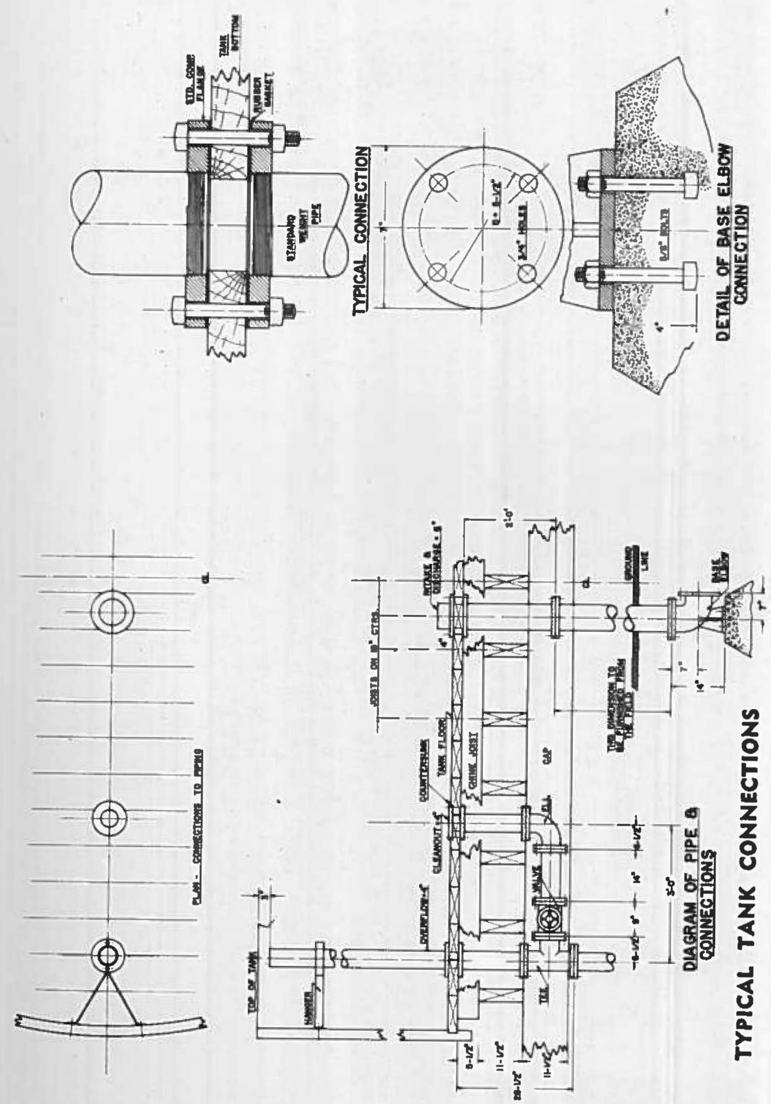
Underwriters' Fire Protection Tanks, constructed to comply with Insurance Underwriters' requirements, and approved by Underwriters such as: The Washington Surveying and Rating Bureau, Associated Factory Mutual Fire Insurance Companies.

- Pulp Mill Tanks
- Special Acid Tanks
- Hot Water Tanks (or for other extremely hot liquids)
- Brewery Tanks
- Mining Tanks (and launders)
- Oil Tanks
- Wagon Tanks
- Rectangular Tanks
- Tanks on Towers

Sizes up to 700,000 gallons capacity can be furnished.



24' x 24' Pulp Mill Acid Tanks



50,000 gallon Douglas Fir Tank on 75-foot Timber Tower

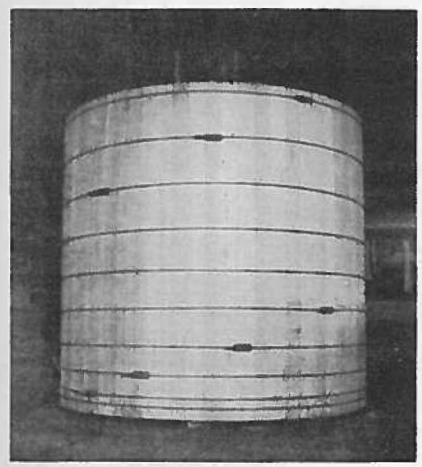
INSTRUCTIONS No. 17A

January, 1942

INSTRUCTIONS FOR SETTING UP FEDERAL WOOD STAVE TANKS

Foundation

Unless foundation timbers are ordered, these are not furnished with the tank. A foundation must be provided which will support the weight of the tank and the water entirely on the bottom of the tank. The ends of the staves must hang free, not supporting any of the weight, and a space of at least one inch should be left under the ends of the staves to permit air circulation. Ordinarily 4 x 6 joists (called chime joists) should be placed immediately under the bottom of the tank. These may be spaced 14 to 20 inches center to center, and should be cut to lengths so that they will form a circle having a diameter about 4 inches less than the inside diameter of the tank. Chime joists should be sized one edge or surfaced four sides to give even bearing. Supporting sills and mud sills or concrete piers will be required under the chime joists; bearing in mind that the weight, including the tank, amounts to about nine or ten pounds per gallon of tank capacity.



Typical Open Top Water Tank. 5000 gallon size shown.

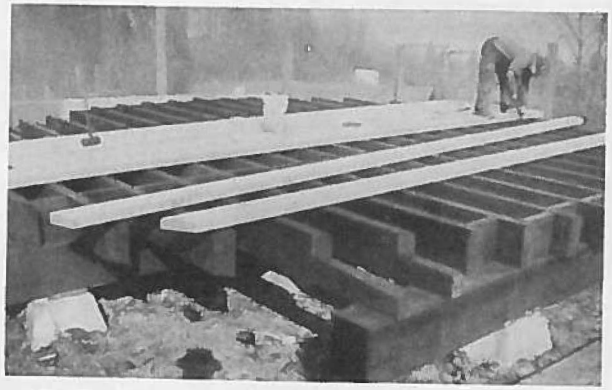
Placing Tank Bottom—Use Wedges

The bottom pieces of the tank are numbered consecutively. These bottom planks should be wedged apart with small wooden wedges while placing the staves. Wedges about 1/8 inch thick should be used, and sufficient of these placed to open cracks between the bottom planks totalling 1/2 inch for each eight feet of tank diameter. These wedges are to be removed after all of the staves are in place.

This use of wedges is important as it permits placing enough staves so that the tank will have straight sides, and not an "hourglass" shape when finished. A well built tank will have sides straight, or bulging slightly outward, so that stave edges will fit closely at the level of the tank bottom, and below the bottom. Obviously, care must be taken not to use too many staves, as in this case they would not fit tightly to the tank bottom.

Placing Staves

To provide a guide, the depth of the croze in the staves is marked on each bottom piece. Place the first stave on the longest bottom plank, tapping it on to one-half the depth of the croze, and leaning the top slightly outward. Continue, placing staves with edges tightly together, and hold in position by nailing overlapping lathes to form temporary hoops.



Starting to place bottom planks for 50,000 gallon Tank on Creosoted Timber Foundation.

By selecting the last few staves that go into the tank, the fitting required will be reduced to a minimum. Should it be necessary to rip, and plane the last stave, be sure that the edges are planed to the proper bevel.

Placing Bands

A number of staves will be marked to show the position of bands, and these staves should be placed at intervals around the tank. Cinch the bands just fairly tight, then go around the tank, inside and outside, and hammer on the staves as required to bring the edges flush, giving a smooth surface at all points. Use a block of wood, and do not strike the staves directly with a hammer, as this breaks the fibres of the wood.

Lugs should be placed spirally around the tank. Cinch the bands carefully, and keep all bands at about the same tension. In other words, do not try to draw up the staves with one band. Hammer on the bands to some extent while cinching, as this seats them slightly in the staves, and cinch them tightly before stopping.

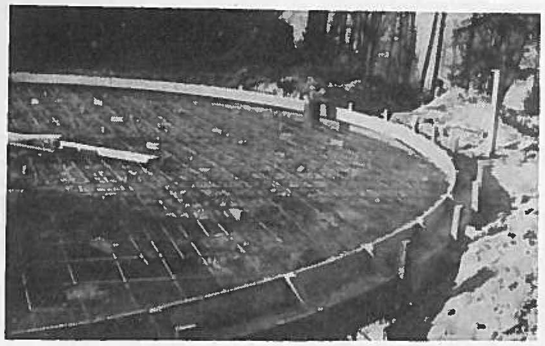
When two sizes of bands are furnished, the larger size is to be placed at the bottom of the tank.

Painting

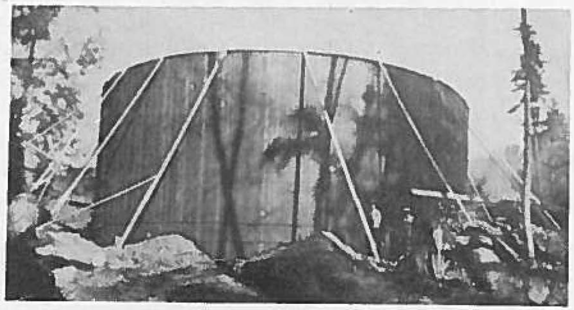
Use a stain, instead of an air-tight lead and oil paint to obtain the maximum years of service from the tank. Do not apply paint or stain inside of the tank.

NOTE: *Many tanks have been erected by purchasers, without previous experience, by following the above instructions. In the case of the larger sizes (at least those over 50,000 gallons capacity) it is usually advisable to contract with FEDERAL for installation in place, or let FEDERAL furnish competent erection supervision.*

200,000-gallon, 43-foot diameter x 20 foot stave Creosoted Tank on Concrete Slab Floor and Foundation, for Shipyard Fire Protection.



Ready to Pour Concrete Floor



Stave Circle completed and some bands placed

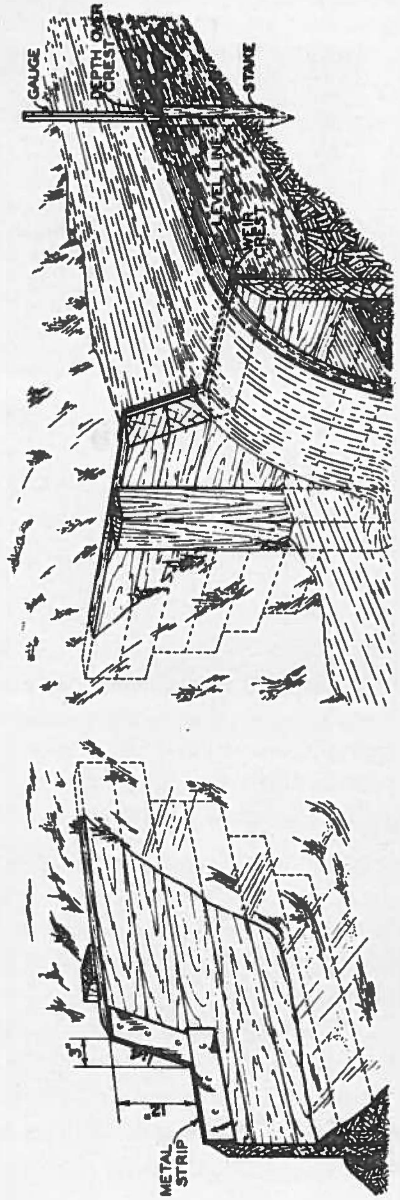
Tank Erection about completed

SECTION III

FLOW TABLES, AND OTHER DATA

The tables found in this section, especially those relative to hydraulics, will be a convenience for all who have occasion to use such information. An earnest attempt has been made to present simple explanations of various ordinary problems in hydrostatics and hydraulics. It has been our experience, over the years, that many who handle water problems from time to time, may overlook fundamentals or important minor details, and we have spared no pains in an endeavor to clarify such matters, regardless of how trivial they may seem. It is hoped that our treatment of the subject will be of value to Water Superintendents, Irrigation Project Superintendents, Power Plant Operators and Mine Operators, etc., and possibly those Engineers who are only occasionally called upon to handle water problems.

We could not possibly offer any more sincere advice than to urge the employment of a competent Engineer for work of any reasonable magnitude. It is hoped, for instance, that the explanation of total water pressure against a wall will indicate the advisability of seeking expert advice to prepare a suitable design for the particular problem of this nature which may be under consideration. Technical advice should be obtained before proceeding with any major supply line, distribution system, power plant, or any fairly large installation involving the delivery, distribution or storage of water.



Cipolletti Weir — Sectional Views

MEASUREMENT OF WATER

This is frequently the first requirement as a basis for the selection of the proper dimensions of a conduit. The minimum, maximum and average flow should receive consideration.

The measurement of large streams calls for special equipment, such as current meters, and special skill for their operation and interpretation. Small springs or streams up to a maximum of about 25 C.F.S. may, however, be measured with reasonable accuracy by anyone who will give careful consideration to the following instructions.

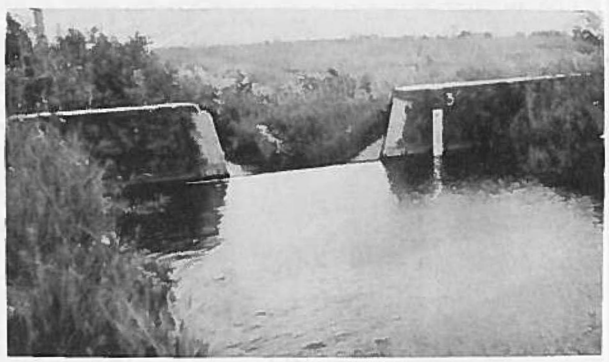
The Cipolletti Weir

The drawing shows the general details of construction. In the case of temporary weirs, and for approximate measurements, the metal strip may be omitted from around the upstream face, in which case the opening will be cut on a bevel in a board or plank, and to finished dimensions. Care must be taken in the location and setting of a weir and the following rules should be observed as closely as possible.

1. Cipolletti weirs up to 25 or 30 feet, or even greater length, are used, particularly in the irrigated areas, but we are here principally concerned only with more moderate sizes. The suitable range of sizes overlaps to some extent, but in general the following will be found to give the best results:

Quantity of Water in Cubic Feet per Second	*Length of Weir Crest*
0.05 to 0.50	Use 90° V-Notch
0.20 to 0.90	1 Foot
0.60 to 1.75	1½ Feet
1.00 to 4.00	2 Feet
2.50 to 10.00	3 Feet
7.50 to 22.00	4 Feet

2. The depth of water below the crest, immediately above the weir, and the distance which water extends out at each side above the weir opening, should be at least two to three times the depth of water flowing over the crest.
3. Measurement of depth of water flowing over the weir must not be taken at the crest, but some distance out on either side (or both sides, for a check), or in the pool above, from a point which is exactly level with the weir crest. An ordinary rule may be used for measuring, but enamel surfaced gauges are particularly suitable.
4. The weir crest must be level and should be placed approximately at right angles to the stream. The pool of water above the weir should be large enough to still the water and practically eliminate any velocity of approach. Baffle boards or brush placed in the upper portion of the pool may be of assistance in this respect. No appreciable amount of dirt or debris must be permitted to collect in the pool—a detail which may easily be neglected in the case of permanent, continuously operated weirs.
5. The weir crest must be located higher than the surface of the water into which the weir discharges. The clearance should be sufficient so that air may circulate freely beneath the overflowing water.



U. S. Bureau of Reclamation 3-foot Cipolletti Weir

Ten Inch Continuous Stave Submarine Pipe Line shown on Launchway

DISCHARGE OVER CIPOLLETTI WEIR

Discharge in Cubic Feet per Second and Acre Feet per 24 Hours over Cipolletti Weir One Foot in Length
(For larger Weirs multiply values given by length in feet)

Table No. 14

Calculations Based on Formula: $Q = 3.367\ LH^{3/2}$

DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours	DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours
½	0.04	0.03	0.06	6¾	0.56	1.41	2.80
⅝	0.05	0.04	0.08	6⅞	0.57	1.45	2.88
¾	0.06	0.05	0.10	7	0.58	1.49	2.96
⅞	0.07	0.06	0.12	7⅛	0.59	1.53	3.03
1	0.08	0.08	0.16	7¼	0.60	1.57	3.11
1⅛	0.09	0.09	0.18	7⅜	0.61	1.60	3.17
1¼	0.10	0.11	0.22	7½	0.62	1.64	3.25
1⅜	0.11	0.12	0.24	7⅝	0.63	1.68	3.33
1½	0.12	0.14	0.28	7¾	0.65	1.76	3.49
1⅝	0.14	0.18	0.36	7⅞	0.66	1.80	3.57
1¾	0.15	0.20	0.40	8	0.67	1.85	3.67
1⅞	0.16	0.22	0.44	8⅛	0.68	1.90	3.77
2	0.17	0.24	0.48	8¼	0.69	1.93	3.83
2⅛	0.18	0.26	0.52	8⅜	0.70	1.99	3.95
2¼	0.19	0.28	0.55	8½	0.71	2.01	3.99
2⅜	0.20	0.30	0.59	8⅝	0.72	2.06	4.09
2½	0.21	0.32	0.63	8¾	0.73	2.10	4.17
2⅝	0.22	0.35	0.69	8⅞	0.74	2.14	4.25
2¾	0.23	0.37	0.73	9	0.75	2.19	4.35
2⅞	0.24	0.40	0.79	9⅛	0.76	2.23	4.43
3	0.25	0.42	0.83	9¼	0.77	2.27	4.50
3⅛	0.26	0.45	0.89	9⅜	0.78	2.32	4.60
3¼	0.27	0.47	0.93	9½	0.79	2.36	4.68
3⅜	0.28	0.50	0.99	9⅝	0.80	2.41	4.78
3½	0.29	0.53	1.05	9¾	0.81	2.45	4.86
3⅝	0.30	0.55	1.09	9⅞	0.82	2.50	4.96
3¾	0.31	0.58	1.15	10	0.83	2.55	5.06
3⅞	0.32	0.61	1.21	10⅛	0.84	2.59	5.14
4	0.33	0.64	1.27	10¼	0.85	2.64	5.24
4⅛	0.34	0.67	1.33	10⅜	0.86	2.69	5.34
4¼	0.35	0.70	1.39	10½	0.87	2.73	5.42
4⅜	0.36	0.73	1.45	10⅝	0.88	2.78	5.52
4½	0.37	0.76	1.51	10¾	0.90	2.87	5.69
4⅝	0.39	0.82	1.63	10⅞	0.91	2.92	5.79
4¾	0.40	0.85	1.69	11	0.92	2.97	5.89
4⅞	0.41	0.88	1.74	11⅛	0.93	3.02	5.99
5	0.42	0.92	1.82	11¼	0.94	3.07	6.09
5⅛	0.43	0.95	1.88	11⅜	0.95	3.12	6.19
5¼	0.44	0.98	1.94	11½	0.96	3.17	6.29
5⅜	0.45	1.02	2.04	11⅝	0.97	3.22	6.39
5½	0.46	1.05	2.08	11¾	0.98	3.27	6.49
5⅝	0.47	1.09	2.14	11⅞	0.99	3.32	6.59
5¾	0.48	1.12	2.22	12	1.00	3.37	6.68
5⅞	0.49	1.16	2.30	12⅛	1.01	3.42	6.78
6	0.50	1.20	2.38	12¼	1.02	3.47	6.88
6⅛	0.51	1.22	2.42	12⅜	1.03	3.52	6.98
6¼	0.52	1.26	2.50	12½	1.04	3.57	7.08
6⅜	0.53	1.30	2.58	12⅝	1.05	3.62	7.18
6½	0.54	1.34	2.66	12¾	1.06	3.67	7.28
6⅝	0.55	1.38	2.74	12⅞	1.07	3.73	7.40

DISCHARGE OVER CIPOLLETTI WEIR

Discharge in Cubic Feet per Second and Acre Feet per 24 Hours over Cipolletti Weir One Foot in Length
(For larger Weirs multiply values given by length in feet)

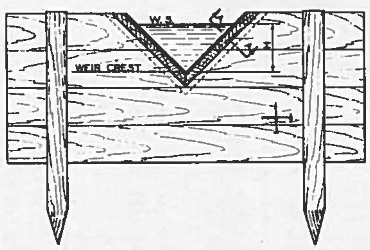
Table No. 14

Calculations Based on Formula: $Q = 3.367\ LH^{3/2}$

DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours	DEPTH ON CREST In.	DEPTH ON CREST Ft.	Cubic Feet per Sec.	Acre Feet per 24 Hours
13	1.08	3.78	7.50	19⅜	1.61	6.88	13.65
13⅛	1.09	3.83	7.60	19½	1.62	6.94	13.77
13¼	1.10	3.88	7.70	19⅝	1.63	7.01	13.90
13⅜	1.11	3.94	7.82	19¾	1.65	7.14	14.16
13½	1.12	3.99	7.92	19⅞	1.66	7.20	14.28
13⅝	1.14	4.10	8.14	20	1.67	7.27	14.42
13¾	1.15	4.15	8.24	20⅛	1.68	7.33	14.54
13⅞	1.16	4.21	8.36	20¼	1.69	7.40	14.68
14	1.17	4.26	8.45	20⅜	1.70	7.46	14.80
14⅛	1.18	4.32	8.57	20½	1.71	7.53	14.93
14¼	1.19	4.37	8.67	20⅝	1.72	7.59	15.05
14⅜	1.20	4.43	8.79	20¾	1.73	7.66	15.19
14½	1.21	4.48	8.89	20⅞	1.74	7.73	15.33
14⅝	1.22	4.54	9.01	21	1.75	7.79	15.45
14¾	1.23	4.59	9.11	21⅛	1.76	7.86	15.59
14⅞	1.24	4.65	9.23	21¼	1.77	7.93	15.72
15	1.25	4.70	9.33	21⅜	1.78	8.00	15.86
15⅛	1.26	4.76	9.44	21½	1.79	8.06	15.99
15¼	1.27	4.82	9.56	21⅝	1.80	8.13	16.12
15⅜	1.28	4.88	9.68	21¾	1.81	8.20	16.26
15½	1.29	4.93	9.78	21⅞	1.82	8.27	16.40
15⅝	1.30	4.99	9.90	22	1.83	8.34	16.54
15¾	1.31	5.05	10.02	22⅛	1.84	8.40	16.66
15⅞	1.32	5.10	10.09	22¼	1.85	8.47	16.80
16	1.33	5.16	10.24	22⅜	1.86	8.54	16.94
16⅛	1.34	5.22	10.36	22½	1.87	8.61	17.07
16¼	1.35	5.28	10.47	22⅝	1.88	8.68	17.21
16⅜	1.36	5.34	10.60	22¾	1.90	8.82	17.49
16½	1.37	5.40	10.71	22⅞	1.91	8.89	17.63
16⅝	1.38	5.46	10.83	23	1.92	8.96	17.77
16¾	1.39	5.52	10.95	23⅛	1.93	9.03	17.91
16⅞	1.41	5.64	11.19	23¼	1.94	9.10	18.05
17	1.42	5.70	11.30	23⅜	1.95	9.17	18.18
17⅛	1.43	5.76	11.43	23½	1.96	9.24	18.32
17¼	1.44	5.82	11.55	23⅝	1.97	9.31	18.47
17⅜	1.45	5.88	11.66	23¾	1.98	9.38	18.60
17½	1.46	5.94	11.78	23⅞	1.99	9.45	18.74
17⅝	1.47	6.00	11.90	24	2.00	9.52	18.88
17¾	1.48	6.06	12.02	25	2.08	10.10	20.03
17⅞	1.49	6.12	12.13	26	2.17	10.76	21.35
18	1.50	6.19	12.27	27	2.25	11.36	22.53
18⅛	1.51	6.25	12.39	28	2.33	11.97	23.75
18¼	1.52	6.31	12.51	29	2.42	12.67	25.13
18⅜	1.53	6.37	12.63	30	2.50	13.31	26.40
18½	1.54	6.43	12.75	31	2.58	13.95	27.68
18⅝	1.55	6.50	12.89	32	2.67	14.69	29.13
18¾	1.56	6.56	13.01	33	2.75	15.36	30.48
18⅞	1.57	6.62	13.13	34	2.83	16.03	31.80
19	1.58	6.69	13.27	35	2.92	16.80	33.32
19⅛	1.59	6.75	13.39	36	3.00	17.49	34.70
19¼	1.60	6.81	13.51				

The 90° V-Notch Weir

This type of weir may be used for rather large flows, but is particularly suited to the measurement of small springs or little streams, because a slight inaccuracy in measurement of depth flowing over the crest is not nearly so important as a similar inaccuracy in measuring an extremely shallow depth over a Cipolletti weir. The same general rules as presented for the construction and operation of a Cipolletti weir, apply for this type. Water depth must be measured at a point some distance from the crest from an elevation exactly the same as the lowest point of the notch.



90° V-Notch Weir

DISCHARGE OVER 90° V-NOTCH WEIR

Discharge in Cubic Feet per Second
Calculations based on Formula

$$Q = 2.54 \; H^{5/2}$$

Table No. 15

H — Depth over Notch in Feet	Cubic Feet Per Second	H — Depth over Notch in Feet	Cubic Feet Per Second
0.20	0.045	0.40	0.26
0.21	.051	0.41	.27
0.22	.058	0.42	.29
0.23	.064	0.43	.31
0.24	.072	0.44	.33
0.25	.079	0.45	.35
0.26	.088	0.46	.36
0.27	.096	0.47	.38
0.28	.105	0.48	.41
0.29	.115	0.49	.43
0.30	.125	0.50	.45
0.31	.136	0.51	.47
0.32	.147	0.52	.49
0.33	.159	0.53	.52
0.34	.171	0.54	.54
0.35	.184	0.55	.57
0.36	.198	0.56	.60
0.37	.212	0.57	.62
0.38	.226	0.58	.65
0.39	.241	0.59	.68

APPROXIMATE WATER MEASUREMENTS

It is frequently necessary to obtain at least a rough approximation of the amount of water flowing through a channel or pipe. This information may be needed, for instance, as a basis for the selection of the proper length of a Cipolletti weir for a more accurate measurement. The following suggestions may be helpful for such approximations.

Weir Shapes

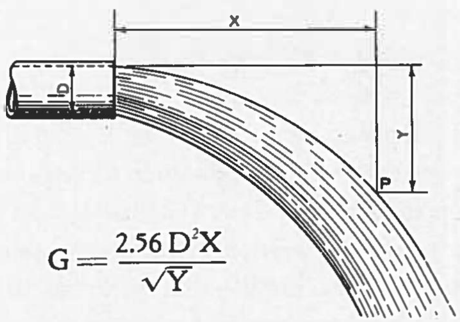
Water flowing in a stream or canal may drop over an obstruction or flashboards so that the conditions simulate those prevailing for a Cipolletti weir. If the flow is over a sharp crest and with full side contractions, application of the weir table will serve for an approximation of flow. Coefficients have been established for other than sharp crested weirs. Presentation of such coefficients would take up considerable space, but it should be borne in mind that flow over rounded crests may be 2½, and even 4, times greater than over a sharp crest.

Color

Color may be introduced and its rate of flow timed to establish the average velocity in feet per second. Multiplying by the cross-sectional area of the channel or pipe in square feet, will give the discharge in C.F.S. This method will give quite accurate results if the color is all introduced at the same instant, and if accurately timed to the peak of color at the point of discharge. Special chemicals may be obtained which are particularly suitable for this purpose, but ordinary fruit coloring may be used with reasonable satisfaction. A sloppy mixture of mud is a possible alternate for a rough approximation, if the velocity is high enough to keep all particles in suspension.

Determining Flow From a Horizontal Pipe*

The quantity of water or sewage flowing from a horizontal pipe, as illustrated by the accompanying sketch, can be determined with surprising accuracy by simply measuring the horizontal distance, X, and the vertical distance, Y, to any convenient point, P. The following formula is based on the well-known law of physics which establishes the fact that a horizontally projected body falls at precisely the same rate as does a body that is dropped vertically from a state of rest:



$$G = \frac{2.56\,D^2X}{\sqrt{Y}}$$

In which:

G = Gallons per minute
D = Inside diameter of pipe, in inches
X = Horizontal distance to point P, in inches
Y = Vertical distance to point P, in inches

Example:

D = 2 inches
X = 20 inches
Y = 25 inches
Then G = 40.96 gallons per minute

For convenience in extracting the square root of Y, locate point P so that Y will be 9 inches, 16 inches, 25 inches, or 36 inches, etc.

**From article by W. F. Schaphorst, M.E., in "Water Works and Sewerage."*

CONTINUOUS WATER MEASUREMENTS

We have presented some of the various methods of water measurement, particularly with the thought of temporary measurement or approximation. Weirs may be, and are, widely used for a reasonably accurate, permanent method of measurement, and we wish to mention a few of the many other devices commonly used for continuous service.

Meters, with recording apparatus, are about the most common for small flows and are available for rather large capacities. Such equipment is exceptionally accurate. Venturi meters are particularly adapted to measuring the flow through large diameter pipes.

Open channel flow, or flow into a pipe line, may be measured by means of a Submerged Orifice. The Parshall Measuring Flume is a relatively simple structure, of the Venturi type, which has gained rapidly in popularity for such measurements. Both of these operate with a relatively slight loss of head, and possess the further advantage of being practically self-cleaning.

Parshall Measuring Flume at head of FEDERAL 24" Flume

PRESSURE OF WATER

Table No. 16

Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch
1	0.43	42	18.21	83	35.98	124	53.75
2	0.87	43	18.64	84	36.41	125	54.19
3	1.30	44	19.07	85	36.85	126	54.62
4	1.73	45	19.51	86	37.28	127	55.06
5	2.17	46	19.94	87	37.72	128	55.49
6	2.60	47	20.37	88	38.15	129	55.92
7	3.03	48	20.81	89	38.58	130	56.36
8	3.47	49	21.24	90	39.02	131	56.79
9	3.90	50	21.68	91	39.45	132	57.22
10	4.34	51	22.11	92	39.88	133	57.66
11	4.77	52	22.54	93	40.32	134	58.09
12	5.20	53	22.98	94	40.75	135	58.52
13	5.64	54	23.41	95	41.18	136	58.96
14	6.07	55	23.84	96	41.62	137	59.39
15	6.50	56	24.28	97	42.05	138	59.82
16	6.94	57	24.71	98	42.48	139	60.26
17	7.37	58	25.14	99	42.92	140	60.69
18	7.80	59	25.58	100	43.35	141	61.12
19	8.24	60	26.01	101	43.78	142	61.56
20	8.67	61	26.44	102	44.22	143	62.00
21	9.10	62	26.88	103	44.65	144	62.43
22	9.54	63	27.31	104	45.08	145	62.86
23	9.97	64	27.74	105	45.52	146	63.29
24	10.40	65	28.18	106	45.95	147	63.73
25	10.84	66	28.61	107	46.39	148	64.16
26	11.27	67	29.05	108	46.82	149	64.59
27	11.70	68	29.48	109	47.25	150	65.03
28	12.14	69	29.91	110	47.69	151	65.46
29	12.57	70	30.35	111	48.12	152	65.89
30	13.01	71	30.78	112	48.55	153	66.33
31	13.44	72	31.21	113	48.99	154	66.76
32	13.87	73	31.65	114	49.42	155	67.19
33	14.31	74	32.08	115	49.85	156	67.63
34	14.74	75	32.51	116	50.29	157	68.06
35	15.17	76	32.95	117	50.72	158	68.49
36	15.61	77	33.38	118	51.15	159	68.93
37	16.04	78	33.81	119	51.59	160	69.36
38	16.47	79	34.25	120	52.02	161	69.79
39	16.91	80	34.68	121	52.45	162	70.23
40	17.34	81	35.11	122	52.89	163	70.66
41	17.77	82	35.55	123	53.32	164	71.10

Construction Crew Cinching Bands

PRESSURE OF WATER

Table No. 16 (Continued)

Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch	Head in feet	Pressure in lbs. per sq. inch
165	71.53	207	89.73	249	107.93	290	125.71
166	71.96	208	90.15	250	108.37	291	126.14
167	72.40	209	90.60	251	108.80	292	126.58
168	72.83	210	91.03	252	109.23	293	127.01
169	73.26	211	91.46	253	109.67	294	127.44
170	73.70	212	91.90	254	110.10	295	127.88
171	74.13	213	92.33	255	110.53	296	128.31
172	74.56	214	92.76	256	110.97	297	128.74
173	75.00	215	93.20	257	111.40	298	129.18
174	75.43	216	93.63	258	111.83	299	129.61
175	75.86	217	94.06	259	112.27	300	130.05
176	76.30	218	94.50	260	112.71	305	132.22
177	76.73	219	94.93	261	113.14	310	134.39
178	77.16	220	95.37	262	113.57	315	136.55
179	77.60	221	95.80	263	114.01	320	138.72
180	78.03	222	96.23	264	114.44	325	140.89
181	78.46	223	96.67	265	114.87	330	143.06
182	78.90	224	97.10	266	115.31	335	145.22
183	79.33	225	97.53	267	115.74	340	147.39
184	79.77	226	97.97	268	116.17	345	149.56
185	80.20	227	98.40	269	116.61	350	151.73
186	80.63	228	98.83	270	117.04	355	153.89
187	81.07	229	99.27	271	117.47	360	156.06
188	81.50	230	99.70	272	117.91	365	158.23
189	81.93	231	100.13	273	118.34	370	160.40
190	82.37	232	100.56	274	118.77	375	162.56
191	82.80	233	101.00	275	119.21	380	164.73
192	83.23	234	101.43	276	119.64	385	166.90
193	83.67	235	101.86	277	120.07	390	169.07
194	84.10	236	102.30	278	120.51	395	171.23
195	84.53	237	102.73	279	120.94	400	173.40
196	84.97	238	103.16	280	121.38	410	177.74
197	85.40	239	103.60	281	121.81	420	182.07
198	85.83	240	104.03	282	122.24	430	186.41
199	86.27	241	104.46	283	122.68	440	190.74
200	86.70	242	104.90	284	123.11	450	195.08
201	87.13	243	105.33	285	123.54	460	199.41
202	87.56	244	105.76	286	123 98	470	203.75
203	88.00	245	106.20	287	124.41	480	208.08
204	88.43	246	106.63	288	124.84	490	212.42
205	88.85	247	107.06	289	125.28	500	216.75
206	89.30	248	107.50				

Hub End Blow-off with Tie Rods

HYDROSTATICS

Water, or other fluids, at rest

Given: 62.4 lbs. = Weight of one cubic foot of water.
= Also, pressure per square foot of a column of water, one foot square x one foot high.
144 sq. inches = Area at base of one foot cube.

Then: $\frac{62.4 \text{ lbs.}}{144} = 0.434$ lbs. = Weight of a column of water one inch square x one foot high.

100 x 0.434 lbs.=43.4 lbs.=Weight of column of water one inch square x 100 feet high; or 43.4 lbs. per square inch pressure is equivalent to 100 foot head.

Pressure in pounds per square inch is in direct proportion for other heads. (See Table No. 16.) It is important to note that elevation of supply is the only source of pressure. (Pumps create pressure due to their ability to raise water to a certain elevation.) The pressure in pounds per square inch of water at rest is independent of volume at the source. This may be stated in the terms of an ordinary problem which is frequently misunderstood. A 500-gallon tank, located with the water surface 50 feet in elevation above a tap in a house will give a water pressure of 21.7 lbs. per square inch at the tap. If the tank has a capacity of 10,000 gallons, or even if the water is taken from a lake at 50 foot elevation, the static pressure will still be 21.7 lbs. per square inch.

Pressure of Water Against Wall

Since water is a liquid, pressure is always directly against the face of any surface which restrains it. At 100 feet elevation below the source, for instance, the pressure will be 43.4 pounds per square inch, up, or down, or horizontal—always at right angles to the surface which is holding the pressure.

Let us assume a vertical wall one foot wide x 18 feet high.
The average pressure is at 9-foot depth;
9 x 62.4 = 561.6 lbs. per square foot.

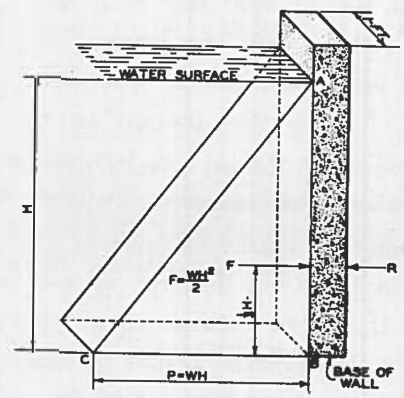
The total horizontal pressure against the wall is 18 x 561.6 lbs. = 10,109 lbs.

This total pressure, or force (F), may be determined by the formula:

$$F = \frac{W\,H^2}{2}$$, which for water becomes

$F = 31.2\,H^2$, which for 18-foot wall, one foot wide = $31.2 \times 18^2 = 10{,}109$ lbs. (as above).

If the wall was 2 feet long, the total pressure would be 20,218 lbs., and if 10 feet long the total would be 101,-090 lbs., etc.



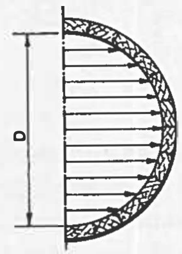
Hydrostatic Triangle

Since pressure increases uniformly from Zero at the top of the wall to a maximum at the bottom of the wall, the pressure against the entire wall, per unit of length, may be represented by the hydrostatic triangle, ABC. The altitude of this triangle (AB) is the height of the water, and the base (BC) is drawn to scale indicating the pressure at the base of the wall.

The total pressure against the wall is equal to the area of the triangle, or one-half of the base times the altitude. The center of pressure, or the point of balancing moments (force x leverage) will be through the center of gravity of the triangle, which is located at F, one-third of the depth above the base. If the pressure against the wall is to be held at one elevation, it should be at R, opposite F.

Pressure on Cylinder

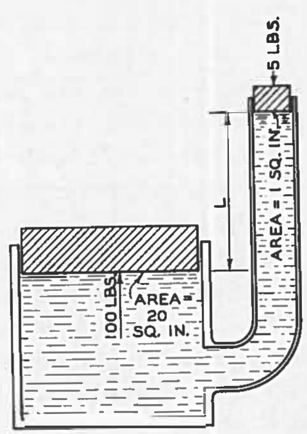
The total pressure (F) acting in one direction against a curved wall (side of a tank, for instance) is the same as for a flat wall. This may be visualized by considering that the water in the semi-circle simply transmits the pressure from a plane through the diameter. Obviously, for a tank, one-half of F must be held at each side of the curved wall.



The same is true of a horizontal pipe, although in this case there is, at any given location, only one pressure in pounds per square inch to deal with, instead of the variable pressure as on a vertical wall.

Transmission of Pressure

Assume the small tube shown at the right has an area of one square inch, and that the large reservoir has an area of 20 square inches. If L is an elevation equivalent to 5 pounds per square inch, the total pressure against the underside of W will be 100 pounds. This is the principle of the hydraulic jack. It should indicate the enormous total pressures created within a drum or closed tank (particularly the force against the heads) if connection is made to a pipe line under high pressure, no matter how small the connecting pipe may be. Incidentally, the operation of a hydraulic jack illustrates the fact that water is practically incompressible. Air, for instance, could not be used satisfactorily, instead of a liquid, for such a purpose.



Buoyancy—The Principle of Archimedes

A body immersed in a liquid is buoyed up by a force equal to the weight of the liquid displaced.

If the body is heavy enough to sink in the liquid, the reduction in weight of the body will still be equal to that of the liquid displaced.

Obviously, in the application of this principle to situations arising in connection with the installation of pipe, the outside dimensions of the pipe will apply if water is not permitted to enter the pipe. If water is permitted to enter the pipe, only the volume of the pipe walls are to be considered when figuring buoyancy.

Air Pressure

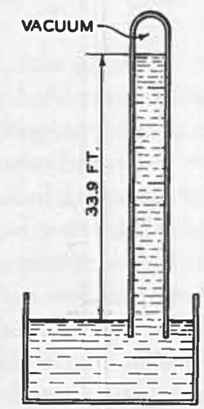
Air pressure varies at different altitudes, but is ordinarily taken at the sea level pressure of 14.7 pounds per square inch. In most water pressure problems the air pressures will balance out, although in some instances this must be given consideration.

Dividing the pressure of one atmosphere by the pressure of one foot water depth, we have:

$$\frac{14.7}{.434} = 33.9 \text{ (approx.)}$$

which is the height in feet at which water pressure will balance air pressure.

If an air-tight tube of sufficient wall strength, and having a tight head at one end, is placed open end down in a body of water, and a perfect vacuum is created in the tube, water will rise in the tube to a height of 33.9 feet. This is the principle involved when air is sucked out of a tube to siphon liquid out of a keg, or for any other true siphon, or a pump suction, or a water wheel draft tube. For such purposes the theoretical height of 33.9 feet will not apply; but, rather, about 20 feet for entirely satisfactory results, with 25 feet as the reasonable limit. Anything ap-



proaching a perfect vacuum is extremely difficult to create, and practically impossible to maintain in operation.

HYDRAULICS

Water, or Other Fluids, in Motion

Under Hydrostatics, a tank with water surface 50 feet above a tap in a house was mentioned as an example of the elevation required to produce 21.7 pounds static pressure at the tap. When the tap is opened, and flow takes place, a portion of this pressure is consumed in overcoming friction between the water and the pipe walls, and at elbows, valves, etc. The amount of this pressure loss depends upon the quantity of water passing through the pipe, and consequent velocity and the size of the pipe. Let us assume different sizes and lengths of pipe from the tank to the tap, and for this purpose consider pipe friction only, neglecting minor head losses. Turning to the wood pipe flow tables, beginning at Page 161, and dealing in approximate fractions only, we find:

Length of Pipe Feet	Size Pipe Inches	Discharge, Gallons Per Minute	Head in Feet Required for Friction, per 1000 feet of Pipe	Total Head Loss Feet	Head Remaining from 50 Foot Static	Equivalent Remaining Pressure Pounds
2500	2	18	10.0	25	25	11
2500	2	10.8	4.0	10	40	17½
2500	3	52	10.0	25	25	11
3500	3	52	10.0	35	15	6½
5000	3	52	10.0	50	0	0

Starting with 21.7 pounds—say 22—we find that a pressure gauge connected in the line at the tap would show 11 pounds remaining pressure in the first and third examples, and 17 pounds in the second example. In the last example, all of the head would be consumed, indicating that 52 G.P.M. is the maximum capacity of a 5000-foot line of 3″ pipe with fifty feet of head available to balance friction losses. Pipe size does not affect static pressure, but when flow is started the size of pipe, discharge, and also pipe length, do affect the remaining pressure. These examples should indicate one of the most important practical differences between water at rest and water in motion. Hydrostatics and Hydraulics

are closely related, but pressures are reduced, or entirely consumed, when flow takes place through a pipe.

Formulas

Water flowing through any channel or conduit is falling from one elevation (or equivalent pressure) to another. Basically, the rate of fall or velocity is subject to the law of falling bodies (See Page 210). If frictional elements are eliminated, the rate of fall is accelerated with increased height of fall. This law of falling bodies does apply directly for the determination of the fall (or head) required for the flow of water to attain a given velocity. This is known as the Velocity Head.

The tendency toward further acceleration of velocity is just balanced by various retarding influences, principally friction between the water and the channel walls.

In 1775, Chezy, a French engineer, presented a basic formula for the calculation of the effect of friction on velocity in either open channels or closed conduits. This formula is:

$$V = c\sqrt{rs}$$

In which

V = Mean Velocity of water in feet per second

r = Hydraulic Radius $= \dfrac{\text{Area in sq. ft.}}{\text{Wetted perimeter in lin. ft.}}$

s = Slope (friction head) in feet per foot of length

c = Coefficient

This is to say, algebraically, that the velocity varies as the square root of the relative extent of contact with the walls of the conduit, and also as the square root of the slope which causes flow, and that both of these are modified by a coefficient.

Chezy believed that the coefficient c was a constant, but it has been established for some time that it varies with the degree of roughness of channel surfaces, as well as with the hydraulic radius, and some other factors. There have been numerous attempts to express the correct value of c in terms which would include the proper evaluation of all of these factors. The well-known Kutter formula, which might properly be called the

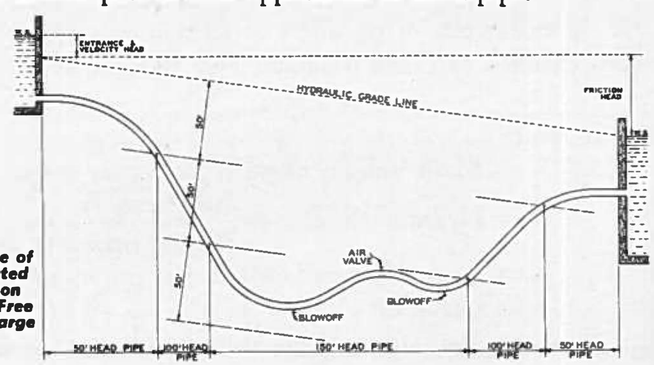
"Chezy-Kutter" formula, is one of these. This formula is used for the flume capacity tables presented in this book (See Page 215). The Manning formula, presented on Page 234, is another modification of the Chezy formula. Both of these formulas introduce a variable *n* (whose value increases with the degree of roughness of the channel) into the determination of *c* in the Chezy formula.

Wood Pipe Capacity

The tables presented herein for the Flow of Water in Wood Pipe were calculated from the Scobey formula, which was derived specifically for the determination of friction head losses in wood pipe. (See Page 155.)

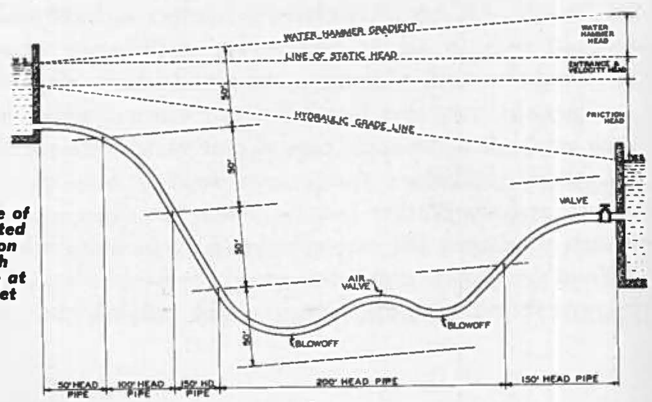
We will endeavor to present, in detail, a consideration of the factors entering into the most common hydraulic problems, particularly with respect to their application to wood pipe.

A



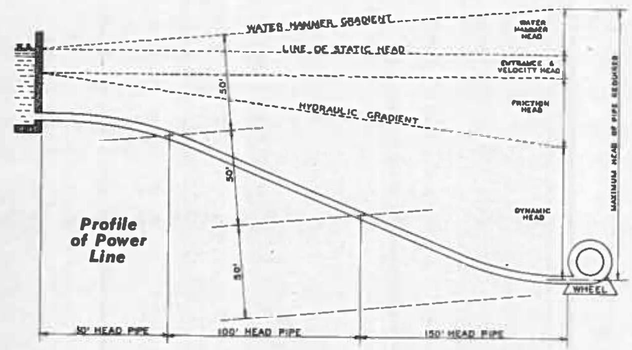
Profile of Inverted Siphon with Free Discharge

B



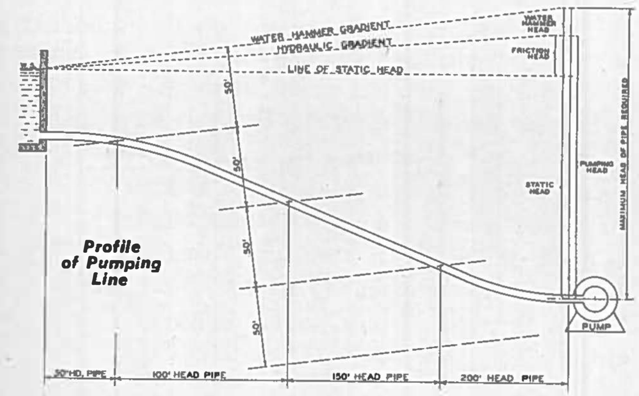
Profile of Inverted Siphon with Valve at Outlet

C



Profile of Power Line

D



Profile of Pumping Line

INVERTED SIPHON WITH FREE DISCHARGE

This is one of the simplest pipe capacity problems, but it includes the principal elements encountered in many other ordinary problems. Suppose we trace the flow of water through such a pipe line, in considerable detail; following which the particular features of other pipe capacity problems may be briefly explained.

Let us consider a pipe line 2030 feet long through which it is desired to deliver 4 cubic feet of water per second. The intake is to be connected with a reservoir, the water surface of which is at Elevation 100, and the pipe is to be located down across a sag and up to the point of discharge into a canal at Elevation 81, or a total fall of 19 feet. What size of pipe will be required?

Capacity

In the first place, we will assume that the capacity of 4 C.F.S. is the maximum required, and that it includes an allowance for capacity which may be needed only occasionally, but which may be most valuable on those occasions. Incidentally, there is frequently more uncertainty as to what the maximum capacity should be, than as to what it will be, particularly when anticipated future requirements are a factor. At any rate, we will in this instance add 5% as a factor of safety, to cover possible shortage in estimated as compared with actual capacity. (See Page 160.) This brings the capacity for design to 4.2 C.F.S.

Pipe Tables

Let us investigate the possibilities of 12" pipe. Turning to the table on Page 168, and going down the column headed "Cubic Feet per Second," it appears that 4.31 is but slightly over the 4.2 C.F.S. desired capacity. The figure of 4.2 might be applied rather exactly by interpolation, but another 2% is not important (when added to some other uncertainties), so we will use the figure of 4.31 C.F.S. Note also, that the Velocity in Feet per Second for this discharge is 5.48. This is the *average* velocity of the water through the pipe, which, multiplied by the area of the pipe in square feet, 0.7854, equals 4.31 C.F.S.

V. & E. Head

Now, to go back to the reservoir, the water must first be dropped a certain distance to acquire the velocity of 5.48 feet per second. How far it must drop to attain this velocity is determined by the law of falling bodies. See Page 210 for table. In this case the distance would be 0.47 feet. There will also be a head loss due to the changes in direction of flow, and general disturbance at the point where the water enters the pipe. This entrance head loss is ordinarily assumed to be one-half of the velocity head. Combined velocity and entrance head would amount to $1\frac{1}{2} \times 0.47 = 0.70$ feet, which is indicated in the column at the extreme right in the pipe flow tables. In the case of very long pipe lines, or if the water velocity is not high, the

Velocity and Entrance Head may be so relatively small as to be negligible. It is important for short lines, particularly if operating at high velocities, and should always be investigated. More than a few pipe lines have failed to deliver as calculated, because the velocity and entrance head was disregarded when selecting the size of pipe to be used.

The Intake

The entrance head may be considerably reduced by a properly designed intake structure. The most efficient of these are expensive and, for moderate velocities, the expenditure is usually not justified. There are, however, a few simple fundamentals which may be observed at little, if any, added cost, and these may well be explained.

In the first place, the elevation of the top of the pipe should be well below the water surface. This is surely elemental, but there have been instances where the water surface in the canal above came to about the center line of the pipe. The depth of water over the top of the pipe should be a minimum of about one foot—or, at least the pipe diameter. We would suggest, also, that it be not less than one-half of the combined velocity and entrance heads. Additional depth may frequently be provided without inconvenience, and is not objectionable from the standpoint of hydraulics.

Install the pipe, or cut off the end of it flush with the inside face of the intake structure. If the pipe shell extends out into the structure, the flow must reverse direction, at least partially, around the end of the pipe. This adds appreciably to the entrance head loss, and is a loss which ordinarily may just as well be avoided.

The lip may very well be rounded slightly, and there will be a marked reduction in entrance head loss for only a very little rounding of the corners at the mouth of the pipe. For high velocities a taper section of reasonable length may be placed in the pipe line at the intake, although this feature does not have the virtue with which it is frequently credited. The bell mouth intake is about the most efficient, but rather costly. The length of bell mouth should be five-eighths of the pipe diameter, and flared out on a radius of one-and-five-eighths of the pipe diameter. Such an intake is seldom provided, nor often justified, but anything approaching a bell mouth is beneficial.

Friction

Allowance has now been made for bringing the water up to the velocity of 5.48 feet per second and entering it into the pipe. These head losses amount to 0.7 feet, leaving a balance of 18.3 feet head, which for this particular problem is all available for pipe friction. We are interested in the average velocity only, but it is true that as the water passes through the pipe, the maximum velocity will be at the center, decreasing to the minimum where it comes in contact with the inside of the pipe. The extent of friction loss between the water and the pipe walls varies with the water velocity and depends very largely on the smoothness of the pipe surface. Wood pipe presents an exceptionally smooth surface and, consequently, has a low friction head loss. The left-hand column of the table shows this to be 9 feet per thousand feet of pipe length. Multiplying by 2.03 for 2030 feet of pipe, we find the total friction head to be 18.27 feet. Assembling the figures, we have:

Required capacity	4.0 C.F.S.	
Factor of safety—5%	0.2 C.F.S.	
Design Capacity	4.2 C.F.S.	
Pipe length	2030 lin. ft.	
Total available head		19.00 feet
12″ wood pipe, using 4.31 C.F.S. capacity—		
V. & E. Head	= 0.70′	
Friction head, 2.03′ x 9	= 18.27′	
Total head consumed		18.97 feet
Negligible Balance		.03 feet

Sizes other than 12″ might have been investigated, but even an approximate determination of the head available for friction per 1000 feet of pipe would have indicated that 10″ pipe was too small, and 14″ probably larger than necessary.

Other Head Losses

Other minor head losses, such as loss of head at angles (See Page 206), and at points of sharp reduction or increase in pipe diameter, might enter into the solution of such a problem, but as a rule only the losses shown in the above tabulation need be considered.

Hydraulic Gradient (See A, Page 136)

The hydraulic gradient, which establishes the slope available to overcome friction, may be indicated on a profile by a straight, sloping line drawn from a point at the intake (below the water surface in the amount of the velocity and entrance head) to the water surface at the outlet. If the pipe line rises above this hydraulic gradient at any point, there will be separate capacity problems each side of this point. Sometimes the pipe is placed above the hydraulic gradient simply through carelessness. The most common location for this seems to be near the intake, where the grade may be permitted to run out quite flat for a short distance, even though this might be avoided by a slightly deeper excavation. Sometimes this flat grade location is unavoidable, and may be so slight as not to reduce the capacity objectionably, but dont forget: that, strictly speaking, this makes more than one pipe capacity problem(and more than one hydraulic gradient) and may call for a larger size out to the point where the steep grade begins. In case of two pipe sizes, there would be two hydraulic gradients—one extending each way from the point of change.

The Outlet

The top of the pipe should be kept below the water surface in the canal. This does not need to be as relatively low as suggested at the intake, but there is a loss of head and an unnecessary element of erosion introduced if the end of the pipe is high. Unless aeration in some degree is being attempted, the intake into a tank should usually be connected at the bottom of the tank, or possibly low on the side. When the water level in the tank has been lowered, this low level connection will make it possible to utilize the additional friction head which becomes available for the pipe which delivers into the tank.

Head of Pipe Required

In the case of this pipe capacity problem, Inverted Siphon with Free Discharge, the maximum pressure against the inside of the pipe at any point is determined by the elevation of that point below the hydraulic gradient. Since wire-wound wood pipe is ordinarily made for 50 foot intervals in head (50 foot head pipe, 100 foot head, 150 foot head, etc.), the head of pipe required for different locations along the line may be determined by drawing lines on the profile parallel to the hydraulic gradient and at 50-foot intervals in elevation below the hydraulic gradient. All pipe above the 50-foot parallel should be 50-foot head pipe. Pipe falling between the 50-foot and 100-foot parallels should be 100-foot head pipe, etc. For continuous stave wood pipe, the parallel lines should be spaced at 10-foot intervals in head. This is true because the spacing of steel bands on continuous stave pipe is ordinarily changed for each 10-foot variation in operating head.

In some instances the head of pipe required will be based on static pressure from the intake, or it may be based on the head developed by water hammer. This is explained in the description of pipe lines for various purposes, and illustrated by the diagrams.

OTHER PIPE PROBLEMS

Flow Line

This is a variation of a pipe line with free discharge. A flow line is one located on a uniform grade from intake to outlet and at the same elevation as the hydraulic gradient; or, it may approach this location so closely as to be a flow line, for all practical purposes. Such a pipe line is not subjected to internal pressure

and, in fact, one method of deciding whether a pipe acts as a flow line is to consider whether a flume might be used instead of a pipe, so far as hydraulic conditions are concerned. Creosoted wood pipe should generally be installed for flow lines. If untreated pipe is used, it should be located, if possible, below the hydraulic gradient so that there will be about 20 pounds per square inch operating pressure, in which case, creosoted pipe need be used only near the intake end.

City Supply Lines

If water is delivered into a tank or reservoir, these and other similar pipe lines may usually be recognized as inverted siphons or flow lines, and the capacity may be determined as indicated above.

If the supply line feeds directly into the distribution system, allowance must be made for the service pressure to be maintained in the distribution system. The head available to overcome friction in the supply line should be based on delivery into an imaginary reservoir located at the required elevation to produce the desired pressure for the distribution system.

City and Town Distribution Lines

The minimum sizes of pipe for trunk lines and main laterals must be adequate to deliver the required capacity to the different sections of the system with sufficient remaining pressure for satisfactory service. As a rule, capacity is based on fire protection requirements, assuming one or more standard fire streams of 250 gallons per minute for any vicinity. Four-inch pipe, feeding from each way toward a hydrant, is about the smallest size which should be considered for use anywhere in a distribution system, and 6″ pipe is the minimum established by some cities.

If only sub-standard fire protection is contemplated, the requirements for lawn sprinkling may fix the minimum pipe sizes. This demand may be figured at about 4 gallons per minute for each garden hose line in operation. Four-inch pipe is a desirable minimum size, although some short stretches of 3″, or even 2″, may give reasonable satisfaction.

Relatively small pipe will provide ample capacity to supply the water needed for strictly domestic purposes. Short stretches of 2", and even 1", may serve reasonably well, but long stretches of small pipe have caused serious dissatisfaction. Small diameter metal pipe is particularly apt to be aggravating in this respect, as it usually becomes very rough on the inside and the area is also reduced so that capacity falls away in a few years to only a fraction of the original.

It is desirable to cross-connect the ends of distribution lines, forming loops, and thus avoid "dead ends."

Power Lines (See C, Page 137)

The head available for power development (dynamic head) is the static head, less the head consumed in velocity and entrance and pipe friction. Accordingly, a size of pipe must be selected which will not have too great a friction head loss. The economic size will depend to a considerable extent on the value of power developed, as compared with added cost for increased size of pipe. It is frequently advisable or necessary to install surge tanks near the power plant. If properly designed, such surge tanks will take care of variations in water demand with a minimum of disturbance, and will practically eliminate water hammer head. Wood pipe or wood tanks are often used for surge tanks.

Unless a suitable surge tank or special equipment is provided to relieve surge, water hammer head should be added to the static head, and the determination of quantities of various heads of pipe required should be based on lines drawn parallel to the water hammer gradient.

See Page 250 for table of power which may be developed by various flows and heads.

Pumping Lines (See D, Page 137)

In pumping from a source of supply up into a reservoir or ditch, the water may be assumed to be lifted straight up to such a height that it will flow by gravity to the point of discharge.

For example, a pump is required to lift 7000 gallons per minute from a lake through 3500 feet of 20-inch pipe, up to a reservoir having its water surface 43 feet above the lake. Referring to the table, it is found that in discharging 7000 gallons per minute through a 20-inch pipe there is a friction head loss of 8 feet per thousand; or, 8 multiplied by 3.5 equals 28 feet total friction head for the discharge pipe.

There will also be a velocity and entrance head loss at the suction pipe intake and a friction head loss through the suction pipe, fittings and foot valve (if used), and we will assume in this instance that these all total to 4 feet. The total pumping head will be 43 feet static, plus 28 friction in the discharge pipe, plus 4 feet friction in the suction line, which amounts to 75 feet.

In the above example, unless only occasional operation of the pump was contemplated, it would ordinarily be advisable to select larger than 20-inch pipe to reduce the friction head. The size selected should be determined largely by the cost of power for pumping, and an experienced engineer should be consulted for an economic consideration of all factors involved.

Water hammer head should be added to static head (not including friction head), and the head of pipe required should be determined by lines drawn parallel to the water hammer gradient or hydraulic gradient, whichever one is located at the higher elevation.

See Page 250 for table of power required for various pumping heads.

Valve at Outlet (See B, Page 136)

Inverted Siphons, Flow Lines, City Service Lines, Power Lines, and others, may be installed with a valve at the outlet. When such a valve is closed slowly, water pressure builds up to static from the elevation of the water surface at the intake. Parallel lines, for determination of heads of pipe required, will be level. It will be obvious that more high head pipe will be required with a valve in the line at the discharge, than without such a valve.

This adds to the cost of pipe, and accordingly the valve at discharge should be omitted, unless it is necessary to accomplish a worth-while purpose.

WATER HAMMER

If the valve at the outlet is closed rapidly, a head in addition to static will be developed. This is known as "Water Hammer Head," and is caused by the sudden stopping of the movement of a column of water. The extent of water hammer head depends largely upon the rapidity of valve closure, and varies with water velocity, length of pipe line, and other factors. The subject is most involved, and even when all factors are known, the most highly qualified experts may differ regarding the extent of water hammer head developed.

The nature of the pipe material is a factor of major importance. Pipe made from material which is inflexible, or relatively so, will not yield and must withstand the force, or fail. Flexible-walled conduits stretch and compress, alternately, and thus start successive waves of pressure up and down the pipe line, which may become super-imposed and develop a maximum force far in excess of the original force which was created at the instant of valve closure. Wood pipe will yield slightly, but the yielding action is of such a nature that it will very largely, if not entirely, absorb and "dampen out" the tendency toward the development of successive pressure waves.

If reasonably possible, any pipe line subject to water hammer should be protected by means of slow-closing valves, stand-pipes, or special equipment designed to stop the flow of water gradually. If such protection is not provided, allowance should be made for water hammer. This applies to all pipe lines having valves at the outlet end which may be closed quickly, or others—such as pumping lines—which normally have check valves or foot valves at the intake end which close quickly when the pump is stopped.

Recognizing the need for workable data regarding water hammer head allowance for wood pipe, the industry offers the following formula and tables which are based on practical experience and observation. It should be distinctly understood that it is not claimed that this formula will indicate the theoretical or actual water hammer head developed, but is intended only for use with wood pipe as a basis for adequate design to determine the head of pipe required for reasonably normal conditions. If the development of water hammer head is anticipated, add to the static head as indicated.

The Formula:

$$h = V^{1.5} + 2L + \frac{2d + H}{14}$$

In which: h = Water Hammer Head for design
V = Velocity of water in pipe
L = Length of pipe in thousands of feet
d = Inside Diameter of pipe in inches
H = Static Head

For convenient application of this formula, add the values given in both of the following tables:

WATER HAMMER HEAD TABLES

These tables give values of "h" which were obtained from practical experience and are for the design of wood stave pipe lines, only.

Values of $h = V^{1.5} + 2L$

Table No. 17

Velocity In Feet Per Second	Length of Pipe in Feet								
	1000	2000	3000	4000	5000	6000	8000	10000	15000
1	2	4	6	8	10	12	16	20	30
2	5	7	9	11	13	15	19	23	33
3	7	9	11	13	15	17	21	25	35
4	10	12	14	16	18	20	24	28	38
5	13	15	17	19	21	23	27	31	41
6	17	19	21	23	25	27	31	35	45
7	21	23	25	27	29	31	35	39	49
8	25	27	29	31	33	35	39	43	53
9	29	31	33	35	37	39	43	47	57
10	34	36	38	40	42	44	48	52	62

$$\text{Values of } h = \frac{2d + H}{14}$$

Table 17 A

Static Head In Feet	Diameter of Pipe in Inches								
	6	12	24	36	48	60	72	84	96
50	4	5	7	9	10	12	14	16	17
100	8	9	11	12	14	16	17	19	21
150	12	12	14	16	18	19	21	23	24
200	15	16	18	19	21	23	25	26	28
250	19	20	21	23	25	26	28	30	32
300	22	23	25	27	28	30	32	33	35

Example: Assume a pumping line

Pipe .... 5000 feet long
Velocity of Water .... 5 feet per second
Size of pipe .... 24" in diameter
Static Head .... 150 feet

Add 21 from first table, and 14 from second table, which gives a total of 35 feet water hammer design head. Adding this to 150 feet static head, results in 185 feet, which is the head of pipe required at the pump. The water hammer gradient on a profile will be a straight line drawn from this 185-foot head point to the water surface at the outlet. Lines drawn at intervals across the profile to determine the head of pipe required should be parallel to the water hammer gradient.

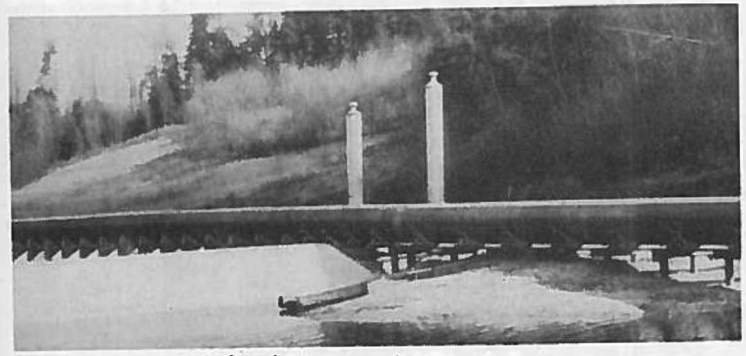
STANDPIPES, AIR RELIEF AND VACUUM VALVES

Some air is taken into a pipe line along with the water. This is particularly apt to occur if the velocity is more than a few feet per second. This air accumulates at summits in the line, with resulting decrease in capacity, and provision should be made to allow this entrapped air to escape.

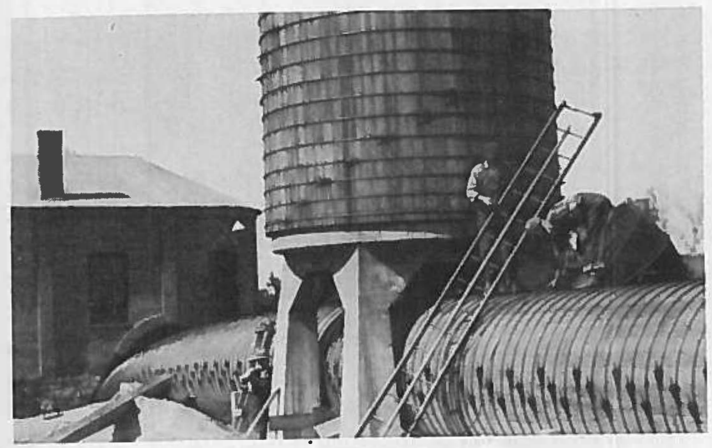
In some instances pipe lines may be subjected to external pressure developed on account of operating conditions which tend to create a vacuum within the pipe. This will occur, for instance, when a valve at the intake is closed rapidly, and may also take place at or near any summits in the line when the flow of water is stopped. Provision should be made to permit the entrance of air at such locations. Wood pipe, up to about 12" diameter,

will stand considerable abuse in this respect, but larger sizes, and particularly the largest sizes, require vacuum protection for safe operation.

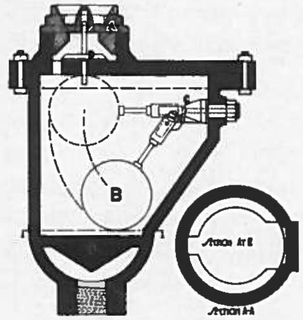
Open top standpipes may usually be employed for air relief and vacuum protection below a valve at intake, and also at summits, if a reasonable length of standpipe will rise above the hydraulic gradient or maximum water elevation at the location under consideration. Surge tanks may serve a similar purpose at the head of a steep penstock pipe line supplying a power plant, or for other similar conditions.



Standpipes on parallel lines of pipe



Surge Tank on 6 Foot Power Line



Air Relief and Vacuum Valve

Standpipes and surge tanks are illustrated. Air relief and vacuum valves may be employed where standpipes of too great a length would be required. The one illustrated allows air to be bled off at the needle valve, C, when the float, B, drops. The poppet valve remains closed after initial closing, while water pressure or air pressure prevails, but acts instantly to provide vacuum protection when water is withdrawn rapidly from the pipe.

The size of air valve required to provide adequate vacuum protection varies widely with operating conditions and selection of the proper size deserves the study of an expert. A rule of thumb for normal conditions is one inch of valve diameter for each eight inches of pipe diameter, and this ratio should seldom be less than one to twelve. Clusters of equivalent total area may be used. Corporation cocks or gate valves should be inserted between air valves and the pipe connection.

Freezing temperatures may cause a standpipe to become ineffective and will also interfere with the functioning of an air valve unless frost protection is provided. Frost boxes with sawdust or similar packing may furnish the necessary protection. The best method which has come to our attention to prevent freezing of air valves, is installation in deep closed-top pits, which necessitates pipe location in deep cuts at summits. Openings must, of course, be provided through any type of frost casing, to permit the entrance and discharge of air.

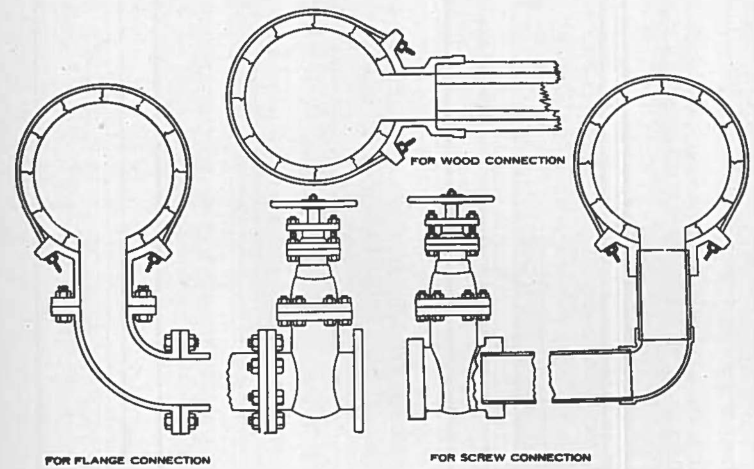
Experience has shown the importance of periodic inspection of air valves, of any make. Inspection in the Fall and Spring is a good rule to follow.

BLOW-OFFS

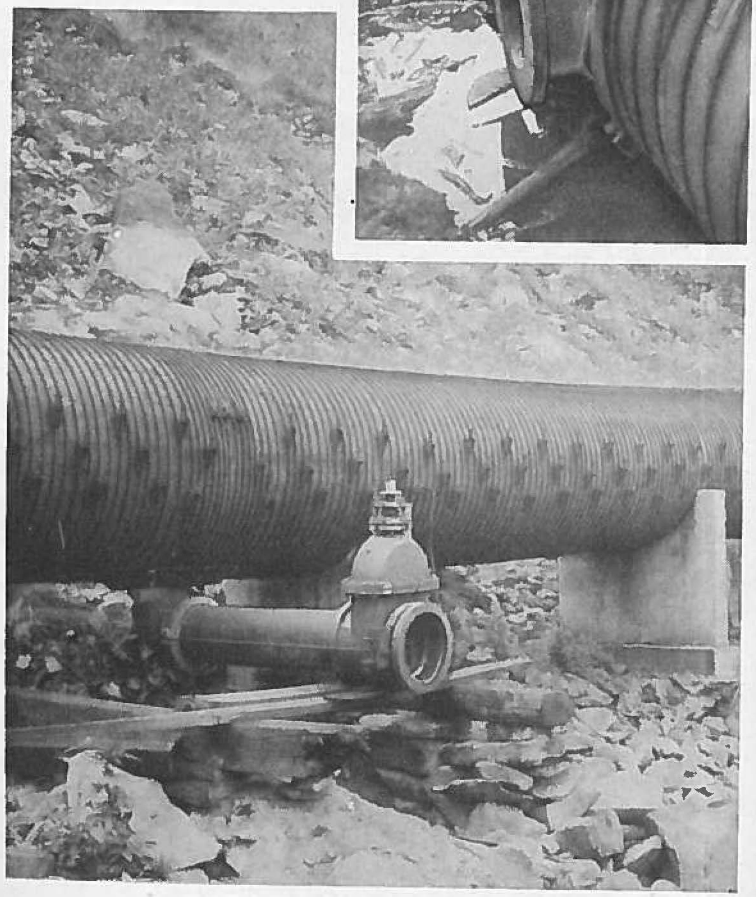
Valves are quite frequently required at low points to permit draining a line. These should be of such size that the pipe may be emptied in a reasonable time. If silting is anticipated, blow-off valves should be installed of large enough size to permit thorough cleaning. Blow-off valves may well be located slightly downstream from the lowest point in the line, as silt tends to carry a little beyond the low point.

Typical Blow-offs are illustrated. Cast iron saddles are suitable for many pipe sizes, but steel saddles are most frequently used in connection with large diameter wood pipe. Special design may be necessary for location at points where pressure is extremely high.

TYPICAL BLOW-OFFS



Flanged Saddle for Blow-off on 34" Continuous Stave Pipe



Hub End Blow-off with tie rods on 38" Pipe

ANCHORS

Anchorage should be provided at angle points and at the outside of sharp curves. Short lines, located on steep slopes, may require anchors at the foot of the hill and for longer lines these may also be needed at intervals up the slope. Buried lines of moderate size usually require only blocking at angle points, in addition to thoroughly tamped backfill material. Heavy concrete piers with steel tie straps over the pipe are commonly used to anchor pipe installed above ground.

MANHOLES

These are seldom provided for wood pipe as it is possible to gain entrance, when necessary, by removing a few bands and staves. If a manhole is considered essential, this may consist of a flanged saddle with blind flange, or a conventional manhole cover designed for internal pressure may be furnished with a plate steel saddle.

EXPANSION JOINTS

Since wood pipe is not subject to longitudinal contraction or expansion, regardless of climatic conditions or location above or below ground, expansion joints are not needed.

WOOD PIPE LOCATION

If the situation permits any choice in location, the most important fact to be kept in mind is that the cost of wood pipe is less for low or moderate operating heads than for high heads. To insure preservation due to water saturation, untreated pipe should be located 25 to 50 feet below the hydraulic gradient. Good design may call for creosoted wood pipe near the intake or for other points of low operating pressure, and untreated pipe for sections of moderate to high operating pressure.

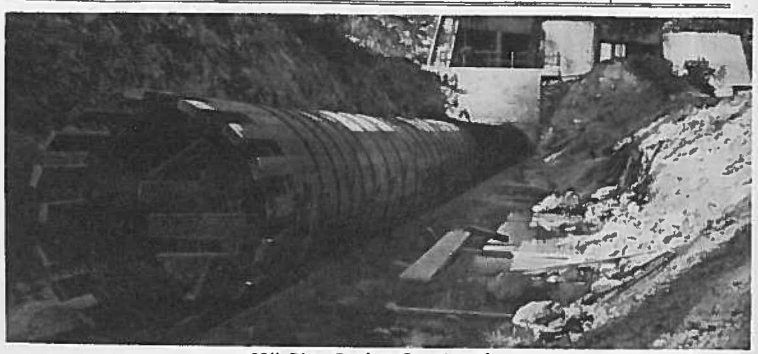
It is frequently desirable to place a pipe line underground, simply to get it out of the way. Wood pipe may, however, be very properly located either above ground or buried, so that possible savings in excavation costs deserve consideration.

QUANTITY OF WATER IN ONE FOOT OF PIPE

Table No. 18

Table Showing Quantity of Water in One Foot of Pipe in Cubic Feet and in U. S. Gallons.

Dia. of Pipe in Inches	Cu. Ft. of Water in 1 Foot of Pipe	U. S. Gals. in 1 Ft. of Pipe	Dia. of Pipe in Inches	Cu. Ft. of Water in 1 Foot of Pipe	U. S. Gals. in 1 Ft. of Pipe
½	0.0014	0.0102	58	18.348	137.3
¾	0.0031	0.0230	60	19.635	146.9
1	0.0055	0.0408	62	20.966	156.8
2	0.0218	0.1632	64	22.340	167.1
3	0.0491	0.3672	66	23.76	177.7
4	0.0873	0.6528	68	25.22	188.7
5	0.1364	1.020	70	26.73	200.0
6	0.1963	1.469	72	28.27	211.5
8	0.3491	2.611	74	29.87	223.4
10	0.5454	4.080	76	31.50	235.6
12	0.7854	5.875	78	33.18	248.2
14	1.069	7.997	80	34.91	261.1
16	1.396	10.44	82	36.67	274.3
18	1.767	13.22	84	38.48	287.9
20	2.182	16.32	86	40.34	301.7
22	2.640	19.75	88	42.24	316.0
24	3.142	23.50	90	44.18	330.5
26	3.687	27.58	92	46.16	345.3
28	4.276	31.99	94	48.19	360.5
30	4.909	36.72	96	50.27	376.0
32	5.585	41.78	98	52.38	391.8
34	6.305	47.16	100	54.54	408.0
36	7.069	52.88	102	56.75	424.5
38	7.876	58.92	104	58.99	441.2
40	8.727	65.28	106	61.28	458.4
42	9.621	71.97	108	63.62	475.9
44	10.559	78.99	110	66.00	493.7
46	11.541	86.33	112	68.42	511.8
48	12.566	94.00	114	70.88	530.2
50	13.635	102.00	116	73.39	549.0
52	14.748	110.3	118	75.94	568.0
54	15.901	119.0	120	78.54	587.5
56	17.104	128.0			



60" Pipe During Construction

FLOW OF WATER THROUGH WOOD PIPE

The following pages contain comprehensive tables showing the discharge of water through wood pipe, in diameters ranging from 2 inches to 240 inches (20 ft.). The basis of calculation is the Scobey formula, which is as follows:

$$Q = 1.272\ D^{2.65}\ H^{0.555}$$

This formula was publicly announced through Bulletin No. 376 of the Department of Agriculture dated November 25, 1916, and revised October, 1925.

The experiments were made under the direction of Fred C. Scobey, Senior Irrigation Engineer of the Department, and cover wood pipes, both large and small, in all parts of the country. The formula, therefore, reflects actual working conditions. Tests of pipe line capacities made since the publication of Bulletin No. 376, and its revision, indicate that the Scobey formula is fully entitled to the general acceptance which it has received.

Because of its carefully planed surface, the inside of wood pipe is exceptionally smooth, and only the most highly polished surfaces offer less resistance to the flow of water. Of even greater importance is the fact that the smooth surface, and consequent high capacity, is almost unchanged throughout the years. These characteristics are fairly reflected in the tables, as the formula is based on actual tests of numerous old and new pipe lines under operating conditions, and is not based on the most favorable results of a few tests under laboratory conditions.

Data obtained in recent years suggests the probability that creosoted wood pipe has a slightly greater capacity than untreated wood pipe, but the evidence is not sufficient to justify any definited statement at the present time. The Scobey formula may, however, be applied to creosoted wood pipe with some assurance that there is a small additional factor of safety.

One of the conclusions arrived at by Mr. Scobey and printed on Page 73 of this bulletin is as follows:

". . . speaking broadly, it is also shown that the capacity of wood stave pipe is about 5 per cent less than that of new cast iron, 15 per cent more than that of new riveted steel or 10-year old cast iron, and 25 per cent more than that of 10-year old riveted steel or 20-year old cast iron pipe."

We present a few examples of the use of these tables which will explain, in simple words, how the size of pipe may be determined to deliver a certain quantity of water; or how, with the size of the pipe given, the loss due to friction may be ascertained. The intelligent use of these tables can be made to do away entirely with the long, tiresome calculations that are beyond the reach of the layman and are a tedious and complicated piece of work for the practicing engineer. The frictional losses shown in the table, as well as the quantities of discharge, may be interpolated with reasonable accuracy.

The reader will note that the first column represents the loss of head due to friction in 1000 feet of pipe when discharging a given quantity of water. This frictional head may be applied to any length of pipe by multiplying by the number of thousand feet and fraction thereof, the result being the total frictional loss in the entire pipe. The second column shows the mean velocity in feet per second. The third column gives the discharge of the pipe in cubic feet per second. Succeeding columns give the discharges in gallons per minute and in miners' inches. The use of Miners' Inches in determining the quantity of discharge of water is rapidly becoming obsolete and the table is merely given in this book to accommodate those localities where its use still prevails.

In the last column is given the combined velocity and extrance heads. These figures indicate the head which must be allowed, at the intake, for the body of water to attain the required velocity and to allow for friction loss at the entrance of the pipe line. This item may be reduced nearly one-third if the intake is correctly designed so as to practically eliminate entrance friction.

HOW TO USE PIPE FLOW TABLE

Examples

1. Given:

Length of pipe, feet	4500
Discharge, second feet	168
Total head, feet	30

Required—Diameter of pipe.

As part of this total head will be lost on account of friction due to velocity and entrance, until the exact velocity be ascertained we can obtain only an approximate result. We, therefore, proceed to divide the total head by the number of thousands of feet of length. 30 divided by 4.5 equals 6.6+. Now let us assume that the .6 ft. will be devoted to velocity and entrance head and the 6 ft. to the friction head in 1000 feet of pipe. Referring to the table and after examining several pages, we find that under a diameter of 52 inches and opposite 6 feet is the required discharge, namely 168 second feet. We now multiply for the exact friction head $6 \times 4.5 = 27$ feet. To this add 3 feet which is the velocity and entrance head as shown in the table opposite the velocity of 11.4. A pipe having a 52-inch inside diameter is therefore the size of pipe required.

2. Given:

Size of pipe, inches	32
Length of pipe, feet	3500
Discharge, cubic feet per second	37

Required—Total Head.

Turning to the table showing a diameter of 32 inches, we find opposite the discharge of 37 cubic feet per second that 4 feet of head is required for friction in each 1000 feet of pipe. The friction in the entire line is, therefore, found by $3.5 \times 4 = 14$ feet. Glancing across the same line from which we obtained the friction head, we find that 1 foot is required for velocity and entrance head. This added to 14 equals 15 feet which is the total head required to discharge the given quantity of water.

3. Given:

Size of pipe, inches	60
Length, feet	5200
Total Head, feet	29

Required—Discharge.

Divide 29 by 5.2 equals 5+. Assuming the friction head to be 5 feet, the total friction head will be 5 multiplied by 5.2 equals 26 feet. Opposite this friction head of 5 feet will be found the velocity and entrance head amounting to 3 feet. This added to the 26 feet makes 29 feet,, the total head given. Since the total head has been consumed the discharge may be found opposite the frictional loss of 5 feet per thousand, namely, 222 second feet.

It must be noted that results do not always come out exactly as shown in these examples and second or even third trials must occasionally be made to get the closest possible results.

More Than One Size of Pipe

Equations may be set up for the solution of such problems, but a "cut-and-try" method is probably less confusing, and may be easily applied. Let us assume a pipe line 3500 feet long, with the water surface 77 feet lower at the outlet than at the intake. We will also assume that the desired capacity, including a suitable safety factor, is 3.35 C.F.S. We might try 1500 feet of 10″ pipe, and 2000 feet of 8″. Turning to the Flow Tables for these sizes we find but slightly higher capacities tabulated, and the friction head loss is found to be as follows:

1500 lin. ft. 10″ pipe @ 14′ per 1000′ = 21′
2000 lin. ft. 8″ pipe @ 40′ per 1000′ = 80′
Total, friction head = 101′

This is more than the available head, so another attempt is made, assuming different quantities of each size of pipe:

2500 lin. ft. 10″ pipe @ 14′ per 1000′ = 35′
1000 lin. ft. 8″ pipe @ 40′ per 1000′ = 40′
Total, friction head = 75′

This leaves two feet of head available to take care of the velocity and entrance head for the 10″ pipe, and since there will also be some loss of head at the point of change in pipe sizes, this may be selected as the proper combination. Three, or even more, pipe sizes may be involved, or one length and size may be fixed, but any such problems may be handled by similar "cut-and-try" methods.

It should be noted that it does not make any difference in capacity whether the 10″ or the 8″ is located at the intake end—the total friction loss is almost exactly the same. One of the most common of the erroneous ideas with respect to pipe line capacities is that a large pipe at the intake will somehow force more water through a small pipe. The advantage of the larger pipe is due entirely to leaving more friction head available for the smaller size of pipe, and it is of no importance whether this saving is made at the intake or outlet ends. Ordinarily the larger pipe would be located at the intake end, and this is sensible and proper, particularly if water is to be taken out along the line. Sometimes the profile of the ground requires a larger pipe to deliver a certain capacity on the rather flat grade near the intake, and there are other reasons why this would be the normal arrangement of sizes; but the point is, that there is no advantage gained by a large area or volume "pushing" on a smaller area or volume. Give reasonable consideration to intake design; but do not, for instance, expect to accomplish anything worth while by placing 50 feet of 18″ pipe at the head end of a 5000-foot line of 10″ pipe.

As a general rule, unless appreciable quantities of water are withdrawn at intervals along the line, it is a mistake to use several sizes of pipe. Instances are on record of installations reducing from about 18-inch at the intake down through all of the various sizes to—say 8-inch at the outlet. As a result, there may be practically no friction head loss in the 18-inch pipe, and a tremendous friction head loss in the smallest sizes. One size, or occasionally two sizes, might have been selected to serve more efficiently.

Safety Factors for Capacity

The Pipe Flow table may be employed with the confidence that it is based on a formula derived by the outstanding independent specialist in this field of hydraulics, after making numerous tests of wood pipe capacity under actual operating conditions.

It may be employed with the further assurance that the inside of wood pipe stays smooth and that the capacity will remain more nearly constant throughout the years than that of almost all, if not all, of the other kinds of pipe in commercial use for a similar range of sizes.

Variations in capacity, above or below that indicated by the table, do occur, however; and, accordingly, factors of safety should be used. The extent of the safety factors which should be applied depends almost entirely upon how serious the penalty may be if the actual discharge is less than that calculated. The following are recommended:

5%—For general application, if clean water is to be handled, or if the velocity is high enough to prevent the accumulation of silt inside of the pipe; provided that little penalty is attached to a slight insufficiency of carrying capacity.

10%—For above conditions of a clean interior, even if some penalty is attached to a slight insufficiency in capacity; or, if some silting may be anticipated and, at the same time, no serious penalty is attached to such slight insufficiency.

15%—The maximum for conditions which are quite unfavorable with respect to silting, even if a rather heavy penalty is attached to discharge of less than estimated capacity.

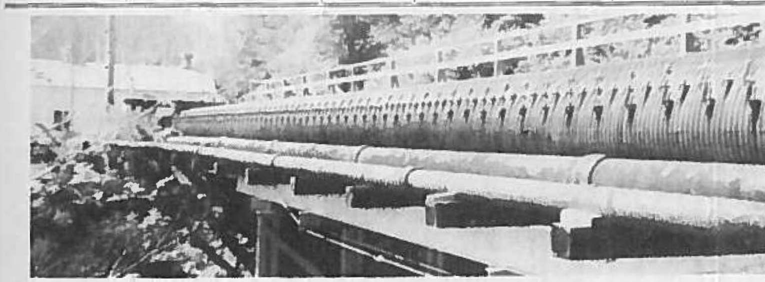
Similar safety factors should be applied to any general formula, for any kind of pipe, and considerably greater factors should be used for some kinds of pipe.

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 2 Inches

Table No. 19 — **Area 0.0218 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.141	0.003	.006	1.4	0.15	0.12	0.00
0.2	0.207	0.005	.010	2.3	0.25	0.20	0.00
0.3	0.259	0.006	.012	2.7	0.30	0.24	0.00
0.4	0.304	0.007	.014	3.2	0.35	0.28	0.00
0.5	0.344	0.008	.016	3.6	0.40	0.32	0.00
0.6	0.381	0.008	.016	3.6	0.40	0.32	0.00
0.7	0.415	0.009	.018	4.0	0.45	0.36	0.00
0.8	0.447	0.010	.020	4.5	0.50	0.40	0.01
0.9	0.477	0.010	.020	4.5	0.50	0.40	0.01
1.0	0.506	0.011	.022	5.0	0.55	0.44	0.01
1.5	0.633	0.014	.028	6.3	0.70	0.56	0.01
2.0	0.743	0.016	.032	7.2	0.80	0.64	0.01
2.5	0.841	0.018	.036	8.1	0.90	0.72	0.02
3.0	0.930	0.020	.040	9.0	1.00	0.80	0.02
3.5	1.01	0.022	.044	9.9	1.10	0.88	0.03
4.0	1.09	0.024	.048	10.8	1.20	0.96	0.03
4.5	1.17	0.026	.052	11.7	1.30	1.04	0.03
5.0	1.24	0.027	.054	12.1	1.35	1.08	0.04
6.0	1.37	0.030	.059	13.5	1.50	1.20	0.05
7.0	1.49	0.033	.065	14.8	1.65	1.32	0.05
8.0	1.60	0.035	.069	15.7	1.75	1.40	0.06
9.0	1.71	0.037	.073	16.6	1.85	1.48	0.07
10.0	1.82	0.040	.079	18.0	2.00	1.60	0.08
12.0	2.01	0.044	.087	19.8	2.20	1.76	0.10
14.0	2.19	0.048	.095	21.6	2.40	1.92	0.11
16.0	2.36	0.052	.103	23.4	2.60	2.08	0.13
18.0	2.51	0.055	.109	24.7	2.75	2.20	0.15
20.0	2.67	0.058	.115	26.0	2.90	2.32	0.17
22.0	2.81	0.061	.121	27.4	3.05	2.44	0.19
24.0	2.95	0.064	.127	28.7	3.20	2.56	0.20
26.0	3.08	0.067	.133	30.1	3.35	2.68	0.22
28.0	3.21	0.070	.139	31.4	3.50	2.80	0.24
30.0	3.34	0.073	.145	32.8	3.65	2.92	0.26
35.0	3.64	0.079	.157	35.5	3.95	3.16	0.31
40.0	3.92	0.085	.169	38.1	4.25	3.40	0.36
45.0	4.18	0.091	.180	40.8	4.55	3.64	0.41
50.0	4.43	0.097	.192	43.5	4.85	3.88	0.46



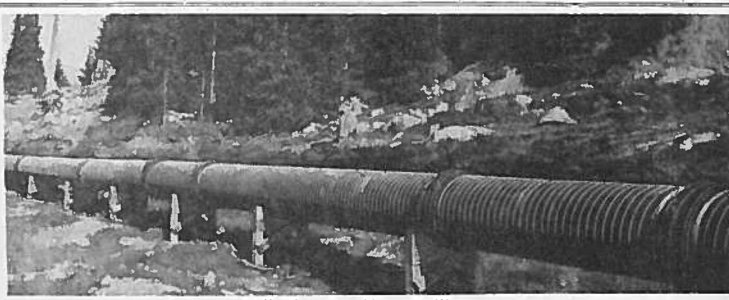
Wire Wound and Continuous Stave Pipe

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 3 Inches

Table No. 19 (Continued) **Area 0.0491 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	Velocity and Entrance Head in Feet
0.1	0.183	**0.009**	.018	4.0	0.45	0.36	0.00
0.2	0.269	**0.013**	.026	5.8	0.65	0.52	0.00
0.3	0.337	**0.017**	.034	7.6	0.85	0.68	0.00
0.4	0.396	**0.019**	.038	8.5	0.95	0.76	0.00
0.5	0.448	**0.022**	.044	9.9	1.10	0.88	0.01
0.6	0.496	**0.024**	.048	10.8	1.20	0.96	0.01
0.7	0.540	**0.026**	.052	11.7	1.30	1.04	0.01
0.8	0.581	**0.028**	.056	12.6	1.40	1.12	0.01
0.9	0.621	**0.030**	.060	13.5	1.50	1.20	0.01
1.0	0.658	**0.032**	.063	14.4	1.60	1.28	0.01
1.5	0.824	**0.040**	.079	18.0	2.00	1.60	0.02
2.0	0.967	**0.048**	.095	21.5	2.40	1.92	0.02
2.5	1.09	**0.054**	.107	24.2	2.70	2.16	0.03
3.0	1.21	**0.059**	.117	26.5	2.95	2.36	0.03
3.5	1.32	**0.065**	.129	29.2	3.25	2.60	0.04
4.0	1.42	**0.070**	.139	31.4	3.50	2.80	0.05
4.5	1.52	**0.075**	.149	33.6	3.75	3.00	0.06
5.0	1.61	**0.079**	.157	35.4	3.95	3.16	0.06
6.0	1.78	**0.087**	.172	39.0	4.35	3.48	0.08
7.0	1.94	**0.095**	.188	42.6	4.75	3.80	0.09
8.0	2.09	**0.102**	.202	45.8	5.10	4.08	0.10
9.0	2.23	**0.109**	.216	49.0	5.45	4.36	0.12
10.0	2.36	**0.116**	.230	52.0	5.80	4.64	0.13
12.0	2.61	**0.128**	.254	57.4	6.40	5.12	0.16
14.0	2.85	**0.140**	.278	62.8	7.00	5.60	0.19
16.0	3.07	**0.151**	.299	67.8	7.55	6.04	0.22
18.0	3.27	**0.160**	.317	71.8	8.00	6.40	0.25
20.0	3.47	**0.170**	.337	76.3	8.50	6.80	0.28
22.0	3.66	**0.180**	.357	80.8	9.00	7.20	0.31
24.0	3.84	**0.189**	.375	84.8	9.45	8.56	0.35
26.0	4.01	**0.197**	.391	88.5	9.85	7.88	0.38
28.0	4.18	**0.205**	.406	92.1	10.3	8.20	0.41
30.0	4.35	**0.214**	.424	96.0	10.7	8.52	0.44
35.0	4.73	**0.232**	.460	104	11.6	9.28	0.52
40.0	5.10	**0.250**	.496	112	12.5	10.0	0.61
45.0	5.44	**0.267**	.530	120	13.4	10.7	0.69
50.0	5.77	**0.283**	.561	127	14.2	11.3	0.78



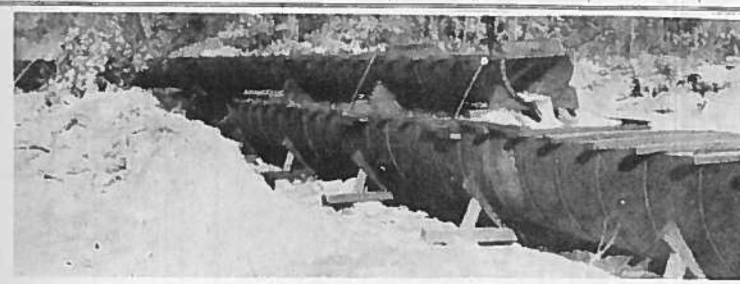
18" Pipe for Mine Tailings

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 4 Inches

Table No. 19 (Continued) **Area 0.0873 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	Velocity and Entrance Head in Feet
0.1	0.221	**0.019**	.038	8.5	0.95	0.76	0.00
0.2	0.325	**0.028**	.056	12.6	1.40	1.12	0.00
0.3	0.407	**0.036**	.071	16.1	1.80	1.44	0.00
0.4	0.477	**0.042**	.083	18.8	2.10	1.68	0.01
0.5	0.540	**0.047**	.093	21.1	2.35	1.88	0.01
0.6	0.597	**0.052**	.103	23.3	2.60	2.08	0.01
0.7	0.651	**0.057**	.113	25.6	2.85	2.28	0.01
0.8	0.701	**0.061**	.121	27.4	3.05	2.44	0.01
0.9	0.748	**0.065**	.129	29.2	3.25	2.60	0.01
1.0	0.793	**0.069**	.137	31.0	3.45	2.76	0.02
1.5	0.993	**0.087**	.172	39.0	4.35	3.48	0.02
2.0	1.17	**0.102**	.202	45.7	5.10	4.08	0.03
2.5	1.32	**0.115**	.228	51.6	5.75	4.60	0.04
3.0	1.46	**0.128**	.254	57.4	6.40	5.12	0.05
3.5	1.59	**0.139**	.276	62.3	6.95	5.56	0.06
4.0	1.71	**0.149**	.295	66.8	7.45	5.96	0.07
4.5	1.83	**0.160**	.317	71.8	8.00	6.40	0.08
5.0	1.94	**0.169**	.335	75.8	8.45	6.76	0.09
6.0	2.14	**0.187**	.371	83.9	9.35	7.48	0.11
7.0	2.34	**0.204**	.404	91.5	10.20	8.16	0.13
8.0	2.52	**0.220**	.436	98.7	11.0	8.80	0.15
9.0	2.69	**0.235**	.466	106	11.7	9.40	0.17
10.0	2.85	**0.249**	.494	112	12.5	9.96	0.19
12.0	3.15	**0.275**	.545	123	13.8	11.0	0.23
14.0	3.43	**0.300**	.595	135	15.0	12.0	0.28
16.0	3.70	**0.323**	.640	145	16.2	12.9	0.32
18.0	3.95	**0.345**	.684	155	17.3	13.8	0.37
20.0	4.18	**0.365**	.724	164	18.3	14.6	0.41
22.0	4.41	**0.385**	.764	173	19.3	15.4	0.46
24.0	4.63	**0.404**	.801	181	20.2	16.2	0.50
26.0	4.84	**0.422**	.837	189	21.1	16.9	0.55
28.0	5.04	**0.440**	.872	197	22.0	17.6	0.59
30.0	5.24	**0.458**	.908	206	22.9	18.3	0.64
35.0	5.71	**0.499**	.990	224	24.9	20.0	0.76
40.0	6.15	**0.536**	1.06	241	26.8	21.4	0.88
45.0	6.56	**0.573**	1.14	257	28.7	22.9	1.0
50.0	6.96	**0.608**	1.21	273	30.4	24.3	1.1



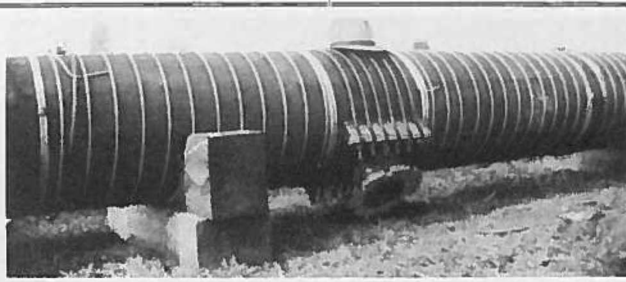
24" and 48" Flumes

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 5 Inches

Table No. 19 (Continued) **Area 0.1364 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.256	**0.035**	.069	15.7	1.75	1.40	0.00
0.2	0.375	**0.051**	.101	22.9	2.55	2.04	0.00
0.3	0.470	**0.064**	.127	28.7	3.20	2.56	0.01
0.4	0.552	**0.075**	.149	33.6	3.75	3.00	0.01
0.5	0.624	**0.085**	.169	38.1	4.25	3.40	0.01
0.6	0.691	**0.094**	.186	42.2	4.70	3.76	0.01
0.7	0.752	**0.102**	.202	45.7	5.10	4.08	0.01
0.8	0.810	**0.110**	.218	49.3	5.50	4.40	0.02
0.9	0.865	**0.118**	.234	52.9	5.90	4.72	0.02
1.0	0.917	**0.125**	.248	56.0	6.25	5.00	0.02
1.5	1.15	**0.157**	.311	70.3	7.85	6.28	0.03
2.0	1.35	**0.184**	.365	82.5	9.20	7.36	0.04
2.5	1.53	**0.209**	.414	93.6	10.2	8.36	0.06
3.0	1.69	**0.230**	.456	103	11.5	9.20	0.07
3.5	1.84	**0 251**	.497	113	12.6	10.0	0.08
4.0	1.98	**0.270**	.536	121	13.5	10.8	0.09
4.5	2.11	**0.288**	.571	129	14.4	11.5	0.11
5.0	2.24	**0.306**	.607	137	15.3	12.2	0.12
8.0	2.48	**0.338**	.670	152	16.9	13.5	0.14
7.0	2.70	**0.368**	.730	165	18.4	14.7	0.17
8.0	2.91	**0.397**	.787	178	19.9	15.9	0.20
9.0	3.11	**0.424**	.841	190	21.2	17.0	0.23
10.0	3.29	**0.448**	.889	201	22.4	17.9	0.25
12.0	3.64	**0.498**	.984	223	24.8	19.8	0.31
14.0	3.97	**0.542**	1.07	243	27.1	21.7	0.37
18.0	4.27	**0.583**	1.16	262	29.2	23.2	0.43
18.0	4.56	**0.822**	1.23	279	31.1	24.9	0.49
20.0	4.84	**0.660**	1.31	296	33.0	26.4	0.55
22.0	5.10	**0.698**	1.38	312	34.8	27.8	0.61
24.0	5.35	**0.730**	1.45	327	36.5	29.2	0.67
28.0	5.59	**0.782**	1.51	342	38.1	30.5	0.73
28.0	5.83	**0.795**	1.58	357	39.8	31.8	0.79
30.0	6.06	**0.827**	1.64	371	41.4	33.1	0.86
35.0	6.60	**0.900**	1.78	404	45.0	36.0	1.0
40.0	7.11	**0.970**	1.92	435	48.5	38.8	1.2
45.0	7.58	**1.03**	2.04	461	51.5	41.2	1.4
50.0	8.04	**1.10**	2.18	493	55.0	44.0	1.5



16" with Saddle for Blow-off

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 6 Inches

Table No. 19 (Continued) **Area 0.1963 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.288	**0.057**	.113	25.6	2.85	2.28	0.00
0.2	0.423	**0.083**	.165	37.2	4.15	3.32	0.00
0.3	0.529	**0.104**	.206	46.7	5.20	4.16	0.01
0.4	0.621	**0.122**	.242	54.7	6.10	4.88	0.01
0.5	0.703	**0.138**	.274	62.0	6.90	5.52	0.01
0.8	0.778	**0.153**	.303	68.7	7.65	6.12	0.01
0.7	0.847	**0.188**	.329	74.5	8.30	6.64	0.02
0.8	0.912	**0.179**	.355	80.4	8.95	7.16	0.02
0.9	0.974	**0.191**	.379	85.7	9.55	7.64	0.02
1.0	1.03	**0.202**	.401	90.7	10.1	8.08	0.02
1.5	1.29	**0.253**	.502	114	12.7	10.1	0.04
2.0	1.52	**0.298**	.591	134	14.9	11.9	0.05
2.5	1.72	**0.337**	.668	151	16.9	13.3	0.07
3.0	1.90	**0.373**	.740	167	18.7	14.9	0.08
3.5	2.07	**0.406**	.805	182	20.3	16.2	0.10
4.0	2.23	**0.438**	.869	197	21.9	17.5	0.12
4.5	2.38	**0.467**	.926	210	23.4	18.7	0.13
5.0	2.52	**0.495**	.982	222	24.8	19.8	0.15
8.0	2.79	**0.548**	1.09	246	27.4	21.9	0.18
7.0	3.04	**0.597**	1.18	268	29.9	23.9	0.22
8.0	3.27	**0.642**	1.27	288	32.1	25.7	0.25
9.0	3.50	**0.888**	1.36	309	34.4	27.5	0.29
10.0	3.71	**0.729**	1.45	327	36.5	29.2	0.32
12.0	4.10	**0.806**	1.60	362	40.3	32.2	0.39
14.0	4.47	**0.878**	1.74	394	43.9	35.1	0.47
18.0	4.81	**0.945**	1.87	424	47.3	37.8	0.54
18.0	5.14	**1.01**	2.00	453	50.5	40.4	0.62
20.0	5.44	**1.07**	2.12	480	53.5	42.8	0.69
22.0	5.74	**1.13**	2.24	507	56.5	45.2	0.77
24.0	6.02	**1.18**	2.34	529	59.0	47.2	0.84
26.0	6.30	**1.24**	2.46	556	62.0	49.6	0.92
28.0	6.56	**1.29**	2.56	579	64.5	51.6	1.0
30.0	6.82	**1.34**	2.66	601	67.0	53.6	1.1
35.0	7.43	**1.46**	2.89	655	73.0	58.4	1.3
40.0	8.00	**1.57**	3.11	705	78.5	62.8	1.5
45.0	8.54	**1.68**	3.33	753	84.0	67.2	1.7
50.0	9.05	**1.78**	3.53	799	89.0	71.2	1.9

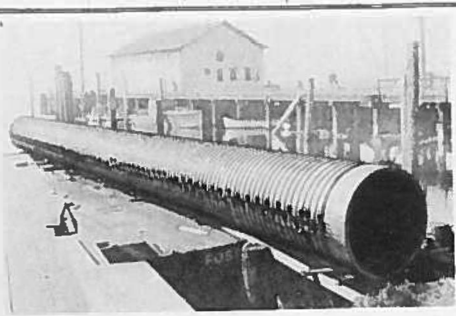
Laying Wire-Wound Pipe

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 8 Inches

Table No. 19 (Continued) **Area 0.3491 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.347	**0.121**	.240	54.3	6.05	4.84	0.00
0.2	0.510	**0.178**	.353	79.9	8.90	7.12	0.01
0.3	0.638	**0.223**	.442	100	11.2	8.92	0.01
0.4	0.749	**0.262**	.520	117	13.1	10.5	0.01
0.5	0.847	**0.296**	.587	133	14.8	11.8	0.02
0.6	0.937	**0.327**	.649	147	16.4	13.1	0.02
0.7	1.02	**0.356**	.706	160	17.8	14.2	0.03
0.8	1.10	**0.384**	.762	172	19.2	15.3	0.03
0.9	1.17	**0.408**	.809	183	20.4	16.3	0.03
1.0	1.25	**0.436**	.865	196	21.8	17.4	0.04
1.5	1.56	**0.545**	1.08	245	27.3	21.8	0.06
2.0	1.83	**0.640**	1.27	287	32.0	25.6	0.08
2.5	2.07	**0.723**	1.43	325	36.2	28.9	0.10
3.0	2.29	**0.800**	1.59	359	40.0	32.0	0.12
3.5	2.50	**0.874**	1.73	392	43.7	35.0	0.15
4.0	2.69	**0.940**	1.86	422	47.0	37.6	0.17
4.5	2.87	**1.00**	1.98	449	50.0	40.0	0.19
5.0	3.04	**1.06**	2.10	476	53.0	42.4	0.22
6.0	3.37	**1.18**	2.34	530	59.0	47.2	0.27
7.0	3.67	**1.28**	2.54	574	64.0	51.2	0.31
8.0	3.95	**1.38**	2.74	620	69.0	55.2	0.36
9.0	4.21	**1.47**	2.91	660	73.5	58.8	0.41
10.0	4.47	**1.56**	3.09	700	78.0	62.4	0.47
12.0	4.94	**1.73**	3.43	776	86.5	69.2	0.57
14.0	5.39	**1.88**	3.73	844	94.0	75.2	0.68
16.0	5.80	**2.03**	4.03	911	102	81.2	0.79
18.0	6.19	**2.16**	4.28	970	108	86.4	0.89
20.0	6.56	**2.29**	4.54	1030	115	91.6	1.0
22.0	6.92	**2.41**	4.78	1080	121	96.4	1.1
24.0	7.26	**2.53**	5.02	1140	127	101	1.2
26.0	7.59	**2.65**	5.26	1190	133	106	1.3
28.0	7.91	**2.76**	5.48	1240	138	110	1.5
30.0	8.22	**2.87**	5.69	1290	144	115	1.6
35.0	8.95	**3.12**	6.19	1400	156	125	1.9
40.0	9.64	**3.37**	6.68	1510	169	135	2.2
45.0	10.3	**3.60**	7.14	1620	180	144	2.5
50.0	10.9	**3.81**	7.56	1710	191	152	2.8



60" Creosoted Outfall Sewer

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 10 Inches

Table No. 19 (Continued) **Area 0.5454 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.401	**.219**	.434	88	11.0	8.76	0.00
0.2	0.589	**.322**	.639	145	16.1	12.9	0.01
0.3	0.738	**.403**	.798	181	20.2	16.1	0.01
0.4	0.865	**.472**	.936	212	23.6	18.9	0.02
0.5	0.979	**.534**	1.06	240	26.7	21.4	0.02
0.6	1.08	**.589**	1.17	265	29.5	23.6	0.03
0.7	1.18	**.644**	1.28	289	32.2	25.8	0.03
0.8	1.27	**.693**	1.37	311	34.7	27.7	0.04
0.9	1.36	**.742**	1.47	333	37.1	29.7	0.04
1.0	1.44	**.785**	1.56	352	39.3	31.4	0.05
1.2	1.59	**.868**	1.72	390	43.4	34.7	0.06
1.4	1.73	**.944**	1.87	423	47.2	37.8	0.07
1.6	1.87	**1.02**	2.02	458	51.0	40.8	0.08
1.8	1.99	**1.09**	2.16	490	54.5	43.6	0.09
2.0	2.11	**1.15**	2.28	517	57.5	46.0	0.11
2.5	2.39	**1.30**	2.58	584	65.0	52.0	0.13
3.0	2.65	**1.45**	2.88	651	72.5	58.0	0.16
3.5	2.88	**1.57**	3.11	705	78.5	62.8	0.19
4.0	3.11	**1.70**	3.37	764	85.0	68.0	0.23
4.5	3.32	**1.81**	3.59	813	90.5	72.4	0.26
5.0	3.52	**1.92**	3.81	863	96.0	76.8	0.29
6.0	3.89	**2.12**	4.20	953	106	84.8	0.35
7.0	4.24	**2.32**	4.60	1040	116	92.8	0.42
8.0	4.56	**2.49**	4.94	1120	125	99.6	0.49
9.0	4.87	**2.66**	5.28	1190	133	106	0.55
10.0	5.17	**2.82**	5.59	1270	141	113	0.63
12.0	5.71	**3.12**	6.19	1400	156	125	0.76
14.0	6.23	**3.40**	6.74	1530	170	136	0.91
16.0	6.70	**3.66**	7.26	1640	183	146	1.1
18.0	7.16	**3.91**	7.76	1760	196	156	1.2
20.0	7.59	**4.14**	8.21	1860	207	166	1.4
22.0	8.00	**4.36**	8.65	1960	218	174	1.5
24.0	8.40	**4.58**	9.08	2060	229	183	1.7
26.0	8.78	**4.79**	9.50	2150	240	192	1.8
28.0	9.15	**4.99**	9.90	2240	250	200	2.0
30.0	9.50	**5.18**	10.3	2330	259	207	2.1

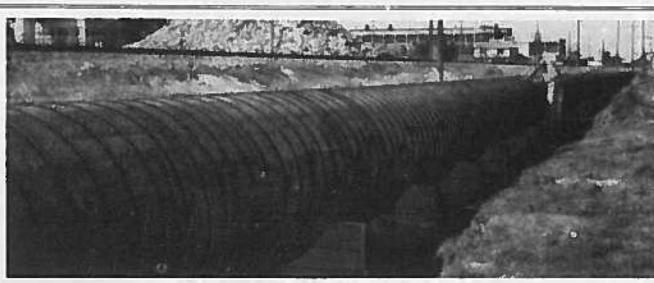
Tee and Valve Box

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 12 Inches
(1 ft. 0 in.)

Table No. 19 (Continued) **Area 0.7854 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	0.451	**0.354**	.702	159	17.7	14.2	0.01
0.2	0.663	**0.521**	1.03	234	26.1	20.8	0.01
0.3	0.831	**0.653**	1.29	293	32.7	26.1	0.02
0.4	0.974	**0.765**	1.52	343	38.3	30.6	0.02
0.5	1.10	**0.864**	1.71	388	43.2	34.6	0.03
0.6	1.22	**0.958**	1.90	430	47.9	38.3	0.04
0.7	1.33	**1.04**	2.06	467	52.0	41.6	0.04
0.8	1.43	**1.12**	2.22	503	56.0	44.8	0.05
0.9	1.53	**1.20**	2.38	539	60.0	48.0	0.05
1.0	1.62	**1.27**	2.52	570	63.5	50.8	0.06
1.2	1.79	**1.41**	2.80	633	70.5	56.4	0.08
1.4	1.95	**1.53**	3.03	686	76.5	61.2	0.09
1.6	2.10	**1.65**	3.27	740	82.5	66.0	0.11
1.8	2.25	**1.77**	3.51	794	88.5	70.8	0.12
2.0	2.38	**1.87**	3.71	840	93.5	74.8	0.13
2.5	2.69	**2.11**	4.18	947	106	84.4	0.17
3.0	2.98	**2.34**	4.64	1050	117	93.6	0.21
3.5	3.25	**2.55**	5.06	1140	128	102	0.25
4.0	3.50	**2.75**	5.46	1230	138	110	0.29
4.5	3.73	**2.93**	5.81	1310	147	117	0.32
5.0	3.96	**3.11**	6.17	1400	156	124	0.37
6.0	4.38	**3.45**	6.84	1550	173	138	0.45
7.0	4.77	**3.75**	7.44	1680	188	150	0.53
8.0	5.14	**4.04**	8.01	1810	202	162	0.62
9.0	5.48	**4.31**	8.55	1930	216	172	0.70
10.0	5.82	**4.57**	9.06	2050	229	183	0.79
12.0	6.43	**5.05**	10.00	2270	253	202	0.97
14.0	7.01	**5.51**	10.9	2470	276	220	1.2
16.0	7.55	**5.93**	11.8	2660	297	237	1.3
18.0	8.06	**6.33**	12.6	2840	317	253	1.5
20.0	8.54	**6.70**	13.3	3010	335	268	1.7
22.0	9.01	**7.08**	14.0	3180	354	283	1.9
24.0	9.45	**7.43**	14.7	3330	372	297	2.1
26.0	9.88	**7.76**	15.4	3480	388	310	2.3
28.0	10.3	**8.09**	16.0	3630	405	324	2.5
30.0	10.7	**8.40**	16.6	3770	420	336	2.7



54" Creosoted Pulp Mill Supply Line

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 14 Inches
(1 ft. 2 in.)

Table No. 19 (Continued) **Area 1.069 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	0.499	**0.534**	1.06	240	26.7	21.4	0.01
0.2	0.733	**0.784**	1.55	352	39.2	31.4	0.01
0.3	0.918	**0.983**	1.95	442	49.2	39.3	0.02
0.4	1.08	**1.16**	2.30	520	58.0	46.4	0.03
0.5	1.22	**1.30**	2.58	583	65.0	52.0	0.03
0.6	1.35	**1.44**	2.86	646	72.0	57.6	0.04
0.7	1.47	**1.57**	3.11	705	78.5	62.8	0.05
0.8	1.58	**1.69**	3.35	758	84.5	67.6	0.06
0.9	1.69	**1.81**	3.59	812	90.5	72.4	0.07
1.0	1.79	**1.92**	3.81	862	96.0	76.8	0.08
1.2	1.98	**2.12**	4.20	952	106	84.8	0.09
1.4	2.16	**2.31**	4.58	1040	116	92.4	0.11
1.6	2.33	**2.49**	4.94	1120	125	99.6	0.13
1.8	2.48	**2.65**	5.26	1190	133	106	0.14
2.0	2.63	**2.82**	5.59	1260	141	113	0.16
2.5	2.98	**3.19**	6.33	1430	160	128	0.21
3.0	3.30	**3.53**	7.00	1580	177	141	0.25
3.5	3.59	**3.84**	7.62	1720	192	154	0.30
4.0	3.87	**4.14**	8.21	1860	207	166	0.35
4.5	4.13	**4.42**	8.77	1980	221	177	0.40
5.0	4.38	**4.68**	9.28	2100	234	187	0.45
6.0	4.84	**5.18**	10.30	2320	259	207	0.55
7.0	5.27	**5.64**	11.2	2530	282	226	0.65
8.0	5.68	**6.08**	12.1	2730	304	243	0.75
9.0	6.06	**6.48**	12.9	2910	324	259	0.86
10.0	6.43	**6.87**	13.6	3090	344	275	0.97
12.0	7.11	**7.61**	15.1	3420	381	304	1.2
14.0	7.75	**8.29**	16.4	3720	415	332	1.4
16.0	8.34	**8.93**	17.7	4010	447	357	1.6
18.0	8.91	**9.53**	18.9	4280	477	381	1.9
20.0	9.45	**10.1**	20.0	4530	505	404	2.1
22.0	9.96	**10.7**	21.2	4800	535	428	2.3
24.0	10.5	**11.2**	22.2	5030	560	448	2.6
26.0	10.9	**11.7**	23.2	5250	585	468	2.8
28.0	11.4	**12.2**	24.2	5470	610	488	3.0
30.0	11.8	**12.6**	25.0	5650	630	504	3.3

26" Irrigation Line

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 16 Inches

(1 ft. 4 in.)

Table No. 19 (Continued) **Area 1.396 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.544	**.760**	1.51	341	38.0	30.4	0.01
0.2	0.799	**1.11**	2.20	498	55.5	44.4	0.02
0.3	1.00	**1.40**	2.78	629	70.0	56.0	0.02
0.4	1.17	**1.63**	3.23	732	81.5	65.2	0.03
0.5	1.33	**1.86**	3.69	835	93.0	74.4	0.04
0.6	1.47	**2.05**	4.06	920	103	82.0	0.05
0.7	1.60	**2.23**	4.42	1000	112	89.2	0.06
0.8	1.73	**2.42**	4.80	1090	121	96.8	0.07
0.9	1.84	**2.57**	5.10	1150	129	103	0.08
1.0	1.95	**2.72**	5.40	1220	136	109	0.09
1.2	2.16	**3.02**	5.99	1350	151	121	0.11
1.4	2.35	**3.28**	6.50	1470	164	131	0.13
1.6	2.54	**3.55**	7.04	1590	178	142	0.15
1.8	2.71	**3.78**	7.50	1700	189	151	0.17
2.0	2.87	**4.01**	7.95	1800	201	160	0.19
2.5	3.25	**4.54**	9.00	2040	227	182	0.25
3.0	3.59	**5.01**	9.94	2250	251	200	0.30
3.5	3.91	**5.46**	10.8	2450	273	218	0.36
4.0	4.22	**5.89**	11.7	2640	295	236	0.42
4.5	4.50	**6.28**	12.5	2820	314	251	0.47
5.0	4.77	**6.66**	13.2	2990	333	266	0.53
6.0	5.28	**7.37**	14.6	3310	369	295	0.65
7.0	5.75	**8.03**	15.9	3610	402	321	0.77
8.0	6.19	**8.65**	17.2	3880	433	346	0.89
9.0	6.61	**9.23**	18.3	4140	462	369	1.0
10.0	7.01	**9.80**	19.4	4400	490	392	1.2
12.0	7.76	**10.8**	21.4	4850	540	432	1.4
14.0	8.45	**11.8**	23.4	5300	590	472	1.7
16.0	9.10	**12.7**	25.2	5700	635	508	1.9
18.0	9.71	**13.6**	27.0	6100	680	544	2.2
20.0	10.3	**14.4**	28.6	6460	720	576	2.5
22.0	10.9	**15.2**	30.1	6820	760	608	2.8
24.0	11.4	**15.9**	31.5	7140	795	636	3.0
26.0	11.9	**16.6**	32.9	7460	830	664	3.3
28.0	12.4	**17.3**	34.3	7770	865	692	3.6
30.0	12.9	**18.0**	35.7	8080	900	720	3.9

Placing Collars on Pipe at Factory

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 18 Inches

(1 ft. 6 in.)

Table No. 19 (Continued) **Area 1.767 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.588	**1.04**	2.06	467	52.0	41.6	0.01
0.2	0.863	**1.52**	3.01	682	76.0	60.8	0.02
0.3	1.08	**1.91**	3.79	858	95.5	76.4	0.03
0.4	1.27	**2.24**	4.44	1010	112	89.6	0.04
0.5	1.44	**2.54**	5.04	1140	127	102	0.05
0.6	1.59	**2.81**	5.57	1260	141	112	0.06
0.7	1.73	**3.06**	6.07	1370	153	122	0.07
0.8	1.86	**3.28**	6.51	1470	164	131	0.08
0.9	1.99	**3.51**	6.96	1580	176	140	0.09
1.0	2.11	**3.73**	7.40	1680	187	149	0.10
1.2	2.33	**4.12**	8.17	1850	206	165	0.13
1.4	2.54	**4.49**	8.90	2020	225	180	0.15
1.6	2.74	**4.84**	9.60	2170	242	194	0.18
1.8	2.92	**5.16**	10.2	2320	258	206	0.20
2.0	3.10	**5.48**	10.9	2460	274	219	0.22
2.5	3.51	**6.20**	12.3	2780	310	248	0.29
3.0	3.88	**6.86**	13.6	3080	343	274	0.35
3.5	4.23	**7.48**	14.8	3360	374	299	0.42
4.0	4.55	**8.05**	16.0	3610	403	322	0.48
4.5	4.86	**8.59**	17.0	3860	430	344	0.55
5.0	5.15	**9.10**	18.0	4080	455	364	0.62
6.0	5.70	**10.1**	20.0	4540	505	404	0.76
7.0	6.21	**11.0**	21.8	4940	550	440	0.90
8.0	6.69	**11.8**	23.4	5300	590	472	1.0
9.0	7.14	**12.6**	25.0	5660	630	504	1.2
10.0	7.57	**13.4**	26.6	6020	670	536	1.3
12.0	8.37	**14.8**	29.3	6650	740	592	1.6
14.0	9.12	**16.1**	31.9	7230	805	644	1.9
18.0	9.82	**17.3**	34.3	7770	865	692	2.2
18.0	10.5	**18.5**	36.7	8310	925	740	2.6
20.0	11.1	**19.6**	38.9	8800	980	784	2.9
22.0	11.7	**20.7**	41.0	9300	1035	828	3.2
24.0	12.3	**21.7**	43.0	9750	1085	868	3.5
28.0	12.9	**22.8**	45.2	10200	1140	912	3.9
28.0	13.4	**23.7**	47.0	10600	1185	948	4.2
30.0	13.9	**24.5**	48.6	11000	1225	980	4.5

20" Untreated Power Plant Line

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 20 Inches

(1 ft. 8 in.)

Table No. 19 (Continued) **Area 2.182 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.629	**1.37**	2.72	615	68.5	54.8	0.01
0.2	0.924	**2.02**	4.01	907	101	80.8	0.02
0.3	1.16	**2.53**	5.02	1140	127	101	0.03
0.4	1.36	**2.97**	5.89	1330	149	119	0.04
0.5	1.54	**3.36**	6.66	1510	168	134	0.06
0.6	1.70	**3.71**	7.36	1670	186	148	0.07
0.7	1.85	**4.04**	8.01	1820	202	162	0.08
0.8	2.00	**4.37**	8.67	1960	219	175	0.09
0.9	2.13	**4.65**	9.22	2090	233	186	0.11
1.0	2.26	**4.94**	9.80	2220	247	198	0.12
1.2	2.50	**5.46**	10.8	2450	273	218	0.15
1.4	2.72	**5.94**	11.8	2670	297	238	0.17
1.6	2.93	**6.40**	12.7	2870	320	256	0.20
1.8	3.13	**6.84**	13.6	3070	342	274	0.23
2.0	3.32	**7.25**	14.4	3260	363	290	0.26
2.5	3.76	**8.22**	16.3	3690	411	329	0.33
3.0	4.16	**9.09**	18.0	4080	455	364	0.40
3.5	4.53	**9.90**	19.6	4450	495	396	0.48
4.0	4.87	**10.6**	21.0	4760	530	424	0.55
4.5	5.20	**11.3**	22.4	5080	565	452	0.63
5.0	5.52	**12.1**	24.0	5430	605	484	0.71
6.0	6.10	**13.3**	26.4	5970	665	532	0.87
7.0	6.65	**14.5**	28.8	6520	725	580	1.0
8.0	7.16	**15.6**	30.9	7000	780	624	1.2
9.0	7.65	**16.7**	33.1	7500	835	668	1.4
10.0	8.11	**17.7**	35.1	7950	885	708	1.5
12.0	8.97	**19.6**	38.9	8800	980	784	1.9
14.0	9.77	**21.3**	42.2	9570	1065	852	2.2
16.0	10.5	**22.9**	45.4	10300	1145	916	2.6
18.0	11.2	**24.5**	48.6	11000	1225	980	2.9
20.0	11.9	**26.0**	51.6	11700	1300	1040	3.3
22.0	12.6	**27.5**	54.6	12300	1375	1100	3.7
24.0	13.2	**28.8**	57.1	12900	1440	1150	4.1
26.0	13.8	**30.1**	59.7	13500	1505	1205	4.5
28.0	14.4	**31.4**	62.2	14100	1570	1255	4.8
30.0	14.9	**32.5**	64.4	14600	1625	1300	5.2

Building 22" Creosoted Irrigation Siphon

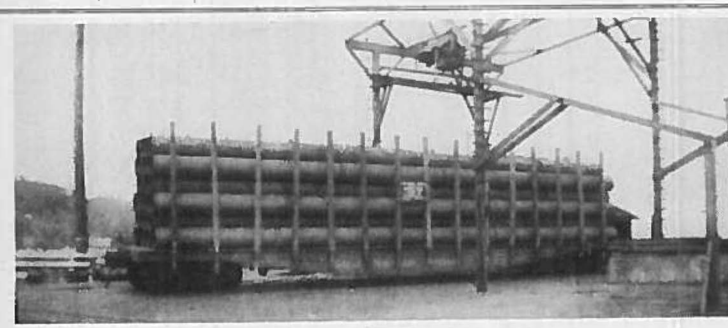
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 22 Inches

(1 ft. 10 in.)

Table No. 19 (Continued) **Area 2.640 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.669	**1.76**	3.49	790	88.0	70.4	0.01
0.2	0.983	**2.60**	5.16	1170	130	104	0.02
0.3	1.23	**3.25**	6.44	1460	163	130	0.04
0.4	1.45	**3.83**	7.60	1720	192	153	0.05
0.5	1.64	**4.33**	8.59	1940	217	173	0.06
0.6	1.81	**4.77**	9.46	2140	239	191	0.08
0.7	1.97	**5.20**	10.3	2330	260	208	0.09
0.8	2.12	**5.59**	11.1	2510	280	227	0.11
0.9	2.27	**5.98**	11.9	2690	299	239	0.12
1.0	2.40	**6.33**	12.6	2840	317	253	0.14
1.2	2.66	**7.02**	13.9	3150	351	281	0.17
1.4	2.90	**7.66**	15.2	3440	383	306	0.20
1.6	3.12	**8.24**	16.3	3700	412	330	0.23
1.8	3.33	**8.79**	17.4	3940	440	352	0.26
2.0	3.53	**9.32**	18.5	4190	466	373	0.29
2.5	3.99	**10.5**	20.8	4720	525	420	0.37
3.0	4.42	**11.7**	23.2	5250	585	468	0.46
3.5	4.81	**12.7**	25.2	5700	635	508	0.54
4.0	5.19	**13.7**	27.2	6150	685	548	0.63
4.5	5.54	**14.6**	29.0	6550	730	584	0.72
5.0	5.87	**15.5**	30.7	6950	775	620	0.80
6.0	6.49	**17.2**	34.1	7720	860	688	0.98
7.0	7.07	**18.6**	36.9	8350	930	744	1.2
8.0	7.62	**20.1**	39.9	9030	1005	804	1.4
9.0	8.13	**21.5**	42.6	9650	1075	860	1.5
10.0	8.62	**22.8**	45.2	10200	1140	912	1.7
12.0	9.54	**25.2**	50.0	11300	1260	1010	2.1
14.0	10.4	**27.5**	54.6	12300	1375	1100	2.5
16.0	11.2	**29.6**	58.7	13300	1480	1185	2.9
18.0	12.0	**31.7**	62.9	14200	1585	1270	3.4
20.0	12.7	**33.5**	66.4	15000	1675	1340	3.8
22.0	13.4	**35.4**	70.2	15900	1770	1415	4.2
24.0	14.0	**37.0**	73.4	16600	1850	1480	4.6
26.0	14.7	**38.8**	77.0	17400	1940	1550	5.1
28.0	15.3	**40.4**	80.1	18100	2020	1615	5.5



Car of FEDERAL 18" Wire-Wound Pipe

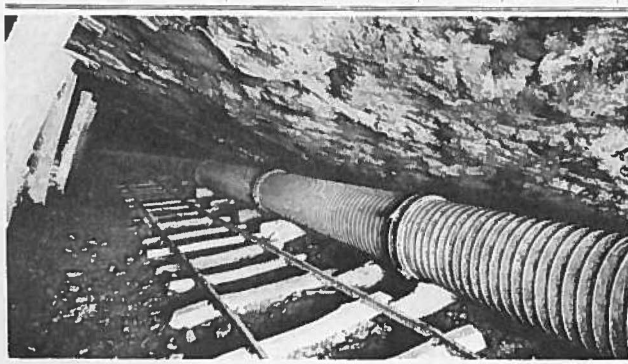
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 24 Inches

(2 ft. 0 in.)

Table No. 19 (Continued) **Area 3.142 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	0.708	2.22	4.40	996	111	88.8	0.01
0.2	1.04	3.27	6.48	1470	164	131	0.03
0.3	1.30	4.08	8.09	1830	204	163	0.04
0.4	1.53	4.81	9.54	2160	241	192	0.05
0.5	1.73	5.44	10.8	2440	272	218	0.07
0.6	1.92	6.04	12.0	2710	302	242	0.09
0.7	2.09	6.57	13.0	2950	329	263	0.10
0.8	2.25	7.07	14.0	3170	354	283	0.12
0.9	2.40	7.54	14.9	3380	377	302	0.13
1.0	2.54	7.98	15.8	3580	399	319	0.15
1.2	2.81	8.83	17.5	3970	442	353	0.18
1.4	3.06	9.61	19.0	4320	481	384	0.22
1.6	3.30	10.4	20.6	4670	520	416	0.25
1.8	3.52	11.1	22.0	4980	555	444	0.29
2.0	3.74	11.7	23.2	5250	585	468	0.33
2.5	4.23	13.3	26.4	5970	665	532	0.42
3.0	4.68	14.7	29.1	6600	735	588	0.51
3.5	5.10	16.0	31.7	7180	800	640	0.61
4.0	5.49	17.3	34.3	7760	865	692	0.70
4.5	5.86	18.4	36.5	8260	920	736	0.80
5.0	6.21	19.5	38.7	8750	975	780	0.90
6.0	6.87	21.6	42.8	9700	1080	864	1.1
7.0	7.49	23.5	46.6	10500	1175	940	1.3
8.0	8.06	25.4	50.4	11400	1270	1015	1.5
9.0	8.61	27.1	53.8	12200	1355	1085	1.7
10.0	9.12	28.7	56.9	12900	1435	1150	1.9
12.0	10.1	31.8	63.1	14300	1590	1270	2.4
14.0	11.0	34.6	68.6	15500	1730	1385	2.8
16.0	11.8	37.1	73.6	16600	1855	1485	3.2
18.0	12.6	39.6	78.6	17800	1980	1585	3.7
20.0	13.4	42.1	83.5	18900	2105	1685	4.2
22.0	14.1	44.3	87.9	19900	2215	1770	4.6
24.0	14.8	46.5	92.2	20900	2325	1860	5.1
26.0	15.5	48.7	96.6	21900	2435	1950	5.6



24" in Coal Mine

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 26 Inches

(2 ft. 2 in.)

Table No. 19 (Continued) **Area 3.687 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	0.746	2.75	5.46	1230	138	110	0.01
0.2	1.10	4.06	8.05	1820	203	162	0.03
0.3	1.37	5.05	10.0	2270	253	202	0.04
0.4	1.61	5.94	11.8	2670	297	238	0.06
0.5	1.82	6.71	13.3	3010	336	268	0.08
0.6	2.02	7.45	14.8	3340	373	298	0.10
0.7	2.20	8.11	16.1	3640	406	324	0.11
0.8	2.37	8.74	17.3	3920	437	350	0.13
0.9	2.53	9.33	18.5	4190	467	373	0.15
1.0	2.68	9.88	19.6	4430	494	395	0.17
1.2	2.96	10.9	21.6	4900	545	436	0.20
1.4	3.23	11.9	23.6	5340	595	476	0.24
1.6	3.48	12.8	25.4	5750	640	512	0.28
1.8	3.71	13.7	27.2	6150	685	548	0.32
2.0	3.94	14.5	28.8	6510	725	580	0.36
2.5	4.45	16.4	32.5	7360	820	656	0.46
3.0	4.93	18.2	36.1	8170	910	728	0.57
3.5	5.37	19.8	39.3	8890	990	792	0.67
4.0	5.78	21.3	42.2	9560	1065	852	0.78
4.5	6.17	22.8	45.2	10200	1140	912	0.89
5.0	6.54	24.1	47.8	10800	1205	964	1.0
6.0	7.24	26.7	53.0	12000	1335	1070	1.2
7.0	7.89	29.1	57.7	13100	1455	1165	1.5
8.0	8.49	31.3	62.1	14000	1565	1250	1.7
9.0	9.07	33.4	66.2	15000	1670	1335	1.9
10.0	9.61	35.4	70.2	15900	1770	1415	2.2
12.0	10.6	39.1	77.6	17600	1955	1565	2.6
14.0	11.6	42.8	84.9	19200	2140	1710	3.1
16.0	12.5	46.1	91.4	20700	2305	1845	3.7
18.0	13.3	49.0	97.2	22000	2450	1960	4.1
20.0	14.1	52.0	103	23400	2600	2080	4.6
22.0	14.9	54.9	109	24600	2745	2195	5.2
24.0	15.6	57.5	114	25800	2875	2300	5.7

54" Creosoted Pipe Cradled in the Ground

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 28 Inches

(2 ft. 4 in.)

Table No. 19 (Continued) **Area 4.276 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.783	3.35	6.64	1500	168	134	0.01
0.2	1.15	4.92	9.76	2210	246	197	0.03
0.3	1.44	6.16	12.2	2770	308	246	0.05
0.4	1.69	7.23	14.3	3250	362	289	0.07
0.5	1.91	8.17	16.2	3670	409	327	0.09
0.6	2.12	9.06	18.0	4070	453	362	0.11
0.7	2.31	9.88	19.6	4440	494	395	0.12
0.8	2.48	10.8	21.0	4760	530	424	0.14
0.9	2.65	11.3	22.4	5080	565	452	0.16
1.0	2.81	12.0	23.8	5390	600	480	0.18
1.2	3.11	13.3	26.4	5970	665	532	0.23
1.4	3.39	14.5	28.7	6510	725	580	0.27
1.6	3.65	15.6	30.9	7000	780	624	0.31
1.8	3.89	16.6	32.9	7450	830	664	0.35
2.0	4.13	17.7	35.1	7940	885	708	0.40
2.5	4.67	20.0	39.7	8980	1000	800	0.51
3.0	5.17	22.1	43.8	9920	1105	884	0.62
3.5	5.63	24.1	47.8	10800	1205	964	0.74
4.0	6.07	26.0	51.6	11700	1300	1040	0.86
4.5	6.47	27.7	54.9	12400	1385	1110	0.98
5.0	6.86	29.4	58.3	13200	1470	1175	1.1
6.0	7.60	32.5	64.4	14600	1625	1300	1.4
7.0	8.27	35.4	70.2	15900	1770	1415	1.6
8.0	8.91	38.1	75.6	17100	1905	1525	1.9
9.0	9.51	40.7	80.7	18300	2035	1630	2.1
10.0	10.1	43.2	85.7	19400	2160	1730	2.4
11.0	10.6	45.3	89.8	20300	2265	1810	2.6
12.0	11.2	47.9	95.0	21500	2395	1915	2.9
13.0	11.7	50.0	99.2	22400	2500	2000	3.2
14.0	12.2	52.2	103	23500	2610	2090	3.5
16.0	13.1	56.0	111	25200	2800	2240	4.0
18.0	14.0	59.9	119	26900	2995	2395	4.6
20.0	14.8	63.3	125	28400	3165	2530	5.1
22.0	15.6	66.7	132	30000	3335	2670	5.7

Truck Loads of 14" Pipe

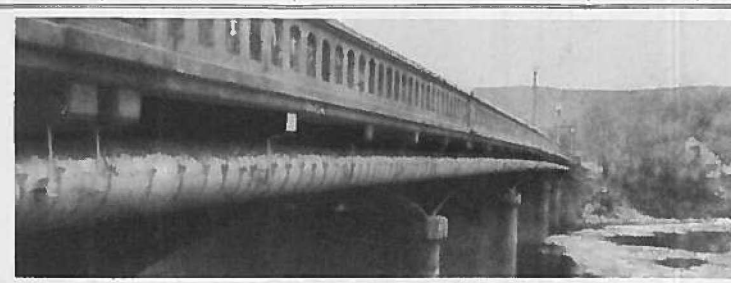
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 30 Inches

(2 ft. 6 in)

Table No. 19 (Continued) **Area 4.909 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	10=1 Sec. Ft.	
0.1	0.819	4.02	7.97	1800	201	161	0.02
0.2	1.20	5.89	11.7	2640	295	236	0.04
0.3	1.51	7.41	14.7	3330	371	296	0.06
0.4	1.77	8.70	17.3	3900	435	348	0.08
0.5	2.00	9.82	19.5	4400	491	393	0.10
0.6	2.21	10.8	21.4	4850	540	432	0.12
0.7	2.41	11.8	23.4	5300	590	472	0.14
0.8	2.60	12.8	25.4	5740	640	512	0.16
0.9	2.77	13.6	27.0	6100	680	544	0.18
1.0	2.94	14.4	28.6	6460	720	576	0.20
1.2	3.25	16.0	31.7	7180	800	640	0.25
1.4	3.54	17.4	34.5	7810	870	696	0.29
1.6	3.82	18.8	37.3	8440	940	752	0.34
1.8	4.07	20.0	39.7	8980	1000	800	0.39
2.0	4.32	21.2	42.0	9510	1060	848	0.44
2.5	4.89	24.0	47.6	10800	1200	960	0.56
3.0	5.41	26.6	52.8	11900	1330	1065	0.68
3.5	5.89	28.9	57.3	13000	1445	1155	0.81
4.0	6.34	31.1	61.7	13900	1555	1245	0.94
4.5	6.77	33.3	66.0	14900	1665	1330	1.1
5.0	7.18	35.3	70.0	15800	1765	1410	1.2
6.0	7.94	39.0	77.4	17500	1950	1560	1.5
7.0	8.65	42.4	84.1	19000	2120	1695	1.7
8.0	9.32	45.8	90.8	20600	2290	1830	2.0
9.0	9.95	48.8	96.8	21900	2440	1950	2.3
10.0	10.6	52.1	103	23400	2605	2085	2.6
11.0	11.1	54.5	108	24400	2725	2180	2.9
12.0	11.7	57.4	114	25800	2870	2295	3.2
13.0	12.2	59.9	119	26900	2995	2395	3.5
14.0	12.7	62.4	124	28000	3120	2495	3.8
16.0	13.7	67.2	133	30100	3360	2690	4.4
18.0	14.6	71.7	142	32200	3585	2870	5.0
20.0	15.5	76.1	151	34100	3805	3045	5.6



Wood Pipe Insulation for River Crossing

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 32 Inches
2 ft. 8 in.)

Table No. 19 (Continued) **Area 5.585 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.854	4.77	9.46	2140	239	191	0.02
0.2	1.26	7.04	14.0	3160	352	282	0.04
0.3	1.57	8.77	17.4	3930	439	351	0.06
0.4	1.84	10.3	20.4	4620	515	412	0.08
0.5	2.09	11.7	23.2	5250	585	468	0.10
0.6	2.31	12.9	25.6	5790	645	516	0.12
0.7	2.52	14.1	28.0	6320	705	564	0.15
0.8	2.71	15.1	29.9	6780	755	604	0.17
0.9	2.89	16.1	31.9	7220	805	644	0.20
1.0	3.07	17.1	33.9	7670	855	684	0.22
1.2	3.39	18.9	37.5	8480	945	756	0.27
1.4	3.69	20.6	40.8	9250	1030	824	0.32
1.6	3.98	22.2	44.0	9960	1110	888	0.37
1.8	4.25	23.7	47.0	10600	1185	948	0.42
2.0	4.50	25.1	49.8	11300	1255	1005	0.47
2.5	5.10	28.5	56.5	12800	1425	1140	0.61
3.0	5.64	31.5	62.5	14100	1575	1260	0.74
3.5	6.14	34.3	68.0	15400	1715	1370	0.88
4.0	6.62	37.0	73.4	16600	1850	1480	1.0
4.5	7.06	39.4	78.2	17700	1970	1575	1.2
5.0	7.49	41.8	82.9	18800	2090	1670	1.3
6.0	8.29	46.3	91.8	20800	2315	1850	1.6
7.0	9.03	50.4	100	22600	2520	2015	1.9
8.0	9.72	54.2	107	24300	2710	2170	2.2
9.0	10.4	58.1	115	26100	2905	2325	2.5
10.0	11.0	61.4	122	27600	3070	2455	2.8
11.0	11.6	64.8	128	29100	3240	2590	3.1
12.0	12.2	68.1	135	30600	3405	2725	3.5
13.0	12.7	71.0	141	31800	3550	2840	3.8
14.0	13.3	74.3	147	33300	3715	2970	4.1
16.0	14.3	79.9	158	35800	3995	3195	4.8
18.0	15,2	84.9	168	38100	4245	3395	5.4

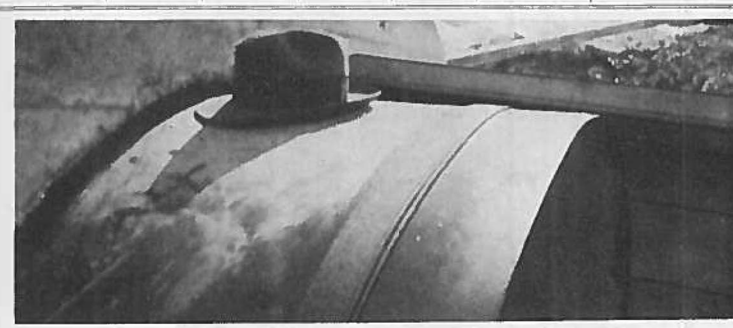
60" Wood to Steel Connection

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 34 Inches
(2 ft. 10 in.)

Table No. 19 (Continued) **Area 6.305 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.888	5.60	11.1	2510	280	224	0.02
0.2	1.31	8.26	16.4	3710	413	330	0.04
0.3	1.63	10.3	20.4	4620	515	412	0.06
0.4	1.92	12.1	24.0	5430	605	484	0.09
0.5	2.17	13.7	27.2	6150	685	548	0.11
0.6	2.40	15.1	29.9	6770	755	604	0.14
0.7	2.62	16.5	32.7	7400	825	660	0.16
0.8	2.82	17.8	35.3	7990	890	712	0.19
0.9	3.01	19.0	37.7	8530	950	760	0.21
1.0	3.19	20.1	39.9	9020	1005	804	0.24
1.2	3.53	22.3	44.2	10000	1115	892	0.29
1.4	3.84	24.2	48.0	10800	1210	968	0.34
1.6	4.14	26.1	51.8	11700	1305	1045	0.40
1.8	4.42	27.9	55.3	12500	1395	1115	0.46
2.0	4.68	29.5	58.5	13200	1475	1180	0.51
2.5	5.30	33.4	66.2	15000	1670	1335	0.66
3.0	5.87	37.0	73.4	16600	1850	1480	0.80
3.5	6.39	40.3	80.0	18100	2015	1610	0.95
4.0	6.88	43.4	86.1	19500	2170	1735	1.1
4.5	7.35	46.3	91.8	20800	2315	1850	1.3
5.0	7.79	49.1	97.4	22000	2455	1965	1.4
6.0	8.62	54.4	108	24400	2720	2175	1.7
7.0	9.39	59.2	117	26600	2960	2370	2.1
8.0	10.1	63.7	126	28600	3185	2550	2.4
9.0	10.8	68.1	135	30600	3405	2725	2.7
10.0	11.4	71.9	143	32200	3595	2875	3.0
11.0	12.1	76.3	151	34200	3815	3050	3.4
12.0	12.7	80.1	159	36000	4005	3205	3.8
13.0	13.2	83.2	165	37300	4160	3330	4.1
14.0	13.8	87.0	172	39000	4350	3480	4.5
16.0	14,9	94.0	186	42200	4700	3760	5.2
18.0	15.9	100	198	44900	5000	4000	5.9



Close-up of Wood to Steel Connection, Showing Rope Gasket

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 36 Inches

(3 ft. 0 in.)

Table No. 19 (Continued) **Area 7.069 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity In Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.922	**6.52**	12.9	2930	326	261	0.02
0.2	1.35	**9.55**	18.9	4280	478	382	0.04
0.3	1.70	**12.0**	23.8	5390	600	480	0.07
0.4	1.99	**14.1**	28.0	6320	705	564	0.09
0.5	2.25	**15.9**	31.5	7130	795	636	0.12
0.6	2.49	**17.6**	34.9	7900	880	704	0.15
0.7	2.71	**19.2**	38.1	8620	960	768	0.17
0.8	2.92	**20.6**	40.8	9250	1030	824	0.20
0.9	3.12	**22.0**	43.6	9870	1100	880	0.23
1.0	3.31	**23.4**	46.4	10500	1170	936	0.26
1.2	3.66	**25.9**	51.4	11600	1295	1035	0.31
1.4	3.99	**28.2**	55.9	12600	1410	1130	0.37
1.6	4.30	**30.4**	60.3	13600	1520	1215	0.43
1.8	4.59	**32.4**	64.3	14500	1620	1295	0.49
2.0	4.86	**34.4**	68.2	15400	1720	1375	0.55
2.5	5.50	**38.9**	77.2	17400	1945	1555	0.70
3.0	6.09	**43.0**	85.3	19300	2150	1720	0.86
3.5	6.63	**46.8**	92.8	21000	2340	1870	1.0
4.0	7.14	**50.4**	100	22600	2520	2015	1.2
4.5	7.62	**53.9**	107	24200	2695	2155	1.4
5.0	8.08	**57.2**	113	25700	2860	2290	1.5
6.0	8.94	**63.2**	125	28400	3160	2530	1.9
7.0	9.74	**68.8**	136	30900	3440	2750	2.2
8.0	10.5	**74.2**	147	33300	3710	2970	2.6
9.0	11.2	**79.2**	157	35500	3960	3170	2.9
10.0	11.9	**84.1**	167	37800	4205	3365	3.3
11.0	12.5	**88.4**	175	39700	4420	3535	3.6
12.0	13.1	**92.6**	184	41600	4630	3705	4.0
13.0	13.7	**96.9**	192	43500	4845	3875	4.4
14.0	14.3	**101**	200	45300	5050	4040	4.8
16.0	15.4	**109**	216	48900	5450	4360	5.5

54" River Crossing

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 38 Inches

(3 ft. 2 in.)

Table No. 19 (Continued) **Area 7.876 Sq. Ft.**

Head in Feet Reqnired for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	0.955	**7.52**	14.9	3370	376	301	0.02
0.2	1.40	**11.0**	21.8	4940	550	440	0.05
0.3	1.76	**13.8**	27.4	6190	690	552	0.07
0.4	2.06	**16.2**	32.1	7270	810	648	0.10
0.5	2.33	**18.4**	36.5	8260	920	736	0.13
0.6	2.58	**20.3**	40.2	9110	1015	812	0.16
0.7	2.81	**22.1**	43.8	9920	1105	884	0.18
0.8	3.03	**23.8**	47.2	10700	1190	952	0.21
0.9	3.23	**25.4**	50.4	11400	1270	1015	0.24
1.0	3.43	**27.0**	53.5	12100	1350	1080	0.27
1.2	3.79	**29.9**	59.3	13400	1495	1195	0.33
1.4	4.13	**32.5**	64.4	14600	1625	1300	0.40
1.6	4.45	**35.0**	69.4	15700	1750	1400	0.46
1.8	4.75	**37.4**	74.2	16800	1870	1495	0.53
2.0	5.04	**39.7**	78.7	17800	1985	1590	0.59
2.5	5.70	**44.9**	89.0	20100	2245	1795	0.76
3.0	6.31	**49.7**	98.6	22300	2485	1990	0.93
3.5	6.87	**54.2**	107	24300	2710	2170	1.1
4.0	7.40	**58.3**	116	26200	2915	2330	1.3
4.5	7.90	**62.2**	123	27900	3110	2490	1.5
5.0	8.37	**65.9**	131	29600	3295	2635	1.6
6.0	9.26	**73.0**	145	32800	3650	2920	2.0
7.0	10.1	**79.5**	158	35700	3975	3180	2.4
8.0	10.9	**85.9**	170	38600	4295	3435	2.8
9.0	11.6	**91.4**	181	41000	4570	3655	3.1
10.0	12.3	**96.9**	192	43500	4845	3875	3.5
11.0	13.0	**102**	202	45700	5100	4080	3.9
12.0	13.6	**107**	212	48000	5350	4280	4.3
13.0	14.2	**112**	222	50200	5600	4480	4.7
14.0	14.8	**117**	232	52500	5850	4680	5.1
16.0	16.0	**126**	250	56500	6300	5040	6.0

Preparing to install 18" Wire-Wound Pipe

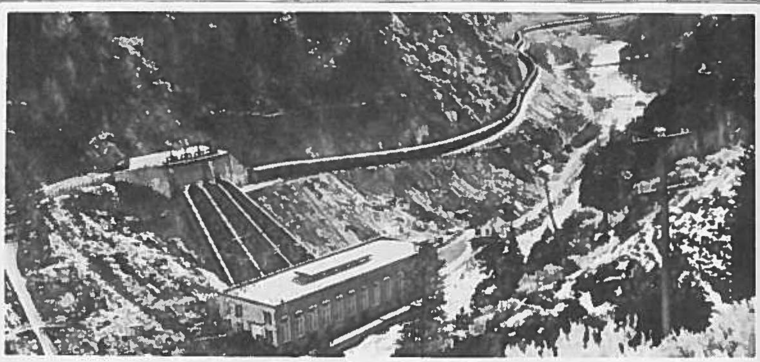
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 40 Inches

(3 ft. 4 in.)

Table No. 19 (Continued) **Area 8.727 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	0.987	**8.62**	17.1	3870	431	345	0.02
0.2	1.45	**12.6**	25.0	5650	630	504	0.05
0.3	1.82	**15.9**	31.5	7140	795	636	0.08
0.4	2.13	**18.6**	36.9	8350	930	744	0.11
0.5	2.41	**21.1**	41.8	9460	1055	844	0.14
0.6	2.67	**23.3**	46.2	10400	1165	932	0.17
0.7	2.91	**25.4**	50.4	11400	1270	1015	0.20
0.8	3.13	**27.3**	54.2	12300	1365	1090	0.23
0.9	3.34	**29.2**	57.9	13100	1460	1170	0.26
1.0	3.54	**30.9**	61.3	13900	1545	1235	0.29
1.2	3.92	**34.2**	67.8	15300	1710	1370	0.36
1.4	4.27	**37.3**	74.0	16700	1865	1490	0.43
1.6	4.60	**40.2**	79.7	18000	2010	1610	0.49
1.8	4.91	**42.8**	84.9	19200	2140	1710	0.56
2.0	5.21	**45.5**	90.2	20400	2275	1820	0.63
2.5	5.89	**51.4**	102	23100	2570	2055	0.81
3.0	6.52	**56.9**	113	25500	2845	2275	0.99
3.5	7.10	**62.0**	123	27800	3200	2480	1.2
4.0	7.65	**66.8**	132	30000	3340	2670	1.4
4.5	8.16	**71.2**	141	32000	3560	2850	1.6
5.0	8.66	**75.6**	150	33900	3780	3025	1.8
6.0	9.58	**83.7**	166	37600	4185	3350	2.1
7.0	10.4	**90.8**	180	40700	4540	3630	2.5
8.0	11.2	**97.8**	194	43900	4890	3910	2.9
9.0	12.0	**105**	208	47100	5250	4200	3.3
10.0	12.7	**111**	220	49800	5550	4440	3.8
11.0	13.4	**117**	232	52500	5850	4680	4.2
12.0	14.1	**123**	244	55200	6150	4920	4.6
13.0	14.7	**128**	254	57400	6400	5120	5.0
14.0	15.3	**134**	266	60100	6700	5360	5.5



13-Foot Power Plant Line

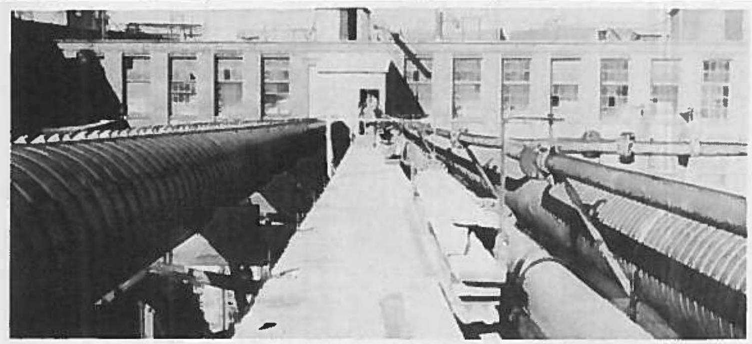
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 42 Inches

(3 ft. 6 in.)

Table No. 19 (Continued) **Area 9.621 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	1.02	**9.82**	19.5	4410	491	393	0.03
0.2	1.50	**14.4**	28.5	6460	720	576	0.05
0.3	1.88	**18.1**	35.9	8120	905	724	0.08
0.4	2.20	**21.2**	42.0	9500	1060	848	0.11
0.5	2.49	**23.9**	47.4	10700	1195	956	0.14
0.6	2.75	**26.4**	52.4	11800	1320	1055	0.18
0.7	3.00	**28.9**	57.3	13000	1445	1155	0.21
0.8	3.23	**31.1**	61.7	14000	1550	1245	0.24
0.9	3.45	**33.2**	65.8	14900	1660	1330	0.28
1.0	3.66	**35.2**	69.8	15800	1760	1410	0.31
1.2	4.05	**39.0**	77.4	17500	1950	1560	0.38
1.4	4.41	**42.4**	84.1	19000	2120	1695	0.45
1.6	4.75	**45.7**	90.6	20500	2285	1830	0.53
1.8	5.07	**48.8**	96.8	21900	2440	1950	0.60
2.0	5.37	**51.7**	102	23200	2585	2070	0.67
2.5	6.08	**58.5**	116	26300	2925	2340	0.86
3.0	6.73	**64.8**	128	29100	3240	2590	1.1
3.5	7.33	**70.5**	140	31700	3525	2820	1.3
4.0	7.89	**75.9**	150	34000	3795	3035	1.5
4.5	8.43	**81.2**	161	36500	4060	3250	1.7
5.0	8.94	**86.0**	170	38600	4300	3440	1.9
6.0	9.89	**95.2**	189	42700	4760	3810	2.3
7.0	10.8	**104**	206	46600	5200	4160	2.7
8.0	11.6	**111**	220	49800	5550	4440	3.1
9.0	12.4	**119**	236	53400	5950	4760	3.6
10.0	13.1	**126**	250	56500	6300	5040	4.0
11.0	13.8	**133**	264	59700	6650	5320	4.4
12.0	14.5	**140**	278	62800	7000	5600	4.9
13.0	15.2	**146**	290	65500	7300	5840	5.4



Paper Company Supply Lines

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 44 Inches
(3 ft. 8 in.)

Table No. 19 (Continued) **Area 10.559 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	1.05	**11.1**	22.0	4980	555	444	0.03
0.2	1.54	**16.3**	32.3	7320	815	652	0.06
0.3	1.93	**20.4**	40.5	9150	1020	816	0.09
0.4	2.27	**24.0**	47.6	10800	1200	960	0.12
0.5	2.57	**27.2**	54.0	12200	1360	1090	0.15
0.6	2.84	**30.0**	59.5	13500	1500	1200	0.19
0.7	3.09	**32.6**	64.7	14600	1630	1305	0.22
0.8	3.33	**35.2**	69.8	15800	1760	1410	0.26
0.9	3.56	**37.6**	74.6	16900	1880	1505	0.30
1.0	3.77	**39.8**	79.0	17800	1990	1590	0.33
1.2	4.17	**44.0**	87.3	19700	2200	1760	0.41
1.4	4.54	**48.0**	95.2	21600	2400	1920	0.48
1.6	4.89	**51.7**	102	23200	2585	2070	0.56
1.8	5.22	**55.2**	109	24800	2760	2210	0.64
2.0	5.54	**58.5**	116	26200	2925	2340	0.72
2.5	6.27	**66.2**	131	29700	3310	2650	0.92
3.0	6.94	**73.3**	145	32900	3665	2930	1.1
3.5	7.56	**79.9**	158	35800	3995	3195	1.3
4.0	8.14	**86.0**	170	38600	4300	3440	1.5
4.5	8.69	**91.8**	182	41200	4590	3670	1.8
5.0	9.21	**97.3**	193	43700	4865	3890	2.0
6.0	10.2	**108**	214	48500	5400	4320	2.4
7.0	11.1	**117**	232	52500	5850	4680	2.9
8.0	12.0	**127**	252	57000	6350	5080	3.4
9.0	12.8	**135**	268	60600	6750	5400	3.8
10.0	13.5	**143**	283	64200	7150	5720	4.3
11.0	14.3	**151**	299	67700	7550	6040	4.8
12.0	15.0	**158**	313	71000	7900	6320	5.3

36" Creosoted Mining Line

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 46 Inches
(3 ft. 10 in.)

Table No. 19 (Continued) **Area 11.541 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	1.08	**12.5**	24.8	5610	625	500	0.03
0.2	1.59	**18.4**	36.5	8250	920	736	0.06
0.3	1.99	**23.0**	45.6	10300	1150	920	0.09
0.4	2.33	**26.9**	53.4	12100	1345	1075	0.13
0.5	2.64	**30.5**	60.5	13700	1525	1220	0.16
0.6	2.92	**33.7**	66.8	15100	1685	1350	0.20
0.7	3.18	**36.7**	72.8	16500	1835	1470	0.24
0.8	3.43	**39.6**	78.6	17800	1980	1585	0.27
0.9	3.66	**42.3**	83.9	19000	2115	1690	0.31
1.0	3.88	**44.8**	88.9	20100	2240	1790	0.35
1.2	4.29	**49.6**	98.4	22300	2480	1985	0.43
1.4	4.68	**54.1**	107	24300	2705	2165	0.51
1.6	5.04	**58.2**	115	26100	2910	2330	0.59
1.8	5.38	**62.2**	123	27900	3110	2490	0.67
2.0	5.70	**65.8**	130	29600	3290	2630	0.76
2.5	6.45	**74.5**	148	33500	3725	2980	0.97
3.0	7.14	**82.5**	163	37000	4125	3300	1.2
3.5	7.78	**89.8**	178	40300	4490	3590	1.4
4.0	8.38	**96.9**	192	43500	4845	3880	1.6
4.5	8.94	**103**	204	46200	5150	4120	1.9
5.0	9.48	**109**	216	48900	5450	4360	2.1
6.0	10.5	**121**	240	54400	6050	4840	2.6
7.0	11.4	**132**	262	59200	6600	5280	3.0
8.0	12.3	**142**	281	63800	7100	5680	3.5
9.0	13.1	**151**	299	67800	7550	6040	4.0
10.0	13.9	**161**	319	72200	8050	6440	4.5
11.0	14.7	**170**	337	76300	8500	6800	5.0
12.0	15.4	**178**	353	80000	8900	7120	5.5

12" Wire-Wound, Ready for Laying

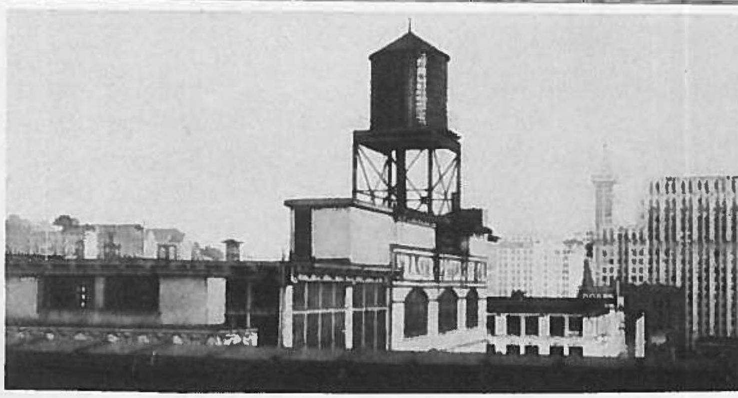
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 48 Inches

(4 ft. 0 in.)

Table No. 19 (Continued) **Area 12.566 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	1.11	**13.9**	27.6	6240	695	556	0.03
0.2	1.63	**20.5**	40.6	9210	1025	820	0.06
0.3	2.05	**25.8**	51.2	11600	1290	1030	0.10
0.4	2.40	**30.1**	59.7	13500	1505	1205	0.14
0.5	2.72	**34.2**	67.8	15400	1710	1370	0.17
0.6	3.00	**37.7**	74.8	16900	1885	1510	0.21
0.7	3.27	**41.1**	81.5	18500	2055	1645	0.25
0.8	3.52	**44.2**	87.7	19800	2210	1770	0.29
0.9	3.76	**47.3**	93.8	21200	2365	1890	0.33
1.0	3.99	**50.2**	99.6	22500	2510	2010	0.37
1.2	4.41	**55.4**	110	24900	2770	2215	0.45
1.4	4.81	**60.5**	120	27200	3025	2420	0.54
1.6	5.18	**65.1**	129	29200	3255	2605	0.63
1.8	5.53	**69.5**	138	31200	3475	2780	0.71
2.0	5.86	**73.7**	146	33100	3685	2950	0.80
2.5	6.63	**83.3**	165	37400	4165	3330	1.0
3.0	7.34	**92.3**	183	41400	4615	3690	1.3
3.5	8.00	**101**	200	45300	5050	4040	1.5
4.0	8.61	**108**	214	48500	5400	4320	1.7
4.5	9.19	**115**	228	51600	5750	4600	2.0
5.0	9.75	**123**	244	55200	6150	4920	2.2
6.0	10.8	**136**	270	61100	6800	5440	2.7
7.0	11.8	**148**	293	66400	7400	5920	3.2
8.0	12.7	**160**	317	71800	8000	6400	3.8
9.0	13.5	**170**	337	76300	8500	6800	4.3
10.0	14.3	**180**	357	80800	9000	7200	4.8
11.0	15.1	**190**	377	85300	9500	7600	5.3



FEDERAL Underwriters Fire Protection Tank

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 50 Inches

(4 ft. 2 in.)

Table No. 19 (Continued) **Area 13.635 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	1.14	**15.5**	30.7	6960	775	620	0.03
0.2	1.68	**22.9**	45.4	10300	1145	916	0.07
0.3	2.10	**28.7**	56.9	12900	1435	1148	0.10
0.4	2.46	**33.6**	66.6	15100	1680	1344	0.14
0.5	2.79	**38.1**	75.6	17100	1905	1524	0.18
0.6	3.09	**42.2**	83.7	18900	2110	1688	0.22
0.7	3.36	**45.8**	90.8	20600	2290	1832	0.26
0.8	3.62	**49.4**	98.0	22200	2470	1976	0.31
0.9	3.86	**52.7**	104	23600	2635	2108	0.35
1.0	4.10	**56.0**	111	25100	2800	2240	0.39
1.2	4.53	**61.9**	123	27800	3095	2476	0.48
1.4	4.94	**67.4**	134	30200	3370	2696	0.57
1.6	5.32	**72.6**	144	32600	3630	2904	0.66
1.8	5.68	**77.5**	154	34800	3875	3100	0.75
2.0	6.02	**82.1**	163	36900	4105	3284	0.84
2.5	6.81	**93.0**	184	41700	4650	3720	1.1
3.0	7.54	**103**	204	46200	5150	4120	1.3
3.5	8.21	**112**	222	50300	5600	4480	1.6
4.0	8.84	**121**	240	54300	6050	4840	1.8
4.5	9.44	**129**	256	57900	6450	5160	2.1
5.0	10.0	**136**	270	61000	6800	5440	2.3
6.0	11.1	**151**	299	67800	7550	6040	2.9
7.0	12.1	**165**	327	74000	8250	6600	3.4
8.0	13.0	**177**	351	79500	8850	7080	3.9
9.0	13.9	**190**	377	85300	9500	7600	4.5
10.0	14.7	**201**	398	90200	10050	8040	5.0
11.0	15.5	**211**	418	94700	10550	8440	5.6

48" Flume to 48" Pipe, with Reducer to 42" Pipe

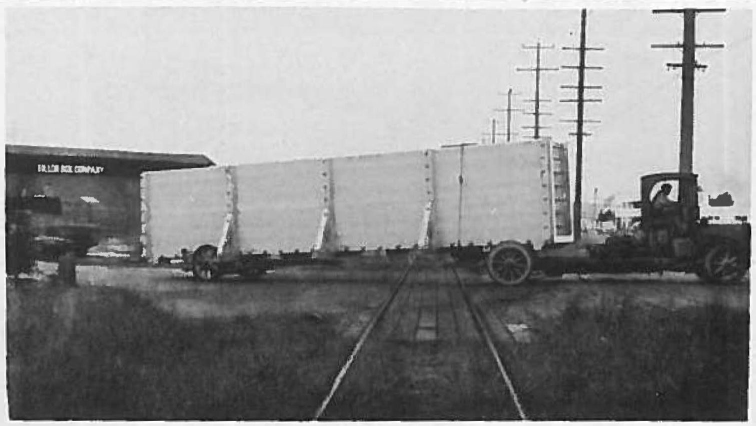
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 52 Inches

(4 ft. 4 in.)

Table No. 19 (Continued) **Area 14.748 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	1.17	17.2	34.1	7720	860	688	0.03
0.2	1.72	25.3	50.2	11400	1265	1012	0.07
0.3	2.15	31.7	62.9	14200	1585	1270	0.11
0.4	2.53	37.3	74.0	16700	1865	1490	0.15
0.5	2.86	42.2	83.7	18900	2110	1690	0.19
0.6	3.16	46.6	92.4	20900	2330	1865	0.23
0.7	3.45	50.9	101	22800	2545	2035	0.28
0.8	3.71	54.7	108	24600	2735	2190	0.32
0.9	3.96	58.4	116	26200	2920	2335	0.36
1.0	4.20	62.0	123	27800	3100	2480	0.41
1.2	4.65	68.6	136	30800	3430	2745	0.50
1.4	5.06	74.6	148	33500	3730	2985	0.60
1.6	5.45	80.5	160	36100	4025	3220	0.69
1.8	5.82	85.8	170	38500	4290	3430	0.79
2.0	6.17	91.0	180	40800	4550	3640	0.89
2.5	6.99	103	204	46200	5150	4120	1.1
3.0	7.73	114	226	51200	5700	4560	1.4
3.5	8.42	124	246	55600	6200	4960	1.7
4.0	9.07	134	266	60100	6700	5360	1.9
4.5	9.68	143	284	64200	7150	5720	2.2
5.0	10.3	152	301	68200	7600	6080	2.5
6.0	11.4	168	333	75400	8400	6720	3.0
7.0	12.4	183	363	82100	9150	7320	3.6
8.0	13.3	196	389	88000	9800	7840	4.1
9.0	14.2	209	414	93900	10450	8360	4.7
10.0	15.1	223	442	100000	11150	8920	5.3



Large Rectangular Tank

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 54 Inches

(4 ft. 6 in.)

Table No. 19 (Continued) **Area 15.904 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches		
					50=1 Sec. Ft.	40=1 Sec. Ft.	
0.1	1.20	19.1	37.9	8570	955	764	0.03
0.2	1.76	28.0	55.6	12600	1400	1120	0.07
0.3	2.21	35.2	69.8	15800	1760	1410	0.11
0.4	2.59	41.3	81.9	18500	2065	1650	0.16
0.5	2.93	46.6	92.4	20900	2330	1865	0.20
0.6	3.24	51.6	102	23200	2580	2065	0.24
0.7	3.53	56.2	111	25200	2810	2250	0.29
0.8	3.81	60.6	120	27200	3030	2425	0.34
0.9	4.06	64.6	128	29000	3230	2585	0.38
1.0	4.31	68.6	136	30800	3430	2745	0.43
1.2	4.77	75.9	150	34100	3795	3035	0.53
1.4	5.19	82.6	164	37100	4130	3305	0.63
1.6	5.59	89.0	176	39900	4450	3560	0.73
1.8	5.97	95.0	188	42600	4750	3800	0.83
2.0	6.33	101	200	45300	5050	4040	0.93
2.5	7.16	114	226	51200	5700	4560	1.2
3.0	7.92	126	250	56600	6300	5040	1.5
3.5	8.63	137	272	61500	6850	5480	1.7
4.0	9.30	148	293	66400	7400	5920	2.0
4.5	9.92	158	313	70900	7900	6320	2.3
5.0	10.5	167	331	75000	8350	6680	2.6
6.0	11.6	185	367	83000	9250	7400	3.1
7.0	12.7	202	401	90600	10100	8080	3.7
8.0	13.7	218	432	97900	10900	8720	4.4
9.0	14.6	232	460	104000	11600	9280	5.0
10.0	15.5	247	490	111000	12350	9880	5.6

Truck Tank

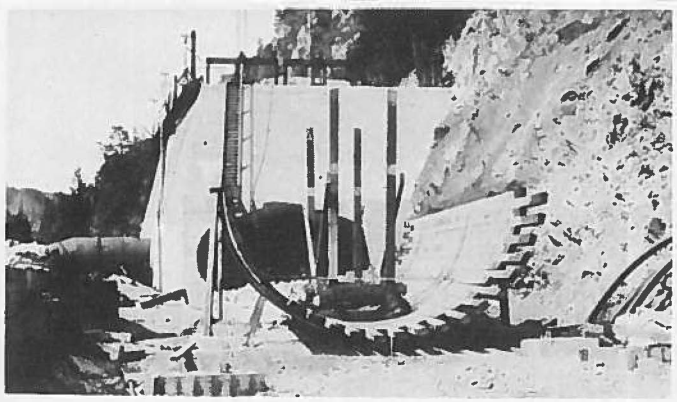
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 56 Inches

(4 ft. 8 in.)

Table No. 19 (Continued) **Area 17.104 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	1.23	21.0	41.6	9430	1050	840	0.04
0.2	1.81	31.0	61.5	13900	1550	1240	0.08
0.3	2.26	38.7	76.8	17400	1935	1550	0.12
0.4	2.65	45.4	90.0	20400	2270	1815	0.16
0.5	3.00	51.3	102	23000	2565	2050	0.21
0.6	3.32	56.8	113	25500	2840	2270	0.26
0.7	3.62	62.0	123	27800	3100	2480	0.30
0.8	3.90	66.8	132	30000	3340	2670	0.35
0.9	4.16	71.2	141	32000	3560	2850	0.40
1.0	4.41	75.5	150	33900	3775	3020	0.45
1.2	4.88	83.7	166	37600	4185	3350	0.55
1.4	5.32	91.1	181	40900	4555	3645	0.66
1.6	5.72	98.0	194	44000	4900	3920	0.76
1.8	6.11	104	206	46700	5200	4160	0.87
2.0	6.48	111	220	49800	5550	4440	0.98
2.5	7.33	125	248	56100	6250	5000	1.3
3.0	8.11	139	276	62400	6950	5560	1.5
3.5	8.84	151	300	67800	7550	6040	1.8
4.0	9.52	163	323	73200	8150	6520	2.1
4.5	10.2	174	345	78100	8700	6960	2.4
5.0	10.8	185	367	83000	9250	7400	2.7
6.0	11.9	204	405	91600	10200	8160	3.3
7.0	13.0	222	440	99600	11100	8880	3.9
8.0	14.0	240	476	108000	12000	9600	4.6
9.0	14.9	255	506	114000	12750	10200	5.2
10.0	15.8	270	536	121000	13500	10800	5.8



Starting Erection of 13-foot Pipe

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 58 Inches

(4 ft. 10 in.)

Table No. 19 (Continued) **Area 18.348 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	1.26	23.1	45.8	10400	1155	924	0.04
0.2	1.85	33.9	67.2	15200	1695	1355	0.08
0.3	2.31	42.3	83.9	19000	2115	1690	0.13
0.4	2.71	49.7	98.6	22300	2485	1990	0.17
0.5	3.07	56.3	112	25300	2815	2250	0.22
0.6	3.40	62.4	124	28000	3120	2495	0.27
0.7	3.70	67.9	135	30500	3395	2715	0.32
0.8	3.99	73.2	145	32900	3660	2930	0.37
0.9	4.26	78.2	155	35100	3910	3130	0.43
1.0	4.51	82.7	164	37100	4135	3310	0.47
1.2	4.99	91.6	182	41200	4580	3665	0.58
1.4	5.44	99.8	198	44800	4990	3990	0.69
1.6	5.86	108	214	48500	5400	4320	0.80
1.8	6.25	115	228	51600	5750	4600	0.91
2.0	6.63	122	242	54800	6100	4880	1.0
2.5	7.50	138	274	62000	6900	5520	1.3
3.0	8.30	152	301	68200	7600	6080	1.6
3.5	9.04	166	329	70000	8300	6640	1.9
4.0	9.74	179	355	80400	8950	7160	2.2
4.5	10.4	191	379	85800	9550	7640	2.5
5.0	11.0	202	401	90700	10100	8080	2.8
6.0	12.2	224	444	101000	11200	8960	3.5
7.0	13.3	244	484	110000	12200	9760	4.1
8.0	14.3	262	520	118000	13100	10480	4.8
9.0	15.3	281	558	126000	14050	11240	5.5

20" Untreated Continuous Stave Pipe

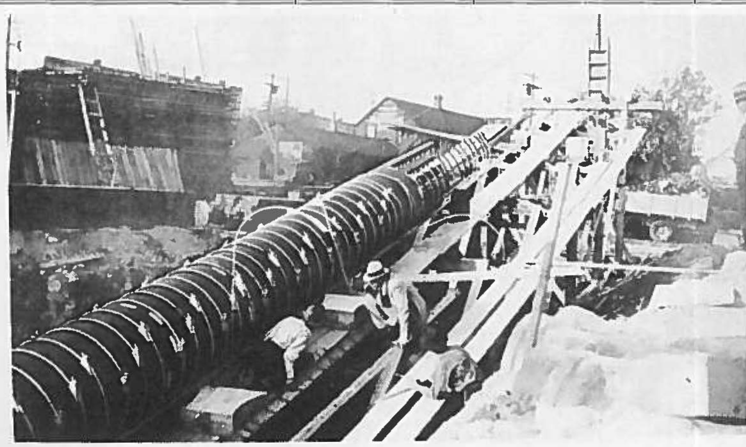
FLOW OF WATER IN WOOD STAVE PIPE

Diameter 60 Inches

(5 ft. 0 in.)

Table No. 19 (Continued) **Area 19.635 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	DISCHARGE					Velocity and Entrance Head in Feet
		Cubic Feet per Second	Acre Feet per 24 Hours	Gallons per Minute	Miners' Inches 50=1 Sec. Ft.	Miners' Inches 40=1 Sec. Ft.	
0.1	1.29	25.3	50.2	11400	1265	1010	0.04
0.2	1.89	37.1	73.6	16700	1855	1485	0.08
0.3	2.36	46.4	92.0	20800	2320	1855	0.13
0.4	2.77	54.4	108	24400	2720	2175	0.18
0.5	3.14	61.7	122	27700	3085	2470	0.23
0.6	3.47	68.2	135	30600	3410	2730	0.28
0.7	3.78	74.3	147	33400	3715	2970	0.33
0.8	4.07	80.0	159	35900	4000	3200	0.39
0.9	4.35	85.5	170	38400	4275	3420	0.44
1.0	4.61	90.6	180	40700	4530	3625	0.50
1.2	5.10	100	198	44900	5000	4000	0.61
1.4	5.56	109	216	49000	5450	4360	0.72
1.6	5.99	118	234	53000	5900	4720	0.84
1.8	6.39	126	250	56600	6300	5040	0.95
2.0	6.78	133	264	59700	6650	5320	1.1
2.5	7.67	151	299	67800	7550	6040	1.4
3.0	8.49	167	331	75000	8350	6680	1.7
3.5	9.24	182	361	81700	9100	7280	2.0
4.0	9.95	195	387	87500	9750	7800	2.3
4.5	10.6	208	413	93500	10400	8320	2.6
5.0	11.3	222	440	99700	11100	8880	3.0
6.0	12.5	246	488	110000	12300	9840	3.6
7.0	13.6	267	530	120000	13350	10680	4.3
8.0	14.6	287	569	129000	14350	11480	5.0
9.0	15.6	306	607	137000	15300	12240	5.7



Launchway for Twin Lines 36" Under-water Installation

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 66 Inches

(5 ft. 6 in.)

Table No. 19 (Continued) **Area 23.76 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.37	32.6	0.04	1.6	6.37	151	0.95
0.2	2.01	47.8	0.09	1.8	6.80	162	1.1
0.3	2.52	59.9	0.15	2.0	7.21	171	1.2
0.4	2.95	70.1	0.20	2.5	8.16	194	1.6
0.5	3.34	79.4	0.26	3.0	9.03	215	1.9
0.6	3.70	88.0	0.32	3.5	9.83	234	2.3
0.7	4.03	95.8	0.38	4.0	10.6	252	2.6
0.8	4.34	103	0.44	4.5	11.3	268	3.0
0.9	4.63	110	0.50	5.0	12.0	285	3.3
1.0	4.91	117	0.56	6.0	13.3	316	4.1
1.2	5.43	129	0.69	7.0	14.5	344	4.9
1.4	5.91	140	0.82	8.0	15.6	371	5.7

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 72 Inches

(6 ft. 0 in.)

Table No. 19 (Continued) **Area 28.27 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.45	41.0	0.05	1.6	6.74	191	1.1
0.2	2.13	60.3	0.11	1.8	7.19	203	1.2
0.3	2.66	75.2	0.17	2.0	7.63	216	1.4
0.4	3.12	88.3	0.23	2.5	8.63	244	1.7
0.5	3.53	99.8	0.29	3.0	9.55	270	2.1
0.6	3.91	110	0.36	3.5	10.4	294	2.5
0.7	4.26	120	0.42	4.0	11.2	317	2.9
0.8	4.59	130	0.49	4.5	12.0	339	3.4
0.9	4.90	139	0.56	5.0	12.7	359	3.8
1.0	5.19	147	0.63	6.0	14.0	396	4.6
1.2	5.75	163	0.77	7.0	15.3	433	5.5
1.4	6.26	177	0.91				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 78 Inches

(6 ft. 6 in.)

Table No. 19 (Continued) **Area 33.18 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.52	50.4	0.05	1.6	7.10	236	1.2
0.2	2.24	74.3	0.12	1.8	7.58	252	1.3
0.3	2.80	93.0	0.18	2.0	8.04	267	1.5
0.4	3.29	109	0.25	2.5	9.09	302	1.9
0.5	3.72	123	0.32	3.0	10.1	335	2.4
0.6	4.12	137	0.40	3.5	11.0	365	2.8
0.7	4.49	149	0.47	4.0	11.8	392	3.3
0.8	4.83	160	0.54	4.5	12.6	418	3.7
0.9	5.16	171	0.62	5.0	13.4	444	4.2
1.0	5.47	182	0.70	6.0	14.8	491	5.1
1.2	6.05	201	0.85	7.0	16.1	534	6.0
1.4	6.59	219	1.0				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 84 Inches

(7 ft. 0 in.)

Table No. 19 (Continued) **Area 38.48 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.60	61.6	0.06	1.4	6.92	266	1.1
0.2	2.35	90.5	0.13	1.6	7.45	287	1.3
0.3	2.94	113	0.20	1.8	7.95	306	1.5
0.4	3.45	133	0.28	2.0	8.43	325	1.7
0.5	3.91	150	0.36	2.5	9.54	367	2.1
0.6	4.32	166	0.44	3.0	10.6	408	2.6
0.7	4.71	181	0.52	3.5	11.5	442	3.1
0.8	5.07	195	0.60	4.0	12.4	477	3.6
0.9	5.41	208	0.68	4.5	13.2	508	4.1
1.0	5.74	221	0.77	5.0	14.0	539	4.6
1.2	6.35	244	0.94	8.0	15.5	596	5.6

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 90 Inches

(7 ft. 6 in.)

Table No. 19 (Continued) **Area 44.18 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.67	73.8	0.07	1.4	7.23	320	1.2
0.2	2.46	109	0.14	1.6	7.79	344	1.4
0.3	3.08	136	0.22	1.8	8.32	366	1.6
0.4	3.61	160	0.30	2.0	8.82	390	1.8
0.5	4.09	181	0.39	2.5	9.98	441	2.3
0.6	4.52	200	0.48	3.0	11.0	486	2.8
0.7	4.92	218	0.57	3.5	12.0	530	3.4
0.8	5.30	234	0.66	4.0	13.0	575	3.9
0.9	5.66	250	0.75	4.5	13.8	610	4.4
1.0	6.00	265	0.84	5.0	14.7	650	5.0
1.2	6.64	293	1.0	6.0	16.2	716	6.1

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 96 Inches

(8 ft. 0 in.)

Table No. 19 (Continued) **Area 50.27 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.74	87.5	0.07	1.4	7.54	379	1.3
0.2	2.56	129	0.15	1.6	8.13	409	1.5
0.3	3.21	161	0.24	1.8	8.67	436	1.8
0.4	3.76	189	0.33	2.0	9.20	463	2.0
0.5	4.26	214	0.42	2.5	10.4	523	2.5
0.6	4.71	237	0.52	3.0	11.5	578	3.1
0.7	5.14	259	0.62	3.5	12.6	634	3.7
0.8	5.53	278	0.71	4.0	13.5	679	4.3
0.9	5.90	297	0.81	4.5	14.4	724	4.8
1.0	6.26	315	0.92	5.0	15.3	770	5.5
1.2	6.93	349	1.1				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 102 Inches

(8 ft. 6 in.)

Table No. 19 (Continued) **Area 56.75 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.81	103	0.07	1.2	7.20	409	1.2
0.2	2.67	152	0.17	1.4	7.85	446	1.4
0.3	3.34	190	0.26	1.6	8.45	480	1.7
0.4	3.92	223	0.36	1.8	9.02	512	1.9
0.5	4.43	252	0.46	2.0	9.57	543	2.1
0.6	4.90	278	0.56	2.5	10.8	613	2.7
0.7	5.34	303	0.66	3.0	12.0	681	3.4
0.8	5.75	326	0.77	3.5	13.1	744	4.0
0.9	6.14	348	0.88	4.0	14.1	800	4.6
1.0	6.51	370	0.99	4.5	15.0	852	5.3

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 108 Inches

(9 ft. 0 in.)

Table No. 19 (Continued) **Area 63.62 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.88	120	0.08	1.2	7.48	476	1.3
0.2	2.77	176	0.18	1.4	8.15	519	1.6
0.3	3.46	220	0.28	1.6	8.77	559	1.8
0.4	4.06	258	0.38	1.8	9.36	596	2.0
0.5	4.60	293	0.49	2.0	9.93	632	2.3
0.6	5.09	324	0.60	2.5	11.2	713	2.9
0.7	5.54	353	0.72	3.0	12.4	790	3.6
0.8	5.97	380	0.83	3.5	13.5	860	4.3
0.9	6.37	406	0.95	4.0	14.6	930	5.0
1.0	6.76	430	1.1	4.5	15.6	994	5.7

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 114 Inches

(9 ft. 6 in.)

Table No. 19 (Continued) **Area 70.88 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.1	1.95	138	0.09	1.2	7.74	548	1.4
0.2	2.87	203	0.19	1.4	8.44	598	1.7
0.3	3.59	254	0.30	1.6	9.09	644	1.9
0.4	4.21	298	0.42	1.8	9.70	687	2.2
0.5	4.76	337	0.53	2.0	10.3	730	2.5
0.6	5.27	374	0.65	2.5	11.6	822	3.1
0.7	5.74	407	0.77	3.0	12.9	915	3.9
0.8	6.18	438	0.89	3.5	14.0	993	4.6
0.9	6.60	468	1.0	4.0	15.1	1070	5.3
1.0	7.00	496	1.2				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 120 Inches

(10 ft. 0 in.)

Table No. 19 (Continued) **Area 78.54 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.02	159	0.10	0.80	6.39	502	0.95
0.15	2.53	199	0.15	0.85	6.61	520	1.0
0.20	2.96	233	0.20	0.90	6.83	537	1.1
0.25	3.35	283	0.26	0.95	7.03	552	1.2
0.30	3.71	292	0.32	1.0	7.24	569	1.3
0.35	4.04	318	0.38	1.2	8.01	630	1.5
0.40	4.35	342	0.44	1.4	8.72	685	1.8
0.45	4.65	365	0.50	1.6	9.39	738	2.1
0.50	4.93	388	0.57	1.8	10.0	785	2.3
0.55	5.19	408	0.63	2.0	10.6	833	2.6
0.60	5.45	428	0.69	2.5	12.0	943	3.4
0.65	5.70	448	0.76	3.0	13.3	1040	4.1
0.70	5.94	467	0.82	3.5	14.5	1140	4.9
0.75	6.17	485	0.89	4.0	15.6	1230	5.7

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 126 Inches

(10 ft. 6 in.)

Table No. 19 (Continued) **Area 86.59 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.08	180	0.10	0.80	6.60	571	1.0
0.15	2.61	226	0.16	0.85	6.83	591	1.1
0.20	3.06	265	0.22	0.90	7.05	610	1.2
0.25	3.46	300	0.28	0.95	7.26	629	1.2
0.30	3.83	332	0.34	1.0	7.47	647	1.3
0.35	4.17	361	0.41	1.2	8.27	716	1.6
0.40	4.49	389	0.47	1.4	9.00	780	1.9
0.45	4.80	415	0.54	1.6	9.70	840	2.2
0.50	5.08	440	0.60	1.8	10.4	900	2.5
0.55	5.36	464	0.67	2.0	11.0	953	2.8
0.60	5.63	488	0.74	2.5	12.4	1070	3.6
0.65	5.88	509	0.81	3.0	13.7	1190	4.4
0.70	6.13	531	0.88	3.5	15.0	1300	5.2
0.75	6.37	552	0.95				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 132 Inches

(11 ft. 0 in.)

Table No. 19 (Continued) **Area 95.03 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.15	204	0.11	0.80	6.80	646	1.1
0.15	2.69	256	0.17	0.85	7.04	669	1.2
0.20	3.15	300	0.23	0.90	7.26	690	1.2
0.25	3.57	339	0.30	0.95	7.48	711	1.3
0.30	3.95	375	0.36	1.0	7.70	732	1.4
0.35	4.30	409	0.43	1.2	8.52	810	1.7
0.40	4.63	440	0.50	1.4	9.28	883	2.0
0.45	4.94	470	0.57	1.6	9.99	950	2.3
0.50	5.24	498	0.64	1.8	10.7	1020	2.7
0.55	5.53	526	0.71	2.0	11.3	1070	3.0
0.60	5.80	551	0.78	2.5	12.8	1220	3.8
0.65	6.06	576	0.85	3.0	14.2	1350	4.7
0.70	6.32	601	0.93	3.5	15.4	1460	5.5
0.75	6.56	624	1.0				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 138 Inches

(11 ft. 6 in.)

Table No. 19 (Continued) **Area 103.87 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.21	230	0.11	0.80	7.00	727	1.1
0.15	2.77	288	0.18	0.85	7.24	752	1.2
0.20	3.24	337	0.24	0.90	7.47	776	1.3
0.25	3.67	381	0.31	0.95	7.70	800	1.4
0.30	4.06	422	0.38	1.0	7.93	824	1.5
0.35	4.43	460	0.46	1.2	8.77	911	1.8
0.40	4.77	496	0.53	1.4	9.55	992	2.1
0.45	5.09	529	0.60	1.6	10.3	1070	2.5
0.50	5.39	560	0.68	1.8	11.0	1140	2.8
0.55	5.69	592	0.75	2.0	11.6	1200	3.1
0.60	5.97	621	0.83	2.5	13.2	1370	4.1
0.65	6.24	648	0.91	3.0	14.6	1520	5.0
0.70	6.50	675	0.99	3.5	15.9	1650	5.9
0.75	6.76	702	1.1				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 144 Inches

(12 ft. 0 in.)

Table No. 19 (Continued) **Area 113.10 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.27	257	0.12	0.75	6.95	787	1.1
0.15	2.84	322	0.19	0.80	7.20	815	1.2
0.20	3.34	378	0.26	0.85	7.44	842	1.3
0.25	3.77	427	0.33	0.90	7.68	870	1.4
0.30	4.18	473	0.41	0.95	7.92	896	1.5
0.35	4.55	515	0.48	1.0	8.15	923	1.6
0.40	4.90	555	0.56	1.2	9.01	1020	1.9
0.45	5.23	592	0.64	1.4	9.82	1110	2.2
0.50	5.55	628	0.72	1.6	10.6	1200	2.6
0.55	5.85	662	0.80	1.8	11.3	1280	3.0
0.60	6.14	695	0.88	2.0	12.0	1360	3.4
0.65	6.41	726	0.96	2.5	13.6	1540	4.3
0.70	6.68	756	1.0	3.0	15.0	1700	5.2

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 150 Inches
(12 ft. 6 in.)

Table No. 19 (Continued) **Area 122.72 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.33	288	0.13	0.75	7.13	875	1.2
0.15	2.92	358	0.20	0.80	7.39	906	1.3
0.20	3.42	419	0.27	0.85	7.64	937	1.4
0.25	3.88	476	0.35	0.90	7.89	968	1.5
0.30	4.29	527	0.43	0.95	8.13	997	1.6
0.35	4.67	573	0.51	1.0	8.37	1030	1.7
0.40	5.03	617	0.59	1.2	9.26	1140	2.0
0.45	5.37	659	0.67	1.4	10.1	1240	2.4
0.50	5.69	698	0.76	1.6	10.9	1340	2.8
0.55	6.00	736	0.84	1.8	11.6	1420	3.1
0.60	6.30	773	0.92	2.0	12.3	1510	3.5
0.65	6.59	809	1.0	2.5	13.9	1710	4.5
0.70	6.86	841	1.1	3.0	15.4	1810	5.5

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 156 Inches
(13 ft. 0 in.)

Table No. 19 (Continued) **Area 132.73 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.39	317	0.13	0.75	7.32	971	1.3
0.15	2.99	397	0.21	0.80	7.58	1010	1.3
0.20	3.51	486	0.29	0.85	7.84	1040	1.4
0.25	3.98	528	0.37	0.90	8.09	1070	1.5
0.30	4.40	584	0.45	0.95	8.34	1110	1.6
0.35	4.79	636	0.54	1.0	8.58	1140	1.7
0.40	5.16	685	0.62	1.2	9.50	1260	2.1
0.45	5.51	731	0.71	1.4	10.3	1370	2.5
0.50	5.84	775	0.80	1.8	11.1	1470	2.9
0.55	6.16	817	0.89	1.8	11.9	1580	3.3
0.60	6.46	857	0.97	2.0	12.6	1670	3.7
0.65	6.76	897	1.1	2.5	14.3	1900	4.8
0.70	7.04	934	1.2	3.0	15.8	2100	5.8

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 162 Inches
(13 ft. 6 in.)

Table No. 19 (Continued) **Area 143.14 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.45	351	0.14	0.75	7.50	1070	1.3
0.15	3.07	440	0.22	0.80	7.77	1110	1.4
0.20	3.60	515	0.30	0.85	8.04	1150	1.5
0.25	4.08	585	0.39	0.90	8.30	1190	1.6
0.30	4.51	646	0.47	0.95	8.55	1220	1.7
0.35	4.91	703	0.56	1.0	8.80	1260	1.8
0.40	5.29	758	0.65	1.2	9.73	1390	2.2
0.45	5.65	810	0.74	1.4	10.6	1520	2.6
0.50	5.99	858	0.84	1.6	11.4	1630	3.0
0.55	6.31	904	0.93	1.8	12.2	1750	3.5
0.60	6.62	947	1.0	2.0	12.9	1850	3.9
0.65	6.93	993	1.1	2.5	14.6	2090	5.0
0.70	7.22	1030	1.2	3.0	16.2	2320	6.1

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 168 Inches
(14 ft. 0 in.)

Table No. 19 (Continued) **Area 153.94 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.51	386	0.15	0.75	7.68	1180	1.4
0.15	3.14	483	0.23	0.80	7.96	1220	1.5
0.20	3.69	568	0.32	0.85	8.23	1270	1.6
0.25	4.17	642	0.41	0.90	8.49	1310	1.7
0.30	4.62	710	0.50	0.95	8.75	1350	1.8
0.35	5.03	774	0.59	1.0	9.01	1400	1.9
0.40	5.42	834	0.68	1.2	9.96	1530	2.3
0.45	5.78	889	0.78	1.4	10.9	1680	2.8
0.50	6.13	944	0.88	1.6	11.7	1800	3.2
0.55	6.46	994	0.97	1.8	12.5	1920	3.6
0.60	6.78	1040	1.1	2.0	13.2	2030	4.1
0.65	7.09	1090	1.2	2.5	15.0	2310	5.2
0.70	7.39	1140	1.3				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 174 Inches

(14 ft. 6 in.)

Table No. 19 (Continued) **Area 165.13 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.57	424	0.15	0.75	7.85	1300	1.4
0.15	3.22	532	0.24	0.80	8.14	1340	1.6
0.20	3.77	623	0.33	0.85	8.42	1390	1.7
0.25	4.27	705	0.43	0.90	8.69	1440	1.8
0.30	4.72	780	0.52	0.95	8.95	1480	1.9
0.35	5.15	851	0.62	1.0	9.21	1520	2.0
0.40	5.54	899	0.72	1.2	10.2	1680	2.4
0.45	5.92	978	0.82	1.4	11.1	1830	2.9
0.50	6.27	1040	0.92	1.6	12.0	1980	3.4
0.55	6.61	1090	1.0	1.8	12.8	2120	3.8
0.60	6.94	1150	1.1	2.0	13.5	2230	4.3
0.65	7.25	1200	1.2	2.5	15.3	2530	5.5
0.70	7.56	1250	1.3				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 180 Inches

(15 ft. 0 in.)

Table No. 19 (Continued) **Area 176.72 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.62	463	0.16	0.75	8.03	1420	1.5
0.15	3.29	581	0.25	0.80	8.32	1470	1.6
0.20	3.86	682	0.35	0.85	8.61	1520	1.7
0.25	4.36	770	0.44	0.90	8.88	1570	1.8
0.30	4.83	853	0.54	0.95	9.15	1620	2.0
0.35	5.26	930	0.65	1.0	9.42	1660	2.1
0.40	5.66	1000	0.75	1.2	10.4	1840	2.5
0.45	6.05	1070	0.85	1.4	11.4	2010	3.0
0.50	6.41	1130	0.96	1.6	12.2	2160	3.5
0.55	6.76	1190	1.1	1.8	13.1	2320	4.0
0.60	7.09	1250	1.2	2.0	13.8	2440	4.4
0.65	7.42	1310	1.3	2.5	15.7	2770	5.7
0.70	7.73	1370	1.4				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 192 Inches

(16 ft. 0 in.)

Table No. 19 (Continued) **Area 201.06 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.74	551	0.18	0.75	8.37	1680	1.6
0.15	3.43	690	0.27	0.80	8.68	1750	1.8
0.20	4.02	808	0.38	0.85	8.98	1810	1.9
0.25	4.55	915	0.48	0.90	9.26	1860	2.0
0.30	5.04	1010	0.59	0.95	9.55	1920	2.1
0.35	5.49	1100	0.70	1.0	9.82	1970	2.2
0.40	5.91	1190	0.81	1.2	10.9	2190	2.8
0.45	6.31	1270	0.93	1.4	11.8	2370	3.2
0.50	6.69	1350	1.0	1.6	12.8	2570	3.8
0.55	7.05	1420	1.2	1.8	13.6	2730	4.3
0.80	7.40	1490	1.3	2.0	14.4	2890	4.8
0.65	7.73	1550	1.4	2.5	16.3	3280	6.2
0.70	8.06	1620	1.5				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 204 Inches

(17 ft. 0 in.)

Table No. 19 (Continued) **Area 226.98 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.85	647	0.19	0.70	8.38	1900	1.6
0.15	3.57	810	0.30	0.75	8.71	1980	1.8
0.20	4.18	949	0.41	0.80	9.03	2050	1.9
0.25	4.73	1070	0.52	0.85	9.34	2120	2.0
0.30	5.24	1190	0.64	0.90	9.64	2190	2.2
0.35	5.71	1300	0.76	0.95	9.93	2250	2.3
0.40	6.14	1390	0.88	1.0	10.2	2310	2.4
0.45	6.56	1490	1.0	1.2	11.3	2560	3.0
0.50	6.95	1580	1.1	1.4	12.3	2790	3.5
0.55	7.33	1660	1.3	1.6	13.3	3020	4.1
0.60	7.69	1740	1.4	1.8	14.2	3220	4.7
0.65	8.04	1820	1.5	2.0	15.0	3400	5.2

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 216 Inches
(18 ft. 0 in.)

Table No. 19 (Continued) **Area 254.47 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	2.95	751	0.20	0.70	8.70	2210	1.8
0.15	3.70	942	0.32	0.75	9.04	2300	1.9
0.20	4.34	1100	0.44	0.80	9.37	2380	2.0
0.25	4.91	1250	0.56	0.85	9.69	2460	2.2
0.30	5.44	1380	0.69	0.90	10.0	2540	2.3
0.35	5.92	1510	0.82	0.95	10.3	2620	2.5
0.40	6.38	1620	0.95	1.0	10.6	2700	2.6
0.45	6.81	1730	1.1	1.2	11.7	2980	3.2
0.50	7.22	1840	1.2	1.4	12.8	3260	3.8
0.55	7.61	1940	1.4	1.6	13.8	3510	4.4
0.60	7.99	2030	1.5	1.8	14.7	3740	5.0
0.65	8.35	2120	1.6	2.0	15.6	3970	5.7

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 228 Inches
(19 ft. 0 in.)

Table No. 19 (Continued) **Area 283.53 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	3.06	868	0.22	0.70	9.01	2550	1.9
0.15	3.83	1090	0.34	0.75	9.36	2650	2.0
0.20	4.50	1280	0.47	0.80	9.70	2750	2.2
0.25	5.09	1440	0.60	0.85	10.0	2840	2.3
0.30	5.63	1600	0.74	0.90	10.4	2950	2.5
0.35	6.13	1740	0.88	0.95	10.7	3030	2.7
0.40	6.61	1870	1.0	1.0	11.0	3120	2.8
0.45	7.05	2000	1.2	1.2	12.2	3460	3.5
0.50	7.48	2120	1.3	1.4	13.2	3740	4.1
0.55	7.88	2230	1.5	1.6	14.3	4050	4.8
0.60	8.27	2340	1.6	1.8	15.2	4310	5.4
0.65	8.65	2450	1.7				

FLOW OF WATER IN WOOD STAVE PIPE

Diameter 240 Inches
(20 ft. 0 in.)

Table No. 19 (Continued) **Area 314.16 Sq. Ft.**

Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet	Head in Feet Required for Friction in 1000 Feet of Pipe	Velocity in Feet per Second	Discharge Cubic Feet per Second	Velocity and Entrance Head in Feet
0.10	3.16	993	0.23	0.70	9.32	2930	2.0
0.15	3.96	1240	0.37	0.75	9.68	3040	2.2
0.20	4.65	1460	0.50	0.80	10.0	3140	2.3
0.25	5.26	1650	0.65	0.85	10.4	3270	2.5
0.30	5.82	1830	0.79	0.90	10.7	3360	2.7
0.35	6.34	1990	0.94	0.95	11.0	3450	2.8
0.40	6.83	2150	1.1	1.0	11.4	3580	3.0
0.45	7.29	2290	1.2	1.2	12.6	3960	3.7
0.50	7.73	2430	1.4	1.4	13.7	4300	4.4
0.55	8.15	2560	1.6	1.6	14.7	4620	5.0
0.60	8.55	2690	1.7	1.8	15.7	4930	5.7
0.65	8.94	2810	1.9				

36" Creosoted Sewer Pipe

LOSS OF HEAD — BENDS

Table Showing Head Loss in Feet Due to the Resistance of One Angular Bend

Table No. 20

Velocity in Feet per Second	ANGLES OF DEFLECTION					
	15° Fric'n Head	30° Fric'n Head	40° Fric'n Head	60° Fric'n Head	90° Fric'n Head	120° Fric'n Head
1	.0002	.0005	.002	.006	.015	.029
2	.0010	.0019	.009	.023	.061	.116
3	.0022	.0042	.019	.051	.138	.260
4	.004	.008	.035	.090	.245	.462
5	.006	.012	.054	.141	.382	.723
6	.009	.017	.078	.204	.550	1.04
7	.012	.023	.106	.277	.749	1.42
8	.016	.030	.138	.362	.978	1.85
10	.025	.047	.216	.565	1.53	2.89
15	.056	.105	.486	1.27	3.44	6.50

Welded Steel Bend, Ready for Connection

FLOW TABLE FOR STANDARD STEEL PIPE

Loss of Head in Feet per 100 Lineal Feet of standard steel or wrought iron pipe, with screw couplings.

Table No. 21

Flow in Gallons Per Minute	Nominal Diameter of Pipe									
	⅜"	½"	¾"	1"	1¼"	1½"	2"	2½"	3"	4"
1	6.4	2.1	......	......	......	......	......	......	......	......
2	23.3	7.4	1.9	......	......	......	......	......	......	......
3	49.0	15.8	4.1	1.3	......	......	......	......	......	......
4	84.0	27.0	7.0	2.1	0.6	......	......	......	......	......
5	126.0	41.0	10.5	3.3	0.8	0.4	......	......	......	......
6	......	57.0	14.7	4.6	1.2	0.6	......	......	......	......
8	......	98.0	25.0	7.8	2.0	1.0	0.3	......	......	......
10	......	147.0	38.0	11.7	3.1	1.4	0.5	......	......	......
12	......	......	53.0	16.4	4.3	2.0	0.7	......	......	......
14	......	......	70.0	22.0	5.7	2.7	0.9	0.3	......	......
16	......	......	90.0	28.0	7.3	3.4	1.2	0.4	......	......
18	......	......	111.0	35.0	9.1	4.2	1.5	0.5	......	......
20	......	......	136.0	42.0	11.1	5.2	1.8	0.6	0.3	......
25	......	......	......	64.0	16.6	7.9	2.7	0.9	0.4	......
30	......	......	......	89.0	23.5	11.0	3.8	1.3	0.5	......
35	......	......	......	119.0	31.2	14.7	5.1	1.7	0.7	......
40	......	......	......	......	40.0	18.8	6.6	2.2	0.9	0.2
50	......	......	......	......	60.0	28.4	9.9	3.3	1.4	0.3
60	......	......	......	......	85.0	39.6	13.9	4.7	1.9	0.5
70	......	......	......	......	113.0	53.0	18.4	6.2	2.6	0.6
80	......	......	......	......	......	68.0	23.7	7.9	3.3	0.8
90	......	......	......	......	......	84.0	29.4	9.8	4.1	1.0
100	......	......	......	......	......	102.0	35.8	12.0	5.0	1.2
110	......	......	......	......	......	122.0	42.9	14.3	6.0	1.5
120	......	......	......	......	......	......	50.0	16.8	7.0	1.7
130	......	......	......	......	......	......	58.0	19.6	8.1	2.0
140	......	......	......	......	......	......	67.0	22.3	9.2	2.3
160	......	......	......	......	......	......	86.0	29.0	11.8	2.9
180	......	......	......	......	......	......	107.0	35.7	14.8	3.6
200	......	......	......	......	......	......	129.0	43.1	17.8	4.4
220	......	......	......	......	......	......	......	52.0	21.3	5.2
240	......	......	......	......	......	......	......	61.0	25.1	6.2
260	......	......	......	......	......	......	......	70.0	29.1	7.2
280	......	......	......	......	......	......	......	81.0	33.4	8.2
300	......	......	......	......	......	......	......	92.0	38.0	9.3
320	......	......	......	......	......	......	......	103.0	42.8	10.5
340	......	......	......	......	......	......	......	116.0	47.9	11.7
360	......	......	......	......	......	......	......	......	53.0	13.1
380	......	......	......	......	......	......	......	......	59.0	14.5
400	......	......	......	......	......	......	......	......	65.0	16.0

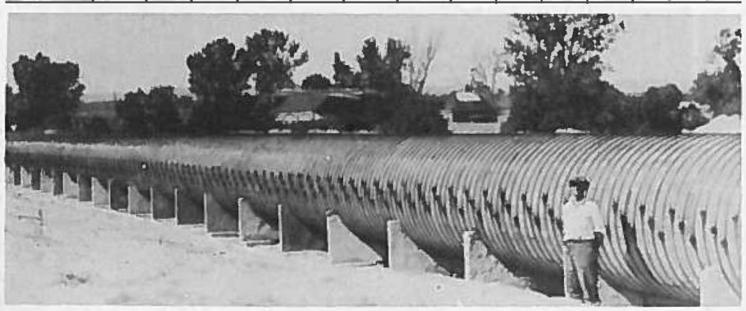
Based on Hazen-Williams C = 100.

Multiply values by 0.434, or see Table page 128, for equivalent pounds pressure loss per 100 feet of pipe length.

THEORETICAL DISCHARGE OF NOZZLES IN U. S. GALLONS PER MINUTE

Table No. 22

Head		Velocity of Disch. Ft. per Sec.	DIAMETER OF NOZZLE IN INCHES												
Lbs	Feet		1/16	1/8	3/16	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8
10	23.1	38.6	0.37	1.48	3.32	5.91	13.3	23.6	36.9	53.1	72.4	94.5	120	148	179
15	34.6	47.25	0.45	1.81	4.06	7.24	16.3	28.9	45.2	65.0	88.5	116.	147	181	219
20	46.2	54.55	0.52	2.09	4.69	8.35	18.8	33.4	52.2	75.1	102.	134.	169	209	253
25	57.7	61.0	0.58	2.34	5.25	9.34	21.0	37.3	58.3	84.0	114.	149.	189	234	283
30	69.3	66.85	0.64	2.56	5.75	10.2	23.0	40.9	63.9	92.0	125.	164.	207	256	309
35	80.8	72.2	0.69	2.77	6.21	11.1	24.8	44.2	69.0	99.5	135.	177.	224	277	334
40	92.4	77.2	0.74	2.96	6.64	11.8	26.6	47.3	73.8	106.	145.	189.	239	296	357
45	103.9	81.8	0.78	3.13	7.03	12.5	28.2	50.1	78.2	113.	153.	200.	253	313	379
50	115.5	86.25	0.83	3.30	7.41	13.2	29.7	52.8	82.5	119.	162.	211.	267	330	399
55	127.0	90.4	0.87	3.46	7.77	13.8	31.1	55.3	86.4	125.	169.	221.	280	346	418
60	138.6	94.5	0.90	3.62	8.12	14.5	32.5	57.8	90.4	130.	177.	231.	293	362	438
65	150.1	98.3	0.94	3.77	8.45	15.1	33.8	60.2	94.0	136.	184.	241.	305	376	455
70	161.7	102.1	0.98	3.91	8.78	15.7	35.2	62.5	97.7	141.	191.	250.	317	391	473
75	173.2	105.7	1.01	4.05	9.08	16.2	36.4	64.7	101.	146.	198.	259.	327	404	489
80	184.8	109.1	1.05	4.18	9.39	16.7	37.6	66.8	104.	150.	205.	267.	338	418	505
85	196.3	112.5	1.08	4.31	9.67	17.3	38.8	68.9	108.	155.	211.	276.	349	431	521
90	207.9	115.8	1.11	4.43	9.95	17.7	39.9	70.8	111.	160.	217.	284.	359	443	536
95	219.4	119.0	1.14	4.56	10.2	18.2	41.0	72.8	114.	164.	223.	292.	369	456	551
100	230.9	122.0	1.17	4.67	10.5	18.7	42.1	74.7	117.	168.	229.	299.	378	467	565
105	242.4	125.0	1.20	4.79	10.8	19.2	43.1	76.5	120.	172.	234.	306.	388	479	579
110	254.0	128.0	1.23	4.90	11.0	19.6	44.1	78.4	122.	176.	240.	314.	397	490	593
115	265.5	130.9	1.25	5.01	11.2	20.0	45.1	80.1	125.	180.	245.	320.	406	501	606
120	277.1	133.7	1.28	5.12	11.5	20.5	46.0	81.8	128.	184.	251.	327.	414	512	619
125	288.6	136.4	1.31	5.22	11.7	20.9	47.0	83.5	130.	188.	256.	334.	423	522	632
130	300.2	139.1	1.33	5.33	12.0	21.3	48.0	85.2	133.	192.	261.	341.	432	533	645
135	311.7	141.8	1.36	5.43	12.2	21.7	48.9	86.7	136.	195.	266.	347.	439	543	656
140	323.3	144.3	1.38	5.53	12.4	22.1	49.8	88.4	138.	199.	271.	354.	448	553	668
145	334.8	146.9	1.41	5.62	12.6	22.5	50.6	89.9	140.	202.	275.	360.	455	562	680
150	346.4	149.5	1.43	5.72	12.9	22.9	51.5	91.5	143.	206.	280.	366.	463	572	692
175	404.1	161.4	1.55	6.18	13.9	24.7	55.6	98.8	154.	222.	302.	395.	500	618	747
200	461.9	172.6	1.65	6.61	14.8	26.4	59.5	106.	165.	238.	323.	423.	535	660	799
250	577.4	193.0	1.85	7.39	16.6	29.6	66.5	118.	185.	266.	362.	473.	598	739	894
300	692.8	211.2	2.02	8.08	18.2	32.4	72.8	129.	202.	291.	396.	517.	655	808	977



72" for Water Power Plant

THEORETICAL DISCHARGE OF NOZZLES IN U. S. GALLONS PER MINUTE

Table No. 22 (Continued)

Head		Velocity of Disch. Ft. per Sec.	DIAMETER OF NOZZLE IN INCHES												
Lbs	Feet		1 1/2	1 3/4	2	2 1/4	2 1/2	2 3/4	3	3 1/2	4	4 1/2	5	5 1/2	6
10	23.1	38.6	213	289	378	479	591	714	851	1158	1510	1915	2365	2855	3405
15	34.6	47.25	260	354	463	585	723	874	1041	1418	1850	2345	2890	3490	4165
20	46.2	54.55	301	409	535	676	835	1009	1203	1638	2135	2710	3340	4040	4810
25	57.7	61.0	336	458	598	756	934	1128	1345	1830	2385	3025	3730	4510	5380
30	69.3	66.85	368	501	655	828	1023	1236	1473	2005	2615	3315	4090	4940	5895
35	80.8	72.2	398	541	708	895	1106	1335	1591	2168	2825	3580	4415	5340	6370
40	92.4	77.2	425	578	756	957	1182	1428	1701	2315	3020	3830	4725	5710	6810
45	103.9	81.8	451	613	801	1015	1252	1512	1802	2455	3200	4055	5000	6050	7210
50	115.5	86.25	475	647	845	1070	1320	1595	1900	2590	3375	4275	5280	6380	7600
55	127.0	90.4	498	678	886	1121	1385	1671	1991	2710	3540	4480	5530	6690	7970
60	138.6	94.5	521	708	926	1172	1447	1748	2085	2835	3700	4685	5790	6980	8330
65	150.1	98.3	542	737	964	1220	1506	1819	2165	2950	3850	4875	6020	7270	8670
70	161.7	102.1	563	765	1001	1267	1565	1888	2250	3065	4000	5060	6250	7560	9000
75	173.2	105.7	582	792	1037	1310	1619	1955	2330	3170	4135	5240	6475	7820	9320
80	184.8	109.1	602	818	1070	1354	1672	2020	2405	3280	4270	5410	6690	8080	9630
85	196.3	112.5	620	844	1103	1395	1723	2080	2480	3375	4400	5575	6890	8320	9920
90	207.9	115.8	638	868	1136	1436	1773	2140	2550	3475	4530	5740	7090	8560	10210
95	219.4	119.0	656	892	1168	1476	1824	2200	2625	3570	4655	5900	7290	8800	10500
100	230.9	122.0	672	915	1196	1512	1870	2255	2690	3660	4775	6050	7470	9030	10770
105	242.4	125.0	689	937	1226	1550	1916	2312	2755	3750	4890	6200	7650	9250	11020
110	254.0	128.0	705	960	1255	1588	1961	2366	2820	3840	5010	6350	7840	9470	11300
115	265.5	130.9	720	980	1282	1621	2005	2420	2885	3930	5120	6490	8010	9680	11550
120	277.1	133.7	736	1002	1310	1659	2050	2470	2945	4015	5225	6630	8180	9900	11800
125	288.6	136.4	751	1022	1338	1690	2090	2520	3005	4090	5340	6760	8350	10100	12030
130	300.2	139.1	767	1043	1365	1726	2132	2575	3070	4175	5450	6900	8530	10300	12290
135	311.7	141.8	780	1063	1390	1759	2173	2620	3125	4250	5550	7030	8680	10490	12510
140	323.3	144.3	795	1082	1415	1790	2212	2670	3180	4330	5650	7160	8850	10690	12730
145	334.8	146.9	809	1100	1440	1820	2250	2715	3235	4410	5740	7280	8990	10880	12960
150	346.4	149.5	824	1120	1466	1853	2290	2760	3295	4485	5850	7410	9150	11070	13200
175	404.1	161.4	890	1210	1582	2000	2473	2985	3560	4840	6310	8000	9890	11940	14250
200	461.9	172.6	950	1294	1691	2140	2645	3190	3800	5175	6750	8550	10580	12770	15220
250	577.4	193.0	1063	1447	1891	2392	2955	3570	4250	5795	7550	9570	11820	14290	17020
300	692.8	211.2	1163	1582	2070	2615	3235	3900	4650	6330	8260	10480	12940	15620	18610

NOTE—The actual quantities will vary from these figures, the amount of variation depending upon the shape of nozzle and size of pipe at the point where the pressure is determined. Discharge for a smooth, tapered nozzle may be from 90 to 95% of amount shown by table.

LAW OF FALLING BODIES

The increase in velocity of any body falling freely through space is 32.2 feet per second in each second of time. The governing factors are:

h = height, the distance in feet fallen through space
t = time in seconds consumed in falling
V = velocity in feet per second
g = 32.2, the acceleration of gravity

FORMULAS

$$\begin{cases} h = 16.1t^2 \\ t = \sqrt{\dfrac{h}{16.1}} \\ V = 32.2t \end{cases}$$

Examples

1. Given time = 4 seconds—then 16.1 x 4 x 4 = 257.6 ft height.

2. Given height = 257.6—then 257.6 ÷ 16.1 = 16 and the square root of 16 = 4 seconds time.

3. Given time = 4 seconds—then 32.2 x 4 = 128.8 ft. = velocity at the end of 4 seconds.

Table No. 23

Time In Seconds	Height In Feet	Velocity in Feet Per Second
1	16.1	32.2
2	64.4	64.4
3	144.9	96.6
4	257.6	128.8
5	402.5	161.0
6	579.6	193.2
7	788.9	225.4
8	1030.4	257.6
9	1304.1	289.8
10	1610.0	322.0

TABLE SHOWING LOSS OF HEAD (Hv) IN FEET DUE TO VELOCITY

Table No. 24

Vel. in Feet per Sec.	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0		.00	.00	.00	.00	.01	.01	.01	.01	.02
1	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06
2	.06	.07	.08	.03	.09	.10	.11	.12	.12	.13
3	.14	.15	.16	.17	.18	.19	.20	.21	.22	.24
4	.25	.26	.27	.29	.30	31	.33	.34	.36	.37
5	.39	.40	.42	.44	.45	.47	.49	.50	.52	.54
6	.56	.58	.60	.62	.63	.66	.68	.70	.72	.74
7	.76	.78	.80	.83	.85	.87	.90	.92	.94	.97
8	.99	1.01	1.04	1.07	1.09	1.12	1.15	1.17	1.20	1.23
9	1.26	1.28	1.31	1.34	1.37	1.40	1.43	1.46	1.49	1.52
10	1.55	1.58	1.62	1.65	1.68	1.72	1.75	1.78	1.81	1.85
11	1.88	1.92	1.95	1.98	2.02	2.06	2.09	2.13	2.16	2.20
12	2.24	2.27	2.31	2.35	2.39	2.43	2.47	2.50	2.54	2.58
13	2.63	2.67	2.71	2.75	2.79	2.83	2.87	2.92	2.96	3.00
14	3.04	3.09	3.13	3.17	3.22	3.26	3.31	3.36	3.40	3.45
15	3.50	3.54	3.59	3.64	3.68	3.73	3.78	3.83	3.88	3.93

Example: Velocity =7 4 feet per second. From the table the Velocity Head is found to be 85 feet.

Building 58" Pipe

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

The flume capacity tables presented on the following pages are calculated by the well-known Kutter formula using a value of n = 0.013. The selection of this value of n is in accordance with the recommendations appearing in Bulletin No. 393 of the U. S. Department of Agriculture entitled, "The Flow of Water in Flumes," by F. C. Scobey, Senior Engineer of the Department. On Page 54 of this bulletin, n = 0.013 is recommended for—

> "*treated wood-stave flumes where experience indicates that little or no algae or insect growth will reduce the capacity or where brushing or chemical treatment is anticipated, thus insuring a reasonably clean flume.*"

Since algae growth does not occur in many instances, and may be readily controlled where it does occur, n = 0.013 may be properly applied to stave flumes.

The value of n for several of the Semi-Circular Wood Flumes tested by Mr. Scobey was considerably lower than 0.013, and a value of n = 0.012 may be properly applied in some instances. However, this company wishes to be conservative, and does not care to offer capacity tables, for general use, based on a more favorable coefficient of friction than that advocated in the conclusions of so eminent an authority, as expressed in the above quotation.

Bulletin No. 393 will be of great interest to those who frequently have occasion to estimate flume capacities. Copies may be obtained from the Superintendent of Documents, Washington, D. C. The price is 15 cents.

It should be especially noted that Federal Wood Stave Flumes are built to a semi-circle, plus a freeboard depth of one inch in depth to each foot of diameter. A six foot diameter flume, for instance, would have a mid-depth of three feet six inches. The following tables are calculated for a water depth up to the line of a semi-circle, with that above being allowed for freeboard. This fact *should not be overlooked* when comparing the capacities shown by the following tables with those shown by some other tables, based on a flume being entirely filled with water and giving the impression of capacities which cannot be obtained in actual practice.

HOW TO USE FLUME FLOW TABLE

As will be seen, the flow table shows the velocity in feet per second and the discharge in cubic feet per second for various falls in feet per thousand. This fall is generally called the Loss in Head Due to Friction, and must be considered in connection with the Loss in Head Due to Velocity. (See table No. 24.)

The loss in head occasioned by friction at the entrance is not here considered inasmuch as it is assumed that structures will be so designed that the water will flow without interruption from the ditch into the flume, and therefore without loss of head.

The recovery in velocity head is not here considered as it is a refinement of calculation that might lead to serious error when handled by anyone not an expert.

The determination of the proper size of flume to use for any given quantity of water on a given slope may be determined with sufficient accuracy by means of the table of velocity heads and the table of discharges here printed.

The velocity head is determined when the velocity is ascertained and is a direct deduction from the total fall. The actual slope of the flume is determined from the difference in elevation between the water surface at the intake and the water surface at the discharge by dividing the said difference by the total length of line, after the velocity head shall have been deducted.

In order to make this perfectly simple, we assume a total fall of 6 feet in a flume 3000 feet long. The velocity is found to be 6.2 feet per second. By referring to table of velocity heads (Page 211) it will be found that the velocity head in this instance is .6 of one foot. Deducting .6 from 6 feet we have 5.4 feet as the frictional loss of head in 3000 feet or 1.8 feet per thousand feet of flume length.

48" and 84" Semi-Circular Flumes

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25

Diameter	18"		20"		22"		24"	
Total Area	1.07		1.32		1.60		1.90	
Area to C.L.	.88		1.09		1.32		1.57	
Fall in Feet per 1000 Ft.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
0.10	.51	.45	.56	.61	.60	.79	.65	1.02
0.15	.65	.57	.71	.77	.77	1.02	.82	1.29
0.20	.77	.68	.84	.92	.90	1.19	.96	1.51
0.25	.88	.77	.95	1.04	1.02	1.35	1.09	1.71
0.30	.97	.85	1.05	1.14	1.13	1.49	1.20	1.88
0.35	1.05	.92	1.14	1.24	1.22	1.61	1.30	2.04
0.40	1.13	.99	1.22	1.33	1.31	1.73	1.40	2.20
0.45	1.21	1.06	1.30	1.42	1.40	1.85	1.49	2.34
0.50	1.27	1.12	1.38	1.50	1.48	1.95	1.58	2.48
0.55	1.34	1.18	1.45	1.58	1.55	2.05	1.66	2.61
0.60	1.40	1.23	1.52	1.66	1.63	2.15	1.73	2.72
0.65	1.46	1.28	1.59	1.73	1.70	2.24	1.81	2.84
0.70	1.52	1.34	1.65	1.80	1.76	2.33	1.88	2.95
0.75	1.58	1.39	1.71	1.86	1.83	2.42	1.95	3.06
0.80	1.63	1.43	1.77	1.93	1.89	2.50	2.01	3.16
0.85	1.68	1.48	1.82	1.98	1.95	2.57	2.08	3.27
0.90	1.73	1.52	1.88	2.05	2.01	2.65	2.14	3.36
0.95	1.78	1.57	1.93	2.10	2.07	2.73	2.20	3.45
1.00	1.83	1.61	1.98	2.16	2.12	2.80	2.26	3.55
1.1	1.92	1.69	2.08	2.27	2.23	2.94	2.37	3.72
1.2	2.01	1.77	2.18	2.38	2.33	3.08	2.48	3.89
1.3	2.10	1.85	2.27	2.47	2.43	3.21	2.58	4.05
1.4	2.18	1.92	2.35	2.56	2.52	3.33	2.69	4.22
1.5	2.26	1.99	2.44	2.66	2.61	3.45	2.78	4.36
1.6	2.33	2.05	2.52	2.75	2.70	3.56	2.87	4.51
1.7	2.40	2.11	2.60	2.83	2.79	3.69	2.96	4.65
1.8	2.48	2.18	2.68	2.92	2.87	3.79	3.05	4.79
1.9	2.55	2.24	2.75	3.00	2.95	3.89	3.13	4.91
2.0	2.61	2.30	2.82	3.07	3.02	3.99	3.22	5.06
2.5	2.93	2.58	3.16	3.45	3.38	4.46	3.60	5.65
3.0	3.20	2.82	3.47	3.78	3.70	4.88	3.95	6.20
3.5	3.46	3.04	3.75	4.09	4.00	5.28	4.27	6.70
4.0	3.71	3.26	4.01	4.37	4.28	5.65	4.57	7.18
4.5	3.93	3.46	4.25	4.63	4.54	5.99	4.85	7.62
5.0	4.15	3.65	4.48	4.88	4.78	6.31	5.11	8.02

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter.......	26″		28″		30″	
Total Area...... / Area to C.L......	2.23 / 1.84		2.59 / 2.14		2.97 / 2.46	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	.69	1.27	.73	1.56	.77	1.89
0.15	.87	1.60	.92	1.97	.97	2.39
0.20	1.02	1.88	1.08	2.31	1.13	2.78
0.25	1.16	2.13	1.22	2.61	1.28	3.15
0.30	1.28	2.35	1.35	2.89	1.41	3.47
0.35	1.39	2.56	1.46	3.12	1.53	3.76
0.40	1.49	2.74	1.57	3.36	1.64	4.03
0.45	1.58	2.91	1.67	3.57	1.75	4.30
0.50	1.67	3.07	1.76	3.77	1.85	4.55
0.55	1.76	3.24	1.85	3.96	1.95	4.80
0.60	1.84	3.39	1.94	4.15	2.04	5.02
0.65	1.92	3.53	2.02	4.32	2.12	5.22
0.70	1.99	3.66	2.10	4.49	2.19	5.39
0.75	2.07	3.81	2.18	4.67	2.28	5.61
0.80	2.14	3.94	2.25	4.82	2.36	5.80
0.85	2.20	4.06	2.33	4.99	2.44	6.00
0.90	2.27	4.18	2.39	5.12	2.51	6.18
0.95	2.33	4.29	2.46	5.26	2.58	6.35
1.00	2.40	4.42	2.52	5.39	2.65	6.52
1.1	2.51	4.62	2.65	5.67	2.78	6.84
1.2	2.63	4.84	2.77	5.93	2.91	7.16
1.3	2.74	5.04	2.89	6.18	3.03	7.45
1.4	2.85	5.24	3.00	6.42	3.15	7.75
1.5	2.95	5.43	3.10	6.64	3.26	8.02
1.6	3.05	5.61	3.21	6.87	3.37	8.29
1.7	3.14	5.78	3.31	7.08	3.47	8.54
1.8	3.24	5.96	3.41	7.30	3.57	8.78
1.9	3.33	6.13	3.50	7.49	3.67	9.03
2.0	3.41	6.27	3.60	7.70	3.77	9.28
2.5	3.82	7.03	4.02	8.60	4.22	10.4
3.0	4.19	7.71	4.41	9.44	4.63	11.4
3.5	4.53	8.34	4.77	10.2	5.00	12.3
4.0	4.84	8.91	5.10	10.9	5.34	13.1
4.5	5.14	9.46	5.41	11.6	5.67	13.9
5.0	5.42	9.97	5.70	12.2	5.98	14.7

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter......	3′		3½′		4′	
Total Area...... / Area to C.L......	4.28 / 3.54		5.82 / 4.81		7.61 / 6.28	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	.88	3.12	.99	4.76	1.10	6.91
0.15	1.11	3.93	1.24	5.96	1.37	8.60
0.20	1.30	4.60	1.45	6.97	1.60	10.0
0.25	1.47	5.20	1.63	7.84	1.80	11.3
0.30	1.62	5.73	1.80	8.66	1.98	12.4
0.35	1.75	6.19	1.95	9.38	2.15	13.5
0.40	1.88	6.66	2.10	10.1	2.30	14.4
0.45	2.00	7.08	2.23	10.7	2.45	15.4
0.50	2.11	7.47	2.35	11.3	2.58	16.2
0.55	2.22	7.86	2.47	11.9	2.71	17.0
0.60	2.32	8.21	2.59	12.5	2.84	17.8
0.65	2.42	8.57	2.69	12.9	2.96	18.6
0.70	2.51	8.89	2.80	13.5	3.07	19.3
0.75	2.61	9.24	2.90	13.9	3.18	20.0
0.80	2.69	9.52	3.00	14.4	3.29	20.7
0.85	2.78	9.84	3.09	14.9	3.39	21.3
0.90	2.86	10.1	3.18	15.3	3.49	21.9
0.95	2.94	10.4	3.27	15.7	3.59	22.5
1.00	3.02	10.7	3.36	16.2	3.68	23.1
1.1	3.17	11.2	3.52	16.9	3.86	24.2
1.2	3.31	11.7	3.68	17.7	4.04	25.4
1.3	3.45	12.2	3.83	18.4	4.21	26.4
1.4	3.58	12.7	3.98	19.1	4.37	27.4
1.5	3.71	13.1	4.12	19.8	4.52	28.4
1.6	3.83	13.6	4.26	20.5	4.67	29.3
1.7	3.95	14.0	4.40	21.2	4.82	30.3
1.8	4.07	14.4	4.53	21.8	4.96	31.1
1.9	4.18	14.8	4.65	22.4	5.10	32.0
2.0	4.29	15.2	4.77	22.9	5.23	32.8
2.5	4.80	17.0	5.34	25.7	5.85	36.7
3.0	5.27	18.7	5.85	28.1	6.42	40.3
3.5	5.69	20.1	6.32	30.4	6.93	43.5
4.0	6.08	21.5	6.76	32.5	7.42	46.6
4.5	6.46	22.9	7.17	34.5	7.86	49.4
5.0	6.81	24.1	7.56	36.4	8.29	52.1

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	4½′		5′		5½′	
Total Area	9.62		11.89		14.38	
Area to C.L.	7.95		9.82		11.88	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	1.20	9.54	1.29	12.7	1.38	16.4
0.15	1.49	11.8	1.61	15.8	1.72	20.4
0.20	1.74	13.8	1.87	18.4	2.00	23.8
0.25	1.96	15.6	2.10	20.6	2.24	26.6
0.30	2.15	17.1	2.31	22.7	2.47	29.3
0.35	2.33	18.5	2.50	24.5	2.67	31.7
0.40	2.50	19.9	2.68	26.3	2.86	34.0
0.45	2.66	21.1	2.85	28.0	3.04	36.1
0.50	2.81	22.3	3.01	29.6	3.21	38.1
0.55	2.95	23.5	3.16	31.0	3.37	40.0
0.60	3.08	24.5	3.30	32.4	3.52	41.8
0.65	3.21	25.5	3.44	33.8	3.67	43.6
0.70	3.33	26.5	3.58	35.2	3.81	45.3
0.75	3.45	27.4	3.70	36.3	3.94	46.8
0.80	3.56	28.3	3.83	37.6	4.07	48.4
0.85	3.68	29.2	3.95	38.8	4.20	49.9
0.90	3.79	30.1	4.07	40.0	4.33	51.4
0.95	3.90	31.0	4.18	41.0	4.45	52.9
1.00	4.00	31.8	4.29	42.1	4.56	54.2
1.1	4.20	33.4	4.50	44.2	4.79	56.9
1.2	4.38	34.8	4.70	46.1	5.00	59.4
1.3	4.56	36.2	4.89	48.0	5.21	61.9
1.4	4.74	37.7	5.08	49.9	5.40	64.2
1.5	4.91	39.0	5.26	51.6	5.60	66.6
1.6	5.07	40.3	5.43	53.3	5.78	68.7
1.7	5.23	41.6	5.60	55.0	5.96	70.8
1.8	5.38	42.8	5.76	56.6	6.14	73.0
1.9	5.53	44.0	5.92	58.1	6.31	75.0
2.0	5.67	45.1	6.08	59.7	6.48	77.0
2.5	6.34	50.4	6.81	66.9	7.25	86.2
3.0	6.96	55.3	7.46	73.2	7.94	94.4
3.5	7.51	59.7	8.06	79.2	8.58	102.
4.0	8.03	63.8	8.61	84.6	9.17	109.
4.5	8.53	67.8	9.14	89.8	9.70	115.
5.0	8.98	71.4	9.64	94.7	10.2	121.

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	6′		6½′		7′	
Total Area	17.11		20.08		23.29	
Area to C.L.	14.14		16.59		19.24	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	1.46	20.6	1.56	25.9	1.64	31.5
0.15	1.82	25.7	1.93	32.0	2.03	39.1
0.20	2.12	30.0	2.24	37.2	2.36	45.4
0.25	2.38	33.6	2.51	41.7	2.64	50.8
0.30	2.62	37.0	2.76	48.8	2.90	55.8
0.35	2.83	40.0	2.99	49.6	3.14	60.4
0.40	3.03	42.8	3.20	53.1	3.36	64.6
0.45	3.22	45.5	3.40	56.4	3.57	68.7
0.50	3.40	48.1	3.59	59.6	3.77	72.5
0.55	3.57	50.5	3.77	62.5	3.95	76.0
0.60	3.74	52.9	3.94	65.4	4.13	79.5
0.65	3.89	55.0	4.10	68.0	4.30	92.7
0.70	4.04	57.1	4.26	70.7	4.47	86.0
0.75	4.18	59.1	4.41	73.2	4.63	89.1
0.80	4.32	61.1	4.55	75.5	4.78	92.0
0.85	4.45	62.9	4.69	77.8	4.93	94.9
0.90	4.59	64.9	4.83	80.1	5.08	97.7
0.95	4.72	66.7	4.97	82.5	5.21	100.
1.00	4.84	68.4	5.10	84.6	5.35	103.
1.1	5.07	71.7	5.35	88.8	5.62	108.
1.2	5.30	74.9	5.59	92.7	5.87	113.
1.3	5.52	78.1	5.81	96.4	6.11	118.
1.4	5.73	81.0	6.04	100.	6.34	122.
1.5	5.93	83.9	6.25	104.	6.56	126.
1.6	6.13	86.7	6.46	107.	6.77	130.
1.7	6.32	89.4	6.66	110.	6.98	134.
1.8	6.51	92.1	6.85	114.	7.19	138.
1.9	6.68	94.5	7.03	117.	7.39	142.
2.0	6.85	96.9	7.22	120.	7.58	146.
2.5	7.67	108.	8.07	134.	8.49	163.
3.0	8.41	119.	8.86	147.	9.31	179.
3.5	9.08	128.	9.57	159.	10.0	192.
4.0	9.71	137.	10.2	169.	10.7	206.
4.5	10.3	146.	10.9	181.	11.4	219.
5.0	10.9	154.	11.4	189.	12.0	231.

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	7½′		8′		8½′	
Total Area	26.74		30.43		34.35	
Area to C.L.	22.09		25.14		28.38	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	1.72	38.0	1.80	45.3	1.88	53.3
0.15	2.13	47.0	2.23	56.1	2.32	65.8
0.20	2.47	54.6	2.58	64.9	2.68	76.1
0.25	2.77	61.2	2.89	72.7	3.01	85.4
0.30	3.04	67.2	3.18	80.0	3.30	93.7
0.35	3.29	72.7	3.44	86.5	3.56	101.
0.40	3.52	77.8	3.68	92.5	3.82	108.
0.45	3.74	82.6	3.90	98.1	4.05	115.
0.50	3.94	87.0	4.11	103.	4.28	121.
0.55	4.14	91.4	4.32	109.	4.49	127.
0.60	4.32	95.4	4.51	113.	4.69	133.
0.65	4.50	99.4	4.70	118.	4.89	139.
0.70	4.67	103.	4.87	122.	5.07	144.
0.75	4.84	107.	5.05	127.	5.27	150.
0.80	5.00	110.	5.22	131.	5.43	154.
0.85	5.15	114.	5.38	135.	5.59	159.
0.90	5.30	117.	5.53	139.	5.77	164.
0.95	5.45	120.	5.69	143.	5.91	168.
1.00	5.60	124.	5.84	147.	6.06	172.
1.1	5.87	130.	6.12	154.	6.36	180.
1.2	6.13	135.	6.39	161.	6.65	189.
1.3	6.38	141.	6.66	167.	6.92	196.
1.4	6.63	146.	6.91	174.	7.18	204.
1.5	6.86	151.	7.16	180.	7.44	211.
1.6	7.08	156.	7.38	186.	7.68	218.
1.7	7.31	161.	7.61	191.	7.92	225.
1.8	7.52	166.	7.83	197.	8.15	231.
1.9	7.73	171.	8.06	203.	8.38	238.
2.0	7.93	175.	8.27	208.	8.60	244.
2.5	8.87	196.	9.24	232.	9.62	273.
3.0	9.72	215.	10.1	254.	10.5	298.
3.5	10.5	232.	10.9	274.	11.4	324.
4.0	11.2	247.	11.7	294.	12.1	343.
4.5	11.9	263.	12.4	312.	12.9	366.
5.0	12.6	278.	13.1	329.	13.6	386.

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	9′		9½′		10′	
Total Area	38.51		42.90		47.54	
Area to C.L.	31.81		35.44		39.27	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	1.95	62.0	2.03	71.9	2.10	82.4
0.15	2.41	76.7	2.50	88.6	2.58	101.
0.20	2.79	88.7	2.89	102.	2.99	117.
0.25	3.12	99.2	3.24	115.	3.35	132.
0.30	3.43	109.	3.55	126.	3.67	144.
0.35	3.71	118.	3.84	136.	3.97	156.
0.40	3.97	126.	4.11	146.	4.25	167.
0.45	4.21	134.	4.36	155.	4.50	177.
0.50	4.44	141.	4.59	163.	4.75	186.
0.55	4.66	148.	4.82	171.	4.98	195.
0.60	4.86	155.	5.04	179.	5.21	205.
0.65	5.07	161.	5.25	186.	5.42	213.
0.70	5.26	167.	5.45	193.	5.63	221.
0.75	5.44	173.	5.64	200.	5.82	228.
0.80	5.63	179.	5.83	207.	6.02	236.
0.85	5.80	185.	6.00	213.	6.20	243.
0.90	5.97	190.	6.18	219.	6.38	250.
0.95	6.13	195.	6.35	225.	6.56	258.
1.00	6.29	200.	6.51	231.	6.73	264.
1.1	6.60	210.	6.84	242.	7.06	277.
1.2	6.90	219.	7.14	253.	7.38	290.
1.3	7.18	228.	7.43	263.	7.68	301.
1.4	7.45	237.	7.72	273.	7.97	313.
1.5	7.72	245.	7.99	283.	8.25	324.
1.6	7.97	254.	8.25	292.	8.52	334.
1.7	8.22	262.	8.50	301.	8.78	345.
1.8	8.46	269.	8.74	310.	9.04	355.
1.9	8.69	276.	8.98	318.	9.28	364.
2.0	8.92	284.	9.22	327.	9.52	374.
2.5	9.96	317.	10.3	365.	10.7	420.
3.0	10.9	347.	11.3	400.	11.7	459.
3.5	11.9	377.	12.2	432.	12.6	495.
4.0	12.6	401.	13.0	461.	13.5	530.
4.5	13.4	426.	13.8	489.	14.3	561.
5.0	14.1	449.	14.6	517	15.1	592.

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	11′		12′		13′	
Total Area	57.52		68.46		80.34	
Area to C.L.	47.52		56.55		66.37	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	2.24	106.	2.38	135.	2.51	167.
0.15	2.75	131.	2.92	165.	3.07	204.
0.20	3.18	151.	3.37	190.	3.55	235.
0.25	3.56	169.	3.77	213.	3.97	263.
0.30	3.90	185.	4.13	234.	4.35	289.
0.35	4.22	201.	4.46	252.	4.69	311.
0.40	4.51	214.	4.77	270.	5.02	333.
0.45	4.79	227.	5.06	288.	5.32	353.
0.50	5.05	240.	5.34	302.	5.61	372.
0.55	5.29	251.	5.59	318.	5.89	391.
0.60	5.53	263.	5.84	330.	6.14	407.
0.65	5.76	274.	6.08	344.	6.40	425.
0.70	5.97	284.	6.31	357.	6.64	441.
0.75	6.19	294.	6.54	370.	6.87	458.
0.80	6.39	304.	6.76	382.	7.10	471.
0.85	6.59	313.	6.96	393.	7.31	485.
0.90	6.78	322.	7.16	405.	7.54	500.
0.95	6.97	331.	7.36	418.	7.74	514.
1.00	7.15	340.	7.55	427.	7.93	527.
1.1	7.52	357.	7.92	448.	8.32	552.
1.2	7.84	373.	8.27	468.	8.70	577.
1.3	8.16	388.	8.61	487.	9.05	601.
1.4	8.46	402.	8.94	505.	9.40	624.
1.5	8.76	416.	9.25	523.	9.72	645.
1.6	9.04	430.	9.55	540.	10.0	664.
1.7	9.33	443.	9.84	556.	10.3	683.
1.8	9.59	456.	10.1	571.	10.6	704.
1.9	9.86	468.	10.4	588.	11.0	730.
2.0	10.1	480.	10.7	605.	11.2	744.
2.5	11.3	537.	11.9	673.	12.5	830.
3.0	12.4	589.	13.1	741.	13.7	909.
3.5	13.4	637.	14.1	798.	14.8	982.
4.0	14.3	680.	15.1	854.		
4.5	15.2	722.				

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	14′		15′		16′	
Total Area	93.18		106.97		121.70	
Area to C.L.	76.97		88.36		100.53	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	2.63	202.	2.76	244.	2.88	290.
0.15	3.22	248.	3.37	298.	3.52	354.
0.20	3.72	286.	3.89	344.	4.05	407.
0.25	4.16	320.	4.34	383.	4.53	456.
0.30	4.55	350.	4.75	420.	4.95	498.
0.35	4.92	379.	5.13	453.	5.35	538.
0.40	5.26	405.	5.48	484.	5.71	574.
0.45	5.58	430.	5.82	514.	6.06	610.
0.50	5.88	453.	6.13	542.	6.38	641.
0.55	6.17	475.	6.43	568.	6.69	673.
0.60	6.44	496.	6.71	593.	6.99	703.
0.65	6.70	516.	6.99	617.	7.27	731.
0.70	6.95	535.	7.26	641.	7.55	759.
0.75	7.20	554.	7.51	663.	7.82	787.
0.80	7.44	573.	7.75	685.	8.08	813.
0.85	7.66	589.	7.99	707.	8.32	837.
0.90	7.89	607.	8.23	727.	8.55	860.
0.95	8.10	623.	8.45	747.	8.79	884.
1.00	8.31	640.	8.67	766.	9.02	907.
1.1	8.72	671.	9.10	804.	9.45	950.
1.2	9.10	700.	9.50	839.	9.88	993.
1.3	9.48	729.	9.90	875.	10.3	1040.
1.4	9.83	757.	10.3	910.	10.7	1080.
1.5	10.2	785.	10.6	937.	11.0	1110.
1.6	10.5	808.	11.0	972.	11.4	1150.
1.7	10.8	831.	11.3	998.	11.8	1190.
1.8	11.1	855.	11.6	1020.	12.1	1220.
1.9	11.4	878.	11.9	1050.	12.4	1250.
2.0	11.7	901.	12.2	1080.	12.8	1290.
2.5	13.1	1010.	13.7	1210.	14.2	1430.
3.0	14.4	1110.	15.0	1330.	15.6	1570.
3.5	15.5	1190.				

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	17′		18′		19′	
Total Area / Area to C.L.	137.39 / 113.49		154.03 / 127.24		171.62 / 141.77	
Fall in Feet per 1000 Ft.	Velocity	Discharge	Velocity	Discharge	Velocity	Discharge
0.10	2.99	339.	3.11	396.	3.22	457.
0.15	3.65	414.	3.79	482.	3.92	556.
0.20	4.21	478.	4.36	555.	4.51	640.
0.25	4.69	532.	4.87	620.	5.04	715.
0.30	5.14	583.	5.33	678.	5.51	781.
0.35	5.55	630.	5.75	732.	5.94	842.
0.40	5.93	673.	6.15	783.	6.35	900.
0.45	6.29	714.	6.52	830.	6.73	954.
0.50	6.62	752.	6.87	875.	7.09	1000.
0.55	6.95	789.	7.20	916.	7.42	1050.
0.60	7.26	824.	7.52	957.	7.76	1100.
0.65	7.55	857.	7.83	996.	8.08	1150.
0.70	7.84	890.	8.12	1030.	8.38	1190.
0.75	8.12	922.	8.40	1070.	8.68	1230.
0.80	8.37	950.	8.67	1100.	8.96	1270.
0.85	8.63	979.	8.94	1140.	9.24	1310.
0.90	8.88	1010.	9.20	1170.	9.51	1350.
0.95	9.12	1030.	9.44	1200.	9.76	1380.
1.00	9.36	1060.	9.70	1230.	10.0	1420.
1.1	9.81	1110.	10.2	1300.	10.5	1490.
1.2	10.2	1160.	10.6	1350.	10.9	1550.
1.3	10.7	1210.	11.0	1400.	11.4	1620.
1.4	11.1	1260.	11.5	1460.	11.9	1690.
1.5	11.4	1290.	11.9	1510.	12.2	1730.
1.6	11.8	1340.	12.2	1550.	12.6	1790.
1.7	12.2	1380.	12.6	1600.	13.0	1840.
1.8	12.6	1430.	13.0	1650.	13.4	1900.
1.9	12.9	1460.	13.3	1690.	13.8	1960.
2.0	13.2	1500.	13.7	1740.	14.1	2000.
2.5	14.8	1680.	15.3	1950.	15.8	2240.

FLOW OF WATER THROUGH SEMI-CIRCULAR WOOD FLUME

Areas in Square Feet.
Velocity in Feet per Second.
Discharge in Cubic Feet per Second, for Area to Center Line.
(n = 0.013)

Table No. 25 (Continued)

Diameter	20′				
Total Area / Area to C.L.	190.16 / 157.08				
Fall in Feet per 1000 Ft.	Vel.	Dis.	Fall in Feet per 1000 Ft.	Vel.	Dis.
0.10	3.32	522.	0.85	9.52	1500.
0.15	4.05	636.	0.90	9.80	1540.
0.20	4.66	732.	0.95	10.1	1590.
0.25	5.20	817.	1.00	10.3	1620.
0.30	5.68	892.	1.1	10.8	1700.
0.35	6.13	963.	1.2	11.3	1780.
0.40	6.55	1030.	1.3	11.8	1850.
0.45	6.94	1090.	1.4	12.2	1920.
0.50	7.32	1150.	1.5	12.6	1960.
0.55	7.67	1200.	1.6	13.0	2040.
0.60	8.00	1260.	1.7	13.4	2100.
0.65	8.34	1310.	1.8	13.8	2170.
0.70	8.65	1360.	1.9	14.2	2230.
0.75	8.95	1410.	2.0	14.6	2290.
0.80	9.24	1450.	2.5	16.3	2560.

HIGH VELOCITY FLUMES

This company has, over the years, installed a number of semi-circular flumes on relatively steep grades. These grades have been considerably steeper than those ordinarily encountered for normal flume service; but, at the same time, not steep enough so that the structures could be properly classified as chutes.

High velocities are developed, and our flume seems particularly suitable for such service. The freeboard is curved in above the water surface, which tends to level off surface irregularities which are certain to develop as a result of the high velocity. The flume has remarkable resistence to abrasion and a lining may be easily applied, if and when required. It has exceptional strength, coupled with natural characteristics which tend to dampen out any tendency toward rythmic vibration, which is frequently associated with high velocity. In some instances, particularly if

HIGH VELOCITY SEMI-CIRCULAR FLUME FLOW TABLE

Table No. 26

Size of Flume	24″		30″		36″		48″		60″		72″		84″	
Slope Feet, Per 1000 Feet	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.	V.	Q.
5	5.11	8.02	5.99	14.7	6.82	24.1	8.29	52.1	9.64	94.6	10.9	154.	12.0	231.
6	5.59	8.77	6.55	16.1	7.45	26.3	9.07	57.0	10.5	103.	11.9	168	13.1	252.
8	6.45	10.1	7.57	18.6	8.61	30.4	10.5	65.9	12.2	120	13.8	195	15.1	275.
10	7.21	11.3	8.47	20.8	9.62	34.0	11.7	73.6	13.6	133	15.4	207.	16.9	309.
15	8.84	13.9	10.4	25.5	11.8	41.8	14.3	89.9	16.7	156.	18.9	253.	20.7	358.
20	10.2	16.0	12.0	29.5	13.6	48.1	16.5	99.	19.3	179.	21.8	287.	23.9	414.
25	11.4	17.9	13.4	32.9	15.2	51.1	18.5	110.	21.5	190.	24.4	310.	27.	437.
50	10.1	23.9	18.9	44.2	21.5	68.5	26.	139.	30.	239.	34.	390.	38.	583.
75	19.7	29.3	23.1	51.	26.	79.1	.....	.....	.....	.....	.....	.....	.....	.....
100	22.8	32.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Size of Flume	**96″**		**102″**		**108″**		**114″**		**120″**		**132″**		**144″**	
5	13.1	330	13.6	386.	14.1	448	14.6	517	15.1	562	15.9	718.	16.9	908.
6	14.3	360	14.9	423.	15.4	465	15.9	535.	16.5	615	17.4	786	18.5	993.
8	16.6	396.	17.2	464	17.8	538	18.5	623	19.1	713	20.2	864	21.3	1085.
10	18.5	442.	19.2	517	19.9	602.	20.6	657.	21.3	752	22.5	963.	23.9	1215.
15	22.7	514.	23.5	600	24.4	698	25	762	26.	871	28.	1113	29.	1407.
20	26.	560.	27.	656	28.	762	29	879.	30.	946	32.	1210.	34.	1527.
25	29.	635.	30.	689	31	800.	33	924.	34.	1057.	36.	1360.	38.	1703.
50	41.	780.	43.	916	45.	1062	46.	1225.	48.	1404.	50.	1675.	53.	2110.

V. = Velocity in Feet per Second.
Q. = Discharge in C. F. S., with factor of safety.

spray may accumulate in the form of ice on the spreaders, we would suggest the open top type of flume illustrated on Page 103.

The above table is presented to supply information needed when such high velocity flumes are being considered. It has been prepared in consultation with an eminent authority. Factors of safety for discharge which increase with increased velocity, have been included in the capacity figures presented. Judgment must be employed in the application of this table, and we wish to emphasize the importance of giving careful attention to the following:

Intakes should deliver squarely into the flume. Extra freeboard, and possibly a cover, should be provided near the intake. Velocities are all faster than critical, so that sharp curvature or a series of curves may cause "hydraulic jump." Accordingly, sharp

curves should not be attempted as they may cause serious difficulty, particularly for the very high velocities.

The behavior of such flumes should be closely observed when service is started. The necessity for covers may be anticipated, at least for flows below the solid black line established across the table. Covers may be attached to the underside of flume spreaders, and should be provided with openings at intervals of about 100 feet for release of possible vacuum. These openings might well be a minimum of 1-foot deep, extending all the way across the flume and with the down-stream cover overlapping the up-stream cover in shingle fashion. A substantial grating across such an opening is necessary, because a strong down-draft might easily suck a child—or even a man—into the flume.

Outlet of High Velocity Flume

Curved Pipe and Flume

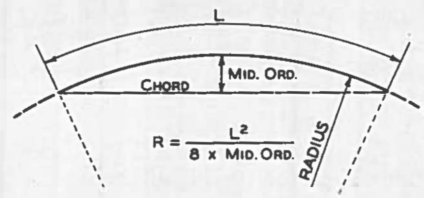
Compound Curve — horizontal and vertical

CURVATURE

How to Determine Radius of a Curve

(Approximate, but sufficiently accurate for curves as encountered for pipe line location)

Lay off any convenient length arc (L) on the curve, establish the chord of the arc, and measure the middle ordinate.



Example: L = 64 ft.
Mid. Ord. = 4 ft.

$$\frac{64^2}{8 \times 4} = 128 \text{ feet radius}$$

It may also be convenient to apply the equation in this form:

$$\text{Mid. Ord.} = \frac{L^2}{8 \times R}$$

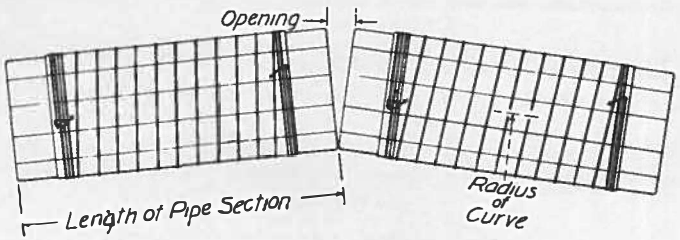
RADII OF CURVES

Radius 1° Curve = 5729.65 Feet

Table No. 27

Degree	Radius in Ft.	Degree	Radius in Ft.	Degree	Radius in Ft.
5	1146	18	320	35	166
6	955	19	303	40	146
7	819	20	288	45	131
8	717	21	274	50	118
9	637	22	262	60	100
10	574	23	251	70	87
11	522	24	240	80	78
12	478	25	231	90	71
13	442	26	222	100	65
14	410	27	214	110	61
15	383	28	207	120	58
16	359	29	200	130	55
17	338	30	193		

CURVATURE IN WIRE-WOUND PIPE



The minimum radius for the installation of wire-wound pipe depends upon the permissible opening between ends of sections, at the outside, at each coupling. For a given opening, the shorter the length of pipe sections, the sharper is the curvature which may be accomplished.

Pipe is shipped in random lengths from 6 to 20 feet long. If the shorter pieces are used for curves, the ordinary assortment of lengths will take care of considerable moderate curvature. Curvature should be investigated, however, and it is advisable to tabulate the footage required for various radii. Relatively small orders, intended for locations having considerable sharp curvature, deserve particular attention, as small lots of pipe might not include the normal assortment of section lengths.

A ⅜″ opening has frequently been exceeded for rather high-head lines with entirely satisfactory results, but we recommend selection of lengths for curves, as follows:

Heads up to and including 250 feet............⅜″ opening
Heads 300 feet and up to 400 feet..................¼″ opening
Heads over 400 feet..⅛″ opening

Backfilling and tamping at the outside of sharp curves should be handled with particular care to prevent movement when the pipe is placed under pressure. Blocking will be necessary for pipe lines placed above ground.

WIRE WOUND PIPE CURVATURE CALCULATIONS

RADII IN FEET

Table No. 28

I. D. of Pipe	2″	3″	4″	5″	6″	8″	10″	12″	14″	16″	18″	20″	22″	24″
Length of Pipe Sections, Feet														
	Opening ⅛ Inch													
2	64	80	98	114	132	164	196	230	262	296	328	362	394	426
3	96	120	147	171	198	246	294	345	393	444	492	543	591	639
4	128	160	196	228	264	328	392	460	524	592	656	724	788	852
5	160	200	245	285	330	410	490	575	655	740	820	905	985	1065
6	192	240	295	342	396	492	588	690	786	888	984	1086	1182	1278
	Opening ¼ Inch													
2	32	40	49	57	66	82	98	115	131	148	164	181	197	213
3	48	60	74	86	99	123	147	173	197	222	246	272	296	320
4	64	80	98	114	132	164	196	230	262	296	328	362	394	426
5	80	100	123	143	165	205	245	288	328	370	410	453	493	533
6	96	120	147	171	198	246	294	345	393	444	492	543	591	639
	Opening ⅜ Inch													
2	22	27	33	38	44	55	66	77	88	99	110	121	132	142
3	32	40	49	57	66	82	98	115	131	148	164	181	197	213
4	43	54	66	76	88	110	131	152	175	196	219	242	263	284
5	54	67	82	95	110	137	164	192	219	247	274	302	329	355
6	64	80	98	114	132	164	196	230	262	296	328	362	394	436

Example: 6″ pipe, for heads of 250 feet, or less, permitting ⅜″ opening for good design. Radius of curve, 125 feet. Glancing at the table, it will be seen that 6-foot lengths are suitable for radii of from 110 to 132 feet, and sufficient six-foot lengths should be specified for this curve. For 300, 350 and 400-foot head pipe, with ¼″ permissible opening, sufficient four-foot lengths should be ordered.

8″ on Reverse Curve

CURVATURE FOR CONTINUOUS STAVE PIPE AND FLUME CONSTRUCTION

Continuous Stave Pipes and Flumes are almost invariably constructed on curves by building a section on tangent, placing only a few bands moderately tightened to hold the circular shape; and then the pipe is forced over into the curve. After this, the staves are driven to produce tight butt joints, and the bands tightened. Building in securely anchored cradles, the curves are partially built in, but since the pipe tends to climb on the outside, the curve is completed largely by means of forcing the outside down at the same time it is forced over into the cradles.

Small sizes can be forced into moderate curves simply by the entire building crew lifting and prying, and the cost is slight if there is sufficient width of trench to permit building a twenty-foot section on tangent, before "throwing in" the curve. In the case of larger sizes on moderate curvature, or small sizes on sharp curvature, additional power must be obtained by means of jacks or block and tackle; and, obviously, there must be something solid against which power can be applied.

The above general explanation of the method of building on a curve has been included to indicate the conditions required for building on curves, and to point out the fact that working conditions are of equal, or even greater, importance than the size of pipe. It will be apparent that it is almost impossible to fix definite limits for curvature, and the following table is presented to indicate the reasonable economical radius for continuous stave pipe and flume construction.

Excellent Conditions

Extremely sharp curvature is possible for experienced workmen constructing pipe under ideal conditions, with ample width of trench or bench, and with favorable conditions for the use of jacks or block and tackle. Such construction is expensive, and it is only rarely that curvature should be contemplated sharper than indicated below for "good conditions."

Good Conditions

Construction costs increase appreciably for curvature listed under this heading. Radii listed under this heading call for reasonably favorable conditions, and should be selected only in case location on easier curvature involves considerable expense.

Average Conditions

Construction on curvatures listed adds something to construction costs, but this may be disregarded for a few short curves comprising only a small percentage of a pipe line. The radii listed under this heading may ordinarily be selected as most suitable for design.

Poor Conditions

These values should be selected for minimum radius for conditions which are unfavorable. The added cost of construction is ordinarily very slight.

MINIMUM ECONOMICAL CURVATURE FOR CONTINUOUS STAVE WOOD PIPE AND FLUME

Radii in Feet

Table No. 29

Pipe or Flume Diameter in Feet	Good Conditions Radius	Average Conditions Radius	Poor Conditions Radius
2	80	100	120
2½	100	125	150
3	120	150	180
3½	145	175	210
4	165	205	245
4½	185	230	275
5	210	260	310
5½	230	285	340
6	250	310	370
7	300	370	440
8	345	425	500
9	395	485	575
10	435	535	635
11	475	580	690
12	510	630	750
13	550	675	805
14	580	720	860
16	660	815	980
18	750	910	1100
20	800	1000	1200

THE MANNING FORMULA

This formula, derived in 1890 by Manning, an Irish engineer, is adapted to the determination of the capacities of canals, flumes, pipes, streams and channels of all types. The results obtained, using this formula, differ but slightly from those obtained using the well-known Kutter Formula; and, because of its simplicity, it has gained rapidly in popularity. Although the Scobey Formula has been employed herein for wood pipe because of its acknowledged accuracy for this particular conduit and, even though the Kutter Formula has been used for semi-circular wood stave flumes because of a long established precedent, we do join with many others in favoring the Manning Formula for general use.

Expressed as a modification of the Chezy Formula (See Page 135), the Manning Formula is:

$$V = \frac{1.486\ r^{1/6}}{n} \sqrt{r\ s}$$

As usually stated, for general application, it is:

$$V = \frac{1.486}{n}\ r^{2/3}\ s^{1/2}$$

In which V = Velocity of water in feet per second

n = Coefficient of roughness (Kutter)

r = Hydraulic Radius = $\frac{\text{Cross-sectional Area of Water in Square Feet}}{\text{Wetted Perimeter in lin. ft.}}$

NOTE: *In the case of circular conduits flowing full, or exactly one-half full, the hydraulic radius is always one-fourth of the diameter.*

s = Slope in feet per foot of length = $\frac{\text{Fall in Feet}}{\text{Length in Feet}}$

Selection of the proper value of "n" is a most important consideration in the application of this or any similar formula and is usually a matter of some uncertainty. Laboratory tests and the most favorable field tests may indicate rather low values, but numerous tests under operating conditions during the past quarter of a century have resulted in the general adoption of somewhat more conservative values than those formerly used. Extensive information on this subject is available from various sources, but any table of recommended values requires considerable judgment or experience for its proper application. The following table represents a consensus of opinion of values for "n" for general use, for the particular types of channels which we have attempted to cover:

Approximate Values of "n" for Manning Formula

Channel Surface	*Coefficient of Roughness "n"*
Glazed or enameled, in perfect order	.010
Semi-circular wood flumes, or other planed wood	.013
Unplaned plank flumes, or exceptionally smooth concrete lined canals	.014
Plank flumes with battens, or reasonably smooth concrete lined canals	.015
Canals of fine, firm gravel in excellent condition	.020
Canals of coarse gravel or earth, in fair condition, with no vegetation	.025
Canals or natural streams, in rather poor condition, with some weeds and stones	.030
Canals or natural streams, in poor condition and with reasonably extensive vegetation	.035
Canals or natural streams, in quite bad condition, with considerable vegetation	.040

Solution of Manning Formula

The table beginning on Page 243 gives the 2/3 powers of numbers, and a table of the square roots of decimal numbers will be found on Page 247. These may be used for direct solution of the formula. The table beginning on Page 239 will, however, be found suitable for most problems and offers an easy solution.

FLOW OF WATER IN CHANNELS AND CONDUITS OF ALL TYPES

Determination of A = Area

The cross-sectional area in square feet of water flowing through the channel must be determined. This is a very simple calculation in the case of rectangular flumes, and is not at all difficult for other standard canal sections. The approximate total area of small streams may be determined by adding the area of various vertical sections.

Determination of Wetted Perimeter

This must be determined as a step toward establishing the hydraulic radius of the channel. It is the length in linear feet of the bottom of a channel, plus the length of the sides which come in contact with the water. It is simply the length in feet, measured on a cross-section of the channel, of that portion of the channel walls which would be wetted. In a pipe flowing full this would, of course, be the inside circumference in feet.

The following table may assist in the determination of A and for the wetted perimeter.

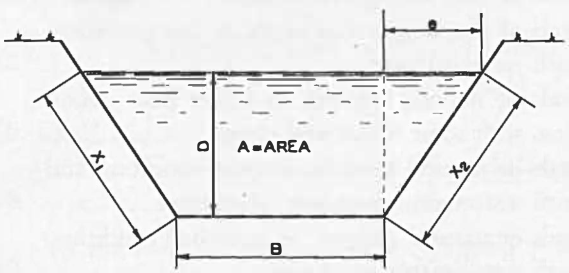


Table No. 30

Slope of Sides, or Ratio of Horizontal to Vertical	To Determine "e", Multiply D by —	To Determine X_1 or X_2, the Length of either Wetted Side, Multiply D by —
½ to 1	0.5	1.118
1 to 1	1.0	1.414
1½ to 1	1.5	1.803
2 to 1	2.0	2.236
2½ to 1	2.5	2.692
3 to 1	3.0	3.162

Determine e as indicated, add B, and multiply by D for area, A.

Determine X_1 and X_2 as indicated, add together, and add B, for the wetted perimeter.

$$\text{Then: } r = \frac{A}{\text{Wetted Perimeter}}$$

Use of Tables

Turn to the flow table and find the tabular number under this value of r which is opposite the fall in feet per thousand feet in length of the channel. Divide this tabular number as indicated at the top of the table for the particular coefficient of n which may be selected. This will give the average velocity of the water flowing through the channel in feet per second. Multiply the area, A, by the velocity, to obtain Q, the discharge in cubic feet per second.

Example: Problem: To find capacity, Q, for a concrete lined canal.

Given: A canal 6 feet wide at base,
1½ : 1 side slopes
2 feet water depth
Total length—5000 ft.
Total fall— 6 ft.

Solution:

$e = 2 \times 1.5 = 3$

$A = e + B = 9$ ft., multiplied by $D = 18$ sq. ft.

Wetted Perimeter $= X_1 = 2 \times 1.803 = 3.606$

$X_2 = 2 \times 1.803 = 3.606$

$B = 6.$

13.212

$$r = \frac{18}{13.212} = 1.36 +$$

$$\text{Slope} = \frac{6 \text{ feet}}{5} = 1.2 \text{ ft. fall per 1000 feet of length.}$$

Under $r = 1.4$ and opposite 1.2 feet fall per 1000 feet of length in the table, we find the tabular number 64.4.

Selecting a value $n = 0.015$ for concrete lined canals,

$$V = \frac{64.4}{15} = 4.3 \text{ feet per second.}$$

$$Q = AV = 18 \times 4.3 = 77.4 \text{ cubic feet per second.}$$

NOTE: *Tabular numbers for intermediate values of r or for the fall in feet per 1000 feet, may be established from the table by interpolation. For instance—to determine a more accurate tabular number in the above example:*

Tabular number for $r = 1.4 = 64.4$

Tabular number for $r = 1.2 = 58.1$

Difference $= 6.3$

To find tabular number for $r = 1.36$

$16/20 \times 6.3 =$ 5.04

Adding 58.10

Tabular number, by interpolation 63.14

$$\text{Then: } V = \frac{63.14}{15} = 4.21$$

$$Q = 18 \times 4.21 = 75.8$$

Which shows a reduction of 2½% for this more accurate calculation.

Velocity Head Allowance

In addition to the above total fall of 6 feet, allowance must be made at the intake for the fall required to develop a velocity of 4.3 feet per second. Turning to the table on Page 211, this is found to be 0.29 feet. If this head is not available at the intake, in addition to the total fall of 6 feet, deduct 0.29 feet from 6 feet, and divide by 5, to arrive at the figure of 1.14 as the fall in feet per 1000 feet. The problem should then be re-solved for this fall per 1000 feet, to obtain the correct velocity and discharge.

CHANNEL FLOW TABLE

Flow of Water in Channels and Conduits of all Types

Table for Solution of Manning Formula (Values of 1000 nV)

To determine velocity in Feet per Second:—
Using Kutter's n=0.010 divide tabular number by 10
Using Kutter's n=0.011 divide tabular number by 11, etc.

Table No. 31

Fall in Ft. per 1000 Ft. of Length	HYDRAULIC RADIUS (r) IN FEET											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4
0.05	2.3	3.6	4.7	5.7	6.6	7.5	8.3	9.1	9.8	10.5	11.9	13.2
0.10	3.2	5.1	6.7	8.1	9.4	10.6	11.7	12.8	13.9	14.9	16.8	18.6
0.15	3.9	6.2	8.2	9.9	11.5	13.0	14.4	15.7	17.0	18.2	20.6	22.8
0.20	4.5	7.2	9.4	11.4	13.2	15.0	16.6	18.1	19.6	21.0	23.7	26.3
0.25	5.1	8.0	10.5	12.8	14.8	16.7	18.5	20.3	21.9	23.5	26.5	29.4
0.30	5.6	8.8	11.5	14.0	16.2	18.3	20.3	22.2	24.0	25.7	29.1	32.2
0.35	6.0	9.5	12.5	15.1	17.5	19.8	21.9	24.0	25.9	27.8	31.4	34.8
0.40	6.4	10.2	13.3	16.1	18.7	21.1	23.4	25.6	27.7	29.7	33.6	37.2
0.45	6.8	10.8	14.1	17.1	19.9	22.4	24.9	27.2	29.4	31.6	35.6	39.5
0.50	7.2	11.4	14.9	18.0	20.9	23.6	26.2	28.6	31.0	33.2	37.5	41.6
0.60	7.8	12.5	16.3	19.8	22.9	25.9	28.7	31.4	33.9	36.4	41.1	45.6
0.70	8.5	13.5	17.6	21.3	24.8	28.0	31.0	33.9	36.7	39.3	44.4	49.2
0.80	9.1	14.4	18.8	22.8	26.5	29.9	33.1	36.2	39.2	42.0	47.5	52.6
0.90	9.6	15.3	20.0	24.2	28.1	31.7	35.1	38.4	41.6	44.6	50.3	55.8
1.0	10.1	16.1	21.1	25.5	29.6	33.4	37.0	40.5	43.9	47.0	53.1	58.8
1.2	11.1	17.6	23.1	28.0	32.4	36.6	40.6	44.4	48.0	51.5	58.1	64.4
1.4	11.9	19.0	24.9	30.2	35.0	39.5	43.8	47.9	51.8	55.6	62.8	69.6
1.6	12.8	20.3	26.6	32.3	37.5	42.3	46.9	51.2	55.4	59.4	67.1	74.4
1.8	13.6	21.6	28.3	34.2	39.7	44.9	49.7	54.3	58.7	63.0	71.2	78.9
2.0	14.3	22.7	29.8	36.1	41.9	47.3	52.4	57.3	62.0	66.5	75.1	83.2
2.5	16.0	25.4	33.3	40.3	46.8	52.9	58.6	64.1	69.3	74.3	83.9	93.0
3.0	17.5	27.8	36.5	44.2	51.3	57.9	64.2	70.2	75.9	81.4	91.9	101.9
3.5	18.9	30.1	39.4	47.7	55.4	62.5	69.3	75.8	82.0	87.9	99.3	110.0
4.0	20.2	32.1	42.1	51.0	59.2	66.9	74.1	81.0	87.6	94.0	106.1	117.6
4.5	21.5	34.1	44.7	54.1	62.8	70.9	78.6	85.9	92.9	99.7	112.6	124.8
5.0	22.6	35.9	47.1	57.0	66.2	74.8	82.8	90.6	98.0	105.1	118.7	131.5
6.0	24.8	39.4	51.6	62.5	72.5	81.9	90.8	99.2	107.3	115.1	130.0	144.1
7.0	26.8	42.5	55.7	67.5	78.3	88.4	98.0	107.1	115.9	124.3	140.4	155.6
8.0	28.6	45.5	59.6	72.2	83.7	94.6	104.8	114.5	123.9	132.9	150.1	166.4
9.0	30.4	48.2	63.2	76.5	88.8	100.3	111.1	121.5	131.4	141.0	159.2	176.4
10.0	32.0	50.8	66.6	80.7	93.6	105.7	117.2	128.1	138.5	148.6	167.8	186.0

CHANNEL FLOW TABLE

Flow of Water in Channels and Conduits of all Types

Table for Solution of Manning Formula (Values of 1000 nV)

To determine velocity in Feet per Second:—
Using Kutter's n=0.010 divide tabular number by 10
Using Kutter's n=0.011 divide tabular number by 11, etc.

Table No. 31 (Continued)

Fall in Ft. per 1000 Ft. of Length	HYDRAULIC RADIUS (r) IN FEET										
	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6
0.05	14.4	15.6	16.7	17.8	18.8	19.9	20.9	21.9	22.8	23.8	24.7
0.10	20.3	22.0	23.6	25.1	26.6	28.1	29.5	30.9	32.3	33.6	34.9
0.15	24.9	26.9	28:9	30.8	32.6	34.4	36.2	37.9	39.5	41.2	42.8
0.20	28.8	31.1	33.4	35.6	37.7	39.7	41.7	43.7	45.6	47.5	49.4
0.25	32.1	34.8	37.3	39.7	42.1	44.4	46.7	48.9	51.0	53.1	55.2
0.30	35.2	38.1	40.9	43.5	46.2	48.7	51.1	53.5	55.9	58.2	60.5
0.35	38.0	41.1	44.1	47.0	49.8	52.6	55.2	57.8	60.4	62.9	65.3
0.40	40.7	44.0	47.2	50.3	53.3	56.2	59.0	61.8	64.5	67.2	69.8
0.45	43.1	46.7	50.0	53.3	56.5	59.6	62.6	65.6	68.5	71.3	74.1
0.50	45.4	49.2	52.8	56.2	59.6	62.8	66.0	69.1	72.2	75.1	78.1
0.60	49.8	53.9	57.8	61.6	65.3	68.8	72.3	75.7	79.1	82.3	85.5
0.70	53.8	58.2	62.4	66.5	70.5	74.3	78.1	81.8	85.4	88.9	92.4
0.80	57.5	62.2	66.7	71.1	75.3	79.5	83.5	87.4	91.3	95.0	98.7
0.90	61.0	66.0	70.8	75.4	79.9	84.3	88.6	92.7	96.8	100.8	104.7
1.0	64.3	69.5	74.6	79.5	84.2	88.9	93.4	97.8	102.1	106.3	110.4
1.2	70.4	76.2	81.7	87.1	92.3	97.3	102.3	107.1	111.8	116.4	120.9
1.4	76.1	82.3	88.3	94.1	99.7	105.1	110.5	115.7	120.7	125.7	130.6
1.6	81.3	88.0	94.4	100.6	106.6	112.4	118.1	123.6	129.1	134.4	139.6
1.8	86.2	93.3	100.1	106.6	113.0	119.2	125.2	131.1	136.9	142.6	148.1
2.0	90.9	98.4	105.5	112.4	119.1	125.7	132.0	138.2	144.3	150.3	156.1
2.5	101.6	109.9	118.0	125.7	133.2	140.5	147.6	154.6	161.4	168.0	174.5
3.0	111.3	120.4	129.2	137.7	145.9	153.9	161.7	169.3	176.8	184.0	191.2
3.5	120.3	130.1	139.6	148.7	157.6	166.2	174.7	182.9	190.9	198.8	206.5
4.0	128.6	139.1	149.2	159.0	168.5	177.7	186.7	195.5	204.1	212.5	220.8
4.5	136.4	147.5	158.2	168.6	178.7	188.5	198.0	207.4	216.5	225.4	234.2
5.0	143.8	155.5	166.8	177.7	188.4	198.7	208.7	218.6	228.2	237.6	246.8
6.0	157.5	170.3	182.7	194.7	206.3	217.7	228.7	239.4	250.0	260.3	270.4
7.0	170.1	184.0	197.4	210.3	222.9	235.1	247.0	258.6	270.0	281.1	292.0
8.0	181.8	196.7	211.0	224.8	238.3	251.3	264.0	276.5	288.6	300.5	312.2
9.0	192.9	208.6	223.8	238.5	252.7	266.6	280.1	293.2	306.1	318.8	331.1
10.0	203.3	219.9	235.9	251.4	266.4	281.0	295.2	309.1	322.7	336.0	349.1

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To determine velocity in Feet per Second:—
Using Kutter's n=0.010 divide tabular number by 10
Using Kutter's n=0.011 divide tabular number by 11, etc.

Table No. 31 (Continued)

Fall in Ft. per 1000 Ft. of Length	HYDRAULIC RADIUS (r) IN FEET										
	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0
0.05	25.6	26.5	27.4	28.2	29.1	29.9	30.7	31.5	32.3	33.1	33.9	34.7
0.10	36.2	37.4	38.7	39.9	41.1	42.3	43.5	44.6	45.7	46.9	48.0	49.1
0.15	44.3	45.9	47.4	48.9	50.3	51.8	53.2	54.6	56.0	57.4	58.8	60.1
0.20	51.2	53.0	54.7	56.4	58.1	59.8	61.5	63.1	64.7	66.3	67.8	69.4
0.25	57.2	59.2	61.2	63.1	65.0	66.9	68.7	70.5	72.3	74.1	75.9	77.6
0.30	62.7	64.9	67.0	69.1	71.2	73.2	75.3	77.3	79.2	81.2	83.1	85.0
0.35	67.7	70.1	72.4	74.7	76.9	79.1	81.3	83.4	85.6	87.7	89.7	91.8
0.40	72.4	74.9	77.4	79.8	82.2	84.6	86.9	89.2	91.5	93.7	95.9	98.1
0.45	76.8	79.4	82.1	84.6	87.2	89.7	92.2	94.6	97.0	99.4	101.8	104.1
0.50	80.9	83.7	86.5	89.2	91.9	94.6	97.2	99.7	102.3	104.8	107.3	109.7
0.60	88.6	91.7	94.8	97.7	100.7	103.6	106.4	109.2	112.0	114.8	117.5	120.2
0.70	95.7	99.1	102.4	105.6	108.7	111.9	115.0	118.0	121.0	124.0	126.9	129.8
0.80	102.4	105.9	109.4	112.9	116.3	119.6	122.9	126.2	129.4	132.5	135.7	138.8
0.90	108.6	112.3	116.1	119.7	123.3	126.9	130.4	133.8	137.2	140.6	143.9	147.2
1.0	114.4	118.4	122.3	126.2	130.0	133.7	137.4	141.0	144.6	148.2	151.7	155.3
1.2	125.4	129.7	134.0	138.2	142.4	146.5	150.5	154.5	158.4	162.3	166.2	170.0
1.4	135.4	140.1	144.7	149.3	153.8	158.2	162.6	166.9	171.1	175.3	179.5	183.6
1.6	144.7	149.8	154.7	159.6	164.4	169.1	173.8	178.4	183.0	187.4	191.9	196.3
1.8	153.5	158.9	164.1	169.3	174.4	179.4	184.4	189.2	194.1	198.8	203.5	208.2
2.0	161.8	167.5	173.0	178.4	183.8	189.1	194.3	199.5	204.6	209.6	214.5	219.4
2.5	180.9	187.2	193.4	199.5	205.5	211.4	217.3	223.0	228.7	234.3	239.9	245.4
3.0	198.2	205.1	211.9	218.6	225.1	231.6	238.0	244.3	250.5	256.7	262.8	268.8
3.5	214.1	221.5	228.9	236.1	243.2	250.2	257.1	263.9	270.6	277.2	283.8	290.3
4.0	228.9	236.8	244.7	252.4	260.0	267.4	274.8	282.1	289.3	296.4	303.4	310.3
4.5	242.7	251.2	259.5	267.7	275.7	283.7	291.8	299.2	306.8	314.4	321.8	329.2
5.0	255.9	264.8	273.5	282.1	290.6	299.0	307.2	315.4	323.4	331.4	339.2	347.0
6.0	280.3	290.1	299.6	309.1	318.4	327.5	336.6	345.5	354.3	363.0	371.6	380.1
7.0	302.8	313.3	323.7	333.8	343.9	353.8	363.5	373.2	382.7	392.1	401.4	410.5
8.0	323.7	334.9	346.0	356.9	367.6	378.2	388.6	398.9	409.1	......	......	......
9.0	343.3	355.2	367.0	378.5	389.9	401.2	......	......	......	......	......	......
10.0	361.9	374.5	386.8	399.0	......	......	......	......	......	......	......	......

CHANNEL FLOW TABLE

Flow of Water in Channels and Conduits of all Types

Table for Solution of Manning Formula (Values of 1000 nV)

To determine velocity in Feet per Second:—
Using Kutter's n = 0.010 divide tabular number by 10
Using Kutter's n = 0.011 divide tabular number by 11, etc.

Table No. 31 (Continued)

Fall in Ft. per 1000 Ft. of Length	HYDRAULIC RADIUS (r) IN FEET										
	6.2	6.4	6.6	6.8	7.0	7.5	8.0	8.5	9.0	9.5	10.0
0.05	35.5	36.2	37.0	37.7	38.5	40.2	42.0	43.7	45.5	47.1	48.8
0.10	50.2	51.2	52.3	53.3	54.4	56.9	59.4	61.9	64.3	66.7	69.0
0.15	61.4	62.7	64.0	65.3	66.6	69.7	72.8	75.8	78.7	81.6	84.5
0.20	70.9	72.4	73.9	75.4	76.9	80.5	84.1	87.5	90.9	94.2	97.5
0.25	79.3	81.0	82.7	84.3	86.0	90.1	94.0	97.9	101.7	105.4	109.1
0.30	86.9	88.7	90.6	92.4	94.2	98.6	103.0	107.2	111.4	115.4	119.5
0.35	93.8	95.8	97.8	99.8	101.7	106.5	111.2	115.8	120.3	124.7	129.0
0.40	100.3	102.5	104.6	106.7	108.8	113.9	118.9	123.8	128.6	133.3	138.0
0.45	106.4	108.7	110.9	113.2	115.4	120.7	126.1	131.2	136.4	141.3	146.3
0.50	112.1	114.5	116.9	119.3	121.6	127.2	132.9	138.3	143.8	148.9	154.2
0.60	122.9	125.5	128.1	130.7	133.2	139.5	145.6	151.6	157.5	163.3	169.0
0.70	132.7	135.5	138.3	141.1	143.9	150.6	157.3	163.7	170.1	176.3	182.5
0.80	141.9	144.9	147.9	150.9	153.8	161.0	168.1	175.0	181.9	188.5	195.1
0.90	150.5	153.7	156.9	160.0	163.1	170.9	178.3	185.8	192.9	200.1	206.9
1.0	158.6	162.0	165.3	168.7	172.0	180.1	188.0	195.8	203.3	210.8	218.1
1.2	173.7	177.4	181.1	184.8	188.4	197.3	205.9	214.5	222.7	231.0	238.9
1.4	187.7	191.7	195.6	199.6	203.5	213.1	222.4	231.6	240.6	249.4	258.1
1.6	200.6	204.9	209.1	213.4	217.5	227.8	237.8	247.6	257.2	266.6	275.9
1.8	212.8	217.3	221.8	226.3	230.7	241.8	252.2	262.8	272.8	283.1	292.6
2.0	224.3	229.1	233.8	238.5	243.2	254.8	265.8	277.0	287.5	298.3	308.5
2.5	250.8	256.1	261.4	266.7	271.9	284.7	297.2	309.5	321.5	333.3	344.9
3.0	274.7	280.6	286.4	292.1	297.8	311.9	325.6	339.0	352.2	365.2	377.8
3.5	296.7	303.0	309.3	315.6	321.7	336.8	351.7	366.1	380.4	394.3	408.1
4.0	317.2	324.0	330.7	337.3	343.9	360.2	375.9	391.5	406.6	......	......
4.5	336.4	343.6	350.7	357.8	364.8	382.0	398.7	......	......	......	......
5.0	354.6	362.2	369.7	377.1	384.5	402.7	420.3	......	......	......	......
6.0	388.5	396.8	405.0	413.2	......	......	......	......	......	......	......

TWO-THIRDS POWERS OF NUMBERS

Table No. 32

Number	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	000	.046	.074	.097	.117	.136	.153	.170	.186	.201
.1	.215	.229	.243	.256	.269	.282	.295	.307	.319	.331
.2	.342	.353	.364	.375	.386	.397	.407	.418	.428	.438
.3	.448	.458	.468	.477	.487	.497	.506	.515	.525	.534
.4	.543	.552	.561	.570	.578	.587	.596	.604	.613	.622
.5	.630	.638	.647	.655	.663	.671	.679	.687	.095	.703
.6	.711	.719	.727	.735	.743	.750	.758	.765	.773	.781
.7	.788	.796	.803	.811	.818	.825	.832	.840	.847	.855
.8	.862	.869	.876	.883	.890	.897	.904	.911	.918	.925
.9	.932	.939	.946	.953	.960	.966	.973	.980	.987	.993
1.0	1.000	1.007	1.013	1.020	1.027	1.033	1.040	1.046	1.053	1.059
1.1	1.065	1.072	1.078	1.085	1.091	1.097	1.104	1.110	1.117	1.123
1.2	1.129	1.136	1.142	1.148	1.154	1.160	1.167	1.173	1.179	1.185
1.3	1.191	1.197	1.203	1.209	1.215	1.221	1.227	1.233	1.239	1.245
1.4	1.251	1.257	1.263	1.269	1.275	1.281	1.287	1.293	1.299	1.305
1.5	1.310	1.316	1.322	1.328	1.334	1.339	1.345	1.351	1.357	1.362
1.6	1.368	1.374	1.379	1.385	1.391	1.396	1.402	1.408	1.413	1.419
1.7	1.424	1.430	1.436	1.441	1.447	1.452	1.458	1.463	1.469	1.474
1.8	1.480	1.485	1.491	1.496	1.502	1.507	1.513	1.518	1.523	1.529
1.9	1.534	1.539	1.545	1.550	1.556	1.561	1.566	1.571	1.577	1.582
2.0	1.587	1.593	1.598	1.603	1.608	1.613	1.619	1.624	1.629	1.634
2.1	1.639	1.645	1.650	1.655	1.660	1.665	1.671	1.676	1.681	1.686
2.2	1.691	1.697	1.702	1.707	1.712	1.717	1.722	1.727	1.732	1.737
2.3	1.742	1.747	1.752	1.757	1.762	1.767	1.772	1.777	1.782	1.787
2.4	1.792	1.797	1.802	1.807	1.812	1.817	1.822	1.827	1.832	1.837
2.5	1.842	1.847	1.852	1.857	1.862	1.867	1.871	1.876	1.881	1.886
2.6	1.891	1.896	1.900	1.905	1.910	1.915	1.920	1.925	1.929	1.934
2.7	1.939	1.944	1.949	1.953	1.958	1.963	1.968	1.972	1.977	1.982
2.8	1.987	1.992	1.996	2.001	2.006	2.010	2.015	2.020	2.024	2.029
2.9	2.034	2.038	2.043	2.048	2.052	2.057	2.062	2.066	2.071	2.075
3.0	2.080	2.085	2.089	2.094	2.099	2.103	2.108	2.112	2.117	2.122
3.1	2.126	2.131	2.135	2.140	2.144	2.149	2.153	2.158	2.163	2.167
3.2	2.172	2.176	2.180	2.185	2.190	2.194	2.199	2.203	2.208	2.212
3.3	2.217	2.221	2.226	2.230	2.234	2.239	2.243	2.248	2.252	2.257
3.4	2.261	2.265	2.270	2.274	2.279	2.283	2.288	2.292	2.296	2.301
3.5	2.305	2.310	2.314	2.318	2.323	2.327	2.331	2.336	2.340	2.345
3.6	2.349	2.353	2.358	2.362	2.366	2.371	2.375	2.379	2.384	2.388
3.7	2.392	2.397	2.401	2.405	2.409	2.414	2.418	2.422	2.427	2.431
3.8	2.435	2.439	2.444	2.448	2.452	2.457	2.461	2.465	2.469	2.474
3.9	2.478	2.482	2.486	2.490	2.495	2.499	2.503	2.507	2.511	2.516
4.0	2.520	2.524	2.528	2.532	2.537	2.541	2.545	2.549	2.553	2.558
4.1	2.562	2.566	2.570	2.574	2.579	2.583	2.587	2.591	2.595	2.599
4.2	2.603	2.607	2.611	2.616	2.620	2.624	2.628	2.632	2.636	2.640
4.3	2.644	2.648	2.653	2.657	2.661	2.665	2.669	2.673	2.677	2.681
4.4	2.685	2.689	2.693	2.698	2.702	2.706	2.710	2.714	2.718	2.722
4.5	2.726	2.730	2.734	2.738	2.742	2.746	2.750	2.754	2.758	2.762
4.6	2.766	2.770	2.774	2.778	2.782	2.786	2.790	2.794	2.798	2.802
4.7	2.806	2.810	2.814	2.818	2.822	2.826	2.830	2.834	2.838	2.842
4.8	2.846	2.850	2.854	2.858	2.862	2.865	2.869	2.873	2.877	2.881
4.9	2.885	2.889	2.893	2.897	2.901	2.904	2.908	2.912	2.916	2.920

TWO-THIRDS POWERS OF NUMBERS

Table No. 32 (Continued)

Number	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
5.0	2.924	2.928	2.932	2.936	2.940	2.944	2.947	2.951	2.955	2.959
5.1	2.963	2.967	2.971	2.975	2.979	2.982	2.986	2.990	2.994	2.998
5.2	3.001	3.005	3.009	3.013	3.017	3.021	3.024	3.028	3.032	3.036
5.3	3.040	3.044	3.047	3.051	3.055	3.059	3.063	3.067	3.070	3.074
5.4	3.078	3.082	3.086	3.089	3.093	3.097	3.101	3.105	3.108	3.112
5.5	3.116	3.120	3.123	3.127	3.131	3.135	3.138	3.142	3.146	3.150
5.6	3.154	3.157	3.161	3.165	3.169	3.172	3.176	3.180	3.184	3.187
5.7	3.191	3.195	3.198	3.202	3.206	3.210	3.213	3.217	3.221	3.224
5.8	3.228	3.232	3.236	3.239	3.243	3.247	3.250	3.254	3.258	3.261
5.9	3.265	3.269	3.273	3.276	3.280	3.284	3.287	3.291	3.295	3.298
6.0	3.302	3.306	3.309	3.313	3.317	3.320	3.324	3.328	3.331	3.335
6.1	3.339	3.342	3.346	3.350	3.353	3.357	3.360	3.364	3.368	3.371
6.2	3.375	3.379	3.382	3.386	3.389	3.393	3.397	3.400	3.404	3.408
6.3	3.411	3.415	3.418	3.422	3.426	3.429	3.433	3.436	3.440	3.444
6.4	3.447	3.461	3.454	3.458	3.461	3.465	3.469	3.472	3.476	3.479
6.5	3.483	3.486	3.490	3.494	3.497	3.501	3.504	3.508	3.511	3.515
6.6	3.519	3.522	3.526	3.529	3.533	3.536	3.540	3.543	3.547	3.550
6.7	3.554	3.558	3.561	3.565	3.568	3.572	3.575	3.579	3.582	3.586
6.8	3.589	3.593	3.596	3.600	3.603	3.607	3.610	3.614	3.617	3.621
6.9	3.624	3.628	3.631	3.635	3.638	3.642	3.645	3.649	3.65	3.656
7.0	3.659	3.663	3.666	3.670	3.673	3.677	3.680	3.684	3.687	3.691
7.1	3.694	3.698	3.701	3.705	3.708	3.712	3.715	3.718	3.722	3.725
7.2	3.729	3.732	3.736	3.739	3.742	3.746	3.749	3.753	3.756	3.760
7.3	3.763	3.767	3.770	3.773	3.777	3.780	3.784	3.787	3.791	3.794
7.4	3.797	3.801	3.804	3.808	3.811	3.814	3.818	3.821	3.825	3.828
7.5	3.832	3.835	3.838	3.842	3.845	3.849	3.852	3.855	3.859	3.862
7.6	3.866	3.869	3.872	3.876	3.879	3.883	3.886	3.889	3.893	3.896
7.7	3.899	3.903	3.906	3.910	3.913	3.916	3.920	3.923	3.926	3.930
7.8	3.933	3.937	3.940	3.943	3.947	3.950	3.953	3.957	3.960	3.963
7.9	3.967	3.970	3.973	3.977	3.980	3.983	3.987	3.990	3.993	3.997
8.0	4.000	4.003	4.007	4.010	4.013	4.017	4.020	4.023	4.027	4.030
8.1	4.033	4.037	4.040	4.043	4.047	4.050	4.053	4.057	4.060	4.063
8.2	4.066	4.070	4.073	4.076	4.080	4.083	4.086	4.090	4.093	4.096
8.3	4.099	4.103	4.106	4.109	4.113	4.116	4.119	4.122	4.126	4.129
8.4	4.132	4.136	4.139	4.142	4.145	4.149	4.152	4.155	4.159	4.162
8.5	4.165	4.168	4.172	4.175	4.178	4.181	4.185	4.188	4.191	4.194
8.6	4.198	4.201	4.204	4.207	4.211	4.214	4.217	4.220	4.224	4.227
8.7	4.230	4.233	4.237	4.240	4.243	4.246	4.249	4.253	4.256	4.259
8.8	4.262	4.266	4.269	4.272	4.275	4.279	4.282	4.285	4.288	4.291
8.9	4.295	4.298	4.301	4.304	4.307	4.311	4.314	4.317	4.320	4.324
9.0	4.327	4.330	4.333	4.336	4.340	4.343	4.346	4.349	4.352	4.356
9.1	4.359	4.362	4.365	4.368	4.372	4.375	4.378	4.381	4.384	4.387
9.2	4.391	4.394	4.397	4.400	4.403	4.407	4.410	4.413	4.416	4.419
9.3	4.422	4.426	4.429	4.432	4.435	4.438	4.441	4.445	4.448	4.451
9.4	4.454	4.457	4.460	4.464	4.467	4.470	4.473	4.476	4.479	4.482
9.5	4.486	4.489	4.492	4.495	4.498	4.501	4.504	4.508	4.511	4.514
9.6	4.517	4.520	4.523	4.526	4.530	4.533	4.536	4.539	4.542	4.545
9.7	4.548	4.551	4.555	4.558	4.561	4.564	4.567	4.570	4.573	4.576
9.8	4.580	4.583	4.586	4.589	4.592	4.595	4.598	4.601	4.604	4.608
9.9	4.611	4.614	4.617	4.620	4.623	4.626	4.629	4.632	4.635	4.639

TWO-THIRDS POWERS OF NUMBERS

Table No. 32 (Continued)

Number	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
10.0	4.642	4.645	4.648	4.651	4.654	4.657	4.660	4.663	4.666	4.669
10.1	4.672	4.676	4.679	4.682	4.685	4.688	4.691	4.694	4.697	4.700
10.2	4.703	4.706	4.709	4.712	4.716	4.719	4.722	4.725	4.728	4.731
10.3	4.734	4.737	4.740	4.743	4.746	4.749	4.752	4.755	4.758	4.762
10.4	4.765	4.768	4.771	4.774	4.777	4.780	4.783	4.786	4.789	4.792
10.5	4.795	4.798	4.801	4.804	4.807	4.810	4.813	4.816	4.819	4.822
10.6	4.825	4.828	4.832	4.835	4.838	4.841	4.844	4.847	4.850	4.853
10.7	4.856	4.859	4.862	4.865	4.868	4.871	4.874	4.877	4.880	4.883
10.8	4.886	4.889	4.892	4.895	4.898	4.901	4.904	4.907	4.910	4.913
10.9	4.916	4.919	4.922	4.925	4.928	4.931	4.934	4.937	4.940	4.943
11.0	4.946	4.949	4.952	4.955	4.958	4.961	4.964	4.967	4.970	4.973
11.1	4.976	4.979	4.982	4.985	4.988	4.991	4.994	4.997	5.000	5.003
11.2	5.006	5.009	5.012	5.015	5.018	5.021	5.024	5.027	5.030	5.033
11.3	5.036	5.039	5.042	5.044	5.047	5.050	5.053	5.056	5.059	5.062
11.4	5.065	5.068	5.071	5.074	5.077	5.080	5.083	5.086	5.089	5.092
11.5	5.095	5.098	5.101	5.104	5.107	5.110	5.113	5.115	5.118	5.121
11.6	5.124	5.127	5.130	5.133	5.136	5.139	5.142	5.145	5.148	5.151
11.7	5.154	5.157	5.160	5.163	5.166	5.168	5.171	5.174	5.177	5.180
11.8	5.183	5.186	5.189	5.192	5.195	5.198	5.201	5.204	5.207	5.209
11.9	5.212	5.215	5.218	5.221	5.224	5.227	5.230	5.233	5.236	5.238
12.0	5.241	5.244	5.247	5.250	5.253	5.256	5.259	5.262	5.265	5.268
12.1	5.271	5.273	5.276	5.279	5.282	5.285	5.288	5.291	5.294	5.297
12.2	5.300	5.302	5.305	5.308	5.311	5.314	5.317	5.320	5.323	5.326
12.3	5.329	5.331	5.334	5.337	5.340	5.343	5.346	5.349	5.352	5.354
12.4	5.357	5.360	5.363	5.366	5.369	5.372	5.375	5.377	5.380	5.383
12.5	5.386	5.389	5.392	5.395	5.398	5.400	5.403	5.406	5.409	5.412
12.6	5.415	5.418	5.421	5.423	5.426	5.429	5.432	5.435	5.438	5.440
12.7	5.443	5.446	5.449	5.452	5.455	5.458	5.461	5.463	5.466	5.469
12.8	5.472	5.475	5.478	5.480	5.483	5.486	5.489	5.492	5.495	5.498
12.9	5.500	5.503	5.506	5.509	5.512	5.515	5.517	5.520	5.523	5.526
13.0	5.529	5.532	5.534	5.537	5.540	5.543	5.546	5.549	5.551	5.554
13.1	5.557	5.560	5.563	5.566	5.568	5.571	5.574	5.577	5.580	5.582
13.2	5.585	5.588	5.591	5.594	5.597	5.600	5.602	5.605	5.608	5.611
13.3	5.614	5.616	5.619	5.622	5.625	5.628	5.630	5.633	5.636	5.639
13.4	5.642	5.644	5.647	5.650	5.653	5.656	5.658	5.661	5.664	5.667
13.5	5.670	5.672	5.675	5.678	5.681	5.684	5.686	5.689	5.692	5.695
13.6	5.698	5.700	5.703	5.706	5.709	5.712	5.714	5.717	5.720	5.723
13.7	5.725	5.728	5.731	5.734	5.737	5.739	5.742	5.745	5.748	5.751
13.8	5.753	5.756	5.759	5.762	5.765	5.767	5.770	5.773	5.776	5.778
13.9	5.781	5.784	5.787	5.789	5.792	5.795	5.798	5.801	5.803	5.806
14.0	5.809	5.812	5.814	5.817	5.820	5.823	5.825	5.828	5.831	5.834
14.1	5.836	5.839	5.842	5.845	5.847	5.850	5.853	5.856	5.859	5.861
14.2	5.864	5.867	5.870	5.872	5.875	5.878	5.880	5.883	5.886	5.889
14.3	5.892	5.894	5.897	5.900	5.902	5.905	5.908	5.911	5.913	5.916
14.4	5.919	5.922	5.924	5.927	5.930	5.933	5.935	5.938	5.941	5.944
14.5	5.946	5.949	5.952	5.955	5.957	5.960	5.963	5.965	5.968	5.971
14.6	5.974	5.976	5.979	5.982	5.985	5.987	5.990	5.993	5.995	5.998
14.7	6.001	6.004	6.006	6.009	6.012	6.014	6.017	6.020	6.023	6.025
14.8	6.028	6.031	6.034	6.036	6.039	6.042	6.044	6.047	6.050	6.052
14.9	6.055	6.058	6.061	6.063	6.066	6.069	6.071	6.074	6.077	6.080

TWO-THIRDS POWERS OF NUMBERS

Table No. 32 (Continued)

Number	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
15.0	6.082	6.085	6.088	6.090	6.093	6.096	6.098	6.101	6.104	6.106
15.1	6.109	6.112	6.115	6.117	6.120	6.123	6.125	6.128	6.131	6.133
15.2	6.136	6.139	6.141	6.144	6.147	6.150	6.152	6.155	6.158	6.160
15.3	6.163	6.166	6.168	6.171	6.174	6.176	6.179	6.182	6.184	6.187
15.4	6.190	6.193	6.195	6.198	6.200	6.203	6.206	6.209	6.211	6.214
15.5	6.217	6.219	6.222	6.225	6.227	6.230	6.233	6.235	6.238	6.241
15.6	6.243	6.246	6.249	6.251	6.254	6.257	6.259	6.262	6.265	6.267
15.7	6.270	6.273	6.275	6.278	6.281	6.283	6.286	6.289	6.291	6.294
15.8	6.297	6.299	6.302	6.305	6.307	6.310	6.312	6.315	6.318	6.320
15.9	6.323	6.326	6.328	6.331	6.334	6.336	6.339	6.342	6.344	6.347
16.0	6.350	6.352	6.355	6.358	6.360	6.363	6.365	6.368	6.371	6.373
16.1	6.376	6.379	6.381	6.384	6.387	6.389	6.392	6.394	6.397	6.400
16.2	6.402	6.405	6.408	6.410	6.413	6.416	6.418	6.421	6.423	6.426
16.3	6.429	6.431	6.434	6.437	6.439	6.442	6.444	6.447	6.450	6.452
16.4	6.455	6.458	6.460	6.463	6.465	6.468	6.471	6.473	6.476	6.479
16.5	6.481	6.484	6.486	6.489	6.492	6.494	6.497	6.500	6.502	6.505
16.6	6.507	6.510	6.513	6.515	6.518	6.520	6.523	6.526	6.528	6.531
16.7	6.533	6.536	6.539	6.541	6.544	6.546	6.549	6.552	6.554	6.557
16.8	6.560	6.562	6.565	6.567	6.570	6.573	6.575	6.578	6.580	6.583
16.9	6.586	6.588	6.591	6.593	6.596	6.599	6.601	6.604	6.606	6.609
17.0	6.611	6.614	6.617	6.619	6.622	6.624	6.627	6.630	6.632	6.635
17.1	6.637	6.640	6.643	6.645	6.648	6.650	6.653	6.655	6.658	6.661
17.2	6.663	6.666	6.668	6.671	6.674	6.676	6.679	6.681	6.684	6.686
17.3	6.689	6.692	6.694	6.697	6.699	6.702	6.705	6.707	6.710	6.712
17.4	6.715	6.717	6.720	6.723	6.725	6.728	7.730	6.733	6.735	6.738
17.5	6.740	6.743	6.746	6.748	6.751	6.753	6.756	6.758	6.761	6.764
17.6	6.766	6.769	6.771	6.774	6.776	6.779	6.782	6.784	6.787	6.789
17.7	6.792	6.794	6.797	6.799	6.802	6.805	6.807	6.810	6.812	6.815
17.8	6.817	6.820	6.822	6.825	6.828	6.830	6.833	6.835	6.838	6.840
17.9	6.843	6.845	6.848	6.850	6.853	6.856	6.858	6.861	6.863	6.866
18.0	6.868	6.871	6.873	6.876	6.878	6.881	6.884	6.886	6.889	6.891
18.1	6.894	6.896	6.899	6.901	6.904	6.906	6.909	6.911	6.914	6.917
18.2	6.919	6.922	6.924	6.927	6.929	6.932	6.934	6.937	6.939	6.942
18.3	6.944	6.947	6.949	6.952	6.954	6.957	6.960	6.962	6.965	6.967
18.4	6.970	6.972	6.975	6.977	6.980	6.982	6.985	6.987	6.990	6.992
18.5	6.995	6.997	7.000	7.002	7.005	7.007	7.010	7.013	7.015	7.018
18.6	7.020	7.023	7.025	7.028	7.030	7.032	7.035	7.038	7.040	7.043
18.7	7.045	7.048	7.050	7.053	7.055	7.058	7.060	7.063	7.065	7.068
18.8	7.070	7.073	7.075	7.078	7.080	7.083	7.085	7.088	7.090	7.093
18.9	7.095	7.098	7.100	7.103	7.105	7.108	7.110	7.113	7.115	7.118
19.0	7.120	7.123	7.125	7.128	7.130	7.133	7.135	7.138	7.140	7.143
19.1	7.145	7.148	7.150	7.153	7.155	7.158	7.160	7.163	7.165	7.168
19.2	7.170	7.173	7.175	7.178	7.180	7.183	7.185	7.188	7.190	7.193
19.3	7.195	7.198	7.200	7.203	7.205	7.208	7.210	7.212	7.215	7.217
19.4	7.220	7.222	7.225	7.227	7.230	7.232	7.235	7.237	7.240	7.242
19.5	7.245	7.247	7.250	7.252	7.255	7.257	7.260	7.262	7.265	7.267
19.6	7.270	7.272	7.274	7.277	7.279	7.282	7.284	7.287	7.289	7.292
19.7	7.294	7.297	7.299	7.302	7.304	7.307	7.309	7.311	7.314	7.316
19.8	7.319	7.321	7.324	7.326	7.329	7.331	7.334	7.336	7.339	7.341
19.9	7.343	7.346	7.348	7.351	7.353	7.356	7.358	7.361	7.363	7.366

SQUARE ROOTS OF DECIMAL NUMBERS

Table No. 33

Number	.—0	.—1	.—2	.—3	.—4	.—5	.—6	.—7	.—8	.—9
.00001	.003162	.003317	.003464	.003606	.003742	.003873	.004000	.004123	.004243	.004359
.00002	.004472	.004583	.004690	.004796	.004899	.005000	.005099	.005196	.005292	.005385
.00003	.005477	.005568	.005657	.005745	.005831	.005916	.006000	.006083	.006164	.006245
.00004	.006325	.006403	.006481	.006557	.006633	.006708	.006782	.006856	.006928	.007000
.00005	.007071	.007141	.007211	.007280	.007348	.007416	.007483	.007550	.007616	.007681
.00006	.007746	.007810	.007874	.007937	.008000	.008062	.008124	.008185	.008246	.008307
.00007	.008367	.008426	.008485	.008544	.008602	.008660	.008718	.008775	.008832	.008888
.00008	.008944	.009000	.009055	.009110	.009165	.009220	.009274	.009327	.009381	.009434
.00009	.009487	.009539	.009592	.009644	.009695	.009747	.009798	.009849	.009899	.009950
.00010	.010000	.010050	.010100	.010149	.010198	.010247	.010296	.010344	.010392	.010440
.0001	.01000	.01049	.01095	.01140	.01183	.01225	.01265	.01304	.01342	.01378
.0002	.01414	.01449	.01483	.01517	.01549	.01581	.01612	.01643	.01673	.01703
.0003	.01732	.01761	.01789	.01817	.01844	.01871	.01897	.01924	.01949	.01975
.0004	.02000	.02025	.02049	.02074	.02098	.02121	.02145	.02168	.02191	.02214
.0005	.02236	.02258	.02280	.02302	.02324	.02345	.02366	.02387	.02408	.02429
.0006	.02449	.02470	.02490	.02510	.02530	.02550	.02569	.02588	.02608	.02627
.0007	.02646	.02665	.02683	.02702	.02720	.02739	.02757	.02775	.02793	.02811
.0008	.02828	.02846	.02864	.02881	.02898	.02915	.02933	.02950	.02966	.02983
.0009	.03000	.03017	.03033	.03050	.03066	.03082	.03098	.03114	.03130	.03146
.0010	.03162	.03178	.03194	.03209	.03225	.03240	.03256	.03271	.03286	.03302
.001	.03162	.03317	.03464	.03606	.03742	.03873	.04000	.04123	.04243	.04359
.002	.04472	.04583	.04690	.04796	.04899	.05000	.05099	.05196	.05292	.05385
.003	.05477	.05568	.05657	.05745	.05831	.05916	.06000	.06083	.06164	.06245
.004	.06325	.06403	.06481	.06557	.06633	.06708	.06782	.06856	.06928	.07000
.005	.07071	.07141	.07211	.07280	.07348	.07416	.07483	.07550	.07616	.07681
.006	.07746	.07810	.07874	.07937	.08000	.08062	.08124	.08185	.08246	.08307
.007	.08367	.08426	.08485	.08544	.08602	.08660	.08718	.08775	.08832	.08888
.008	.08944	.09000	.09055	.09110	.09165	.09220	.09274	.09327	.09381	.09434
.009	.09487	.09539	.09592	.09644	.09695	.09747	.09798	.09849	.09899	.09950
.010	.10000	.10050	.10100	.10149	.10198	.10247	.10296	.10344	.10392	.10440
.01	.1000	.1049	.1095	.1140	.1183	.1225	.1265	.1304	.1342	.1378
.02	.1414	.1449	.1483	.1517	.1549	.1581	.1612	.1643	.1673	.1703
.03	.1732	.1761	.1789	.1817	.1844	.1871	.1897	.1924	.1949	.1975
.04	.2000	.2025	.2049	.2074	.2098	.2121	.2145	.2168	.2191	.2214
.05	.2236	.2258	.2280	.2302	.2324	.2345	.2366	.2387	.2408	.2429
.06	.2449	.2470	.2490	.2510	.2530	.2550	.2569	.2588	.2608	.2627
.07	.2646	.2665	.2683	.2702	.2720	.2739	.2757	.2775	.2793	.2811
.08	.2828	.2846	.2864	.2881	.2898	.2915	.2933	.2950	.2966	.2983
.09	.3000	.3017	.3033	.3050	.3066	.3082	.3098	.3114	.3130	.3146
.10	.3162	.3178	.3194	.3209	.3225	.3240	.3256	.3271	.3286	.3302

HYDRAULIC AND MISCELLANEOUS DATA

1 Cubic foot of Water.
- = 1728 cubic inches
- = 7.48052 gallons
  - weighs 62.423 lbs. at 40° F. Sea Level
  - weighs 62.119 lbs. at 90° F. Sea Level
  - weighs 59.7 lbs. at 212° F. Sea Level
- = 28.317 liters
- = 0.028317 cu. meter

1 U. S. Gallon
- = 231 Cubic Inches
- = 0.832673 Imperial Gallon
- = 0.133681 Cubic Foot
- = 3.78543 liters
  - weighs 8.345 lbs. at 40° F. Sea Level
  - 1 million gallons per day = 1.55 Cu. ft. per second

1 Cubic foot of Water per second
- = 1 Sec. ft. or cusec
- = 60 Cubic feet per minute
- = 3600 Cubic feet per hour
- = 86400 Cubic feet per 24 hours
- = 7.48 Gallons per second
- = 448.8 Gallons per minute
- = 26930 Gallons per hour
- = 161580 Gallons per 6 hours
- = 269300 Gallons per 10 hours
- = 646317 Gallons per 24 hours
- = 1 Acre Foot in 12 hrs. 6 min.
- = 1.98 Acre feet in 24 hours
- = 38.4 Miners' inches in Colorado
- = 40 Miners' inches in Arizona, Calif., Montana and Ore.
- = 50 Miners' inches in Idaho, Kansas, Nebraska, New Mexico, North Dakota, South Dakota, Utah, Nevada

1 Million Gallons per day
- = 1.55 cubic feet per second

1 Acre Foot
- = 43560 Cubic feet of Water
- = 1 Second foot flowing 12 hrs. 6 min.

1 Acre Inch
- 3630 Cubic feet of Water
- = 1 Second foot flowing 1 hour

Horsepower (Theoretical) (Use Dynamic Head)
- = Cu. ft. per minute x Head in feet x 62.4 divided by 33000 or simplified
- = Sec. ft. x Head in feet x .1135

Horsepower (80% efficiency at water wheel shaft) (Use Dynamic Head)
- = Sec. ft. x Head in feet divided by 11

  or
- = Sec. ft. x Head in feet x .091
  - 1 Horsepower = 746 Watts
  - 1.34 Horsepower = 1 Kilowatt

Miners' Inch

See values listed under "1 Cubic foot of water per second"

Metric

1 Acre	= 0.4047 Hectare
1 Cubic foot	= 0.0283 Cubic meter
1 Cubic meter	= 35.314 Cubic Feet
1 Foot	= 0.3048 Meter
1 Hectare	= 2.471 Acres
1 Inch	= 2.54 Centimeters
1 Kilogram	= 2.2046 pounds
1 Kilometer	= 3281 feet
1 Liter	= 1.0567 quarts
1 Meter	= 39.37 inches
1 Meter	= 3.280833 feet
1 Mile (5280 feet)	= 1.60936 Kilometers
1 Sq. mile	= 259 Hectares
1 Sq. mile	= 2.59 Sq. kilometers

Electrical

1 Kilowatt	= 1000 Watts
1 Kilowatt	= 1.34 horsepower
1 Horsepower	= 746 Watts
1 Horsepower	= .746 Kilowatt

THEORETICAL HORSEPOWER THAT MAY BE DEVELOPED FROM, OR WHICH IS REQUIRED TO PUMP, ONE CUBIC FOOT OF WATER PER SECOND (approx. 450 G.P.M.)

Table No. 34

Head in Feet	Additional Units of Head in Feet									
	0	1	2	3	4	5	6	7	8	9
0	......	0.113	0.227	0.340	0.454	0.567	0.681	0.794	0.908	1.021
10	1.135	1.248	1.362	1.475	1.589	1.702	1.816	1.929	2.043	2.156
20	2.270	2.383	2.497	2.610	2.724	2.837	2.951	3.064	3.178	3.291
30	3.405	3.518	3.632	3.745	3.859	3.972	4.086	4.199	4.313	4.426
40	4.540	4.653	4.767	4.880	4.994	5.107	5.221	5.334	5.448	5.561
50	5.675	5.788	5.902	6.015	6.129	6.242	6.356	6.469	6.583	6.696
60	6.810	6.923	7.037	7.150	7.264	7.377	7.491	7.604	7.718	7.831
70	7.945	8.058	8.172	8.285	8.399	8.512	8.626	8.739	8.853	8.966
80	9.080	9.193	9.307	9.420	9.534	9.647	9.761	9.874	9.988	10.101
90	10.215	10.328	10.442	10.555	10.669	10.782	10.896	11.009	11.123	11.236
100	11.350	11.463	11.577	11.690	11.804	11.917	12.031	12.144	12.258	12.371
110	12.485	12.598	12.712	12.825	12.939	13.052	13.166	13.279	13.393	13.506
120	13.620	13.733	13.847	13.960	14.074	14.187	14.301	14.414	14.528	14.641
130	14.755	14.868	14.982	15.095	15.209	15.322	15.436	15.549	15.663	15.776
140	15.890	16.003	16.117	16.230	16.344	16.457	16.571	16.684	16.798	16.911
150	17.025	17.138	17.252	17.365	17.479	17.592	17.706	17.819	17.933	18.046
160	18.160	18.273	18.387	18.500	18.614	18.727	18.841	18.954	19.068	19.181
170	19.295	19.408	19.522	19.635	19.749	19.862	19.976	20.089	20.203	20.316
180	20.430	20.543	20.657	20.770	20.884	20.997	21.111	21.224	21.338	21.451
190	21.565	21.678	21.792	21.905	22.019	22.132	22.246	22.359	22.473	22.586
200	22.700	22.813	22.927	23.040	23.154	23.267	23.381	23.494	23.608	23.721

Example: 55 foot head = 6.24 theoretical horsepower. Multiply by number of cubic feet per second.

For instance, for 5 C.F.S., 5 x 6.24 = 31.2 theoretical H.P.

For power lines, use dynamic head, only (after deducting friction).

Multiply by .8 for 80% efficiency, etc., to obtain actual H.P. which may be developed. Small power units may have an overall efficiency as low as 50%.

For pumping lines, add friction head to static head for total pumping head. Small capacity pumps with motors may have an overall efficiency of around 50%, and this ranges up to about 80% for the largest units. Add the following percentages, for instance, to the theoretical H.P. to obtain the actual H.P. required for pumping:

Efficiency of Pump	*Add Per Cent*
50%	100%
60%	66 2/3%
70%	42 3/4%
75%	33 1/3%
80%	25%
85%	17 2/3%

Consult the manufacturers of water wheels and pumps relative to the efficiencies which will apply.

Miscellaneous Data

Doubling the diameter of a pipe multiplies its end area four times.

The expansion of Ice is 1/12 of its original bulk as water. This will rupture metal and concrete pipe but does not seriously injure wood pipe.

Sea water weighs 64 to 64¼ lbs. per cubic foot.

The contents of a Circular Tank in gallons = Dia. in ft. x Dia. in ft. x Height in feet x 5.875.

An Acre = 43560 square feet—nearly 209 feet square.

A common water pail holds 2¼ gallons of water weighing about 19 pounds.

SPECIFIC GRAVITIES AND WEIGHTS

Table No. 35

	Average Specific Gravity	Average Wt. Cu. Ft., Lbs.
Air, atmospheric pressure, 60° F.	.00123	.0765
Alcohol	.834	52.1
Aluminum	2.6	162.
Asphaltum	1.4	87.3
Brass, rolled	8.4	524.
Bronz	8.5	529.
Brick, best pressed		150.
Brick, common hard		125.
Carbonic Acid Gas, is 1½ times as heavy as air	.00187	
Cement. Portland	3.12	75 to 90
Cement, Natural	2.87	50 to 56
Chalk	2.5	156
Charcoal, of pines and oaks		15 to 30
Coal, anthracite	1.50	81 to 106
Coal, bituminous	1.30	78 to 88
Coke	1.00	62.5
Copper, rolled	8.9	555.
Earth, common loam, perfectly dry, loose		72 to 80
Earth, common loam, perfectly dry, shaken		82 to 92
Earth, common loam, perfectly dry, moderately rammed		90 to 100
Earth, common loam, slightly moist, loose		70 to 76
Earth, common loam, more moist, loose		66 to 68
Earth, common loam, more moist, shaken		75 to 90
Earth, common loam, more moist, moderately packed		90 to 100
Earth, common loam, as a soft flowing mud		104 to 112
Earth, common loam, as a soft mud well pressed into a box		110 to 120
Ether	.716	44.6
Fat	.93	58.
Glass	2.98	186.
Granite	2.72	170.
Gold	19.26	1204.
Gravel (about same as sand)		
Hydrogen Gas is 14½ times lighter than air		.00521
Iron and Steel	7.75	475 to 494
Ivory	1.82	114
Ice	.92	57.4
Lard	.95	59.3
Lead	11.38	709.6
Mercury	13.55	844
Mica	2.93	183
Milk	1.02	
Naptha	.848	52.9
Nitrogen Gas is about 1/35 part (about 2.86%) lighter than air		.0744
Oil, whale, olive	.92	57.3
Oil of turpentine	.87	54.3
Oxygen Gas, a little more than 1/10 part (10%) heavier than air	.00136	.0846
Petroleum	.878	54.8
Pitch	1.15	71.7
Platinum	21.50	1342
Quartz	2.65	165
Salt		50 to 70
Sand, pure quartz, perfectly dry, loose		90 to 106
Sand, perfectly wet, voids all full of water		118 to 120
Slate	2.8	175
Snow, fresh fallen		5 to 12
Snow, wet compact		15 to 50
Sulphur	2.	125
Tallow	.94	58.6
Tar	1.	62.4
Tin	7.35	459.
Water at 40° F. Sea Level	1.00	62.423
Water, Sea	1.03	64.3
Wax, bees	.998	60.5
Wines	.61	62.3
Wood (dry)—		
Ash		45 to 47
Bamboo		22 to 25
Beech		43 to 56
Birch		32 to 48
Butternut		24 to 28
Cedar		37 to 38
Cherry		43 to 56
Chestnut		38 to 40
Cork		15.6
Cyprus		32 to 37
Ebony		69 to 83
Elm		35 to 36
Fir, rough green		42
Fir, kiln dried		34 to 37
Fir, creosoted 8-lb. pressure and vacuum process		42 to 45
Hemlock		25 to 29
Hickory		53 to 58
Lignym Vitae		78 to 83
Mahogany		32 to 53
Maple		49 to 50
Oak		37 to 56
Pine		24 to 45
Poplar		24 to 27
Redwood		30 to 32
Spruce		25 to 32
Walnut		38 to 45
Willow		24 to 37
Zinc	7.00	437.5

WIRE AND PLATE GAGES

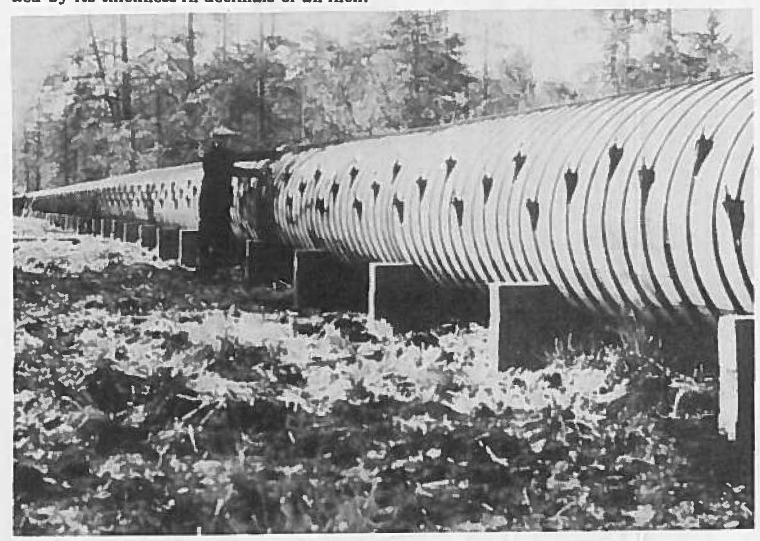
Table No. 36

Number of gage	American or Brown & Sharpe 1	U.S. Steel Wire Gage 2	U.S. Std. for plate 3	Number of gage	American or Brown & Sharpe 1	U.S. Steel Wire Gage 2	U.S. Std. for plate 3
0000000	....	.4900	.5000	12	.0808	.1055	.1094
000000	.5800	.4615	.4688	13	.0720	.0915	.0938
00000	.5165	.4305	.4375	14	.0641	.0800	.0781
0000	.4600	.3938	.4063	15	.0571	.0720	.0703
000	.4096	.3625	.3750	16	.0508	.0625	.0625
00	.3648	.3310	.3438	17	.0453	.0540	.0563
0	.3249	.3065	.3125	18	.0403	.0475	.0500
1	.2893	.2830	.2813	19	.0359	.0410	.0438
2	.2576	.2625	.2656	20	.0320	.0348	.0375
3	.2294	.2437	.2500	21	.0285	.0317	.0344
4	.2043	.2253	.2344	22	.0253	.0286	.0313
5	.1819	.2070	.2188	23	.0226	.0258	.0281
6	.1620	.1920	.2031	24	.0201	.0230	.0250
7	.1443	.1770	.1875	25	.0179	.0204	.0219
8	.1285	.1620	.1719	26	.0159	.0181	.0188
9	.1144	.1483	.1563	27	.0142	.0173	.0172
10	.1019	.1350	.1406	28	.0126	.0162	.0156
11	.0907	.1205	.1250	29	.0113	.0150	.0141

1. Recognized standard in U.S. for wire and sheet metal of copper and other metals except steel and iron.

2. Recognized standard for steel and iron wire. Formerly American Steel and Wire gage or Washburn and Moen.

3. Legalized U. S. Standard for iron and steel plate, although plate is now usually specified by its thickness in decimals of an inch.



Continuous Stave Pipe, Installed on Swampy Ground

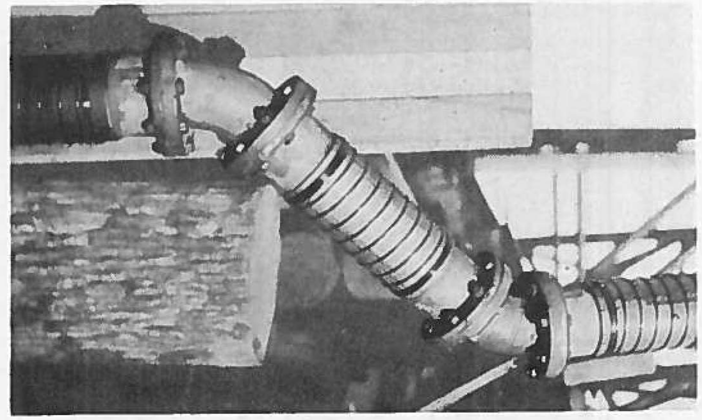
CAST IRON FLANGES

American Standard — 125 lb.

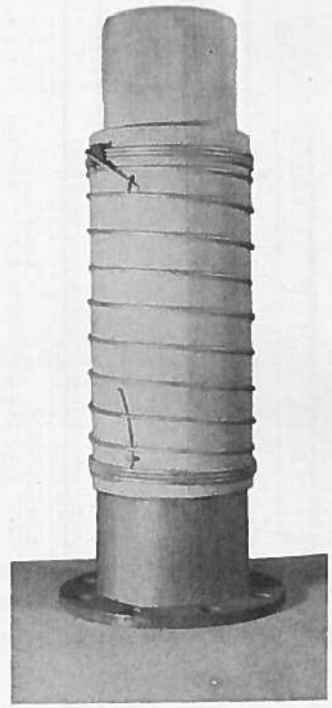
Table No. 37

Size Inches	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches
2½	6	⅝	4¾	4	⅝	2
2½	7	11/16	5½	4	⅝	2¼
3	7½	¾	6	4	⅝	2¼
3½	8½	13/16	7	4	⅝	2½
4	9	15/16	7½	8	⅝	2¾
5	10	15/16	8½	8	¾	2¾
6	11	1	9½	8	¾	3
8	13½	1⅛	11¾	8	¾	3¼
10	16	1 3/16	14¼	12	⅞	3½
12	19	1¼	17	12	⅞	3½
14	21	1⅝	18¾	12	1	4
16	23½	1 7/16	21¼	16	1	4
18	25	1 9/16	22¾	16	1⅛	4½
20	27½	1 11/16	25	20	1⅛	4¾
24	32	1⅞	29½	20	1¼	5¼
26	34¼	2	31¾	24	1¼	5½
28	36½	2 1/16	34	28	1¼	5½
30	38¾	2⅛	36	28	1⅝	5¾
32	41¾	2¼	38½	28	1½	6¼
34	43¾	2 5/16	40½	32	1½	6½
36	46	2⅝	42¾	32	1½	6½
38	48¾	2⅝	45¼	32	1⅝	6¾
40	50¾	2½	47¼	36	1⅝	7
42	53	2⅝	49½	36	1⅝	7¼
44	55¼	2⅝	51¾	40	1⅝	7¼
46	57¼	2 11/16	53¾	40	1⅝	7½
48	59½	2¾	56	44	1⅝	7½
50	61¾	2¾	58¼	44	1¾	7¾
52	64	2⅞	60½	44	1¾	8
54	66¼	3	62¾	44	1¾	8¼
56	68¾	3	65	48	1¾	8¼
58	71	3⅛	67¼	48	1¾	8½
60	73	3⅛	69¼	52	1¾	8½
62	75¾	3¼	71¾	52	1⅞	9
64	78	3¼	74	52	1⅞	9
66	80	3⅝	76	52	1⅞	9¼
68	82¼	3⅝	78¼	56	1⅞	9¼
70	84½	3½	80½	56	1⅞	9½
72	86½	3½	82½	60	1⅞	9½

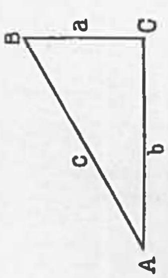
NOTE: *That the number of bolts are in multiples of four, so that fittings may be made to face in any quarter and bolt holes straddle the center line. Bolt holes are drilled ⅛-inch larger than nominal diameter of bolts.*



Malleable Iron Flange Adapters, with Standard Flanged Fittings

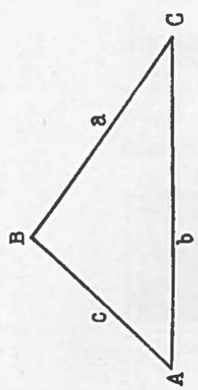


Malleable Iron Wood Pipe Flange for Pulp Mill and Industrial Piping



SOLUTION OF RIGHT TRIANGLES

Given	Formulae	Given	Formulae
TO FIND A			
a, b	$\tan A = \frac{a}{b}$	a, b	$\cot A = \frac{b}{a}$
a, c	$\sin A = \frac{a}{c}$	b, c	$\cos A = \frac{b}{c}$
TO FIND B			
a, b	$\cot B = \frac{a}{b}$	a, b	$\tan B = \frac{b}{a}$
a, c	$\cos B = \frac{a}{c}$	b, c	$\sin B = \frac{b}{c}$
TO FIND a			
A, b	$a = b \tan A$	B, c	$a = c \cos B$
A, c	$a = c \sin A$	B, b	$a = b \cot B$
TO FIND b			
A, c	$b = c \cos A$	B, c	$b = c \sin B$
A, a	$b = a \cot A$	B, a	$b = a \tan B$
TO FIND c			
A, a	$c = \frac{a}{\sin A}$	B, a	$c = \frac{a}{\cos B}$
A, b	$c = \frac{b}{\cos A}$	B, b	$c = \frac{b}{\sin B}$



SOLUTION OF OBLIQUE TRIANGLES

TO FIND a, b, c

Given	Formulae	Given	Formulae
A, B, b	$a = \frac{b \sin A}{\sin B}$	C, c, a	$\sin A = \frac{a \sin C}{c}$
A, B, a	$b = \frac{a \sin B}{\sin A}$	A, a, b	$\sin B = \frac{b \sin A}{a}$
A, C, a	$c = \frac{a \sin C}{\sin A}$	A, c, a	$\sin C = \frac{c \sin A}{a}$

TO FIND A, B, C

Given	Formulae
b, c, s	$\sin \frac{1}{2}A = \sqrt{\frac{(s-c)\ (s-b)}{bc}}$
a, c, s	$\sin \frac{1}{2}B = \sqrt{\frac{(s-c)\ (s-a)}{ac}}$
a, b, s	$\sin \frac{1}{2}C = \sqrt{\frac{(s-a)\ (s-b)}{ab}}$

$s = \frac{1}{2}(a + b + c)$

NATURAL TRIGONOMETRIC FUNCTIONS

Table No. 38

Angle	Sin.	Cosec.	Tan.	Cotan.	Sec.	Cos.	
0°	0.000	....	0.000	....	1.000	1.000	90°
1°	0.017	57.30	0.017	57.29	1.000	1.000	89°
2°	0.035	28.65	0.035	28.64	1.001	0.999	88°
3°	0.052	19.11	0.052	19.08	1.001	0.999	87°
4°	0.070	14.31	0.070	14.30	1.002	0.998	86°
5°	0.087	11.47	0.087	11.430	1.004	0.996	85°
6°	0.105	9.567	0.105	9.514	1.006	0.995	84°
7°	0.122	8.206	0.123	8.144	1.008	0.993	83°
8°	0.139	7.185	0.141	7.115	1.010	0.990	82°
9°	0.156	6.392	0.158	6.314	1.012	0.988	81°
10°	0.174	5.759	0.176	5.671	1.015	0.985	80°
11°	0.191	5.241	0.194	5.145	1.019	0.982	79°
12°	0.208	4.810	0.213	4.705	1.022	0.978	78°
13°	0.225	4.445	0.231	4.331	1.026	0.974	77°
14°	0.242	4.134	0.249	4.011	1.031	0.970	76°
15°	0.259	3.864	0.268	3.732	1.035	0.966	75°
16°	0.276	3.628	0.287	3.487	1.040	0.961	74°
17°	0.292	3.420	0.306	3.271	1.046	0.956	73°
18°	0.309	3.236	0.325	3.078	1.051	0.951	72°
19°	0.326	3.072	0.344	2.904	1.058	0.946	71°
20°	0.342	2.924	0.364	2.747	1.064	0.940	70°
21°	0.358	2.790	0.384	2.605	1.071	0.934	69°
22°	0.375	2.669	0.404	2.475	1.079	0.927	68°
23°	0.391	2.559	0.424	2.356	1.086	0.921	67°
24°	0.407	2.459	0.445	2.246	1.095	0.914	66°
25°	0.423	2.366	0.466	2.145	1.103	0.906	65°
26°	0.438	2.281	0.488	2.050	1.113	0.899	64°
27°	0.454	2.203	0.510	1.963	1.122	0.891	63°
28°	0.469	2.130	0.532	1.881	1.133	0.883	62°
29°	0.485	2.063	0.554	1.804	1.143	0.875	61°
30°	0.500	2.000	0.577	1.732	1.155	0.866	60°
31°	0.515	1.942	0.601	1.664	1.167	0.857	59°
32°	0.530	1.887	0.625	1.600	1.179	0.848	58°
33°	0.545	1.836	0.649	1.540	1.192	0.839	57°
34°	0.559	1.788	0.675	1.483	1.206	0.829	56°
35°	0.574	1.743	0.700	1.428	1.221	0.819	55°
36°	0.588	1.701	0.727	1.376	1.236	0.809	54°
37°	0.602	1.662	0.754	1.327	1.252	0.799	53°
38°	0.616	1.624	0.781	1.280	1.269	0.788	52°
39°	0.629	1.589	0.810	1.235	1.287	0.777	51°
40°	0.643	1.556	0.839	1.192	1.305	0.766	50°
41°	0.656	1.524	0.869	1.150	1.325	0.755	49°
42°	0.669	1.494	0.900	1.111	1.346	0.743	48°
43°	0.682	1.466	0.933	1.072	1.367	0.731	47°
44°	0.695	1.440	0.966	1.036	1.390	0.719	46°
45°	0.707	1.414	1.000	1.000	1.414	0.707	45°
	Cos.	Sec.	Cotan.	Tan.	Cosec.	Sin.	Angle

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39

OF ONE INCH

Fract.	Dec.	Circ.	Area
1/64	.015625	.04909	.00019
1/32	.03125	.09818	.00077
3/64	.046875	.14726	.00173
1/16	.0625	.19635	.00307
5/64	.078125	.24545	.00479
3/32	.09375	.29452	.00690
7/64	.109375	.34363	.00939
1/8	.125	.39270	.01227
9/64	.140625	.44181	.01553
5/32	.15625	.49087	.01917
11/64	.171875	.53999	.02320
3/16	.1875	.58905	.02761
13/64	.203125	.63817	.03241
7/32	.21875	.68722	.03758
15/64	.234375	.73635	.04314
1/4	.25	.78540	.04909
17/64	.265625	.83453	.05542
9/32	.28125	.88357	.06213
19/64	.296875	.93271	.06922
5/16	.3125	.98175	.07670
21/64	.328125	1.0309	.08456
11/32	.34375	1.0799	.09281
23/64	.359375	1.1291	.10144
3/8	.375	1.1781	.11045
25/64	.390625	1.2273	.11984
13/32	.40625	1.2763	.12962
27/64	.421875	1.3254	.13979
7/16	.4375	1.3744	.15033
29/64	.453125	1.4236	.16126
15/32	.46875	1.4726	.17257
31/64	.484375	1.5218	.18427
1/2	.5	1.5708	.19635
33/64	.515625	1.6199	.20880
17/32	.53125	1.6690	.22166
35/64	.546875	1.7181	.23489
9/16	.5625	1.7671	.24850
37/64	.578125	1.8163	.26248
19/32	.59375	1.8653	.27688
39/64	.609375	1.9145	.29164
5/8	.625	1.9635	.30680
41/64	.640625	2.0127	.32232
21/32	.65625	2.0617	.33824
43/64	.671875	2.1108	.35453
11/16	.6875	2.1598	.37122
45/64	.703125	2.2090	.38828
23/32	.71875	2.2580	.40574
47/64	.734375	2.3072	.42356
3/4	.75	2.3562	.44179
49/64	.765625	2.4054	.45253
25/32	.78125	2.4544	.47937
51/64	.796875	2.5036	.49872
13/16	.8125	2.5525	.51849
53/64	.828125	2.6017	.53862
27/32	.84375	2.6507	.55914
55/64	.859375	2.6999	.58003
7/8	.875	2.7489	.60132
57/64	.890625	2.7981	.62298
29/32	.90625	2.8471	.64504
59/64	.921875	2.8963	.66746
15/16	.9375	2.9452	.69029
61/64	.953125	2.9945	.71349
31/32	.96875	3.0434	.73708
63/64	.984375	3.0928	.76097

OF INCHES OR FEET

Diam.	Circum.	Area
1	3.1416	.7854
1 1/8	3.5343	.9940
1 1/4	3.9270	1.2272
1 3/8	4.3197	1.4849
1 1/2	4.7124	1.7671
1 5/8	5.1051	2.0739
1 3/4	5.4978	2.4053
1 7/8	5.8905	2.7612
2	6.2832	3.1416
2 1/8	6.6759	3.5466
2 1/4	7.0686	3.9761
2 3/8	7.4613	4.4301
2 1/2	7.8540	4.9087
2 5/8	8.2467	5.4119
2 3/4	8.6394	5.9396
2 7/8	9.0321	6.4918
3	9.4248	7.0686
3 1/8	9.8175	7.6699
3 1/4	10.2102	8.2958
3 3/8	10.6029	8.9462
3 1/2	10.9956	9.6211
3 5/8	11.3883	10.3206
3 3/4	11.7810	11.0447
3 7/8	12.1737	11.7932
4	12.5664	12.5664
4 1/8	12.9591	13.3640
4 1/4	13.3518	14.1863
4 3/8	13.7445	15.0330
4 1/2	14.1372	15.9043
4 5/8	14.5299	16.8002
4 3/4	14.9226	17.7205
4 7/8	15.3153	18.6655
5	15.7080	19.6350
5 1/8	16.1007	20.6290
5 1/4	16.4934	21.6475
5 3/8	16.8861	22.6906
5 1/2	17.2788	23.7583
5 5/8	17.6715	24.8505
5 3/4	18.0642	25.9672
5 7/8	18.4569	27.1085

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET

Diam.	Circum.	Area
6	18.8496	28.2743
6 1/8	19.2423	29.4647
6 1/4	19.6350	30.6796
6 3/8	20.0277	31.9191
6 1/2	20.4204	33.1831
6 5/8	20.8131	34.4716
6 3/4	21.2058	35.7847
6 7/8	21.5984	37.1223
7	21.9911	38.4845
7 1/8	22.3838	39.8713
7 1/4	22.7765	41.2825
7 3/8	23.1692	42.7183
7 1/2	23.5619	44.1786
7 5/8	23.9546	45.6635
7 3/4	24.3473	47.1730
7 7/8	24.7400	48.7070
8	25.1327	50.2655
8 1/8	25.5254	51.8486
8 1/4	25.9181	53.4562
8 3/8	26.3108	55.0883
8 1/2	26.7035	56.7450
8 5/8	27.0962	58.4263
8 3/4	27.4889	60.1320
8 7/8	27.8816	61.8624
9	28.2743	63.6173
9 1/8	28.6670	65.3967
9 1/4	29.0597	67.2006
9 3/8	29.4524	69.0291
9 1/2	29.8451	70.8822
9 5/8	30.2378	72.7598
9 3/4	30.6305	74.6619
9 7/8	31.0232	76.589
10	31.4159	78.540
10 1/8	31.8086	80.516
10 1/4	32.2013	82.516
10 3/8	32.5940	84.541
10 1/2	32.9867	86.590
10 5/8	33.3794	88.664
10 3/4	33.7721	90.673
10 7/8	34.1648	92.886
11	34.5575	95.033
11 1/8	34.9502	97.205
11 1/4	35.3429	99.402
11 3/8	35.7356	101.623
11 1/2	36.1283	103.869
11 5/8	36.5210	106.139
11 3/4	36.9137	108.434
11 7/8	37.3064	110.753
12	37.6991	113.097
12 1/8	38.0918	115.466
12 1/4	38.4845	117.859
12 3/8	38.8772	120.276
12 1/2	39.2699	122.718
12 5/8	39.6626	125.185
12 3/4	40.0553	127.676
12 7/8	40.4480	130.192
13	40.8407	132.732
13 1/8	41.2334	135.297
13 1/4	41.6261	137.886
13 3/8	42.0188	140.500
13 1/2	42.4115	143.139
13 5/8	42.8042	145.802
13 3/4	43.1969	148.489
13 7/8	43.5896	151.201
14	43.9823	153.938
14 1/8	44.3750	156.699
14 1/4	44.7677	159.485
14 3/8	45.1604	162.295
14 1/2	45.5531	165.130
14 5/8	45.9458	167.989
14 3/4	46.3385	170.873
14 7/8	46.7312	173.782
15	47.1239	176.715
15 1/8	47.5166	179.672
15 1/4	47.9093	182.654
15 3/8	48.3020	185.661
15 1/2	48.6947	188.692
15 5/8	49.0874	191.748
15 3/4	49.4801	194.828
15 7/8	49.8728	197.933
16	50.2655	201.062
16 1/8	50.6582	204.216
16 1/4	51.0509	207.394
16 3/8	51.4436	210.597
16 1/2	51.8363	213.825
16 5/8	52.2290	217.077
16 3/4	52.6217	220.353
16 7/8	53.0144	223.654
17	53.4071	226.980
17 1/8	53.7998	230.330
17 1/4	54.1925	233.705
17 3/8	54.5852	237.104
17 1/2	54.9779	240.528
17 5/8	55.3706	243.977
17 3/4	55.7633	247.450
17 7/8	56.1560	250.947
18	56.5487	254.469
18 1/8	56.9414	258.016
18 1/4	57.3341	261.587
18 3/8	57.7268	265.182
18 1/2	58.1195	268.803
18 5/8	58.5122	272.447
18 3/4	58.9049	276.117
18 7/8	59.2976	279.810
19	59.6903	283.529
19 1/8	60.0830	287.272
19 1/4	60.4757	291.039
19 3/8	60.8684	294.831
19 1/2	61.2611	298.648
19 5/8	61.6538	302.489

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET			OF INCHES OR FEET		
Diam.	Circum.	Area	Diam.	Circum.	Area
19¾	62.0465	306.354	26⅝	83.6449	556.761
19⅞	62.4392	310.245	26¾	84.0376	562.001
20	62.8319	314.159	26⅞	84.4303	567.266
20⅛	63.2246	318.099	27	84.8230	572.555
20¼	63.6173	322.062	27⅛	85.2157	577.869
20⅜	64.0100	326.051	27¼	85.6084	583.207
20½	64.4026	330.064	27⅜	86.0011	588.570
20⅝	64.7953	334.101	27½	86.3938	593.957
20¾	65.1880	338.163	27⅝	86.7865	599.369
20⅞	65.5807	342.250	27¾	87.1792	604.806
21	65.9734	346.361	27⅞	87.5719	610.267
21⅛	66.3661	350.496	28	87.9646	615.752
21¼	66.7588	354.656	28⅛	88.3573	621.262
21⅜	67.1515	358.841	28¼	88.7500	626.797
21½	67.5442	363.050	28⅜	89.1427	632.356
21⅝	67.9369	367.284	28½	89.5354	637.940
21¾	68.3296	371.542	28⅝	89.9281	643.548
21⅞	68.7223	375.825	28¾	90.3208	649.181
22	69.1150	380.133	28⅞	90.7135	654.838
22⅛	69.5077	384.465	29	91.1062	660.520
22¼	69.9004	388.821	29⅛	91.4989	666.226
22⅜	70.2931	393.202	29¼	91.8916	671.957
22½	70.6858	397.608	29⅜	92.2843	677.713
22⅝	71.0785	402.038	29½	92.6770	683.493
22¾	71.4712	406.493	29⅝	93.0697	689.297
22⅞	71.8639	410.972	29¾	93.4624	695.126
23	72.2566	415.476	29⅞	93.8551	700.980
23⅛	72.6493	420.004	30	94.2478	706.858
23¼	73.0420	424.557	30⅛	94.6405	712.761
23⅜	73.4347	429.134	30¼	95.0332	718.688
23½	73.8274	433.736	30⅜	95.4259	724.640
23⅝	74.2201	438.363	30½	95.8186	730.617
23¾	74.6128	443.014	30⅝	96.2113	736.618
23⅞	75.0055	447.689	30¾	96.6040	742.643
24	75.3982	452.389	30⅞	96.9967	748.693
24⅛	75.7909	457.114	31	97.3894	754.768
24¼	76.1836	461.863	31⅛	97.7821	760.867
24⅜	76.5763	466.637	31¼	98.1748	766.990
24½	76.9690	471.435	31⅜	98.5675	773.139
24⅝	77.3617	476.258	31½	98.9602	779.311
24¾	77.7544	481.105	31⅝	99.3529	785.509
24⅞	78.1471	485.977	31¾	99.7456	791.730
25	78.5398	490.874	31⅞	100.1383	797.977
25⅛	78.9325	495.795	32	100.5310	804.248
25¼	79.3252	500.740	32⅛	100.9237	810.543
25⅜	79.7179	505.711	32¼	101.3164	816.863
25½	80.1106	510.705	32⅜	101.7091	823.208
25⅝	80.5033	515.724	32½	102.1018	829.577
25¾	80.8960	520.768	32⅝	102.4945	835.970
25⅞	81.2887	525.836	32¾	102.8872	842.389
26	81.6814	530.929	32⅞	103.280	848.831
26⅛	82.0741	536.047	33	103.673	855.299
26¼	82.4668	541.188	33⅛	104.065	861.790
26⅜	82.8595	546.355	33¼	104.458	868.307
26½	83.2522	551.546	33⅜	104.851	874.848

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET			OF INCHES OR FEET		
Diam.	Circum.	Area	Diam.	Circum.	Area
33½	105.243	881.413	40⅜	126.842	1280.309
33⅝	105.636	888.003	40½	127.235	1288.249
33¾	106.029	894.618	40⅝	127.627	1296.214
33⅞	106.421	901.257	40¾	128.020	1304.203
34	106.814	907.920	40⅞	128.413	1312.216
34⅛	107.207	914.608	41	128.805	1320.254
34¼	107.600	921.321	41⅛	129.198	1328.317
34⅜	107.992	928.058	41¼	129.591	1336.404
34½	108.385	934.820	41⅜	129.983	1344.516
34⅝	108.778	941.607	41½	130.376	1352.652
34¾	109.170	948.417	41⅝	130.769	1360.813
34⅞	109.563	955.253	41¾	131.161	1368.998
35	109.956	962.113	41⅞	131.554	1377.208
35⅛	110.348	968.997	42	131.947	1385.442
35¼	110.741	975.906	42⅛	132.340	1393.701
35⅜	111.134	982.840	42¼	132.732	1401.985
35½	111.527	989.798	42⅜	133.125	1410.293
35⅝	111.919	996.781	42½	133.518	1418.625
35¾	112.312	1003.788	42⅝	133.910	1426.983
35⅞	112.705	1010.820	42¾	134.303	1435.364
36	113.097	1017.876	42⅞	134.696	1443.770
36⅛	113.490	1024.957	43	135.088	1452.201
36¼	113.883	1032.062	43⅛	135.481	1460.657
36⅜	114.275	1039.192	43¼	135.874	1469.136
36½	114.668	1046.347	43⅜	136.267	1477.641
36⅝	115.061	1053.526	43½	136.659	1486.170
36¾	115.454	1060.729	43⅝	137.052	1494.723
36⅞	115.846	1067.957	43¾	137.445	1503.301
37	116.239	1075.210	43⅞	137.837	1511.904
37⅛	116.632	1082.487	44	138.230	1520.531
37¼	117.024	1089.789	44⅛	138.623	1529.183
37⅝	117.417	1097.115	44¼	139.015	1537.859
37½	117.810	1104.466	44⅜	139.408	1546.56
37⅝	118.202	1111.842	44½	139.801	1555.28
37¾	118.595	1119.241	44⅝	140.194	1564.03
37⅞	118.988	1126.666	44¾	140.586	1572.81
38	119.381	1134.115	44⅞	140.979	1581.61
38⅛	119.773	1141.589	45	141.372	1590.43
38¼	120.166	1149.087	45⅛	141.764	1599.28
38⅜	120.559	1156.609	45¼	142.157	1608.15
38½	120.951	1164.156	45⅝	142.550	1617.05
38⅝	121.344	1171.728	45½	142.942	1625.97
38¾	121.737	1179.324	45⅝	143.335	1634.92
38⅞	122.129	1186.945	45¾	143.728	1643.89
39	122.522	1194.591	45⅞	144.121	1652.88
39⅛	122.915	1202.261	46	144.513	1661.90
39¼	123.308	1209.955	46⅛	144.906	1670.95
39⅜	123.700	1217.674	46¼	145.299	1680.02
39½	124.093	1225.417	46⅜	145.691	1689.11
39⅝	124.486	1233.186	46½	146.084	1698.23
39¾	124.878	1240.978	46⅝	146.477	1707.37
39⅞	125.271	1248.795	46¾	146.869	1716.54
40	125.664	1256.637	46⅞	147.262	1725.73
40⅛	126.056	1264.503	47	147.655	1734.94
40¼	126.449	1272.394	47⅛	148.048	1744.19

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET			OF INCHES OR FEET		
Diam.	Circum.	Area	Diam.	Circum.	Area
47¼	148.440	1753.45	54⅛	170.039	2300.84
47⅜	148.833	1762.74	54¼	170.431	2311.48
47½	149.226	1772.05	54⅜	170.824	2322.14
47⅝	149.618	1781.39	54½	171.217	2332.83
47¾	150.011	1790.76	54⅝	171.609	2343.54
47⅞	150.404	1800.14	54¾	172.002	2354.28
48	150.796	1809.56	54⅞	172.395	2365.04
48⅛	151.189	1818.99	55	172.788	2375.83
48¼	151.582	1828.46	55⅛	173.180	2386.64
48⅜	151.975	1837.94	55¼	173.573	2397.48
48½	152.367	1847.45	55⅜	173.966	2408.34
48⅝	152.760	1856.99	55½	174.358	2419.22
48¾	153.153	1866.55	55⅝	174.751	2430.13
48⅞	153.545	1876.13	55¾	175.144	2441.07
49	153.938	1885.74	55⅞	175.536	2452.03
49⅛	154.331	1895.37	56	175.929	2463.01
49¼	154.723	1905.03	56⅛	176.322	2474.02
49⅜	155.116	1914.71	56¼	176.715	2485.05
49½	155.509	1924.42	56⅜	177.107	2496.11
49⅝	155.902	1934.15	56½	177.500	2507.19
49¾	156.294	1943.91	56⅝	177.893	2518.29
49⅞	156.687	1953.69	56¾	178.285	2529.42
50	157.080	1963.50	56⅞	178.678	2540.58
50⅛	157.472	1973.33	57	179.071	2551.76
50¼	157.865	1983.18	57⅛	179.463	2562.96
50⅜	158.258	1993.06	57¼	179.856	2574.19
50½	158.650	2002.96	57⅜	180.249	2585.44
50⅝	159.043	2012.89	57½	180.642	2596.72
50¾	159.436	2022.84	57⅝	181.034	2608.03
50⅞	159.829	2032.82	57¾	181.427	2619.35
51	160.221	2042.82	57⅞	181.820	2630.70
51⅛	160.614	2052.85	58	182.212	2642.08
51¼	161.007	2062.90	58⅛	182.605	2653.48
51⅜	161.399	2072.97	58¼	182.998	2664.91
51½	161.792	2083.07	58⅜	183.390	2676.35
51⅝	162.185	2093.20	58½	183.783	2687.83
51¾	162.577	2103.35	58⅝	184.176	2699.33
51⅞	162.970	2113.52	58¾	184.569	2710.85
52	163.363	2123.72	58⅞	184.961	2722.40
52⅛	163.756	2133.94	59	185.354	2733.97
52¼	164.148	2144.19	59⅛	185.747	2745.57
52⅜	164.541	2154.46	59¼	186.139	2757.19
52½	164.934	2164.75	59⅜	186.532	2768.84
52⅝	165.326	2175.07	59½	186.925	2780.51
52¾	165.719	2185.42	59⅝	187.317	2792.20
52⅞	166.112	2195.79	59¾	187.710	2803.92
53	166.504	2206.18	59⅞	188.103	2815.66
53⅛	166.897	2216.60	60	188.496	2827.43
53¼	167.290	2227.05	60⅛	188.888	2839.23
53⅜	167.683	2237.51	60¼	189.281	2851.04
63½	168.075	2248.01	60⅜	189.674	2862.89
53⅝	168.468	2258.52	60½	190.066	2874.75
53¾	168.861	2269.06	60⅝	190.459	2886.65
53⅞	169.253	2279.63	60¾	190.852	2898.56
54	169.646	2290.22	60⅞	191.244	2910.50

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET			OF INCHES OR FEET		
Diam.	Circum.	Area	Diam.	Circum.	Area
61	191.637	2922.47	67⅞	213.236	3618.34
61⅛	192.030	2934.46	68	213.628	3631.68
61¼	192.423	2946.47	68⅛	214.021	3645.05
61⅜	192.815	2958.51	68¼	214.414	3658.43
61½	193.208	2970.57	68⅜	214.806	3671.85
61⅝	193.601	2982.66	68½	215.199	3685.28
61¾	193.993	2994.77	68⅝	215.592	3698.75
61⅞	194.386	3006.91	68¾	215.984	3712.23
62	194.779	3019.07	68⅞	216.377	3725.74
62⅛	195.171	3031.26	69	216.770	3739.28
62¼	195.564	3043.47	69⅛	217.163	3752.84
62⅜	195.957	3055.70	69¼	217.555	3766.43
62½	196.350	3067.96	69⅜	217.948	3780.04
62⅝	196.742	3080.25	69½	218.341	3793.67
62¾	197.135	3092.55	69⅝	218.733	3807.33
62⅞	197.528	3104.89	69¾	219.126	3821.01
63	197.920	3117.25	69⅞	219.519	3834.72
63⅛	198.313	3129.63	70	219.911	3848.45
63¼	198.706	3142.03	70⅛	220.304	3862.21
63⅜	199.098	3154.47	70¼	220.697	3875.99
63½	199.491	3166.92	70⅜	221.090	3889.79
63⅝	199.884	3179.40	70½	221.482	3903.63
63¾	200.277	3191.91	70⅝	221.875	3917.48
63⅞	200.669	3204.44	70¾	222.268	3931.36
64	201.062	3216.99	70⅞	222.660	3945.26
64⅛	201.455	3229.57	71	223.053	3959.19
64¼	201.847	3242.17	71⅛	223.446	3973.15
64⅜	202.240	3254.80	71¼	223.838	3987.12
64½	202.633	3267.45	71⅜	224.231	4001.13
64⅝	203.025	3280.13	71½	224.624	4015.15
64¾	203.418	3292.83	71⅝	225.017	4029.20
64⅞	203.811	3305.56	71¾	225.409	4043.28
65	204.204	3318.31	71⅞	225.802	4057.38
65⅛	204.596	3331.08	72	226.195	4071.50
65¼	204.989	3343.88	72⅛	226.587	4085.65
65⅜	205.382	3356.71	72¼	226.980	4099.83
65½	205.774	3369.55	72⅜	227.373	4114.03
65⅝	206.167	3382.43	72½	227.765	4128.25
65¾	206.560	3395.33	72⅝	228.158	4142.50
65⅞	206.952	3408.25	72¾	228.551	4156.77
66	207.345	3421.19	72⅞	228.944	4171.07
66⅛	207.738	3434.17	73	229.336	4185.39
66¼	208.131	3447.16	73⅛	229.729	4199.73
66⅜	208.523	3460.18	73¼	230.122	4214.10
66½	208.916	3473.23	73⅜	230.514	4228.50
66⅝	209.309	3486.30	73½	230.907	4242.92
66¾	209.701	3499.39	73⅝	231.300	4257.36
66⅞	210.094	3512.51	73¾	231.692	4271.83
67	210.487	3525.65	73⅞	232.085	4286.32
67⅛	210.879	3538.82	74	232.478	4300.84
67¼	211.272	3552.01	74⅛	232.871	4315.38
67⅜	211.665	3565.23	74¼	233.263	4329.95
67½	212.058	3578.47	74⅜	233.656	4344.54
67⅝	212.450	3591.74	74½	234.049	4359.16
67¾	212.843	3605.03	74⅝	234.441	4373.80

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET			OF INCHES OR FEET		
Diam.	Circum.	Area	Diam.	Circum.	Area
74¾	234.834	4388.46	81⅝	256.433	5232.83
74⅞	235.227	4403.15	81¾	256.825	5248.87
75	235.619	4417.86	81⅞	257.218	5264.93
75⅛	236.012	4432.60	82	257.611	5281.02
75¼	236.405	4447.37	82⅛	258.003	5297.13
75⅜	236.798	4462.15	82¼	258.396	5313.27
75½	237.190	4476.97	82⅜	258.789	5329.43
75⅝	237.583	4491.80	82½	259.181	5345.62
75¾	237.976	4506.66	82⅝	259.574	5361.83
75⅞	238.368	4521.55	82¾	259.967	5378.06
76	238.761	4536.46	82⅞	260.359	5394.32
76⅛	239.154	4551.39	83	260.752	5410.61
76¼	239.546	4566.35	83⅛	261.145	5426.92
76⅜	239.939	4581.34	83¼	261.538	5443.25
76½	240.332	4596.35	83⅜	261.930	5459.61
76⅝	240.725	4611.38	83½	262.323	5475.99
76¾	241.117	4626.44	83⅝	262.716	5492.40
76⅞	241.510	4641.52	83¾	263.108	5508.83
77	241.903	4656.63	83⅞	263.501	5525.29
77⅛	242.295	4671.76	84	263.894	5541.77
77¼	242.688	4686.91	84⅛	264.286	5558.28
77⅜	243.081	4702.09	84¼	264.679	5574.81
77½	243.473	4717.30	84⅜	265.072	5591.36
77⅝	243.866	4732.53	84½	265.465	5607.94
77¾	244.259	4747.78	84⅝	265.857	5624.54
77⅞	244.652	4763.06	84¾	266.250	5641.17
78	245.044	4778.36	84⅞	266.643	5657.82
78⅛	245.437	4793.69	85	267.035	5674.50
78¼	245.830	4809.04	85⅛	267.428	5691.20
78⅜	246.222	4824.42	85¼	267.821	5707.93
78½	246.615	4839.82	85⅜	268.213	5724.68
78⅝	247.008	4855.25	85½	268.606	5741.46
78¾	247.400	4870.70	85⅝	268.999	5758.26
78⅞	247.793	4886.17	85¾	269.392	5775.08
79	248.186	4901.67	85⅞	269.784	5791.93
79⅛	248.579	4917.19	86	270.177	5808.80
79¼	248.971	4932.74	86⅛	270.570	5825.70
79⅜	249.364	4948.32	86¼	270.962	5842.63
79½	249.757	4963.91	86⅜	271.355	5859.57
79⅝	250.149	4979.53	86½	271.748	5876.55
79¾	250.542	4995.18	86⅝	272.140	5893.54
79⅞	250.935	5010.85	86¾	272.533	5910.56
80	251.327	5026.55	86⅞	272.926	5927.61
80⅛	251.720	5042.27	87	273.319	5944.68
80¼	252.113	5058.01	87⅛	273.711	5961.77
80⅜	252.506	5073.78	87¼	274.104	5978.89
80½	252.898	5089.58	87⅜	274.497	5996.04
80⅝	253.291	5105.39	87½	274.889	6013.20
80¾	253.684	5121.24	87⅝	275.282	6030.40
80⅞	254.076	5137.11	87¾	275.675	6047.62
81	254.469	5153.00	87⅞	276.067	6064.86
81⅛	254.862	5168.91	88	276.460	6082.12
81¼	255.254	5184.86	88⅛	276.853	6099.41
81⅜	255.647	5200.82	88¼	277.246	6116.73
81½	256.040	5216.81	88⅜	277.638	6134.07

CIRCUMFERENCES AND AREAS OF CIRCLES

Table No. 39 (Continued)

OF INCHES OR FEET			OF INCHES OR FEET		
Diam.	Circum.	Area	Diam.	Circum.	Area
88½	278.031	6151.43	94⅜	296.488	6995.26
88⅝	278.424	6168.82	94½	296.881	7013.80
88¾	278.816	6186.24	94⅝	297.273	7032.37
88⅞	279.209	6203.68	94¾	297.666	7050.96
89	279.602	6221.14	94⅞	298.059	7069.58
89⅛	279.994	6238.63	95	298.451	7088.22
89¼	280.387	6256.14	95⅛	298.844	7106.88
89⅜	280.780	6273.67	95¼	299.237	7125.57
89½	281.173	6291.24	95⅜	299.629	7144.29
89⅝	281.565	6308.82	95½	300.022	7163.03
89¾	281.958	6326.43	95⅝	300.415	7181.79
89⅞	282.351	6344.07	95¾	300.807	7200.58
90	282.743	6361.73	95⅞	301.200	7219.39
90⅛	283.136	6379.41	96	301.593	7238.23
90¼	283.529	6397.12	96⅛	301.986	7257.09
90⅜	283.921	6414.85	96¼	302.378	7275.98
90½	284.314	6432.61	96⅜	302.771	7294.89
90⅝	284.707	6450.39	96½	303.164	7313.82
90¾	285.100	6468.20	96⅝	303.556	7332.78
90⅞	285.492	6486.03	96¾	303.949	7351.77
91	285.885	6503.88	96⅞	304.342	7370.78
91⅛	286.278	6521.76	97	304.734	7389.81
91¼	286.670	6539.67	97⅛	305.127	7408.87
91⅜	287.063	6557.60	97¼	305.520	7427.95
91½	287.456	6575.55	97⅜	305.913	7447.06
91⅝	287.848	6593.53	97½	306.305	7466.19
91¾	288.241	6611.53	97⅝	306.698	7485.35
91⅞	288.634	6629.56	97¾	307.091	7504.53
92	289.027	6647.61	97⅞	307.483	7523.73
92⅛	289.419	6665.69	98	307.876	7542.96
92¼	289.812	6683.79	98⅛	308.269	7562.22
92⅜	290.205	6701.91	98¼	308.661	7581.50
92½	290.597	6720.06	98⅜	309.054	7600.80
92⅝	290.990	6738.24	98½	309.447	7620.13
92¾	291.383	6756.44	98⅝	309.840	7639.48
92⅞	291.775	6774.66	98¾	310.232	7658.86
93	292.168	6792.91	98⅞	310.625	7678.26
93⅛	292.561	6811.18	99	311.018	7697.69
93¼	292.954	6829.48	99⅛	311.410	7717.14
93⅜	293.346	6847.80	99¼	311.803	7736.61
93½	293.739	6866.15	99⅜	312.196	7756.11
93⅝	294.132	6884.52	99½	312.588	7775.64
93¾	294.524	6902.91	99⅝	312.981	7795.19
93⅞	294.917	6921.33	99¾	313.374	7814.76
94	295.310	6939.78	99⅞	313.767	7834.36
94⅛	295.702	6958.25	100	314.159	7853.98
94¼	296.095	6976.74			

CIRCLES

Circumference equals diameter x 3.1416 or about 3 1/7.

The side of a square equal in area to a given circle equals diameter x 0.8862.

The side of an inscribed square equals diameter x 0.7071.

The diameter of a circle equals the circumference divided by 3.1416.

The area of a circle equals the square of the diameter x 0.7854 or the square of the radius x 3.1416.

Lengths of arcs:

For 1 degree = Radius x .01745329 Log. = 8.2418774
For 1 minute = Radius x .00029089 Log. = 6.4637261
For 1 second = Radius x .000004848 Log. = 4.6855749

Volume of a sphere = 4.188 x the cube of the radius, or 0.01689 x the cube of the circumference.

Area of surface of sphere:

Equals 3.1416 x the square of the diameter.
Equals 0.3183 x the square of the circumference.
Equals the diameter x the circumference.

PYRAMIDS AND CONES

Surface Area of sides of right regular pyramid or right regular cone, equals: Circumference, or perimeter of base, $\times$ ½ slant height. Add area of base, if required.

Volume of right or oblique, regular or irregular, pyramid or cone, equals: Area of base $\times$ 1/3 perpendicular height.

Parallel Lines of 4 Foot Pipe

FRUSTRUM OF PYRAMID OR CONE

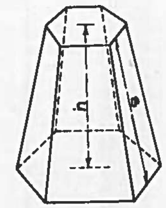


Fig. 1

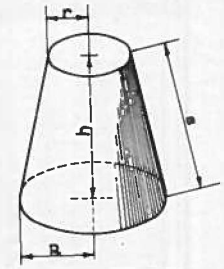


Fig. 2

a = Area of Top
A = Area of Base
M = Area of section parallel to, and midway between, base and top.
h = Perpendicular Height

c = Circumference of Top
C = Circumference of Base
r = Radius of Top
R = Radius of Base
s = Slant Height

NOTE: *In frustrum of pyramid, s must be measured along middle of one side.*

Surface Area of sides of frustrum of right regular pyramid or cone, equals—

$$\frac{s}{2}(c + C)$$

For conic frustrum this becomes:

$$\pi s (r + R)$$

Add Area of Top and Base, if required.

Volume of frustrum of regular or irregular, right or oblique, pyramid or cone, equals—

$$\frac{h}{3}(a + A + \sqrt{a A}) =$$

$$\frac{h}{6}(a + A + 4M)$$

For conic frustrum this becomes:

$$\frac{h}{3}\pi (r^2 + R^2 + r R)$$

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
1	1	1	1.0000	1.0000	1.000000000	3.1416	0.7854
2	4	8	1.4142	1.2599	.500000000	6.2832	3.1416
3	9	27	1.7321	1.4422	.333333333	9.4248	7.0686
4	16	64	2.0000	1.5874	.250000000	12.5664	12.5664
5	25	125	2.2361	1.7100	.200000000	15.7080	19.635
6	36	216	2.4495	1.8171	.166666667	18.850	28.274
7	49	343	2.6458	1.9129	.142857143	21.991	38.485
8	64	512	2.8284	2.0000	.125000000	25.133	50.266
9	81	729	3.0000	2.0801	.111111111	28.274	63.617
10	100	1,000	3.1623	2.1544	.100000000	31.416	78.540
11	121	1,331	3.3166	2.2240	.090909091	34.558	95.033
12	144	1,728	3.4641	2.2894	.083333333	37.699	113.10
13	169	2,197	3.6056	2.3513	.076923077	40.841	132.73
14	196	2,744	3.7417	2.4101	.071428571	43.982	153.94
15	225	3,375	3.8730	2.4662	.666666667	47.124	176.71
16	256	4,096	4.0000	2.5198	.062500000	50.265	201.06
17	289	4,913	4.1231	2.5713	.058823529	53.407	226.98
18	324	5,832	4.2426	2.6207	.055555556	56.549	254.47
19	361	6,859	4.3589	2.6684	.052631579	59.690	283.53
20	400	8,000	4.4721	2.7144	.050000000	62.832	314.16
21	441	9,261	4.5826	2.7589	.047619048	65.973	346.36
22	484	10,648	4.6904	2.8020	.045454545	69.115	380.13
23	529	12,167	4.7958	2.8439	.043478261	72.257	415.48
24	576	13,824	4.8990	2.8845	.041666667	75.398	452.39
25	625	15,625	5.0000	2.9240	.040000000	78.540	490.87
26	676	17,576	5.0990	2.9625	.038461538	81.681	530.93
27	729	19,683	5.1962	3.0000	.037037037	84.823	572.56
28	784	21,952	5.2915	3.0366	.035714286	87.965	615.75
29	841	24,389	5.3852	3.0723	.034482759	91.106	660.52
30	900	27,000	5.4772	3.1072	.033333333	94.248	706.86
31	961	29,791	5.5678	3.1414	.032258065	97.389	754.77
32	1,024	32,768	5.6569	3.1748	.031250000	100.53	804.25
33	1,089	35,937	5.7446	3.2075	.030303030	103.67	855.30
34	1,156	39,304	5.8310	3.2396	.029411765	106.81	907.92
35	1,225	42,875	5.9161	3.2711	.028571429	109.96	962.11
36	1,296	46,656	6.0000	3.3019	.027777778	113.10	1,017.88
37	1,369	50,653	6.0828	3.3322	.027027027	116.24	1,075.21
38	1,444	54,872	6.1644	3.3620	.026315789	119.38	1,134.11
39	1,521	59,319	6.2450	3.3912	.025641026	122.52	1,194.59
40	1,600	64,000	6.3246	3.4200	.025000000	125.66	1,256.64
41	1,681	68,921	6.4031	3.4482	.024390244	128.81	1,320.25
42	1,764	74,088	6.4807	3.4760	.023809524	131.95	1,385.44
43	1,849	79,507	6.5574	3.5034	.023255814	135.09	1,452.20
44	1,936	85,184	6.6332	3.5303	.022727273	138.23	1,520.53
45	2,025	91,125	6.7082	3.5569	,022222222	141.37	1,590.43
46	2,116	97,336	6.7823	3.5830	.021739130	144.51	1,661.90
47	2,209	103,823	6.8557	3,6088	.021276596	147.65	1,734.94
48	2,304	110,592	6.9282	3.6342	.020833333	150.80	1,809.56
49	2,401	117,649	7.0000	3.6593	.020408163	153.94	1,885.74
50	2,500	125,000	7.0711	3.6840	.020000000	157.08	1,963.50
51	2,601	132,651	7.1414	3.7084	.019607843	160.22	2,042.82
52	2,704	140,608	7.2111	3.7325	.019230769	163.36	2,123.72
53	2,809	148,877	7.2801	3.7563	.018867925	166.50	2,206.18
54	2,916	157,464	7.3485	3.7798	.018518519	169.65	2,290.22
55	3,025	166,375	7.4162	3.8030	.018181818	172.79	2,375.83

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
56	3,136	175,616	7.4833	3.8259	.017857143	175.93	2,463.01
57	3,249	185,193	7.5498	3.8485	.017543860	179.07	2,551.76
58	3,364	195,112	7.6158	3.8709	.017241379	182.21	2,642.08
59	3,481	205,379	7.6811	3.8930	.016949153	185.35	2,733.97
60	3,600	216,000	7.7460	3.9149	.016666667	188.50	2,827.43
61	3,721	226,981	7.8102	3.9365	.016393443	191.64	2,922.47
62	3,844	238,328	7.8740	3.9579	.016129032	194.78	3,019.07
63	3,969	250,047	7.9373	3,9791	.015873016	197.92	3,117.25
64	4,096	262,144	8.0000	4.0000	.015625000	201.06	3,216.99
65	4,225	274,625	8.0623	4.0207	.015384615	204.20	3,318.31
66	4,356	287,496	8.1240	4,0412	.015151515	207.34	3,421.19
67	4,489	300,763	8.1854	4.0615	.014925373	210.49	3,525.65
68	4,624	314,432	8.2462	4.0817	.014705882	213.63	3,631.68
69	4,761	328,509	8.3066	4.1016	.014492754	216.77	3,739.28
70	4,900	343,000	8.3666	4.1213	.014285714	219.91	3,848.45
71	5,041	357,911	8.4261	4.1408	.014084507	223.05	3,959.19
72	5,184	373,248	8.4853	4.1602	.013888889	226.19	4,017.50
73	5,329	389,017	8.5440	4.1793	.013698630	229.34	4,185.39
74	5,476	405,224	8.6023	4.1983	.013513514	232.48	4,300.84
75	5,625	421,875	8.6603	4.2172	.013333333	235.62	4,417.86
76	5,776	438,976	8.7178	4.2358	.013157895	238.76	4,536.46
77	5,929	456,533	8.7750	4.2543	.012987013	241.90	4,656.63
78	6,084	474,552	8.8318	4.2727	.012820513	245.04	4,778.36
79	6,241	493,039	8.8882	4.2908	.012658228	248.19	4,901.67
80	6,400	512,000	8.9443	4.3089	.012500000	251.33	5,026.55
81	6,561	531,441	9.0000	4.3267	.012345679	254.47	5,153.00
82	6,724	551,368	9.0554	4.3445	.012195122	257.61	5,281.02
83	6,889	571,787	9.1104	4.3621	.012048193	260.75	5,410.61
84	7,056	592,704	9.1652	4.3795	.011904762	263.89	5,541.77
85	7,225	614,125	9.2195	4.3968	.011764706	267.04	5,674.50
86	7,396	636,056	9.2736	4.4140	.011627907	270.18	5,808.80
87	7,569	658,503	9.3274	4.4310	.011494253	273.32	5,944.68
88	7,744	681,472	9.3808	4.4480	.011363636	276.46	6,082.12
89	7,921	704,969	9.4340	4.4647	.011235955	279.60	6,221.14
90	8,100	729,000	9.4868	4.4814	.011111111	282.74	6,361.73
91	8,281	753,571	9.5394	4.4979	.010989011	285.88	6,503.88
92	8,464	778,688	9.5917	4.5144	.010869565	289.03	6,647.61
93	8,649	804,357	9.6437	4.5307	.010752688	292.17	6,792.91
94	8,836	830,584	9.6954	4.5468	.010638298	295.31	6,939.78
95	9,025	857,375	9.7468	4.5629	.010526316	298.45	7,088.22
96	9,216	884,736	9.7980	4.5789	.010416667	301.59	7,238.23
97	9,409	912,673	9.8489	4.5947	.010309278	304.73	7,389.81
98	9,604	941,192	9.8995	4.6104	.010204082	307.88	7,542.96
99	9,801	970,299	9.9499	4.6261	.010101010	311.02	7,697.69
100	10,000	1,000,000	10.0000	4.6416	.010000000	314.16	7,853.98
101	10,201	1,030,301	10.0499	4.6570	.009900990	317.30	8,011.85
102	10,404	1,061,208	10.0995	4.6723	.009803922	320.44	8,171.28
103	10,609	1,092,727	10.1489	4.6875	.009708738	323.58	8,332.29
104	10,816	1,124,864	10.1980	4.7027	.009615385	326.73	8,494.87
105	11,025	1,157,625	10.2470	4.7177	.009523810	329.87	8,659.01
106	11,236	1,191,016	10.2956	4.7326	.009433962	333.01	8,824.73
107	11,449	1,225,043	10.3441	4.7475	.009345794	336.15	8,992.02
108	11,664	1,259,712	10.3923	4.7622	.009259259	339.29	9,160.88
109	11,881	1,295,029	10.4403	4.7769	.009174312	342.43	9,331.32
110	12,100	1,331,000	10.4881	4.7914	.009090909	345.58	9,503.32

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
111	12,321	1,367,631	10.5357	4.8059	.009009009	348.72	9,676.89
112	12,544	1,404,928	10.5830	4.8203	.008928571	351.86	9,852.03
113	12,769	1,442,897	10.6301	4.8346	.008849558	355.00	10,028.75
114	12,996	1,481,544	10.6771	4.8488	.008771930	358.14	10,207.03
115	13,225	1,520,875	10.7238	4.8629	.008695652	361.28	10,386.89
116	13,456	1,560,896	10.7703	4.8770	.008620690	364.42	10,568.32
117	13,689	1,601,613	10.8167	4.8910	.008547009	367.57	10,751.32
118	13,924	1,643,032	10.8628	4.9049	.008474576	370.71	10,935.88
119	14,161	1,685,159	10.9087	4.9187	.008403361	373.85	11,122.02
120	14,400	1,728,000	10.9545	4.9324	.008333333	376.99	11,309.73
121	14,641	1,771,561	11.0000	4.9461	.008264463	380.13	11,499.01
122	14,884	1,815,848	11.0454	4.9597	.008196721	383.27	11,689.87
123	15,129	1,860,867	11.0905	4.9732	.008130081	386.42	11,882.29
124	15,376	1,906,624	11.1355	4.9866	.008064516	389.56	12,076.28
125	15,625	1,953,125	11.1803	5.0000	.008000000	392.70	12,271.85
126	15,876	2,000,376	11.2250	5.0133	.007936508	395.84	12,468.98
127	16,129	2,048,383	11.2694	5.0265	.007874016	398.98	12,667.69
128	16,384	2,097,152	11.3137	5.0397	.007812500	402.12	12,867.96
129	16,641	2,146,689	11.3578	5.0528	.007751938	405.27	13,069.81
130	16,900	2,197,000	11.4018	5.0658	.007692308	408.41	13,273.23
131	17,161	2,248,091	11.4455	5.0788	.007633588	411.55	13,478.22
132	17,424	2,299,968	11.4891	5.0916	.007575758	414.69	13,684.78
133	17,689	2,352,637	11.5326	5.1045	.007518797	417.83	13,892.91
134	17,956	2,406,104	11.5758	5.1172	.007462687	420.97	14,102.61
135	18,225	2,460,375	11.6190	5.1299	.007407407	424.12	14,313.88
136	18,496	2,515,456	11.6619	5.1426	.007352941	427.26	14,526.72
137	18,769	2,571,353	11.7047	5.1551	.007299270	430.40	14,741.14
138	19,044	2,628,072	11.7473	5.1676	.007246377	433.54	14,957.12
139	19,321	2,685,619	11.7898	5.1801	.007194245	436.68	15,174.68
140	19,600	2,744,000	11.8322	5.1925	.007142857	439.82	15,393.80
141	19,881	2,803,221	11.8743	5.2048	.007092199	442.96	15,614.50
142	20,164	2,863,288	11.9164	5.2171	.007042254	446.11	15,836.77
143	20,449	2,924,207	11.9583	5.2293	.006993007	449.25	16,060.61
144	20,736	2,985,984	12.0000	5.2415	.006944444	452.39	16,286.02
145	21,025	3,048,625	12.0416	5.2536	.006896552	455.53	16,513.00
146	21,316	3,112,136	12.0830	5.2656	.006849315	458.67	16,741.55
147	21,609	3,176,523	12.1244	5.2776	.006802721	461.81	16,971.67
148	21,904	3,241,792	12.1655	5.2896	.006756757	464.96	17,203.36
149	22,201	3,307,949	12.2066	5.3015	.006711409	468.10	17,436.62
150	22,500	3,375,000	12.2474	5.3133	.006666667	471.24	17,671.46
151	22,801	3,442,951	12.2882	5.3251	.006622517	474.38	17,907.86
152	23,104	3,511,008	12.3288	5.3368	.006578947	477.52	18,145.84
153	23,409	3,581,577	12.3693	5.3485	.006535948	480.66	18,385.39
154	23,716	3,652,264	12.4097	5.3601	.006493506	483.81	18,626.50
155	24,025	3,723,875	12.4499	5.3717	.006451613	486.95	18,869.19
156	24,336	3,796,416	12.4900	5.3832	.006410256	490.09	19,113.45
157	24,649	3,869,893	12.5300	5.3947	.006369427	493.23	19,359.28
158	24,964	3,944,312	12.5698	5.4061	.006329114	496.37	19,606.68
159	25,281	4,019,679	12.6095	5.4175	.006289308	499.51	19,855.65
160	25,600	4,096,000	12.6491	5.4288	.006250000	502.65	20,106.19
161	25,921	4,173,281	12.6886	5.4401	.006211180	505.80	20,358.31
162	26,244	4,251,528	12.7279	5.4514	.006172840	508.94	20,611.99
163	26,569	4,330,747	12.7671	5.4626	.006134969	512.08	20,867.24
164	26,896	4,410,944	12.8062	5.4737	.006097561	515.22	21,124.07
165	27,225	4,492,125	12.8452	5.4848	.006060606	518.36	21,382.46

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
166	27,556	4,574,296	12.8841	5.4959	.006024096	521.50	21,642.43
167	27,889	4,657,463	12.9228	5.5069	.005988024	524.65	21,903.97
168	28,224	4,741,632	12.9615	5.5178	.005952381	527.79	22,167.08
169	28,561	4,826,809	13.0000	5.5288	.005917160	530.93	22,431.76
170	28,900	4,913,000	13.0384	5.5397	.005882353	534.07	22,698.01
171	29,241	5,000,211	13.0767	5.5505	.005847953	537.21	22,965.83
172	29,584	5,088,448	13.1149	5.5613	.005813953	540.35	23,235.22
173	29,929	5,177,717	13.1529	5.5721	.005780347	543.50	23,506.18
174	30,276	5,268,024	13.1909	5.5828	.005747126	546.64	23,778.71
175	30,625	5,359,375	13.2288	5.5934	.005714286	549.78	24,052.82
176	30,976	5,451,776	13.2665	5.6041	.005681818	552.92	24,328.49
177	31,329	5,545,233	13.3041	5.6147	.005649718	556.06	24,605.74
178	31,684	5,639,752	13.3417	5.6252	.005617978	559.20	24,884.56
179	32,041	5,735,339	13.3791	5.6357	.005586592	562.35	25,164.94
180	32,400	5,832,000	13.4164	5.6462	.005555556	565.49	25,446.90
181	32,761	5,929,741	13.4536	5.6567	.005524862	586.63	25,730.43
182	33,124	6,028,568	13.4907	5.6671	.005494505	571.77	26,015.53
183	33,489	6,128,487	13.5277	5.6774	.005464481	574.91	26,302.20
184	33,856	6,229,504	13.5647	5.6877	.005434783	578.05	26,590.44
185	34,225	6,331,625	13.6015	5.6980	.005405405	581.19	26,880.25
186	34,596	6,434,856	13.6382	5.7083	.005376344	584.34	27,171.63
187	34,969	6,539,203	13.6748	5.7185	.005347594	587.48	27,464.59
188	35,344	6,644,672	13.7113	5.7287	.005319149	590.62	27,759.11
189	35,721	6,751,269	13.7477	5.7388	.005291005	593.76	28,055.21
190	36,100	6,859,000	13.7840	5.7489	.005263158	596.90	28,352.87
191	36,481	6,967,871	13.8203	5.7590	.005235602	600.04	28,652.11
192	36,864	7,077,888	13.8564	5.7690	.005208333	603.19	28,952.92
193	37,249	7,189,057	13.8924	5.7790	.005181347	606.33	29,255.30
194	37,636	7,301,384	13.9284	5.7890	.005154639	609.47	29,559.25
195	38,025	7,414,875	13.9642	5.7989	.005128205	612.61	29,864.77
196	38,416	7,529,536	14.0000	5.8088	.005102041	615.75	30,171.86
197	38,809	7,645,373	14.0357	5.8186	.005076142	618.89	30,480.52
198	39,204	7,762,392	14.0712	5.8285	.005050505	622.04	30,790.75
199	39,601	7,880,599	14.1067	5.8383	.005025126	625.18	31,102.55
200	40,000	8,000,000	14.1421	5.8480	.005000000	628.32	31,415.93
201	40,401	8,120,601	14.1774	5.8578	.004975124	631.46	31,730.87
202	40,804	8,242,408	14.2127	5.8675	.004950495	634.60	32,047.39
203	41,209	8,365,427	14.2478	5.8771	.004926108	637.74	32,365.47
204	41,616	8,489,664	14.2829	5.8868	.004901961	640.88	32,685.13
205	42,025	8,615,125	14.3178	5.8964	.004878049	644.03	33,006.36
206	42,436	8,741,816	14.3527	5.9059	.004854369	647.17	33,329.16
207	42,849	8,869,743	14.3875	5.9155	.004830918	650.31	33,653.53
208	43,264	8,998,912	14.4222	5.9250	.004807692	653.45	33,979.47
209	43,681	9,129,329	14.4568	5.9345	.004784689	656.59	34,306.98
210	44,100	9,261,000	14.4914	5.9439	.004761905	659.73	34,636.06
211	44,521	9,393,931	14.5258	5.9533	.004739336	662.88	34,966.71
212	44,944	9,528,128	14.5602	5.9627	.004716981	666.02	35,298.94
213	45,369	9,663,597	14.5945	5.9721	.004694836	669.16	35,632.73
214	45,796	9,800,344	14.6287	5.9814	.004672897	672.30	35,968.09
215	46,225	9,938,375	14.6629	5.9907	.004651163	675.44	36,305.03
216	46,656	10,077,696	14.6969	6.0000	.004629630	678.58	36,643.54
217	47,089	10,218,313	14.7309	6.0092	.004608295	681.73	36,983.61
218	47,524	10,360,232	14.7648	6.0185	.004587156	684.87	37,325.26
219	47,961	10,503,459	14.7986	6.0277	.004566210	688.01	37,668.48
220	48,400	10,648,000	14.8324	6.0368	.004545455	691.15	38,013.27

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
221	48,841	10,793,861	14.8661	6.0459	.004524887	694.29	38,359.63
222	49,284	10,941,048	14.8997	6.0550	.004504505	697.43	38,707.56
223	49,729	11,089,567	14.9332	6.0641	.004484305	700.58	39,057.07
224	50,176	11,239,424	14.9666	6.0732	.004464286	703.72	39,408.14
225	50,625	11,390,625	15.0000	6.0822	.004444444	706.86	39,760.78
226	51,076	11,543,176	15.0333	6.0912	.004424779	710.00	40,115.00
227	51,529	11,697,083	15.0665	6.1002	.004405286	713.14	40,470.78
228	51,984	11,852,352	15.0997	6.1091	.004385965	716.28	40,828.14
229	52,441	12,008,989	15.1327	6.1180	.004366812	719.42	41,187.07
230	52,900	12,167,000	15.1658	6.1269	.004347826	722.57	41,547.56
231	53,361	12,326,391	15.1987	6.1358	.004329004	725.71	41,909.63
232	53,824	12,487,168	15.2315	6.1446	.004310345	728.85	42,273.27
233	54,289	12,649,337	15.2643	6.1534	.004291845	731.99	42,638.48
234	54,756	12,812,904	15.2971	6.1622	.004273504	735.13	43,005.26
235	55,225	12,977,875	15.3297	6.1710	.004255319	738.27	43,373.61
236	55,696	13,144,256	15.3623	6.1797	.004237288	741.42	43,743.54
237	56,169	13,312,053	15.3948	6.1885	.004219409	744.56	44,115.03
238	56,644	13,481,272	15.4272	6.1672	.004201681	747.70	44,488.09
239	57,121	13,651,919	15.4596	6.2058	.004184100	750.84	44,862.73
240	57,600	13,824,000	15.4919	6.2145	.004166667	753.98	45,238.93
241	58,081	13,997,521	15.5242	6.2231	.004149378	757.12	45,616.71
242	58,564	14,172,488	15.5563	6.2317	.004132231	760.27	45,996.06
243	59,049	14,348,907	15.5885	6.2403	.004115226	763.41	46,376.98
244	59,536	14,526,784	15.6205	6.2488	.004098361	766.55	46,759.47
245	60,025	14,706,125	15.6525	6.2573	.004081633	769.69	47,143.52
246	60,516	14,886,936	15.6844	6.2658	.004065041	772.83	47,529.16
247	61,009	15,069,223	15.7162	6.2743	.004048583	775.97	47,916.36
248	61,504	15,252,992	15.7480	6.2828	.004032258	779.11	48,305.13
249	62,001	15,438,249	15.7797	6.2912	.004016064	782.26	48,695.47
250	62,500	15,625,000	15.8114	6.2996	.004000000	785.40	49,087.39
251	63,001	15,813,251	15.8430	6.0380	.003984064	788.54	49,480.87
252	63,504	16,003,008	15.8745	6.3164	.003968254	791.68	49,875.92
253	64,009	16,194,277	15.9060	6.3247	.003952569	794.82	50,272.55
254	64,516	16,387,064	15.9374	6.3330	.003937008	797.96	50,670.75
255	65,025	16,581,375	15.9687	6.3413	.003921569	801.11	51,070.52
256	65,536	16,777,216	16.0000	6.3496	.003906250	804.25	51,471.85
257	66,049	16,974,593	16.0312	6.3579	.003891051	807.39	51,874.76
258	66,564	17,173,512	16.0624	6.3661	.003875969	810.53	52,279.24
259	67,081	17,373,979	16.0935	6.3743	.003861004	813.67	52,685.29
260	67,600	17,576,000	16.1245	6.3825	.003846154	816.81	53,092.92
261	68,121	17,779,581	16.1555	6.3907	.003831418	819.96	53,502.11
262	68,644	17,984,728	16.1864	6.3988	.003816794	823.10	53,912.87
263	69,169	18,191,447	16.2173	6.4070	.003802281	826.24	54,325.21
264	69,696	18,399,744	16.2481	6.4151	.003787879	829.38	54,739.11
265	70,225	18,609,625	16.2788	6.4232	.003773585	832.52	55,154.59
266	70,756	18,821,096	16.3095	6.4312	.003759398	835.66	55,571.63
267	71,289	19,034,163	16.3401	6.4393	.003745318	838.81	55,990.25
268	71,824	19,248,832	16.3707	6.4473	.003731343	841.95	56,410.44
269	72,361	19,465,109	16.4012	6.4553	.003717472	845.09	56,832.20
270	72,900	19,683,000	16.4317	6.4633	.003703704	848.23	57,255.53
271	73,441	19,902,511	16.4621	6.4713	.003690037	851.37	57,680.43
272	73,984	20,123,648	16.4924	6.4792	.003676471	854.51	58,106.90
273	74,529	20,346,417	16.5227	6.4872	.003663004	857.65	58,534.94
274	75,076	20,570,824	16.5529	6.4951	.003649635	860.80	58,964.55
275	75,625	20,796,875	16.5831	6.5030	.003636364	863.94	59,395.74

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
276	76,176	21,024,576	16.6132	6.5108	.003623188	867.08	59,828.49
277	76,729	21,253,933	16.6433	6.5187	.003610108	870.22	60,262.82
278	77,284	21,484,952	16.6733	6.5265	.003597122	873.36	60,698.71
279	77,841	21,717,639	16.7033	6.5343	.003584229	876.50	61,136.18
280	78,400	21,952,000	16.7332	6.5421	.003571429	879.65	61,575.22
281	78,961	22,188,041	16.7631	6.5499	.003558719	882.79	62,015.82
282	79,524	22,425,768	16.7929	6.5577	.003546099	885.93	62,458.00
283	80,089	22,665,187	16.8226	6.5654	.003533569	889.07	62,901.75
284	80,656	22,906,304	16.8523	6.5731	.003521127	892.21	63,347.07
285	81,225	23,149,125	16.8819	6.5808	.003508772	895.35	63,793.97
286	81,796	23,393,656	16.9115	6.5885	.003496503	898.50	64,242.43
287	82,369	23,639,903	16.9411	6.5962	.003484321	901.64	64,692.46
288	82,944	23,887,872	16.9706	6.6039	.003472222	904.78	65,144.07
289	83,521	24,137,569	17.0000	6.6115	.003460208	907.92	65,597.24
290	84,100	24,389,000	17.0294	6.6191	.003448276	911.06	66,051.99
291	84,681	24,642,171	17.0587	6.6267	.003436426	914.20	66,508.30
292	85,264	24,897,088	17.0880	6.6343	.003424658	917.35	66,966.19
293	85,849	25,153,757	17.1172	6.6419	.003412969	920.49	67,425.65
294	86,436	25,412,184	17.1464	6.6494	.003401361	923.63	67,886.68
295	87,025	25,672,375	17.1756	6.6569	.003389831	926.77	68,349.28
296	87,616	25,934,336	17.2047	6.6644	.003378378	929.91	68,813.45
297	88,209	26,198,073	17.2337	6.6719	.003367003	933.05	69,279.19
298	88,804	26,463,592	17.2627	6.6794	.003355705	936.19	69,746.50
299	89,401	26,730,899	17.2916	6.6869	.003344482	939.34	70,215.38
300	90,000	27,000,000	17.3205	6.6943	.003333333	942.48	70,685.83
301	90,601	27,270,901	17.3494	6.7018	.003322259	945.62	71,157.86
302	91,204	27,543,608	17.3781	6.7092	.003311258	948.76	71,631.45
303	91,809	27,818,127	17.4069	6.7166	.003300330	951.90	72,106.62
304	92,416	28,094,464	17.4356	6.7240	.003289474	955.04	72,583.36
305	93,025	28,372,625	17.4642	6.7313	.003278689	958.19	73,061.66
306	93,636	28,652,616	17.4929	6.7387	.003267974	961.33	73,541.54
307	94,249	28,934,443	17.5214	6.7460	.003257329	964.47	74,022.99
308	94,864	29,218,112	17.5499	6.7533	.003246753	967.61	74,506.01
309	95,481	29,503,629	17.5784	6.7606	.003236246	970.75	74,990.60
310	96,100	29,791,000	17.6068	6.7679	.003225806	973.89	75,476.76
311	96,721	30,080,231	17.6352	6.7752	.003215434	977.04	75,964.50
312	97,344	30,371,328	17.6635	6.7824	.003205128	980.18	76,453.80
313	97,969	30,664,297	17.6918	6.7897	.003194888	983.32	76,944.67
314	98,596	30,959,144	17.7200	6.7969	.003184713	986.46	77,437.12
315	99,225	31,255,875	17.7482	6.8041	.003174603	989.60	77,931.13
316	99,856	31,554,496	17.7764	6.8113	.003164557	992.74	78,426.72
317	100,489	31,855,013	17.8045	6.8185	.003154574	995.88	78,923.88
318	101,124	32,157,432	17.8326	6.8256	.003144654	999.03	79,422.60
319	101,761	32,461,759	17.8606	6.8328	.003134796	1,002.17	79,922.90
320	102,400	32,768,000	17.8885	6.8399	.003125000	1,005.31	80,424.77
321	103,041	33,076,161	17.9165	6.8470	.003115265	1,008.45	80,928.21
322	103,684	33,386,248	17.9444	6.8541	.003105590	1,011.59	81,433.22
323	104,329	33,698,267	17.9722	6.8612	.003095975	1,014.73	81,939.80
324	104,976	34,012,224	18.0000	6.8683	.003086420	1,017.88	82,447.96
325	105,625	34,328,125	18.0278	6.8753	.003076923	1,021.02	82,957.68
326	106,276	34,645,976	18.0555	6.8824	.003067485	1,024.16	83,468.98
327	106,929	34,965,783	18.0831	6.8894	.003058104	1,027.30	83,981.84
328	107,584	35,287,552	18.1108	6.8964	.003048780	1,030.44	84,496.28
329	108,241	35,611,289	18.1384	6.9034	.003039514	1,033.58	85,012.03
330	108,900	35,937,000	18.1659	6.9104	.003030303	1,036.73	85,529.86

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
331	109,561	36,264,691	18.1934	6.9174	.003021148	1,039.87	86,049.01
332	110,224	36,594,368	18.2209	6.9244	.003012048	1,043.01	86,569.73
333	110,889	36,926,037	18.2483	6.9313	.003003003	1,046.15	87,092.02
334	111,556	37,259,704	18.2757	6.9382	.002994012	1,049.29	87,615.88
335	112,225	37,595,375	18.3030	6.9451	.002985075	1,052.43	88,141.31
336	112,896	37,933,056	18.3303	6.9521	.002976190	1,055.58	88,668.31
337	113,569	38,272,753	18.3576	6.9589	.002967359	1,058.72	89,196.88
338	114,244	38,614,472	18.3848	6.9658	.002958580	1,061.86	89,727.03
339	114,921	38,958,219	18.4120	6.9727	.002949853	1,065.00	90,258.74
340	115,600	39,304,000	18.4391	6.9795	.002941176	1,068.14	90,792.03
341	116,281	39,651,821	18.4662	6.9864	.002932551	1,071.28	91,326.88
342	116,964	40,001,688	18.4932	6.9932	.002923977	1,074.42	91,863.31
343	117,649	40,353,607	18.5203	7.0000	.002915452	1,077.57	92,401.31
344	118,336	40,707,584	18.5472	7.0068	.002906977	1,080.71	92,940.88
345	119,025	41,063,625	18.5742	7.0136	.002898551	1,083.85	93,482.02
346	119,716	41,421,736	18.6011	7.0203	.002890173	1,086.99	94,024.73
347	120,409	41,781,923	18.6279	7.0271	.002881844	1,090.13	94,569.01
348	121,104	42,144,192	18.6548	7.0338	.002873563	1,093.27	95,114.86
349	121,801	42,508,549	18.6815	7.0406	.002865330	1,096.42	95,662.28
350	122,500	42,875,000	18.7083	7.0473	.002857143	1,099.56	96,211.28
351	123,201	43,243,551	18.7350	7.0540	.002849003	1,102.70	96,761.84
352	123,904	43,614,208	18.7617	7.0607	.002840909	1,105.84	97,313.97
353	124,609	43,986,977	18.7883	7.0674	.002832861	1,108.98	97,867.68
354	125,316	44,361,864	18.8149	7.0740	.002824859	1,112.12	98,422.96
355	126,025	44,738,875	18.8414	7.0807	.002816901	1,115.27	98,979.80
356	126,736	45,118,016	18.8680	7.0873	.002808989	1,118.41	99,538.22
357	127,449	45,499,293	18.8944	7.0940	.002801120	1,121.55	100,098.21
358	128,164	45,882,712	18.9209	7.1006	.002793296	1,124.69	100,659.77
359	128,881	46,268,279	18.9473	7.1072	.002785515	1,127.83	101,222.90
360	129,600	46,656,000	18.9737	7.1138	.002777778	1,130.97	101,787.60
361	130,321	47,045,881	19.0000	7.1204	.002770083	1,134.11	102,353.87
362	131,044	47,437,928	19.0263	7.1269	.002762431	1,137.26	102,921.72
363	131,769	47,832,147	19.0526	7.1335	.002754821	1,140.40	103,491.13
364	132,496	48,228,544	19.0788	7.1400	.002747253	1,143.54	104,062.12
365	133,225	48,627,125	19.1050	7.1466	.002739726	1,146.68	104,634.67
366	133,956	49,027,896	19.1311	7.1531	.002732240	1,149.82	105,208.80
367	134,689	49,430,863	19.1572	7.1596	.002724796	1,152.96	105,784.49
368	135,424	49,836,032	19.1833	7.1661	.002717391	1,156.11	106,361.76
369	136,161	50,243,409	19.2094	7.1726	.002710027	1,159.25	106,940.60
370	136,900	50,653,000	19.2354	7.1791	.002702703	1,162.39	107,521.01
371	137,641	51,064,811	19.2614	7.1855	.002695418	1,165.53	108,102.99
372	138,384	51,478,848	19.2873	7.1920	.002688172	1,168.67	108,686.54
373	139,129	51,895,117	19.3132	7.1984	.002680965	1,171.81	109,271.66
374	139,876	52,313,624	19.3391	7.2048	.002673797	1,174.96	109,858.35
375	140,625	52,734,375	19.3649	7.2112	.002666667	1,178.10	110,446.62
376	141,376	53,157,376	19.3907	7.2177	.002659574	1,181.24	111,036.45
377	142,129	53,582,633	19.4165	7.2240	.002652520	1,184.38	111,627.86
378	142,884	54,010,152	19.4422	7.2304	.002645503	1,187.52	112,220.83
379	143,641	54,439,939	19.4679	7.2368	.002638522	1,190.66	112,815.38
380	144,400	54,872,000	19.4936	7.2432	.002631579	1,193.81	113,411.49
381	145,161	55,306,341	19.5192	7.2495	.002624672	1,196.95	114,009.18
382	145,924	55,742,968	19.5448	7.2558	.002617801	1,200.09	114,608.44
383	146,689	56,181,887	19.5704	7.2622	.002610966	1,203.23	115,209.27
384	147,456	56,623,104	19.5959	7.2685	.002604167	1,206.37	115,811.67
385	148,225	57,066,625	19.6214	7.2748	.002597403	1,209.51	116,415.64

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
386	148,996	57,512,456	19.6469	7.2811	.002590674	1,212.65	117,021.18
387	149,769	57,960,603	19.6723	7.2874	.002583979	1,215.80	117,628.30
388	150,544	58,411,072	19.6977	7.2936	.002577320	1,218.94	118,236.98
389	151,321	58,863,869	19.7231	7.2999	.002570694	1,222.08	118,847.24
390	152,100	59,319,000	19.7484	7.3061	.002564103	1,225.22	119,459.06
391	152,881	59,776,471	19.7737	7.3124	.002557545	1,228.36	120,072.46
392	153,664	60,236,288	19.7990	7.3186	.002551020	1,231.50	120,687.42
393	154,449	60,698,457	19.8242	7.3248	.002544529	1,234.65	121,303.96
394	155,236	61,162,984	19.8494	7.3310	.002538071	1,237.79	121,922.07
395	156,025	61,629,875	19.8746	7.3372	.002531646	1,240.93	122,541.75
396	156,816	62,099,136	19.8997	7.3434	.002525253	1,244.07	123,163.00
397	157,609	62,570,773	19.9249	7.3496	.002518892	1,247.21	123,785.82
398	158,404	63,044,792	19.9499	7.3558	.002512563	1,250.35	124,410.21
399	159,201	63,521,199	19.9750	7.3619	.002506266	1,253.50	125,036.17
400	160,000	64,000,000	20.0000	7.3681	.002500000	1,256.64	125,663.71
401	160,801	64,481,201	20.0250	7.3742	.002493766	1,259.78	126,292.81
402	161,604	64,964,808	20.0499	7.3803	.002487562	1,262.92	126,923.48
403	162,409	65,450,827	20.0749	7.3864	.002481390	1,266.06	127,555.73
404	163,216	65,939,264	20.0998	7.3925	.002475248	1,269.20	128,189.55
405	164,025	66,430,125	20.1246	7.3986	.002469136	1,272.35	128,824.93
406	164,836	66,923,416	20.1494	7.4047	.002463054	1,275.49	129,461.89
407	165,649	67,419,143	20.1742	7.4108	.002457002	1,278.63	130,100.42
408	166,464	67,917,312	20.1990	7.4169	.002450980	1,281.77	130,740.52
409	167,281	68,417,929	20.2237	7.4229	.002444988	1,284.91	131,382.19
410	168,100	68,921,000	20.2485	7.4290	.002439024	1,288.05	132,025.43
411	168,921	69,426,531	20.2731	7.4350	.002433090	1,291.19	132,670.24
412	169,744	69,934,528	20.2978	7.4410	.002427184	1,294.34	133,316.63
413	170,569	70,444,997	20.3224	7.4470	.002421308	1,297.48	133,964.58
414	171,396	70,957,944	20.3470	7.4530	.002415459	1,300.62	134,614.10
415	172,225	71,473,375	20.3715	7.4590	.002409639	1,303.76	135,265.20
416	173,056	71,991,296	20.3961	7.4650	.002403846	1,306.90	135,917.86
417	173,889	72,511,713	20.4206	7.4710	.002398082	1,310.04	136,572.10
418	174,724	73,034,632	20.4450	7.4770	.002392344	1,313.19	137,227.91
419	175,561	73,560,059	20.4695	7.4829	.002386635	1,316.33	137,885.29
420	176,400	74,088,000	20.4939	7.4889	.002380952	1,319.47	138,544.24
421	177,241	74,618,461	20.5183	7.4948	.002375297	1,322.61	139,204.76
422	178,084	75,151,448	20.5426	7.5007	.002369668	1,325.75	139,866.85
423	178,929	75,686,967	20.5670	7.5067	.002364066	1,328.89	140,530.51
424	179,776	76,225,024	20.5913	7.5126	.002358491	1,332.04	141,195.74
425	180,625	76,765,625	20.6155	7.5185	.002352941	1,335.18	141,862.54
426	181,476	77,308,776	20.6398	7.5244	.002347418	1,338.32	142,530.92
427	182,329	77,854,483	20.6640	7.5302	.002341920	1,341.46	143,200.86
428	183,184	78,402,752	20.6882	7.5361	.002336449	1,344.60	143,872.38
429	184,041	78,953,589	20.7123	7.5420	.002331002	1,347.74	144,545.46
430	184,900	79,507,000	20.7364	7.5478	.002325581	1,350.88	145,220.12
431	185,761	80,062,991	20.7605	7.5537	.002320186	1,354.03	145,896.35
432	186,624	80,621,568	20.7846	7.5595	.002314815	1,357.17	146,574.15
433	187,489	81,182,737	20.8087	7.5654	.002309469	1,360.31	147,253.52
434	188,356	81,746,504	20.8327	7.5712	.002304147	1,363.45	147,934.46
435	189,225	82,312,875	20.8567	7.5770	.002298851	1,366.59	148,616.97
436	190,096	82,881,856	20.8806	7.5828	.002293578	1,369.73	149,301.05
437	190,969	83,453,453	20.9045	7.5886	.002288330	1,372.88	149,986.70
438	191,844	84,027,672	20.9284	7.5944	.002283105	1,376.02	150,673.93
439	192,721	84,604,519	20.9523	7.6001	.002277904	1,379.16	151,362.72
440	193,600	85,184,000	20.9762	7.6059	.002272727	1,382.30	152,053.08

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
441	194,481	85,766,121	21.0000	7.6117	.002267574	1,385.44	152,745.02
442	195,364	86,350,888	21.0238	7.6174	.002262443	1,388.58	153,438.53
443	196,249	86,938,307	21.0476	7.6232	.002257336	1,391.73	154,133.60
444	197,136	87,528,384	21.0713	7.6289	.002252252	1,394.87	154,830.25
445	198,025	88,121,125	21.0950	7.6346	.002247191	1,398.01	155,528.47
446	198,916	88,716,536	21.1187	7.6403	.002242152	1,401.15	156,228.26
447	199,809	89,314,623	21.1424	7.6460	.002237136	1,404.29	156,929.62
448	200,704	89,915,392	21.1660	7.6517	.002232143	1,407.43	157,632.55
449	201,601	90,518,849	21.1896	7.6574	.002227171	1,410.58	158,337.06
450	202,500	91,125,000	21.2132	7.6631	.002222222	1,413.72	159,043.13
451	203,401	91,733,851	21.2368	7.6688	.002217295	1,416.86	159,750.77
452	204,304	92,345,408	21.2603	7.6744	.002212389	1,420.00	160,459.99
453	205,209	92,959,677	21.2838	7.6801	.002207506	1,423.14	161,170.77
454	206,116	93,576,664	21.3073	7.6857	.002202643	1,426.28	161,883.13
455	207,025	94,196,375	21.3307	7.6914	.002197802	1,429.42	162,597.05
456	207,936	94,818,816	21.3542	7.6970	.002192982	1,432.57	163,213.55
457	208,849	95,443,993	21.3776	7.7026	.002188184	1,435.71	164,029.62
458	209,764	96,071,912	21.4009	7.7082	.002183406	1,438.85	164,748.26
459	210,681	96,702,579	21.4243	7.7138	.002178649	1,441.99	165,468.47
460	211,600	97,336,000	21.4476	7.7194	.002173913	1,445.13	166,190.25
461	212,521	97,972,181	21.4709	7.7250	.002169197	1,448.27	166,913.60
462	213,444	98,611,128	21.4942	7.7306	.002164502	1,451.42	167,638.53
463	214,369	99,252,847	21.5174	7.7362	.002159827	1,454.56	168,365.02
464	215,296	99,897,344	21.5407	7.7418	.002155172	1,457.70	169,093.08
465	216,225	100,544,625	21.5639	7.7473	.002150538	1,460.84	169,822.72
466	217,156	101,194,696	21.5870	7.7529	.002145923	1,463.98	170,553.92
467	218,089	101,847,563	21.6102	7.7584	.002141328	1,467.12	171,286.70
468	219,024	102,503,232	21.6333	7.7639	.002136752	1,470.27	172,021.05
469	219,961	103,161,709	21.6564	7.7695	.002132196	1,473.41	172,756.97
470	220,900	103,823,000	21.6795	7.7750	.002127660	1,476.55	173,494.45
471	221,841	104,487,111	21.7025	7.7805	.002123142	1,479.69	174,233.51
472	222,784	105,154,048	21.7256	7.7860	.002118644	1,482.83	174,974.14
473	223,729	105,823,817	21.7486	7.7915	.002114165	1,485.97	175,716.35
474	224,676	106,496,424	21.7715	7.7970	.002109705	1,489.11	176,460.12
475	225,625	107,171,875	21.7945	7.8025	.002105263	1,492.26	177,205.46
476	226,576	107,850,176	21.8174	7.8079	.002100840	1,495.40	177,952.37
477	227,529	108,531,333	21.8403	7.8134	.002096436	1,498.54	178,700.86
478	228,484	109,215,352	21.8632	7.8188	.002092050	1,501.68	179,450.91
479	229,441	109,902,239	21.8861	7.8243	.002087683	1,504.82	180,202.54
480	230,400	110,592,000	21.9089	7.8297	.002083333	1,507.96	180,955.74
481	231,361	111,284,641	21.9317	7.8352	.002079002	1,511.11	181,710.50
482	232,324	111,980,168	21.9545	7.8406	.002074689	1,514.25	182,466.84
483	233,289	112,678,587	21.9773	7.8460	.002070393	1,517.39	183,224.75
484	234,256	113,379,904	22.0000	7.8514	.002066116	1,520.53	183,984.23
485	235,225	114,084,125	22.0227	7.8568	.002061856	1,523.67	184,745.28
486	236,196	114,791,256	22.0454	7.8622	.002057613	1,526.81	185,507.90
487	237,169	115,501,303	22.0681	7.8676	.002053388	1,529.96	186,272.10
488	238,144	116,214,272	22.0907	7.8730	.002049180	1,533.10	187,037.86
489	239,121	116,930,169	22.1133	7.8784	.002044990	1,536.24	187,805.19
490	240,100	117,649,000	22.1359	7.8837	.002040816	1,539.38	188,574.10
491	241,081	118,370,771	22.1585	7.8891	.002036660	1,542.52	189,344.57
492	242,064	119,095,488	22.1811	7.8944	.002032520	1,545.66	190,116.62
493	243,049	119,823,157	22.2036	7.8998	.002028398	1,548.81	190,890,24
494	244,036	120,553,784	22.2261	7.9051	.002024291	1,551.95	191,665.43
495	245,025	121,287,375	22.2486	7.9105	.002020202	1,555.09	192,442.18

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
496	246,016	122,023,936	22.2711	7.9158	.002016129	1,558.23	193,220.51
497	247,009	122,763,473	22.2935	7.9211	.002012072	1,561.37	194,000.41
498	248,004	123,505,992	22.3159	7.9264	.002008032	1,564.51	194,781.89
499	249,001	124,251,499	22.3383	7.9317	.002004008	1,567.65	195,564.93
500	250,000	125,000,000	22.3607	7.9370	.002000000	1,570.80	196,349.54
501	251,001	125,751,501	22.3830	7.9423	.001996008	1,573.94	197,135.72
502	252,004	126,506,008	22.4054	7.9476	.001992032	1,577.08	197,923.48
503	253,009	127,263,527	22.4277	7.9528	.001988072	1,580.22	198,712.80
504	254,016	128,024,064	22.4499	7.9581	.001984127	1,583.36	199,503.70
505	255,025	128,787,625	22.4722	7.9634	.001980198	1,586.50	200,296.17
506	256,036	129,554,216	22.4944	7.9686	.001976285	1,589.65	201,090.20
507	257,049	130,323,843	22.5167	7.9739	.001972387	1,592.79	201,885.81
508	258,064	131,096,512	22.5389	7.9791	.001968504	1,595.93	202,682.99
509	259,081	131,872,229	22.5610	7.9843	.001964637	1,599.07	203,481.74
510	260,100	132,651,000	22.5832	7.9896	.001960784	1,602.21	204,282.06
511	261,121	133,432,831	22.6053	7.9948	.001956947	1,605.35	205,083.95
512	262,144	134,217,728	22.6274	8.0000	.001953125	1,608.50	205,887.42
513	263,169	135,005,697	22.6495	8.0052	.001949318	1,611.64	206,692.45
514	264,196	135,796,744	22.6716	8.0104	.001945525	1,614.78	207,499.05
515	265,225	136,590,875	22.6936	8.0156	.001941748	1,617.92	208,307.23
516	266,256	137,388,096	22.7156	8.0208	.001937984	1,621.06	209,116.97
517	267,289	138,188,413	22.7376	8.0260	.001934236	1,624.20	209,928.29
518	268,324	138,991,832	22.7596	8.0311	.001930502	1,627.34	210,741.18
519	269,361	139,798,359	22.7816	8.0363	.001926782	1,630.49	211,555.63
520	270,400	140,608,000	22.8035	8.0415	.001923077	1,633.63	212,371.66
521	271,441	141,420,761	22.8254	8.0466	.001919386	1,636.77	213,189.26
522	272,484	142,236,648	22.8473	8.0517	.001915709	1,639.91	214,008.43
523	273,529	143,055,667	22.8692	8.0569	.001912046	1,643.05	214,829.17
524	274,576	143,877,824	22.8910	8.0620	.001908397	1,646.19	215,651.49
525	275,625	144,703,125	22.9129	8.0671	.001904762	1,649.34	216,475.37
526	276,676	145,531,576	22.9347	8.0723	.001901141	1,652.48	217,300.82
527	277,729	146,363,183	22.9565	8.0774	.001897533	1,655.62	218,127.85
528	278,784	147,197,952	22.9783	8.0825	.001893939	1,658.76	218,956.44
529	279,841	148,035,889	23.0000	8.0876	.001890359	1,661.90	219,786.61
530	280,900	148,877,000	23.0217	8.0927	.001886792	1,665.04	220,618.34
531	281,961	149,721,291	23.0434	8.0978	.001883239	1,668.19	221,451.65
532	283,024	150,568,768	23.0651	8.1028	.001879699	1,671.33	222,286.53
533	284,089	151,419,437	23.0868	8.1079	.001876173	1,674.47	223,122.98
534	285,156	152,273,304	23.1084	8.1130	.001872659	1,677.61	223,961.00
535	286,225	153,130,375	23.1301	8.1180	.001869159	1,680.75	224,800.59
536	287,296	153,990,656	23.1517	8.1231	.001865672	1,683.89	225,641.75
537	288,369	154,854,153	23.1733	8.1281	.001862197	1,687.04	226,484.48
538	289,444	155,720,872	23.1948	8.1332	.001858736	1,690.18	227,328.79
539	290,521	156,590,819	23.2164	8.1382	.001855288	1,693.32	228,174.66
540	291,600	157,464,000	23.2379	8.1433	.001851852	1,696.46	229,022.10
541	292,681	158,340,421	23.2594	8.1483	.001848429	1,699.60	229,871.12
542	293,764	159,220,088	23.2809	8.1533	.001845018	1,702.74	230,721.71
543	294,849	160,103,007	23.3024	8.1583	.001841621	1,705.88	231,573.86
544	295,936	160,989,184	23.3238	8.1633	.001838235	1,709.03	232,427.59
545	297,025	161,878,625	23.3452	8.1683	.001834862	1,712.17	233,282.89
546	298,116	162,771,336	23.3666	8.1733	.001831502	1,715.31	234,139.76
547	299,209	163,667,323	23.3880	8.1783	.001828154	1,718.45	234,998.20
548	300,304	164,566,592	23.4094	8.1833	.001824818	1,721.59	235,858.21
549	301,401	165,469,149	23.4307	8.1882	.001821494	1,724.73	236,719.79
550	302,500	166,375,000	23.4521	8.1932	.001818182	1,727.88	237,582.94

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
551	303,601	167,284,151	23.4734	8.1982	.001814882	1,731.02	238,447.67
552	304,704	168,196,608	23.4947	8.2031	.001811594	1,734.16	239,313.96
553	305,809	169,112,377	23.5160	8.2081	.001808318	1,737.30	240,181.83
554	306,916	170,031,464	23.5372	8.2130	.001805054	1,740.44	241,051.26
555	308,025	170,953,875	23.5584	8.2180	.001801802	1,743.58	241,922.27
556	309,136	171,879,616	23.5797	8.2229	.001798561	1,746.73	242,794.85
557	310,249	172,808,693	23.6008	8.2278	.001795332	1,749.87	243,668.99
558	311,364	173,741.112	23.6220	8.2327	.001792115	1,753.01	244,544.71
559	312,481	174,676,879	23.6432	8.2377	.001788909	1,756.15	245,422.00
560	313,600	175,616,000	23.6643	8.2426	.001785714	1,759.29	246,300.86
561	314,721	176,558,481	23.6854	8.2475	.001782531	1,762.43	247,181.30
562	315,844	177,504,328	23.7065	8.2524	.001779359	1,765.58	248,063.30
563	316,969	178,453,547	23.7276	8.2573	.001776199	1,768.72	248,946.87
564	318,096	179,406,144	23.7487	8.2621	.001773050	1,771.86	249,832.01
565	319,225	180,362,125	23.7697	8.2670	.001769912	1,775.00	250,718.73
566	320,356	181,321,496	23.7908	8.2719	.001766784	1,778.14	251,607.01
567	321,489	182,284,263	23.8118	8.2768	.001763668	1,781.28	252,496.87
568	322,624	183,250,432	23.8328	8.2816	.001760563	1,784.42	253,388.30
569	323,761	184,220,009	23.8537	8.2865	.001757469	1,787.57	254,281.29
570	324,900	185,193,000	23.8747	8.2913	.001754386	1,790.71	255,175.86
571	326,041	186,169,411	23.8956	8.2962	.001751313	1,793.85	256,072.00
572	327,184	187,149,248	23.9165	8.3010	.001748252	1,796.99	256,969.71
573	328,329	188,132,517	23.9374	8.3059	.001745201	1,800.13	257,868.99
574	329,476	189,119,224	23.9583	8.3107	.001742160	1,803.27	258,769.85
575	330,625	190,109,375	23.9792	8.3155	.001739130	1,806.42	259,672.27
576	331,776	191,102,976	24.0000	8.3203	.001736111	1,809.56	260,576.26
577	332,929	192,100,033	24.0208	8.3251	.001733102	1,812.70	261,481.83
578	334,084	193,100,552	24.0416	8.3300	.001730104	1,815.84	262,388.96
579	335,241	194,104,539	24.0624	8.3348	.001727116	1,818.98	263,297.67
580	336,400	195,112,000	24.0832	8.3396	.001724138	1,822.12	264,207.94
581	337,561	196,122,941	24.1039	8.3443	.001721170	1,825.27	265,119.79
582	338,724	197,137,368	24.1247	8.3491	.001718213	1,828.41	266,033.21
583	339,889	198,155,287	24.1454	8.3539	.001715266	1,831.55	266,948.20
584	341,056	199,176,704	24.1661	8.3587	.001712329	1,834.69	267,864.76
585	342,225	200,201,625	24.1868	8.3634	.001709402	1,837.83	268,782.89
586	343,396	201,230,056	24.2074	8.3682	.001706485	1,840.97	269,702.59
587	344,569	202,262,003	24.2281	8.3730	.001703578	1,844.11	270,623.86
588	345,744	203,297,472	24.2487	8.3777	.001700680	1,847.26	271,546.70
589	346,921	204,336,469	24.2693	8.3825	.001697793	1,850.40	272,471.12
590	348,100	205,379,000	24.2899	8.3872	.001694915	1,853.54	273,397.10
591	349,281	206,425,071	24.3105	8.3919	.001692047	1,856.68	274,324.66
592	350,464	207,474,688	24.3311	8.3967	.001689189	1,859.82	275,253.78
593	351,649	208,527,857	24.3516	8.4014	.001686341	1,862.96	276,184.48
594	352,836	209,584,584	24.3721	8.4061	.001683502	1,866.11	277,116.75
595	354,025	210,644,875	24.3926	8.4108	.001680672	1,869.25	278,050.58
596	355,216	211,708,736	24.4131	8.4155	.001677852	1,872.39	278,985.99
597	356,409	212,776,173	24.4336	8.4202	.001675042	1,875.53	279,922.97
598	357,604	213,847,192	24.4540	8.4249	.001672241	1,878.67	280,861.52
599	358,801	214,921,799	24.4745	8.4296	.001669449	1,881.81	281,801.65
600	360,000	216,000,000	24.4949	8.4343	.001666667	1,884.96	282,743.34
601	361,201	217,081,801	24.5153	8.4390	.001663894	1,888.10	283,686.60
602	362,404	218,167,208	24.5357	8.4437	.001661130	1,891.24	284,631.44
603	363,609	219,256,227	24.5561	8.4484	.001658375	1,894.38	285,577.84
604	364,816	220,348,864	24.5764	8.4530	.001655629	1,897.52	286,525.82
605	366,025	221,445,125	24.5968	8.4577	.001652893	1,900.66	287,475.36

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
606	367,236	222,545,016	24.6171	8.4623	.001650165	1,903.81	288,426.48
607	368,449	223,648,543	24.6374	8.4670	.001647446	1,906.95	289,379.17
608	369,664	224,755,712	24.6577	8.4716	.001644737	1,910.09	290,333.43
609	370,881	225,866,529	24.6779	8.4763	.001642036	1,913.23	291,289.26
610	372,100	226,981,000	24.6982	8.4809	.001639344	1,916.37	292,246.66
611	373,321	228,099,131	24.7184	8.4856	.001636661	1,919.51	293,205.63
612	374,544	229,220,928	24.7386	8.4902	.001633987	1,922.65	294,166.17
613	375,769	230,346,397	24.7588	8.4948	.001631321	1,925.80	295,128.28
614	376,996	231,475,544	24.7790	8.4994	.001628664	1,928.94	296,091.97
615	378,225	232,608,375	24.7992	8.5040	.001626016	1,932.08	297,057.22
616	379,456	233,744,896	24.8193	8.5086	.001623377	1,935.22	298,024.05
617	380,689	234,885,113	24.8395	8.5132	.001620746	1,938.36	298,992.44
618	381,924	236,029,032	24.8596	8.5178	.001618123	1,941.50	299,962.41
619	383,161	237,176,659	24.8797	8.5224	.001615509	1,944.65	300,933.95
620	384,400	238,328,000	24.8998	8.5270	.001612903	1,947.79	301,907.05
621	385,641	239,483,061	24.9199	8.5316	.001610306	1,950.93	302,881.73
622	386,884	240,641,848	24.9399	8.5362	.001607717	1,954.07	303,857.98
623	388,129	241,804,367	24.9600	8.5408	.001605136	1,957.21	304,835.80
624	389,376	242,970,624	24.9800	8.5453	.001602564	1,960.35	305,815.20
625	390,625	244,140,625	25.0000	8.5499	.001600000	1,963.50	306,796.16
626	391,876	245,314,376	25.0200	8.5544	.001597444	1,966.64	307,778.69
627	393,129	246,491,883	25.0400	8.5590	.001594896	1,969.78	308,762.79
628	394,384	247,673,152	25.0599	8.5635	.001592357	1,972.92	309,748.47
629	395,641	248,858,189	25.0799	8.5681	.001589825	1,976.06	310,735.71
630	396,900	250,047,000	25.0998	8.5726	.001587302	1,979.20	311,724.53
631	398,161	251,239,591	25.1197	8.5772	.001584786	1,982.35	312,714.92
632	399,424	252,435,968	25.1396	8.5817	.001582278	1,985.49	313,706.88
633	400,689	253,636,137	25.1595	8.5862	.001579779	1,988.63	314,700.40
634	401,956	254,840,104	25.1794	8.5907	.001577287	1,991.77	315,695.50
635	403,225	256,047,875	25.1992	8.5952	.001574803	1,994.91	316,692.17
636	404,496	257,259,456	25.2190	8.5997	.001572327	1,998.05	317,690.42
637	405,769	258,474,853	25.2389	8.6043	.001569859	2,001.19	318,690.23
638	407,044	259,694,072	25.2587	8.6088	.001567398	2,004.34	319,691.61
639	408,321	260,917,119	25.2784	8.6132	.001564945	2,007.48	320,694.56
640	409,600	262,144,000	25.2982	8.6177	.001562500	2,010.62	321,699.09
641	410,881	263,374,721	25.3180	8.6222	.001560062	2,013.76	322,705.18
642	412,164	264,609,288	25.3377	8.6267	.001557632	2,016.90	323,712.85
643	413,449	265,847,707	25.3574	8.6312	.001555210	2,020.04	324,722.09
644	414,736	267,089,984	25.3772	8.6357	.001552795	2,023.19	325,732.89
645	416,025	268,336,125	25.3969	8.6401	.001550388	2,026.33	326,745.27
646	417,316	269,586,136	25.4165	8.6446	.001547988	2,029.47	327,759.22
647	418,609	270,840,023	25.4362	8.6490	.001545595	2,032.61	328,774.74
648	419,904	272,097,792	25.4558	8.6535	.001543210	2,035.75	329,791.83
649	421,201	273,359,449	25.4755	8.6579	.001540832	2,038.89	330,810.49
650	422,500	274,625,000	25.4951	8.6624	.001538462	2,042.04	331,830.72
651	423,801	275,894,451	25.5147	8.6668	.001536098	2,045.18	332,852.53
652	425,104	277,167,808	25.5343	8.6713	.001533742	2,048.32	333,875.90
653	426,409	278,445,077	25.5539	8.6757	.001531394	2,051.46	334,900.85
654	427,716	279,726,264	25.5734	8.6801	.001529052	2,054.60	335,927.36
655	429,025	281,011,375	25.5930	8.6845	.001526718	2,057.74	336,955.45
656	430,336	282,300,416	25.6125	8.6890	.001524390	2,060.88	337,985.10
657	431,649	283,593,393	25.6320	8.6934	.001522070	2,064.03	339,016.33
658	432,964	284,890,312	25.6515	8.6978	.001519757	2,067.17	340,049.13
659	434,281	286,191,179	25.6710	8.7022	.001517451	2,070.31	341,083.50
660	435,600	287,496,000	25.6905	8.7066	.001515152	2,073.45	342,119.44

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
661	436,921	288,804,781	25.7099	8.7110	.001512859	2,076.59	343,156.95
662	438,244	290,117,528	25.7294	8.7154	.001510574	2,079.73	344,196.03
663	439,569	291,434,247	25,7488	8.7198	.001508296	2,082.88	345,236.69
664	440,896	292,754,944	25.7682	8.7241	.001506024	2,086.02	346,278.91
665	442,225	294,079,625	25.7876	8.7285	.001503759	2,089.16	347,322.70
666	443,556	295,408,296	25.8070	8.7329	.001501502	2,092.30	348,368.07
667	444,889	296,740,963	25.8263	8.7373	.001499250	2,095.44	349,415.00
668	446,224	298,077,632	25.8457	8.7416	.001497006	2,098.58	350,463.51
669	447,561	299,418,309	25.8650	8.7460	.001494768	2,101.73	351,513.59
670	448,900	300,763,000	25.8844	8.7503	.001492537	2,104.87	352,565.24
671	450,241	302,111,711	25.9037	8.7547	.001490313	2,108.01	353,618.45
672	451,584	303,464,448	25.9230	8.7590	.001488095	2,111.15	354,673.24
673	452,929	304,821,217	25.9422	8.7634	.001485884	2,114.29	355,729.60
674	454,276	306,182,024	25.9615	8.7677	.001483680	2,117.43	356,787.54
675	455,625	307,546,875	25.9808	8.7721	.001481481	2,120.58	357,847.04
676	456,976	308,915,776	26.0000	8.7764	.001479290	2,123.72	358,908.11
677	458,329	310,288,733	26.0192	8.7807	.001477105	2,126.86	359,970.75
678	459,684	311,665,752	26.0384	8.7850	.001474926	2,130.00	361,034.97
679	461,041	313,046,839	26.0576	8.7893	.001472754	2,133.14	362,100.75
680	462,400	314,432,000	26.0768	8.7937	.001470588	2,136.28	363,168.11
681	463,761	315,821,241	26.0960	8.7980	.001468429	2,139.42	364,237.04
682	465,124	317,214,568	26.1151	8.8023	.001466276	2,142.57	365,307.54
683	466,489	318,611,987	26.1343	8.8066	.001464129	2,145.71	366,379.60
684	467,856	320,013,504	26.1534	8.8109	.001461988	2,148.85	367,453.24
685	469,225	321,419,125	26.1725	8.8152	.001459854	2,151.99	368,528.45
686	470,596	322,828,856	26.1916	8.8194	.001457726	2,155.13	369,605.23
687	471,969	324,242,703	26.2107	8.8237	.001455604	2,158.27	370,683.59
668	473,344	325,660,672	26.2298	8.8280	.001453488	2,161.42	371,763.51
689	474,721	327,082,769	26.2488	8.8323	.001451379	2,164.56	372,845.00
690	476,100	328,509,000	26.2679	8.8366	.001449275	2,167.70	373,928.07
691	477,481	329,939,371	26.2869	8.8408	.001447178	2,170.84	375,012.70
692	478,864	331,373,888	26.3059	8.8451	.001445087	2,173.98	376,098.91
693	480,249	332,812,557	26.3249	8.8493	.001443001	2,177.12	377,186.68
694	481,636	334,255,384	26.3439	8.8536	.001440922	2,180.27	378,276.03
695	483,025	335,702,375	26.3629	8.8578	.001438849	2,183.41	379,366.95
696	484,416	337,153,536	26.3818	8.8621	.001436782	2,186.55	380,459.44
697	485,809	338,608,873	26.4008	8.8663	.001434720	2,189.69	381,553.50
698	487,204	340,068,392	26.4197	8.8706	.001432665	2,192.83	382,649.13
699	488,601	341,532,099	26.4386	8.8748	.001430615	2,195.97	383,746.33
700	490,000	343,000,000	26.4575	8.8790	.001428571	2,199.11	384,845.10
701	491,401	344,472,101	26.4764	8.8833	.001426534	2,202.26	385,945.44
702	492,804	345,948,408	26.4953	8.8875	.001424501	2,205.40	387,047.36
703	494,209	347,428,927	26.5141	8.8917	.001422475	2,208.54	388,150.84
704	495,616	348,913,664	26.5330	8.8959	.001420455	2,211.68	389,255.90
705	497,025	350,402,625	26.5518	8.9001	.001418440	2,214.82	390,362.52
706	498,436	351,895,816	26.5707	8.9043	.001416431	2,217.96	391,470.72
707	499,849	353,393,243	26.5895	8.9085	.001414427	2,221.11	392,580.49
708	501,264	354,894,912	26.6083	8.9127	.001412429	2,224.25	393,691.82
709	502,681	356,400,829	26.6271	8.9169	.001410437	2,227.39	394,804.73
710	504,100	357,911,000	26.6458	8.9211	.001408451	2,230.53	395,919.21
711	505,521	359,425,431	26.6646	8.9253	.001406470	2,233.67	397,035.26
712	506,944	360,944,128	26.6833	8.9295	.001404494	2,236.81	398,152.89
713	508,369	362,467,097	26.7021	8.9337	.001402525	2,239.96	399,272.08
714	509,796	363,994,344	26.7208	8.9378	.001400560	2,243.10	400,392.84
715	511,225	365,525,875	26.7395	8.9420	.001398601	2,246.24	401,515.18

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
716	512,656	367,061,696	26.7582	8.9462	.001396648	2,249.38	402,639.08
717	514,089	368,601,813	26.7769	8.9503	.001394700	2,252.52	403,764.56
718	515,524	370,146,232	26.7955	8.9545	.001392758	2,255.66	404,891.60
719	516,961	371,694,959	26.8142	8.9587	.001390821	2,258.81	406,020.22
720	518,400	373,248,000	26.8328	8.9628	.001388889	2,261.95	407,150.41
721	519,841	374,805,361	26.8514	8.9670	.001386963	2,265.09	408,282.17
722	521,284	376,367,048	26.8701	8.9711	.001385042	2,268.23	409,415.50
723	522,729	377,933,067	26.8887	8.9752	.001383126	2,271.37	410,550.40
724	524,176	379,503,424	26.9072	8.9794	.001381215	2,274.51	411,686.87
725	525,625	381,078,125	26.9258	8.9835	.001379310	2,277.65	412,824.91
726	527,076	382,657,176	26.9444	8.9876	.001377410	2,280.80	413,964.52
727	528,529	384,240,583	26.9629	8.9918	.001375516	2,283.94	415,105.71
728	529,984	385,828,352	26.9815	8.9959	.001373626	2,287.08	416,248.46
729	531,441	387,420,489	27.0000	9.0000	.001371742	2,290.22	417,392.79
730	432,900	389,017,000	27.0185	9.0041	.001369863	2,293.36	418,538.68
731	534,361	390,617,891	27.0370	9.0082	.001367989	2,296.50	419,686.15
732	535,824	392,223,168	27.0555	9.0123	.001366120	2,299.65	420,835.19
733	537,269	393,832,837	27.0740	9.0164	.001364256	2,302.79	421,985.79
734	538,756	395,446,904	27.0924	9.0205	.001362398	2,305.93	423,137.97
735	540,225	397,065,375	27.1109	9.0246	.001360544	2,309.07	424,291.72
736	541,696	398,688,256	27.1293	9.0287	.001358696	2,312.21	425,447.04
737	543,169	400,315,553	27.1477	9.0328	.001356852	2,315.35	426,603.94
738	544,644	401,947,272	27.1662	9.0369	.001355014	2,318.50	427,762.40
739	546,121	403,583,419	27.1846	9.0410	.001353180	2,321.64	428,922.43
740	547,600	405,224,000	27.2029	9.0450	.001351351	2,324.78	430,084.03
741	549,081	406,869,021	27.2213	9.0491	.001349528	2,327.92	431,247.21
742	550,564	408,518,488	27.2397	9.0532	.001347709	2,331.06	432,411.95
743	552,049	410,172,407	27.2580	9.0572	.001345895	2,334.20	433,578.27
744	553,536	411,830,784	27.2764	9.0613	.001344086	2,337.34	434,746.16
745	555,025	413,493,625	27.2947	9.0654	.001342282	2,340.49	435,915.62
746	556,516	415,160,936	27.3130	9.0694	.001340483	2,343.63	437,086.64
747	558,009	416,832,723	27.3313	9.0735	.001338688	2,346.77	438,259.24
748	559,504	418,508,992	27.3496	9.0775	.001336898	2,349.91	439,433.41
749	561,001	420,189,749	27.3679	9.0816	.001335113	2,353.05	440,609.16
750	562,500	421,875,000	27.3861	9.0856	.001333333	2,356.19	441,786.47
751	564,001	423,564,751	27.4044	9.0896	.001331558	2,359.34	442,965.35
752	565,504	425,259,008	27.4226	9.0937	.001329787	2,362.48	444,145.80
753	567,009	426,957,777	27.4408	9.0977	.001328021	2,365.62	445,327.83
754	568,516	428,661,064	27.4591	9.1017	.001326260	2,368.76	446,511.42
755	570,025	430,368,875	27.4773	9.1057	.001324503	2,371.90	447,696.59
756	571,536	432,081,216	27.4955	9.1098	.001322751	2,375.04	448,883.32
757	573,049	433,798,093	27.5136	9.1138	.001321004	2,378.19	450,071.63
758	574,564	435,519,512	27.5318	9.1178	.001319261	2,381.33	451,261.51
759	576,081	437,245,479	27.5500	9.1218	.001317523	2,384.47	452,452.96
760	577,600	438,976,000	27.5681	9.1258	.001315789	2,387.61	453,645.98
761	579,121	440,711,081	27.5862	9.1298	.001314060	2,390.75	454,840.57
762	580,644	442,450,728	27.6043	9.1338	.001312336	2,393.89	456,036.73
763	582,169	444,194,947	27.6225	9.1378	.001310616	2,397.04	457,234.46
764	583,696	445,943,744	27.6405	9.1418	.001308901	2,400.18	458,433.77
765	585,225	447,697,125	27.6586	9.1458	.001307190	2,403.32	459,634.64
766	586,756	449,455,096	27.6767	9.1498	.001305483	2,406.46	460,837.08
767	588,289	451,217,663	27.6948	9.1537	.001303781	2,409.60	462,041.10
768	589,824	452,984,832	27.7128	9.1577	.001302083	2,412.74	463,246.69
769	591,361	454,756,609	27.7308	9.1617	.001300390	2,415.88	464,453.84
770	592,900	456,533,000	27.7489	9.1657	.001298701	2,419.03	465,662.57

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
771	594,441	458,314,011	27.7669	9.1996	.001297017	2,422.17	466,872.87
772	595,984	460,099,648	27.7849	9.1736	.001295337	2,425.31	468,084.74
773	597,529	461,889,917	27.8029	9.1775	.001293661	2,428.45	469,298.18
774	599,076	463,684,824	27.8209	9.1815	.001291990	2,431.59	470,513.19
775	600,625	465,484,375	27.8388	9.1855	.001290323	2,434.73	471,729.77
776	602,176	467,288,576	27.8568	9.1894	.001288660	2,437.88	472,947.92
777	603,729	469,097,433	27.8747	9.1933	.001287001	2,441.02	474,167.65
778	605,284	470,910,952	27.8927	9.1973	.001285347	2,444.16	475,388.94
779	606,841	472,729,139	27.9106	9.2012	.001283697	2,447.30	476,611.81
780	608,400	474,552,000	27.9285	9.2052	.001282051	2,450.44	477,836.24
781	609,961	476,379,541	27.9464	9.2091	.001280410	2,453.58	479,062.25
782	611,524	478,211,768	27.9643	9.2130	.001278772	2,456.73	480,289.83
783	613,089	480,048,687	27.9821	9.2170	.001277139	2,459.87	481,518.97
784	614,656	481,890,304	28.0000	9.2209	.001275510	2,463.01	482,749.69
785	616,225	483,736,625	27.0179	9.2248	.001273885	2,466.15	483,981.98
786	617,796	485,587,656	27.0357	9.2287	.001272265	2,469.29	485,215.84
787	619,369	487,443,403	28.0535	9.2326	.001270648	2,472.43	486,451.28
788	620,944	489,303,872	28.0713	9.2365	.001269036	2,475.58	487,688.28
789	622,521	491,169,069	28.0891	9.2404	.001267427	2,478.72	488,926.85
790	624,100	493,039,000	28.1069	9.2443	.001265823	2,481.86	490,166.99
791	625,681	494,913,671	28.1247	9.2482	.001264223	2,485.00	491,408.71
792	627,264	496,793,088	28.1425	9.2521	.001262626	2,488.14	492,651.99
793	628,849	498,677,257	28.1603	9.2560	.001261034	2,491.28	493,896.85
794	630,436	500,566,184	28.1780	9.2599	.001259446	2,494.42	495,143.28
795	632,025	502,459,875	28.1957	9.2638	.001257862	2,497.57	496,391.27
796	633,616	504,358,336	28.2135	9.2677	.001256281	2,500.71	497,640.84
797	635,209	506,261,573	28.2312	9.2716	.001254705	2,503.85	498,891.98
798	636,804	508,169,592	28.2489	9.2754	.001253133	2,506.99	500,144.69
799	638,401	510,082,399	28.2666	9.2793	.001251564	2,510.13	501,398.97
800	640,000	512,000,000	28.2843	9.2832	.001250000	2,513.27	502,654.82
801	641,601	513,922,401	28.3019	9.2870	.001248439	2,516.42	503,912.25
802	643,204	515,849,608	28.3196	9.2909	.001246883	2,519.56	505,171.24
803	644,809	517,781,627	28.3373	9.2948	.001245330	2,522.70	506,431.80
804	646,416	519,718,464	28.3549	9.2986	.001243781	2,525.84	507,693.94
805	648,025	521,660,125	28.3725	9.3025	.001242236	2,528.98	508,957.64
806	649,636	523,606,616	28.3901	9.3063	.001240695	2,532.12	510,222.92
807	651,249	525,557,943	28.4077	9.3102	.001239157	2,535.27	511,489.77
808	652,864	527,514,112	28.4253	9.3140	.001237624	2,538.41	512,758.19
809	654,481	529,475,129	28.4429	9.3179	.001236094	2,541.55	514,028.18
810	656,100	531,441,000	28.4605	9.3217	.001234568	2,544.69	515,299.74
811	657,721	533,411,731	28.4781	9.3255	.001233046	2,547.83	516,572.87
812	659,344	535,387,328	28.4956	9.3294	.001231527	2,550.97	517,847.57
813	660,969	537,367,797	28.5132	9.3332	.001230012	2,554.11	519,123.84
814	662,596	539,353,144	28.5307	9.3370	.001228501	2,557.26	520,401.68
815	664,225	541,343,375	28.5482	9.3408	.001226994	2,560.40	521,681.10
816	665,856	543,338,496	28.5657	9.3447	.001225490	2,563.54	522,962.08
817	667,489	545,338,513	28.5832	9.3485	.001223990	2,566.68	524,244.63
818	669,124	547,343,432	28.6007	9.3523	.001222494	2,569.82	525,528.76
819	670,761	549,353,259	28.6182	9.3561	.001221001	2,572.96	526,814.46
820	672,400	551,368,000	28.6356	9.3599	.001219512	2,576.11	528,101.73
821	674,041	553,387,661	28.6531	9.3637	.001218027	2,579.25	529,390.56
822	675,684	555,412,248	28.6705	9.3675	.001216545	2,582.39	530,680.97
823	677,329	557,441,767	28.6880	9.3713	.001215067	2,585.53	531,972.95
824	678,976	559,476,224	28.7054	9.3751	.001213592	2,588.67	533,266.50
825	680,625	561,515,625	28.7228	9.3789	.001212121	2,591.81	534,561.62

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
826	682,276	563,559,976	28.7402	9.3827	.001210654	2,594.96	535,858.32
827	683,929	565,609,283	28.7576	9.3865	.001209190	2,598.10	537,156.58
828	685,584	567,663,552	28.7750	9.3902	.001207729	2,601.24	538,456.41
829	687,241	569,722,789	28.7924	9.3940	.001206273	2,604.38	539,757.82
830	688,900	571,787,000	28.8097	9.3978	.001204819	2,607.52	541,060.79
831	690,561	573,856,191	28.8271	9.4016	.001203369	2,610.66	542,365.34
832	692,224	575,930,368	28.8444	9.4053	.001201923	2,613.81	543,671.46
833	693,889	578,009,537	28.8617	9.4091	.001200480	2,616.95	544,979.15
834	695,556	580,093,704	28.8791	9.4129	.001199041	2,620.09	546,288.40
835	697,225	582,182,875	28.8964	9.4166	.001197605	2,623.23	547,599.23
836	698,896	584,277,056	28.9137	9.4204	.001196172	2,626.37	548,911.63
837	700,569	586,376,253	28.9310	9.4241	.001194743	2,629.51	550,225.61
838	702,244	588,480,472	28.9482	9.4279	.001193317	2,632.65	551,541.15
839	703,921	590,589,719	28.9655	9.4316	.001191895	2,635.80	552,858.26
840	705,600	592,704,000	28.9828	9.4354	.001190476	2,638.94	554,176.94
841	707,281	594,823,321	29.0000	9.4391	.001189061	2,642.08	555,497.20
842	708,964	596,947,688	29.0172	9.4429	.001187648	2,645.22	556,819.02
843	710,649	599,077,107	29.0345	9.4466	.001186240	2,648.36	558,142.42
844	712,336	601,211,584	29.0517	9.4503	.001184834	2,651.50	559,467.39
845	714,025	603,351,125	29.0689	9.4541	.001183432	2,654.65	560,793.92
846	715,716	605,495,736	29.0861	9.4578	.001182033	2,657.79	562,122.03
847	717,409	607,645,423	29.1033	9.4615	.001180638	2,660.93	563,451.71
848	719,104	609,800,192	29.1204	9.4652	.001179245	2,664.07	564,782.96
849	720,801	611,960,049	29.1376	9.4690	.001177856	2,667.21	566,115.78
850	722,500	614,125,000	29.1548	9.4727	.001176471	2,670.35	567,450.17
851	724,201	616,295,051	29.1719	9.4764	.001175088	2,673.50	568,786.14
852	725,904	618,470,208	29.1890	9.4801	.001173709	2,676.64	570,123.67
853	727,609	620,650,477	29.2062	9.4838	.001172333	2,679.78	571,462.77
854	729,316	622,835,864	29.2233	9.4875	.001170960	2,682.92	572,803.45
855	731,025	625,026,375	29.2404	9.4912	.001169591	2,686.06	574,145.69
856	732,736	627,222,016	29.2575	9.4949	.001168224	2,689.20	575,489.51
857	734,449	629,422,793	29.2746	9.4986	.001166861	2,692.34	576,834.90
858	736,164	631,628,712	29.2916	9.5023	.001165501	2,695.49	578,181.85
859	737,881	633,839,779	29.3087	9.5060	.001164144	2,698.63	579,530.38
860	739,600	636,056,000	29.3258	9.5097	.001162791	2,701.77	580,880.48
861	741,321	638,277,381	29.3428	9.5134	.001161440	2,704.91	582,232.15
862	743,044	640,503,928	29.3598	9.5171	.001160093	2,708.05	583,585.39
863	744,769	642,735,647	29.3769	9.5207	.001158749	2,711.19	584,940.20
864	746,496	644,972,544	29.3939	9.5244	.001157407	2,714.34	586,296.59
865	748,225	647,214,625	29.4109	9.5281	.001156069	2,717.48	587,654.54
866	749,956	649,461,896	29.4279	9.5317	.001154734	2,720.62	589,014.07
867	751,689	651,714,363	29.4449	9.5354	.001153403	2,723.76	590,375.16
868	753,424	653,972,032	29.4618	9.5391	.001152074	2,726.90	591,737.83
869	755,161	656,234,909	29.4788	9.5427	.001150748	2,730.04	593,102.06
870	756,900	658,503,000	29.4958	9.5464	.001149425	2,733.19	594,467.87
871	758,641	660,776,311	29.5127	9.5501	.001148106	2,736.33	595,835.25
872	760,384	663,054,848	29.5296	9.5537	.001146789	2,739.47	597,204.20
873	762,129	665,338,617	29.5466	9.5574	.001145475	2,742.61	598,574.72
874	763,876	667,627,624	29.5635	9.5610	.001144165	2,745.75	599,946.81
875	765,625	669,921,875	29.5804	9.5647	.001142857	2,748.89	601,320.47
876	767,376	672,221,376	29.5973	9.5683	.001141553	2,752.04	602,695.70
877	769,129	674,526,133	29.6142	9.5719	.001140251	2,755.18	604,072.50
878	770,884	676,836,152	29.6311	9.5756	.001138952	2,758.32	605,450.88
879	772,641	679,151,439	29.6479	9.5792	.001137656	2,761.46	606,830.82
880	774,400	681,472,000	29.6648	9.5828	.001136364	2,764.60	608,212.34

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
881	776,161	683,797,841	29.6816	9.5865	.001135074	2,767.74	609,595.42
882	777,924	686,128,968	29.6985	9.5901	.001133787	2,770.88	610,980.08
883	779,689	688,465,387	29.7153	9.5937	.001132503	2,774.03	612,366.31
884	781,456	690,807,104	29.7321	9.5973	.001131222	2,777.17	613,754.11
885	783,225	693,154,125	29.7489	9.6010	.001129944	2,780.31	615,143.48
886	784,996	695,506,456	29.7658	9.6046	.001128668	2,783.45	616,534.42
887	786,769	697,864,103	29.7825	9.6082	.001127396	2,786.59	617,926.93
888	788,544	700,227,072	29.7993	9.6118	.001126126	2,789.73	619,321.01
889	790,321	702,595 369	29.8161	9.6154	.001124859	2,792.89	620,716.66
890	792,100	704,969,000	29.8329	9.6190	.001123596	2,796.02	622,113.89
891	793,881	707,347,971	29.8496	9.6226	.001122334	2,799.16	623,512.68
892	795,664	709,932,288	29.8664	9.6262	.001121076	2,802.30	624,913.04
893	797,449	712,121,957	29,8831	9.6298	.001119821	2,805.44	626,314.98
894	799,236	714,516,984	29.8998	9.6334	.001118568	2,808.58	627,718.49
895	801,025	716,917,375	29.9166	9.6370	.001117318	2,811.73	629,123.56
896	802,816	719,323,136	29.9333	9.6406	.001116071	2,814.87	630,530.21
897	804,609	721,734,273	29.9500	9.6442	.001114827	2,818.01	631,938.43
898	806,404	724,150,792	29.9666	9.6477	.001113586	2,821.15	633,348.22
899	808,201	726,572,699	29.9833	9.6513	.001112347	2,824.29	634,759.58
900	810,000	729,000,000	30.0000	9.6549	.001111111	2,827.43	636,172.51
901	811,801	731,432,701	30.0167	9.6585	.001109878	2,830.58	637,587.01
902	813,604	733,870,808	30.0333	9.6620	.001108647	2,833.72	639,003.09
903	815,409	736,314,327	30.0500	9.6656	.001107420	2,836.86	640,420.73
904	817,216	738,763,264	30.0666	9.6692	.001106195	2,840.00	641,839.95
905	819,025	741,217,625	30.0832	9.6727	.001104972	2,843.14	643,260.73
906	820,836	743,677,416	30.0998	9.6763	.001103753	2,846.28	644,683.09
907	822,649	746,142,643	30.1164	9.6799	.001102536	2,849.42	646,107.01
908	824,464	748,613,312	30.1330	9.6834	.001101322	2,852.57	647,532.51
909	826 281	751,089,429	30.1496	9.6870	.001100110	2,855.71	648,959.58
910	828,100	753,571,000	30,1662	9.6905	.001098901	2,858.85	650,388.22
911	829,921	756,058,031	30.1828	9.6941	.001097695	2,861.99	651,818.43
912	831,744	758,550,528	30.1993	9.6976	.001096491	2,865.13	653,250.21
913	833,569	761,048,497	30.2159	9.7012	.001095290	2,868.27	654,683.56
914	835,396	763,551,944	30.2324	9.7047	.001094092	2,871.42	656,118.48
915	837,225	766,060,875	30.2490	9.7082	.001092896	2,874.56	657,554.98
916	839,056	768,575,296	30.2655	9.7118	.001091703	2,877.70	658,993.04
917	840,889	771,095,213	30.2820	9.7153	.001090513	2,880.84	660,432.68
918	842,724	773,620,632	30.2985	9.7188	.001089325	2,883.98	661,873.88
919	844,561	776,151,559	30.3150	9.7224	.001088139	2,887.12	663,316.66
920	846,400	778,688,000	30.3315	9.7259	.001086957	2,890.27	664,761.01
921	848,241	781,229,961	30.3480	9.7294	.001085776	2,893.41	666,206.92
922	850,084	783,777,448	30.3645	9.7329	.001084599	2,896.55	667,654.41
923	851,929	786,330.467	30.3809	9.7364	.001083424	2,899.69	669,103.47
924	853,776	788,889,024	30.3974	9.7400	.001082251	2,902.83	670,554.10
925	855,625	791,453,125	30.4138	9.7435	.001081081	2,905.97	672,006.30
926	857,476	794,022,776	30.4302	9.7470	.001079914	2,909.11	673,460.08
927	859,329	796,597,983	30.4467	9.7505	.001078749	2,912.26	674,915.42
928	861,184	799,178,752	30.4631	9.7540	.001077586	2,915.40	676,372.33
929	863,041	801,765,089	30.4795	9.7575	.001076426	2,918.54	677,830.82
930	864,900	804,357,000	30.4959	9.7610	.001075269	2,921.68	679,290.87
931	866,761	806,954,491	30.5123	9.7645	.001074114	2,924.82	680,752.50
932	868,624	809,557,568	30.5287	9.7680	.001072961	2,927.96	682,215.69
933	870,489	812,166,237	30.5450	9.7715	.001071811	2,931.11	683,680.46
934	872,356	814,780,504	30.5614	9.7750	.001070664	2,934.25	685,146.80
935	874,225	817,400,375	30.5778	9.7785	.001069519	2,937.39	686,614.71

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
936	876,096	820,025,856	30.5941	9.7819	.001068376	2,940.53	688,084.19
937	877,969	822,656,953	30.6105	9.7854	.001067236	2,943.67	689,555.24
938	879,844	825,293,672	30.6268	9.7889	.001066098	2,946.81	691,027.86
939	881,721	827,936,019	30.6431	9.7924	.001064963	2,949.96	692,502.05
940	883,600	830,584,000	30.6594	9.7959	.001063830	2,953.10	693,977.82
941	885,481	833,237,621	30.6757	9.7993	.001062699	2,956.24	695,455.15
942	887,364	835,896,888	30,6920	9.8028	.001061571	2,959.38	696,934.06
943	889,249	838,561,807	30.7083	9.8063	.001060445	2,962.52	698,414.53
944	891,136	841,232,384	30.7246	9.8097	.001059322	2,965.66	699,896.58
945	893,025	843,908,625	30.7409	9.8132	.001058201	2,968.81	701,380.19
946	894,916	846,590,536	30.7571	9.8167	.001057082	2,971.95	702,865.38
947	896,809	849,278,123	30.7734	9.8201	.001055966	2,975.09	704,352.14
948	898,704	851,971,392	30.7896	9.8236	.001054852	2,978.23	705,840.47
949	900,601	854,670,349	30.8058	9.8270	.001053741	2,981.37	707,330.37
950	902,500	857,375,000	30.8221	9.8305	.001052632	2,984.51	708,821.84
951	904,401	860,085,351	30.8383	9.8339	.001051525	2,987.65	710,314.88
952	906,304	862,801,408	30.8545	9.8374	.001050420	2,990.90	711,809.50
953	908,209	865,523,177	30.8707	9.8408	.001049318	2,993.94	713,305.68
954	910,116	868,250,664	30.8869	9.8443	.001048218	2,997.08	714,803.43
955	912,025	870,983,875	30.9031	9.8477	.001047120	3,000.22	716,302.76
956	913,936	873,722,816	30.9192	9.8511	.001046025	3,003.36	717,803.66
957	915,849	876,467,493	30.9354	9.8546	.001044932	3,006.50	719,306.12
958	917,764	879,217,912	30.9516	9.8580	.001043841	3,009.65	720,810.16
959	919,681	881,974,079	30.9677	9.8614	.001042753	3,012.79	722,315.77
960	921,600	884,736,000	30.9839	9.8648	.001041667	3,015.93	723,822.95
961	923,521	887,503,681	31.0000	9.8683	.001040583	3,019.07	725,331.70
962	925,444	890,277,128	31.0161	9.8717	.001039501	3,022.21	726,842.02
963	927,369	893,056,347	31.0322	9.8751	.001038422	3,025.35	728,353.91
964	929,296	895,841,344	31.0483	9.8785	.001037344	3,028.50	729,867.37
965	931,225	898,632,125	31.0644	9.8819	.001036269	3.031.64	731,382.40
966	933,156	901,428,696	31.0805	9.8854	.001035197	3,034.78	732,899.01
967	935,089	904,231,063	31.0966	9.8888	.001034126	3,037.92	734,417.18
968	937,024	907,039,232	31.1127	9.8922	.001033058	3,041.06	735,936.93
969	938,961	909,853,209	31.1288	9.8956	.001031992	3,044.20	737,458.24
970	940,900	912,673,000	31.1448	9.8990	.001030928	3,047.34	738,981.13
971	942,841	915,498,611	31.1609	9.9024	.001029866	3,050.49	740,505.59
972	944,784	918,330,048	31.1769	9.9058	.001028807	3,053.63	742,031.62
973	946,729	921,167,317	31.1929	9.9092	.001027749	3,056.77	743,559.22
974	948,676	924,010,424	31.2090	9.9126	.001026694	3,059.91	745,088.39
975	950,625	926,859,375	31.2250	9.9160	.001025641	3,063.05	746,619.13
976	952,576	929,714,176	31.2410	9.9194	.001024590	3,066.19	748,151.44
977	954,529	932,574,833	31.2570	9.9227	.001023541	3,069.34	749,685.32
978	956,484	935,441,352	31.2730	9.9261	.001022495	3,072.48	751,220.78
979	958,441	938,313,739	31.2890	9.9295	.001021450	3,075.62	752,757.80
980	960,400	941,192,000	31.3050	9.9329	.001020408	3,078.76	754,296.40
981	962,361	944,076,141	31.3209	9.9363	.001019368	3,081.90	755,836.56
982	964,324	946,966,168	31.3369	9.9396	.001018330	3,085.04	757,378.30
983	966,289	949,862,087	31.3528	9.9430	.001017294	3,088.19	758,921.61
984	968,256	952,763,904	31.3688	9.9464	.001016260	3,091.33	760,466.48
985	970,225	955,671,625	31.3847	9.9497	.001015228	3,094.47	762,012.93
986	972,196	958,585,256	31.4006	9.9531	.001014199	3,097.61	763,560.95
987	974,169	961,504,803	31.4166	9.9565	.001013171	3,100.75	765,110.54
988	976,144	964,430,272	31.4325	9.9598	.001012146	3.103.89	766,661.70
989	978,121	967,361,669	31.4484	9.9632	.001011122	3,107.04	768,214.44
990	980,100	970,299,000	31.4643	9.9666	.001010101	3,110.18	769,768.74

SQUARES, CUBES, SQUARE AND CUBE ROOTS, RECIPROCALS, CIRCUMFERENCES, AND AREAS

Table No. 40 (Continued)

No.	Square	Cube	Sq. Root	Cu. Root	Reciprocal	Circum.	Area
991	982,081	973,242,271	31.4802	9.9699	.001009082	3,113.32	771,324.61
992	984,064	976,191,488	31.4960	9.9733	.001008065	3,116.46	772,882.06
993	986,049	979,146,657	31.5119	9.9766	.001007049	3,119.60	744,441.07
994	988,036	982,107,784	31.5278	9.9800	.001006036	3,122.74	776,001.66
995	990,025	985,074,875	31.5436	9.9833	.001005025	3,125.88	777,563.82
996	992,016	988,047,936	31.5595	9.9866	.001004016	3,129.03	779,127.54
997	994,009	991,026,973	31.5753	9.9900	.001003009	3,132.17	780,692.84
998	996,004	994,011,992	31.5911	9.9933	.001002004	3,135.31	782,259.71
999	998,001	997,002,999	31.6070	9.9967	.001001001	3,138.45	783,828.15
1000	1,000,000	1,000,000,000	31.6228	10.0000	.001000000	3,141.59	785,398.16

13 Foot Pipe for Hydro-Electric Plant

DECIMAL EQUIVALENTS

Table No. 41

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

INCHES AND FRACTIONS OF AN INCH IN DECIMALS OF A FOOT

Table No. 42

Inches	0	1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0	.0104	.0208	.0313	.0417	.0521	.0625	.0729
1	.0833	.0938	.1042	.1146	.1250	.1354	.1458	.1563
2	.1667	.1771	.1875	.1979	.2083	.2188	.2292	.2396
3	.2500	.2604	.2708	.2813	.2917	.3021	.3125	.3229
4	.3333	.3438	.3542	.3646	.3750	.3854	.3958	.4063
5	.4167	.4271	.4375	.4479	.4583	.4688	.4792	.4896
6	.5000	.5104	.5208	.5313	.5417	.5521	.5625	.5729
7	.5833	.5938	.6042	.6146	.625	.6354	.6458	.6563
8	.6667	.6771	.6875	.6979	.7083	.7188	.7292	.7396
9	.7500	.7604	.7708	.7813	.7917	.8021	.8125	.8229
10	.8333	.8438	.8542	.8646	.8750	.8854	.8958	.9063
11	.9167	.9271	.9375	.9479	.9583	.9688	.9792	.9896

LUMBER TABLE

Board Feet in One Piece of Various Sizes and Lengths

Table No. 43

SIZES IN INCHES	LENGTH IN FEET									
	8	10	12	14	16	18	20	22	24	26
1 x 2	1.33333	1.66667	2.	2.33333	2.66667	3.	3.33333	3.66667	4.	4.33333
1 x 3	2.	2.5	3.	3.5	4.	4.5	5.	5.5	6.	6.5
1 x 4	2.66667	3.33333	4.	4.66667	5.33333	6.	6.66667	7.33333	8.	8.66667
1 x 5	3.33333	4.16667	5.	5.83333	6.66667	7.5	8.33333	9.16667	10.	10.83333
1 x 6	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1 x 8	5.33333	6.66667	8.	9.33333	10.66667	12.	13.33333	14.66667	16.	17.33333
1 x 10	6.66667	8.33333	10.	11.66667	13.33333	15.	16.66667	18.33333	20.	21.66667
1 x 12	8.	10.	12.	14.	16.	18.	20.	22.	24.	26.
1 x 14	9.33333	11.66667	14.	16.33333	18.66667	21.	23.33333	25.66667	28.	30.33333
1 x 16	10.66667	13.33333	16.	18.66667	21.33333	24.	26.66667	29.33333	32.	34.66667
1 x 18	12.	15.	18.	21.	24.	27.	30.	33.	36.	39.
1 x 20	13.33333	16.66667	20.	23.33333	26.66667	30.	33.33333	36.66667	40.	43.33333
1¼ x 4	3.33333	4.16667	5.	5.83333	6.66667	7.5	8.33333	9.16667	10.	10.83333
1¼ x 5	4.16667	5.20833	6.25	7.29167	8.33333	9.375	10.41667	11.45833	12.5	13.54167
1¼ x 6	5.	6.25	7.5	8.75	10.	11.25	12.5	13.75	15.	16.25
1¼ x 8	6.66667	8.33333	10.	11.66667	13.33333	15.	16.66667	18.33333	20.	21.66667
1¼ x 10	8.33333	10.41667	12.5	14.58333	16.66667	18.75	20.83333	22.91667	25.	27.08333
1¼ x 12	10.	12.5	15.	17.5	20.	22.5	25.	27.5	30.	32.5
1½ x 4	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1½ x 5	5.	6.25	7.5	8.75	10.	11.25	12.5	13.75	15.	16.25
1½ x 6	6.	7.5	9.	10.5	12.	13.5	15.	16.5	18.	19.5
1½ x 8	8.	10.	12.	14.	16.	18.	20.	22.	24.	26.
1½ x 10	10.	12.5	15.	17.5	20.	22.5	25.	27.5	30.	32.5
1½ x 12	12.	15.	18.	21.	24.	27.	30.	33.	36.	39.
2 x 4	5.33333	6.66667	8.	9.33333	10.66667	12.	13.33333	14.66667	16.	17.33333
2 x 6	8.	10.	12.	14.	16.	18.	20.	22.	24.	26.
2 x 8	10.66667	13.33333	16.	18.66667	21.33333	24.	26.66667	29.33333	32.	34.66667
2 x 10	13.33333	16.66667	20.	23.33333	26.66667	30.	33.33333	36.66667	40.	43.33333
2 x 12	16.	20.	24.	28.	32.	36.	40.	44.	48.	52.
2 x 14	18.66667	23.33333	28.	32.66667	37.33333	42.	46.66667	51.33333	56.	60.66667

SIZES IN INCHES	LENGTH IN FEET									
	8	10	12	14	16	18	20	22	24	26
2 x 16	21.33333	26.66667	32.	37.33333	42.66667	48.	53.33333	58.66667	64.	69.33333
2½ x 12	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.
2½ x 14	23.33333	29.16667	35.	40.83333	46.66667	52.5	58.33333	64.16667	70.	75.83333
2½ x 16	26.66667	33.33333	40.	46.66667	53.33333	60.	66.66667	73.33333	80.	86.66667
3 x 6	12.	15.	18.	21.	24.	27.	30.	33.	36.	39.
3 x 8	16.	20.	24.	28.	32.	36.	40.	44.	48.	52.
3 x 10	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.
3 x 12	24.	30.	36.	42.	48.	54.	60.	66.	72.	78.
3 x 14	28.	35.	42.	49.	56.	63.	70.	77.	84.	91.
3 x 16	32.	40.	48.	56.	64.	72.	80.	88.	96.	104.
4 x 4	10.66667	13.33333	16.	18.66667	21.33333	24.	26.66667	29.33333	32.	34.66667
4 x 6	16.	20.	24.	28.	32.	36.	40.	44.	48.	52.
4 x 8	21.33333	26.66667	32.	37.33333	42.66667	48.	53.33333	58.66667	64.	69.33333
4 x 10	26.66667	33.33333	40.	46.66667	53.33333	60.	66.66667	73.33333	80.	86.66667
4 x 12	32.	40.	48.	56.	64.	72.	80.	88.	96.	104.
4 x 14	37.33333	46.66667	56.	65.33333	74.66667	84.	93.33333	102.66667	112.	121.33333
6 x 6	24.	30.	36.	42.	48.	54.	60.	66.	72.	78.
6 x 8	32.	40.	48.	56.	64.	72.	80.	88.	96.	104.
6 x 10	40.	50.	60.	70.	80.	90.	100.	110.	120.	130.
6 x 12	48.	60.	72.	84.	96.	108.	120.	132.	144.	156.
6 x 14	56.	70.	84.	98.	112.	126.	140.	154.	168.	182.
6 x 16	64.	80.	96.	112.	128.	144.	160.	176.	192.	208.
8 x 8	42.66667	53.33333	64.	74.66667	85.33333	96.	106.66667	117.33333	128.	138.66667
8 x 10	53.33333	66.66667	80.	93.33333	106.66667	120.	133.33333	146.66667	160.	173.33333
8 x 12	64.	80.	96.	112.	128.	144.	160.	176.	192.	208.
8 x 14	74.66667	93.33333	112.	130.66667	149.33333	168.	186.66667	205.33333	224.	242.66667
10 x 10	66.66667	83.33333	100.	116.66667	133.33333	150.	166.66667	183.33333	200.	216.66667
10 x 12	80.	100.	120.	140.	160.	180.	200.	220.	240.	260.
10 x 14	93.33333	116.66667	140.	163.33333	186.66667	210.	233.33333	256.66667	280.	303.33333
10 x 16	106.66667	133.33333	160.	186.66667	213.33333	240.	266.66667	293.33333	320.	346.66667
12 x 12	96.	120.	144.	168.	192.	216.	240.	264.	288.	312.
12 x 14	112.	140.	168.	196.	224.	252.	280.	308.	336.	364.
12 x 16	128.	160.	192.	224.	256.	288.	320.	352.	384.	416.
14 x 14	130.66667	163.33333	196.	228.66667	261.33333	294.	326.66667	359.33333	392.	424.66667
14 x 16	149.33333	186.66667	224.	261.33333	298.66667	336.	373.33333	410.66667	448.	485.33333

48" Creosoted Continuous Stave Pipe

SECTION IV

LIST PRICES

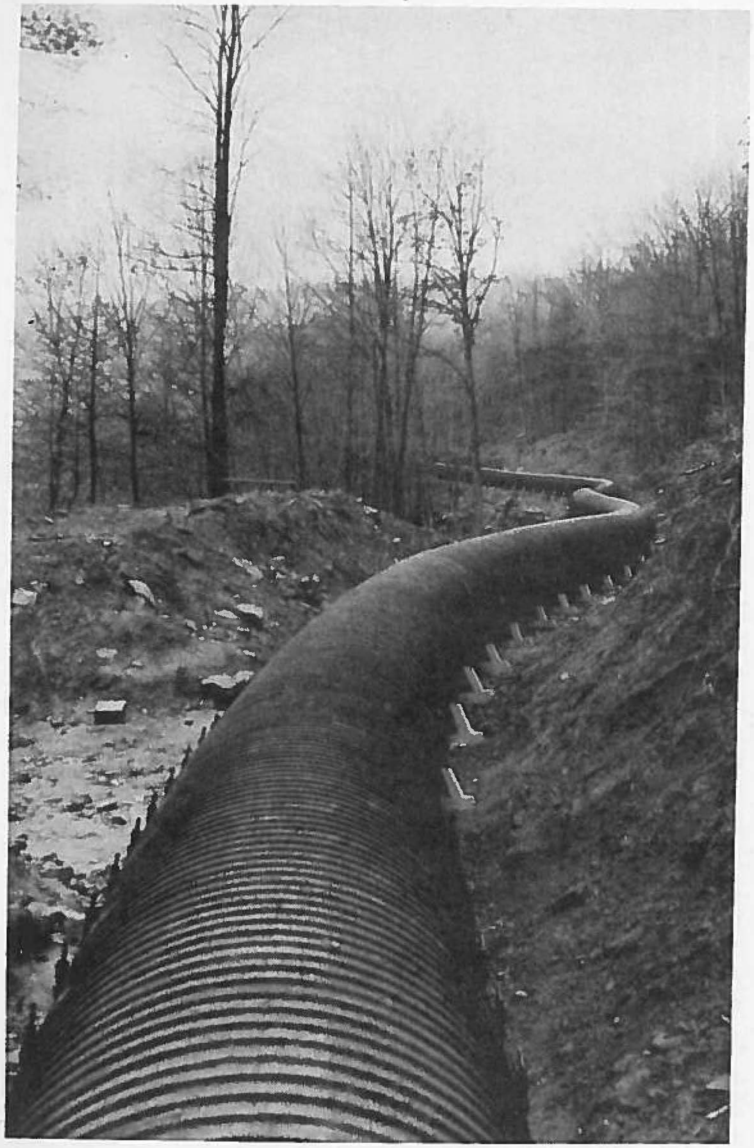
List prices have been included in this catalog, because we are confident that such information can be of value. If not properly interpreted, however, list prices may be misleading and, accordingly, we wish to be very definite regarding the proper use of these prices.

First: All of the prices presented for pipe, tanks, fittings, etc., are List Prices, only, and over the years these may be subject to various discounts or advances.

Second: These prices are to be used for approximate purposes, only, for the preparation of preliminary estimates, and are not quotations—in any sense of the word.

Third: These List Prices are intended to serve a useful purpose, primarily by comparison with current quotations or prices. For instance, if quotations or invoices of a recent date are available for a carload of 8" 250′ head, untreated-coated wood pipe; the approximate cost of about the same quantity of other sizes and heads and types of pipe may be considered as having about the same relation to the List.

Fourth: We accept no responsibility for any application of these list prices. Discounts or advances, or list prices themselves, are subject to change without notice. We urge that, whenever possible, estimating or final prices be obtained from our representatives, or direct from our office. Sample forms, indicating information required in order that we may quote intelligently, are presented on the next few pages.



84" Pipe for Water Power Plant

(Note: Do NOT tear this order form from book—use it as a guide)

PRICES AND ESTIMATES ON FEDERAL PIPE

Wire Wound Pipe—Sizes 2 in. to 24 in. Inside Diameter

Prices and estimates on wood pipe can be intelligently made only when sufficient information is at hand on which to make recommendations as to the pipe best suited for the purpose intended. When writing for prices, therefore, you should supply as much as possible of the information listed below:

1. Indicate in the following schedule the purpose for which your pipe will be used:

    Municipal water system........................

    Private water system........................

    Irrigation system........................

    Power Line........................

    Any other purpose........................

2. Will the project be gravity or pumping system?........................

3. If a pumping or power system, state type of pump or wheel ....

4. Quantity of water to be delivered........................
5. Amount of power to be generated?........................
6. If possible send plans, profile, or sketch showing pipe location, elevation of water and pipe at intake, discharge points, etc. ....
7. Will there be any angles or sharp curves in the line?........................ If possible, state the degree of the angles and the minimum radii of the curves........................
8. Give list of fittings that you will require........................

(*Over*)

9. Name railway station or point on common carrier to which it is desired that pipe shall be delivered..........

....

10. When do you plan commencement and completion of the installation? ....
11. Do you wish now merely preliminary prices to aid you in making approximate estimates or do you intend to place your order immediately?..........
12. Write the size of pipe and the length in feet required under each head in feet as shown in the following table:

	Size..........	Size..........	Size..........
HEAD	Length	Length	Length
50 Ft.	Ft.	Ft.	Ft.
100 Ft.	Ft.	Ft.	Ft.
150 Ft.	Ft.	Ft.	Ft.
200 Ft.	Ft.	Ft.	Ft.
250 Ft.	Ft.	Ft.	Ft.
300 Ft.	Ft.	Ft.	Ft.
350 Ft.	Ft.	Ft.	Ft.
400 Ft.	Ft.	Ft.	Ft.

Name..........

Address..........

Date..........

(Note: Do NOT tear this order form from book—use it as a guide)

PRICES AND ESTIMATES ON FEDERAL PIPE

Continuous Stave Pipe—Sizes 4 in. to 20 ft. Inside Diameter

Prices and estimates on wood pipe can be intelligently made only when sufficient information is at hand on which to make recommendations as to the type best suited for the purpose intended. When writing for prices, you should supply as much as possible of the information listed below:

1. Indicate in the following schedule the purpose for which your pipe will be used:

   Municipal water system..........

   Private water system..........

   Irrigation system..........

   Power Line..........

   Any other purpose..........
2. Will the project be gravity or pumping system?..........

   ....
3. If a pumping or power system, state type of pump or wheel

   ....
4. Quantity of water to be delivered?..........
5. Amount of power to be generated?..........
6. If possible send plans, profile, or sketch showing pipe location, elevation of water and pipe at intake, discharge points, etc. ....
7. Will there be any angles or sharp curves in the line?.......... If possible, state the degree of the angles and the minimum radii of the curves..........
8. Give a list of fittings that you will require..........

   ....

(Over)

9. Name railway station or point on common carrier to which it is desired that pipe shall be delivered ....

10. When do you plan commencement and completion of the installation? ....
11. Do you wish now merely preliminary prices to aid you in making approximate estimates or do you intend to place your order immediately?................................
12. Do you wish prices for material only, K.D., or including erection? ....

    If erected, state average wage for common labor applying at site of the proposed installation................................
13. Write the size of pipe and the length in feet required under each head in feet as shown below:

Size of Pipe..................

Head	Quantity	Head	Quantity	Head	Quantity
10		110		210	
20		120		220	
30		130		230	
40		140		240	
50		150		250	
60		160		260	
70		170		270	
80		180		280	
90		190		290	
100		200		300	

Name................................

Address................................

Date................................

(Note: Do NOT tear this order form from book—use it as a guide)

PRICES AND ESTIMATES FOR FEDERAL FLUME

Sizes 18 inch to 16 feet Diameter

Prices and estimates on Creo-Wood Flume can be intelligently made only when sufficient information is at hand on which to make recommendations as to the type best suited for the purpose intended. When writing for prices, you should supply as much as possible of the information listed below:

1. State diameter of flume required................................

   Or if a replacement state kind and size of old flume..........
2. State length of flume required................................
3. Quantity of water to be delivered................................
4. Total fall from water surface at intake to water surface at outlet ....
5. Will there be any angles or sharp curves in the line?..........

   If possible, state the degree of the angles and the minimum radii of the curves................................
6. Velocity of water in ditch at intake end................................
7. Velocity of water in ditch at discharge end................................
8. Name railway station or point on common carrier to which it is desired that material shall be delivered ....
9. When do you plan commencement and completion of the installation? ....
10. State average wage for common labor applying at the site of the proposed installation ....
11. Do you wish now merely preliminary prices to aid you in making approximate estimates, or do you intend to place your order immediately?................................

Name................................

Address................................

Date................................

(Over)

PRICES AND ESTIMATES FOR FEDERAL FLUME

Will Be Made as Follows:

This company will contract to manufacture and ship, in knocked-down form, complete material and erect the flume in place, covering the cost of labor of erection, filling and testing to purchaser's satisfaction. The materials to be furnished under terms of this proposal are:

Spreaders, washers, rods, staves and cradles, all wood parts being creosoted.

Under the terms of this proposal, purchasers will unload cars, tally, sort, haul, and distribute material on top of the substructure in the manner directed by us, and will furnish the substructure, including caps, complete in place, and will furnish water for the test upon the completion of the installation.

NOTE: *We use only the vacuum and pressure creosoting process as specified elsewhere.*

As noted, we do not include in our quotation caps, sills or running boards. If the purchaser desires, however, we will furnish these additional items either creosoted or untreated at reasonable cost.

7 ft. Flume connecting with 5½ ft. pipe discharge

(Note: Do NOT tear this order form from book—use it as a guide)

PRICES AND ESTIMATES FOR FEDERAL TANKS

Sizes 100 Gallons to 700,000 Gallons Capacity

When requesting quotations for wood tanks, furnish as much of the following information as required to describe the tank which you plan to purchase:

1. Capacity in gallons ____________
2. Approximate outside diameter and outside height, if you require or wish a tank of certain dimensions.
   ____________ O.D. x ____________ O. Hght.
3. Purpose for which tank is required:
   a. Domestic water storage ____________
   b. Fire protection storage ____________
   c. Mining operations ____________
   d. Pulp mill ____________
   e. Acid container. What Acid? ____________
   f. Other uses ____________
4. Do you wish an open top tank, or a head set in the top, or is a conical cover desired?
   a. Open top ____________
   b. Headed ____________
   c. Conical cover ____________
5. Height of Tower, if any.
   a. Height from ground surface to bottom of tank ____________ feet
6. Do you wish prices for material, only, K.D., or is erection in place to be included? ____________
7. Name railway station or point on common carrier to which it is desired that material shall be delivered ____________
   ____
8. When do you plan commencement and completion of the installation? ____________

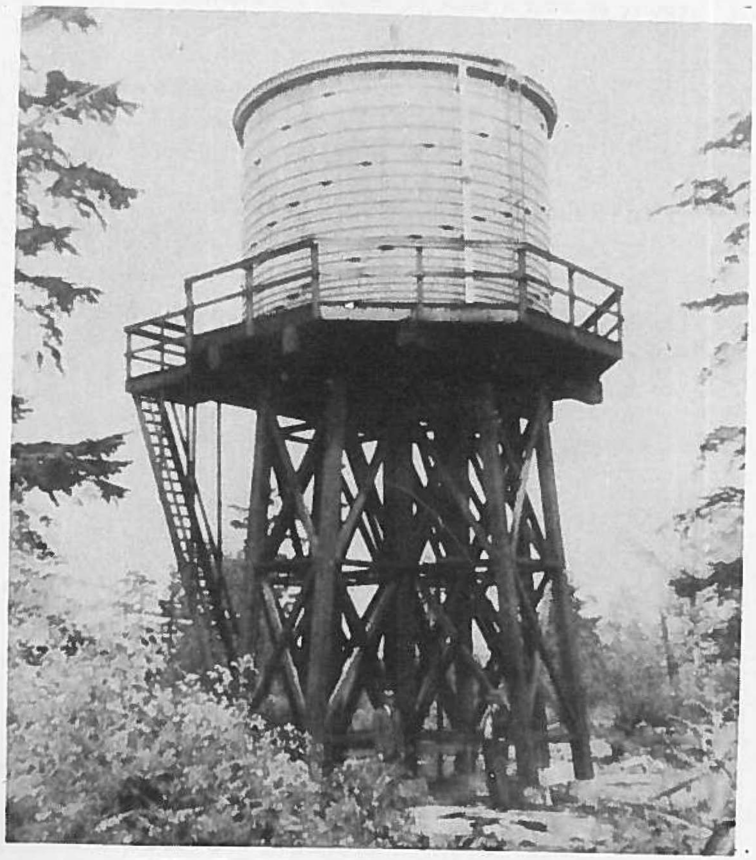
(Over)

9. Do you wish preliminary prices to aid you in making approximate estimates, or do you intend to place your order immediately? ____________

Name ____________

Address ____________

Date ____________



34,000-gallon Cedar Tank on 24-ft. creosoted Fir Tower

PRICES FOR FEDERAL WIRE-WOUND WOOD PIPE

Instructions Applying to Price List No. 10

The prices listed are per 100 linear feet of pipe, f.o.b. cars, Seattle, Washington.

Minimum Car:

Weights and car capacities are given immediately following the price list. The minimum carload weight is 30,000 pounds. If the capacity of the car in linear feet will not make this minimum weight, use the 30,000 pounds minimum carload weight in calculating freight and divide by the number of hundreds of linear feet that the car will hold. This will give the correct freight charge per hundred feet of pipe. If the quantity of pipe required is less than the minimum car of 30,000 pounds, it may be cheaper to ship as a minimum car, rather than to figure freight on the less-than-carload basis.

Specified Lengths:

Wire-wound wood pipe is furnished in random lengths and, as a rule, it is necessary to make an extra charge if pieces are furnished to a specified length or if runs are to be furnished to a specified total length; however, if it is desired that pipe be furnished to exact length we must have definite information to indicate the points between which measurements are to be taken. A sketch showing the method of measurement is desirable, particularly if the order involves fittings.

We frequently use the term "shoulder-to-shoulder" to describe length accurately, and it may be convenient to use this term when ordering. In the case of Inserted Joint pipe, this means that measurement is to be taken from joint-to-joint (sometimes referred to as "seam-to-seam"), as the pipe appears when installed. For pipe with any kind of collar couplings, this means from one end of a collar to the corresponding end of another collar.

In the case of pipe furnished with, or milled for, special malleable iron flange couplings (as is rather common for pulp mills), measurement is figured from face-to-face of flanges.

FEDERAL WIRE WOUND PIPE

Price List No. 10

Size	Head in Feet	Type of Joint	LIST PRICES—Per 100 Feet of Pipe: Untreated Coated	Creosoted Uncoated	Creosoted Coated	*Add for Collars
2″	50	IJ	$20.00	$23.00	$24.00	$2.00
	100	″	21.00	24.00	25.00	2.00
	150	″	22.00	25.00	26.00	2.00
	200	″	23.00	26.00	27.00	2.00
	250	″	24.00	27.00	28.00	2.00
	300	6″WWC	27.00	30.00	31.00	
	350	″	28.00	31.00	32.00	
	400	″	29.00	32.00	33.00	
3″	50	IJ	25.00	29.00	30.00	2.00
	100	″	26.00	30.00	31.00	2.00
	150	″	27.00	31.00	32.00	2.00
	200	″	29.00	33.00	34.00	2.00
	250	6″WWC	33.00	37.00	38.00	
	300	″	34.00	38.00	39.00	
	350	″	35.00	39.00	40.00	
	400	″	36.00	40.00	41.00	
4″	50	IJ	31.00	37.00	39.00	3.00
	100	″	32.00	38.00	40.00	3.00
	150	″	33.00	39.00	41.00	3.00
	200	6″WWC	38.00	44.00	46.00	
	250	″	40.00	46.00	48.00	
	300	″	42.00	48.00	50.00	
	350	″	44.00	50.00	52.00	
	400	″	46.00	52.00	54.00	
5″	50	IJ	36.00	43.00	45.00	3.00
	100	″	38.00	45.00	47.00	3.00
	150	6″WWC	44.00	51.00	53.00	
	200	″	46.00	53.00	55.00	
	250	″	48.00	55.00	57.00	
	300	″	50.00	57.00	59.00	
	350	″	52.00	59.00	61.00	
	400	″	55.00	62.00	64.00	
6″	50	IJ	44.00	52.00	54.00	4.00
	100	″	46.00	54.00	56.00	4.00
	150	6″WWC	53.00	61.00	63.00	
	200	″	55.00	63.00	65.00	
	250	″	57.00	65.00	67.00	
	300	″	60.00	68.00	70.00	
	350	″	63.00	71.00	73.00	
	400	″	67.00	75.00	77.00	
8″	50	IJ	55.00	65.00	68.00	4.00
	100	″	58.00	68.00	71.00	4.00
	150	6″WWC	66.00	76.00	79.00	
	200	″	70.00	80.00	83.00	
	250	″	74.00	84.00	87.00	
	300	″	79.00	89.00	92.00	
	350	″	85.00	95.00	98.00	
	400	″	91.00	101.00	104.00	

FEDERAL WIRE WOUND PIPE

Price List No. 10 (Continued)

Size	Head in Feet	Type of Joint	LIST PRICES—Per 100 Feet of Pipe: Untreated Coated	Creosoted Uncoated	Creosoted Coated	*Add for Collars
10″	50	IJ	$69.00	$82.00	$85.00	$5.00
	100	″	74.00	87.00	90.00	5.00
	150	6″WWC	86.00	99.00	102.00	
	200	″	90.00	103.00	106.00	
	250	″	95.00	108.00	111.00	
	300	″	103.00	116.00	119.00	
	350	″	111.00	124.00	127.00	
	400	″	119.00	132.00	135.00	
12″	50	IJ	79.00	95.00	99.00	6.00
	100	″	85.00	101.00	105.00	6.00
	150	6″WWC	100.00	116.00	120.00	
	200	″	107.00	123.00	127.00	
	250	8″WWC	117.00	133.00	137.00	
	300	″	127.00	143.00	147.00	
	350	″	137.00	153.00	157.00	
	400	″	147.00	163.00	167.00	
14″	50	IJ	92.00	110.00	114.00	7.00
	100	RIJ	102.00	120.00	124.00	7.00
	150	8″WWC	122.00	140.00	144.00	
	200	″	132.00	150.00	154.00	
	250	″	145.00	163.00	167.00	
	300	″	158.00	176.00	180.00	
	350	″	171.00	189.00	193.00	
	400	″	185.00	203.00	207.00	
16″	50	RIJ	116.00	137.00	142.00	9.00
	100	″	127.00	148.00	153.00	9.00
	150	8″IB	156.00	177.00	182.00	
	200	″	174.00	195.00	200.00	
	250	″	189.00	210.00	215.00	
	300	″	215.00	236.00	241.00	
	350	″	229.00	250.00	255.00	
	400	″	255.00	276.00	281.00	
18″	50	RIJ	131.00	155.00	160.00	11.00
	100	″	148.00	172.00	177.00	11.00
	150	8″IB	184.00	208.00	213.00	
	200	″	203.00	227.00	232.00	
	250	″	234.00	258.00	263.00	
	300	″	255.00	279.00	284.00	
	350	″	284.00	308.00	313.00	
	400	″	307.00	331.00	336.00	
20″	50	RIJ	147.00	174.00	180.00	13.00
	100	″	169.00	196.00	202.00	13.00
	150	8″IB	213.00	240.00	246.00	
	200	″	239.00	266.00	272.00	
	250	″	266.00	293.00	299.00	
	300	″	294.00	321.00	327.00	
	350	″	335.00	362.00	368.00	
	400	″	350.00	377.00	383.00	

FEDERAL WIRE WOUND PIPE

Price List No. 10 (Continued)

Size	Head in Feet	Type of Joint	LIST PRICES—Per 100 Feet of Pipe: Untreated Coated	Creosoted Uncoated	Creosoted Coated	*Add for Collars
22″	50	RIJ	$157.00	$187.00	$193.00	$15.00
	100	"	186.00	216.00	222.00	15.00
	150	8″IB	239.00	269.00	275.00	
	200	"	276.00	306.00	312.00	
	250	"	304.00	334.00	340.00	
	300	"	331.00	361.00	367.00	
	350	"	371.00	401.00	407.00	
	400	"	398.00	428.00	434.00	
24″	50	RIJ	173.00	206.00	213.00	17.00
	100	"	210.00	243.00	250.00	17.00
	150	8″IB	270.00	303.00	310.00	
	200	"	312.00	345.00	352.00	
	250	"	346.00	379.00	386.00	
	300	"	389.00	422.00	429.00	
	350	"	432.00	465.00	472.00	
	400	"	452.00	485.00	492.00	

Type of Joint (Coupling)

- IJ — Inserted Joint.
- 6″WWC — Wire-wound Collars, 6″ long.
- 8″WWC — Wire-Wound Collars, 8″ long.
- RIJ — Reinforced Inserted Joint.
- 8″IB — Individual Banded Collars, 8″ long.

*Wire-wound Collars, or Double Seal Metal Collar Couplings will be furnished instead of Inserted Joint Couplings, at List Prices indicated by the additions in the column at the extreme right. Likewise, Individual Banded Collars or Double Seal Metal Collar Couplings will be furnished instead of Reinforced Inserted Joint Couplings, at List Prices indicated by the additions in the column at the extreme right.

For instance—for 2″ 150′ head Untreated-Coated pipe with Collar Couplings, the List Price would be $24.00, and if Creosoted-Coated the list price would be $28.00.

WEIGHTS OF "FEDERAL" WIRE WOUND WOOD PIPE

Per 100 ft. of Pipe

Table No. 44

Diam. Pipe Inches	Head Feet	WEIGHT—In Pounds: Untreated Coated	Creosoted Uncoated	Creosoted Coated
2	50	327	327	371
	100	337	337	381
	150	347	347	391
	200	362	362	406
	250	375	375	419
	300	383	383	427
	350	394	394	438
	400	407	407	451
3	50	426	426	481
	100	440	440	495
	150	455	455	510
	200	478	478	533
	250	497	497	552
	300	510	510	565
	350	527	527	582
	400	549	549	604
4	50	563	574	641
	100	579	590	657
	150	601	612	679
	200	623	634	701
	250	646	657	724
	300	672	683	750
	350	696	707	774
	400	728	739	806
5	50	668	683	762
	100	687	702	781
	150	719	734	813
	200	750	765	844
	250	774	789	868
	300	808	823	902
	350	839	854	933
	400	884	899	978
6	50	852	877	968
	100	870	895	986
	150	916	941	1032
	200	958	983	1074
	250	990	1015	1106
	300	1033	1058	1149
	350	1095	1120	1211
	400	1156	1181	1272
8	50	1081	1118	1231
	100	1119	1156	1269
	150	1176	1213	1326
	200	1239	1276	1389
	250	1305	1342	1455
	300	1383	1420	1533
	350	1458	1495	1608
	400	1507	1544	1651
10	50	1367	1476	1551
	100	1430	1479	1614
	150	1552	1601	1736
	200	1585	1634	1769
	250	1675	1724	1859
	300	1907	1956	2091
	350	1998	2047	2182
	400	2124	2173	2308

Diam. Pipe Inches	Head Feet	WEIGHT—In Pounds: Untreated Coated	Creosoted Uncoated	Creosoted Coated
12	50	1680	1755	1915
	100	1769	1844	2004
	150	1935	2010	2170
	200	2040	2115	2275
	250	2155	2230	2390
	300	2408	2483	2643
	350	2581	2656	2816
	400	2698	2773	2933
14	50	1957	2046	2228
	100	2097	2186	2368
	150	2323	2412	2594
	200	2464	2553	2735
	250	2692	2781	2963
	300	2960	3049	3231
	350	3161	3250	3432
	400	3431	3520	3702
16	50	2404	2525	2729
	100	2549	2670	2874
	150	2780	2901	3105
	200	2989	3110	3314
	250	3354	3475	3679
	300	3655	3776	3980
	350	3811	3932	4136
	400	4168	4289	4493
18	50	2674	2811	3037
	100	2880	3017	3243
	150	3187	3324	3550
	200	3429	3566	3792
	250	3941	4078	4304
	300	4193	4330	4556
	350	4591	4728	4954
	400	4872	5009	5235
20	50	3059	3235	3485
	100	3346	3522	3772
	150	3715	3891	4141
	200	4048	4224	4474
	250	4580	4756	5006
	300	4948	5124	5374
	350	5480	5656	5906
	400	5834	6010	6260
22	50	3360	3554	3829
	100	3761	3955	4230
	150	4213	4407	4682
	200	4809	5003	5278
	250	5217	5411	5686
	300	5652	5846	6121
	350	6082	6276	6551
	400	6432	6626	6901
24	50	3641	3853	4153
	100	4144	4356	4656
	150	4725	4937	5237
	200	5357	5569	5869
	250	5854	6066	6366
	300	6437	6649	6949
	350	6953	7165	7465
	400	7435	7647	7947

APPROXIMATE FREIGHT CAR CAPACITY

Wire Wound Pipe

Table No. 45

Inside Diameter of Pipe in Inches	Lineal Feet of Pipe in Standard 50-ft. Box Car 9'0" Wide 10'0" High	Inside Diameter of Pipe in Inches	Lineal Feet of Pipe in Standard 50-ft. Box Car 9'0" Wide 10'0" High
2	19,250	12	2,300
3	14,150	14	1,850
4	12,000	16	1,300
5	9,600	18	1,050
6	7,200	20	920
8	4,650	22	780
10	3,300	24	600

NOTE: *In the case of Federal Special Creosoted Irrigation Pipe sufficient footage can be loaded in a car to make the 30,000-pound minimum weight.*

CUBIC MEASUREMENT OF FEDERAL WIRE WOUND PIPE FOR EXPORT BY STEAMER

One Cubic Ton = Forty Cubic Feet

Table No. 46

Size Pipe in.	Cubic Feet Per Foot of Pipe	Lin. Feet of Pipe Per Ton	Cubic Tons per 100 feet of Pipe
2	0.14	286	.35
3	0.23	174	.58
4	0.33	121	.83
5	0.44	91	1.10
6	0.62	64.5	1.55
8	0.87	46.0	2.17
10	1.22	32.8	3.05
12	1.67	24.0	4.17
14	2.15	18.6	5.38
16	2.75	14.6	6.88
18	3.36	11.9	8.41
20	4.06	9.86	10.15
22	4.80	8.33	12.00
24	5.57	7.18	13.93

Both pipes and collars are included in table.

A saving in freight may be effected by nesting the smaller sizes in the larger, but the cost of nesting and blocking pipe is too great to be considered except for ocean shipment to distant points. 2" pipe may be nested in 5", 3" in 6", 4" in 8", etc.

Pipes and collars are properly crated for ocean shipment.

FEDERAL SPECIAL CREOSOTED IRRIGATION & DRAINAGE PIPE

Price List No. 12

Size	Head	Joint	Shell	Wire	Spacing	PER 100 FEET Weight	List Price
3"	40	Steel Collar	11/16"	8	3"	292 lbs.	$23.00
4"	40	"	"	8	3"	370 lbs.	27.00
5"	40	"	"	8	3"	471 lbs.	31.00
6"	40	"	"	8	3"	552 lbs.	34.00
8"	40	"	"	8	3"	715 lbs.	44.00
10"	40	"	"	6	3"	916 lbs.	60.00
12"	40	"	"	6	3"	1086 lbs.	75.00

LIST PRICE BURLAP WRAPPED PIPE

Add to weights and prices of untreated coated pipe as follows: Per 100 Feet

Price List No. 14

SIZE IN INCHES	WEIGHT IN POUNDS	PRICE
2"	71	$ 6.00
3"	85	7.00
4"	98	8.00
5"	123	9.00
6"	142	10.00
8"	177	12.00
10"	216	14.00
12"	247	16.00
14"	281	18.00
16"	319	20.00
18"	351	22.00
20"	387	24.00
22"	421	26.00
24"	456	28.00

Loading Pipe on cars

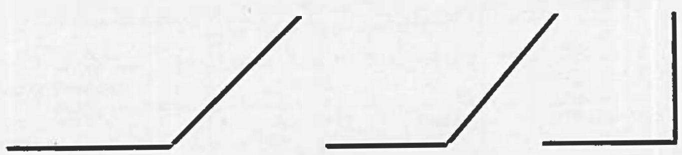
LIST PRICES — CAST IRON FITTINGS

List prices are for hub end fittings, to fit wood pipe of the sizes indicated. See Page 70 regarding dimensions of hubs, and information regarding fittings for pipe and various types of couplings.

FEDERAL cast iron fittings are furnished with truly round hub ends. These hub ends are designed particularly for use with wood pipe and will give satisfactory results, and we wish to point out that satisfactory results may not always be obtained when using fittings having hubs designed for a caulked connection with other types of pipe.

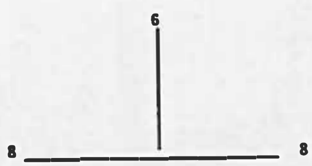
How to Describe a Cast Iron Fitting

The angle of a bend or elbow is measured by the angle of deflection from a straight line, thus:

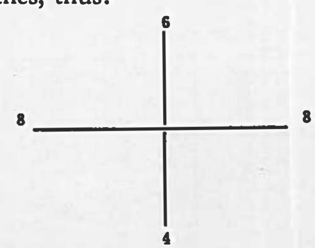


45° 60° 90°

In describing tees and crosses, the run or main line is read first and then the outlets or branches, thus:



8 x 8 x 6 Tee



8 x 8 x 6 x 4 Cross

The size of fittings is the inside diameter of the pipe with which they are used, not the diameter of the bell, viz.: a 4″—90° Elbow is for use with 4″ pipe. This also applies to gate valves, etc.

If regular hub ends are desired for connection with wood pipe, no designation is necessary when describing the fittings.

If connection is to be made to other kinds of pipe at any of the outlets, use the following abbreviations:

s = Tapped to receive Standard Threaded Steel Pipe.

F = Standard Flange, faced and drilled standard.

(See Page 254 for drilling templates.)

C = Hub End for Standard Cast Iron pipe, with lead retainer groove.

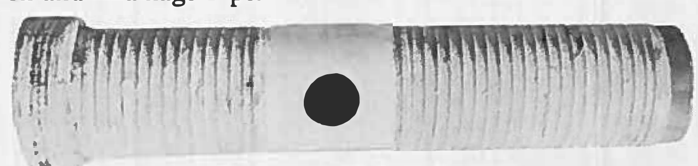
For instance, a fitting described as an 8x6sx4F Tee would have an 8″ wood pipe connection at one end, a 6″ threaded steel connection at the other end, and 4″ flanged side outlet.

If there is any question regarding the proper description of a fitting, a sketch should be sent along with the order.

Prices for Saddles include the necessary bands and gasket for attaching to wood pipe. When ordering, advise the approximate operating head where the saddle is to be located.

When ordering Wood Plugs, state whether these are to be used in pipe, or in fittings.

When ordering Driving Plugs, always specify whether for Inserted Joint, Wood Collar, or Double Metal Collar couplings; or, Single Metal Collar couplings, in the case of Special Irrigation and Drainage Pipe.



Pipe Section with Space for Saddle

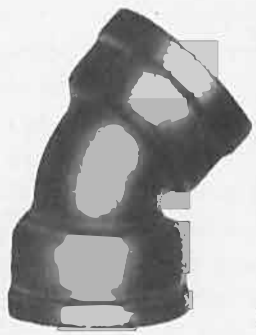
Flanged Saddle attached to Pipe Section

CAST IRON FITTINGS FOR WOOD PIPE

List Prices

Price List No. 16

90° Bend



22½° Bend

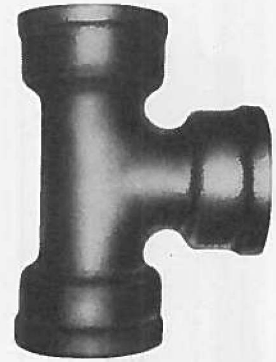
BENDS

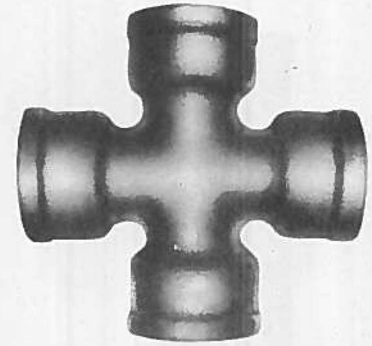
Size Inches	90° Wt. Lbs.	90° Price	60° Wt. Lbs.	60° Price	45° Wt. Lbs.	45° Price	30° Wt. Lbs.	30° Price	22½° & 11¼° Wt. Lbs.	22½° & 11¼° Price
2	18	$3.00	16	$3.00	15	$2.50	14	$2.40	13	$2.40
3	28	3.85	28	3.85	28	3.85	27	3.75	25	3.75
4	40	4.95	34	4.95	32	4.00	30	3.85	30	3.85
5	48	5.30	46	5.30	36	4.10	34	4.00	32	4.00
6	65	6.70	54	6.70	53	5.50	50	5.20	46	5.10
8	100	9.65	88	8.90	82	7.30	72	6.90	70	6.90
10	155	14.00	125	12.10	115	10.30	105	9.50	100	9.40
12	210	18.90	196	17.60	170	15.40	150	13.50	145	13.30
14	315	28.00	280	18.70	248	22.20	225	20.00	220	20.00
16	440	45.35	400	40.75	323	33.00	......	......	......	......
18	510	52.80	480	49.50	410	41.00	......	......	......	......
20	1010	96.25	......	......	......	......	......	......	......	......

CAST IRON FITTINGS FOR WOOD PIPE

List Prices

Price List No. 16 (Continued)



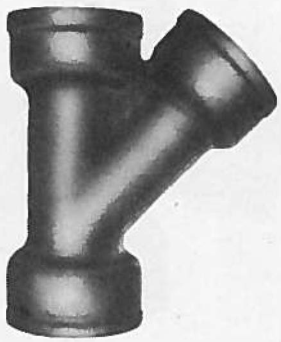


TEES Size	Weight Pounds	Price	CROSSES Size	Weight Pounds	Price
2 x 2 x 2	27	$ 4.50	2 x 2 x 2 x 2	32	$ 5.30
3 x 3 x 3	42	5.70	3 x 3 x 3 x 3	60	9.60
4 x 4 x 4	54	6.00	4 x 4 x 4 x 4	68	9.60
5 x 5 x 5	70	7.70	5 x 5 x 5 x 5	100	11.00
6 x 6 x 6	94	9.00	6 x 6 x 6 x 6	115	11.50
8 x 8 x 8	145	13.10	8 x 8 x 8 x 8	185	17.75
10 x 10 x 10	230	20.50	10 x 10 x 10 x 10	300	27.00
12 x 12 x 12	315	28.00	12 x 12 x 12 x 12	380	34.00
14 x 14 x 14	390	35.00	14 x 14 x 14 x 14	650	58.30
3 x 3 x 2	47	5.70	3 x 3 x 2 x 2	58	9.60
4 x 4 x 2	47	6.00	4 x 4 x 2 x 2	60	9.60
4 x 4 x 3	50	6.00	4 x 4 x 3 x 3	64	9.60
6 x 6 x 3	80	8.25	6 x 6 x 3 x 3	100	11.00
6 x 6 x 4	85	8.80	6 x 6 x 4 x 4	104	11.00
8 x 8 x 4	135	13.00	8 x 8 x 4 x 4	150	14.40
8 x 8 x 6	137	13.10	8 x 8 x 6 x 6	170	16.40
10 x 10 x 4	205	18.50	10 x 10 x 4 x 4	240	21.50
10 x 10 x 6	205	18.50	10 x 10 x 6 x 6	244	22.00
10 x 10 x 8	210	18.80	10 x 10 x 8 x 8	260	23.00
12 x 12 x 6	270	24.20	12 x 12 x 6 x 6	300	27.00
12 x 12 x 8	275	24.60	12 x 12 x 8 x 8	310	28.00
14 x 14 x 6	395	35.50	14 x 14 x 6 x 6	455	41.00
14 x 14 x 8	440	39.60	14 x 14 x 8 x 8	475	42.50
16 x 16 x 12	545	53.50			

CAST IRON FITTINGS FOR WOOD PIPE

List Prices

Price List No. 16 (Continued)



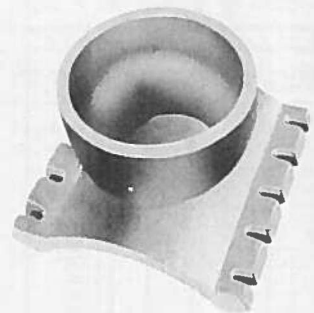
45° WYES / REDUCERS

45° Wyes Size	Weight Pounds	Price	Reducers Size	Weight Pounds	Price
3 x 3 x 3	51	$ 8.25	3 x 2	20	$ 2.75
4 x 4 x 4	72	9.75	4 x 2	35	4.80
5 x 5 x 5	100	11.60	4 x 3	35	4.80
6 x 6 x 6	120	11.60	5 x 4	38	5.10
8 x 8 x 8	186	20.50	6 x 3	45	5.10
10 x 10 x 10	300	31.00	6 x 4	45	5.10
12 x 12 x 12	430	44.00	6 x 5	48	5.20
14 x 14 x 14	600	61.50	8 x 3	65	6.20
16 x 16 x 16	800	86.50	8 x 4	65	6.20
4 x 4 x 3	60	9.65	8 x 5	65	6.20
6 x 6 x 4	105	11.60	8 x 6	76	7.40
8 x 8 x 4	140	15.40	10 x 4	100	9.00
8 x 8 x 6	165	18.00	10 x 6	102	9.10
10 x 10 x 4	200	20.50	10 x 8	105	9.35
10 x 10 x 6	225	23.00	12 x 6	118	10.70
12 x 12 x 6	306	32.00	12 x 8	120	10.80
12 x 12 x 8	336	34.50	12 x 10	138	12.35
14 x 14 x 10	550	56.50	14 x 12	150	16.80
14 x 14 x 12	570	59.00	16 x 8	366	33.00
			16 x 14	415	37.40

CAST IRON FITTINGS FOR WOOD PIPE

List Prices

Price List No. 16 (Continued)



SADDLES — Hub End Outlets, Including Bands and Gasket / SEWER PIPE 45° SADDLE WYES — Hub End Outlets, Including Bands and Gasket

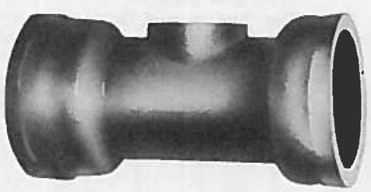
Saddles SIZE		PRICE	Sewer Pipe 45° Saddle Wyes SIZE		PRICE
Pipe Inches	Outlet Inches		Pipe Inches	Outlet Inches	
4	2	$ 4.50	6	4	$ 8.50
6	2	4.50	8	4	8.50
6	3	4.75	10	4	8.50
6	4	5.00	12	4	8.50
8	2	5.25	14	4	8.50
8	3	5.25	16	4	8.50
8	4	6.00	18	4	8.50
8	6	6.50	8	6	10.00
10	4	8.00	10	6	10.00
10	6	8.25	12	6	10.00
12	4 or 6	9.00	14	6	10.00
12	8	9.50	16	6	10.00
14	4 or 6	10.00	18	6	10.00
14	8	10.50	10	8	15.50
16	4 or 6	12.00	12	8	15.50
16	8	13.00			
18	4 or 6	13.00			
18	8	14.00			
20	6 or 8	15.00			
24	8 or 10	17.50			

THREADED OR FLANGED OUTLETS

Approximate additions to apply to all fittings, for each outlet of fitting tapped for standard screw pipe or furnished with standard flanges, F & D, instead of wood pipe hub end outlets.

Price List No. 17

Size Inches	THREADED	FLANGED	
	Price	Added Weight Pounds	Price
2	$1.25	20	$ 2.00
3	2.00	25	2.50
4	2.50	30	3.00
5	3.00	40	3.75
6	3.75	50	5.00
8	5.00	60	6.50
10	6.25	80	7.50
12	7.50	110	9.00
14	....	140	10.00
16	....	170	12.50
18	....	200	15.00



Tee with threaded outlet

Tee with flanged outlet

Wood Pipe to Threaded Steel Pipe Adapter

EXTRA COLLARS

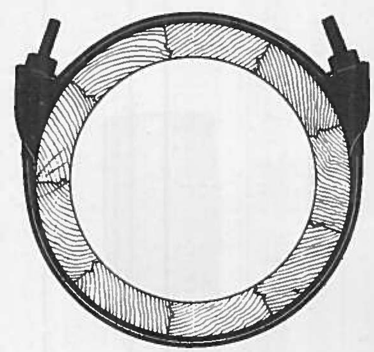
Standard creosoted wood collars for any size and head of pipe will be furnished at one and one-half times the price of one foot of pipe—for each collar—for the corresponding size and head of pipe. This applies to wire-wound collars for sizes up to 12″ pipe.

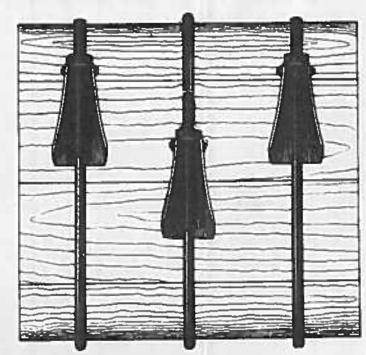
For creosoted staves only—per collar, and for individual bands for collars, use the following schedule of list prices:

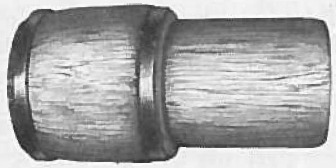
Price List No. 18

Size Pipe Inches	Staves Only Per Collar	Bands Per Each	Size Pipe Inches	Staves Only Per Collar	Bands Per Each
4	$0.21	3/8″ $0.35	14	$0.50	7/16″ $0.45
5	0.25	3/8″ 0.35	16	0.56	7/16″ 0.50
6	0.28	3/8″ 0.35	18	0.65	7/16″ 0.55
8	0.35	3/8″ 0.35	20	0.70	7/16″ 0.60
10	0.38	3/8″ 0.35	22	0.75	1/2″ 0.65
12	0.44	3/8″ 0.35	24	0.80	1/2″ 0.70

Prices on staves in above table based on 6″ lengths. For 8″ lengths add one-third to above prices.







FIR WOOD PLUGS
For Pipe and Fittings

Price List No. 20

Size	Price
2"	$0.50
3"	0.55
4"	0.60
5"	0.70
6"	1.00
8"	1.25
10"	1.50
12"	2.00
14"	3.00
16"	4.00
18"	5.00
20"	6.00
22"	7.00
24"	8.00

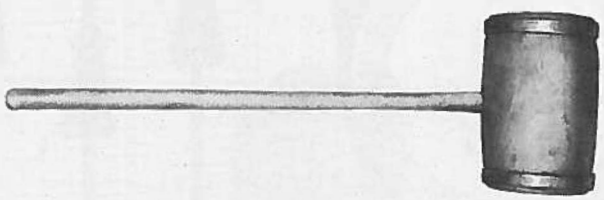
In ordering Wood Plugs, specify whether for pipe or fittings.

OAK DRIVING PLUGS
Completely Ironed

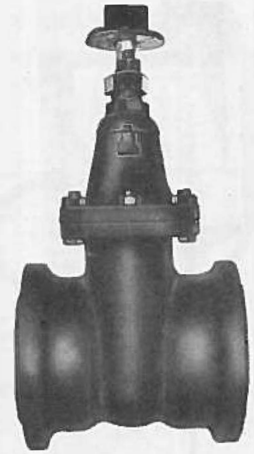
Price List No. 21

Size	Price
2"	$1.50
3"	1.75
4"	2.00
5"	2.25
6"	2.50
8"	3.00
10"	4.00
12"	5.00
14"	6.00
16"	7.00

In ordering Driving Plugs, specify whether for Inserted Joint or Collar Pipe.



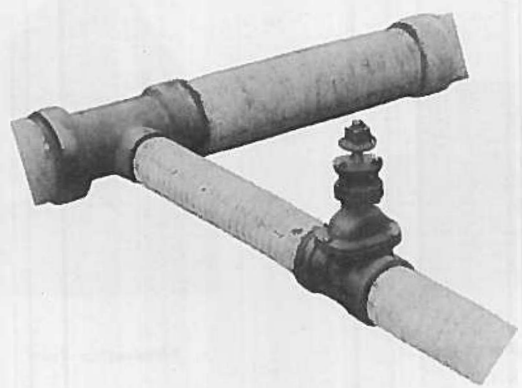
Wooden Mauls, completely ironed as illustrated, price, each $3.00

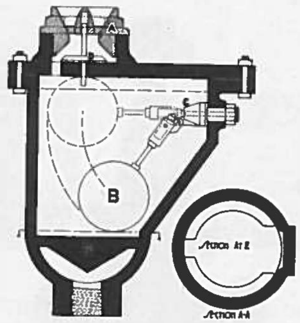


HUB END GATE VALVES
Iron Body, Bronze Mounted — 300-lb. Test

Price List No. 22

Size in Inches	Weight in Pounds	List Price
2	33	$ 12.55
3	67	17.15
4	75	18.15
5	110	25.30
6	150	30.25
8	225	46.70
10	320	77.90
12	440	102.00





Air Relief and Vacuum Valve

McCRACKEN COMBINED AIR RELIEF AND VACUUM VALVES

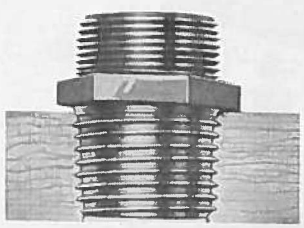
Price List No. 23

Size Inches	Weight Pounds	List Price
½	17	$17.50
¾	17	19.00
1	24	20.50
1½	36	23.50
2	46	25.50
3	66	39.50
4	100	60.50

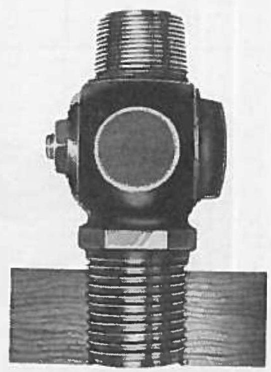
BRASS CONNECTIONS—Tapered Wood Thread to Standard Iron Thread

Price List No. 24

Size Inches	Tapping Nipples	Corporation Cocks
½	$0.55	$ 1.00
⅝	0.55	1.20
¾	0.60	1.50
1	0.75	2.50
1¼	1.30	5.50
1½	1.50	8.75
2	2.00	14.50



Tapping Nipple



Corporation Cock

FEDERAL DOUGLAS FIR WOOD TANKS

(Sizes most frequently used)

Price List No 25

2" Lumber

Approximate Capacity Gallons	DIMENSIONS		Weight in Pounds	List Price
	Outside Diam.	Outside Height		
500	5′-1″	4′	440	$ 32.00
800	6′	5′	645	43.00
1000	6′-6″	5′	730	50.00
1500	8′	5′	935	61.00
2000	8′	6′	1070	70.00
2500	8′	7′	1200	78.00
3000	9′	7′	1350	88.00
4000	9′	9′	1645	107.00
5000	10′	9′	1860	121.00
6000	12′	8′	2130	139.00
7000	12′	9′	2330	152.00
8000	12′	10′	2520	165.00
10000	13′-8″	10′	2965	195.00

3" Lumber

10000	13′-8″	10′	4740	274.00
12000	14′	12′	5620	323.00
15000	16′	12′	6600	378.00
20000	18′	12′	7810	453.00
25000	18′	14′	8920	523.00
30000	20′	14′	10210	598.00
40000	23′	14′	12370	730.00
50000	24′	16′	14810	886.00
60000	26′	16′	16520	990.00
75000	29′	16′	19290	1165.00
100000	30′	20′	24980	1546.00

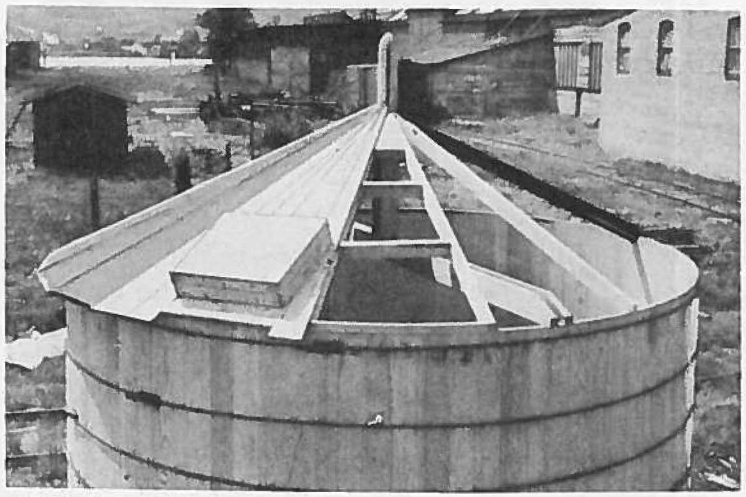
Above prices are for tanks knocked down. Material furnished consists of staves, tank bottom, and the required number of threaded round steel rods with lugs.

PLAIN CONICAL COVERS FOR WOOD TANKS

Price List No. 25a

DIAMETER OF TANK	WEIGHT IN POUNDS	PRICE
5′-1″	275	$19.00
6′	300	22.00
6′-6″	375	23.00
8′	450	29.50
9′	570	32.50
10	670	40.00
12	840	47.00
14	1200	61.50
16	1480	64.50
18	1850	85.50
20	2200	102.00
22	2460	112.00
24	3890	141.50
26	4175	155.00
28	4525	174.00
30	5315	203.00

The above prices apply for plain conical covers, knocked down. Material would consist of center post (or cross beams with stub post for small sizes), rafters and rafter plates, 1″ sheathing, and cedar shingles or prepared roofing paper. A square manhole frame, with door complete with hinges and hasp, would be included.



Conical Cover Showing Steps in Construction

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26

Out-side Diam. Feet	Out-side Height Feet	Cap-acity Cubic Feet	Approx. Capac-ity Gallons	Two-inch Stock		Three-inch Stock	
				Approx. Weight	List Price	Approx. Weight	List Price
5	2	26.7	200	285	$ 20.00	....	....
	3	44.1	330	355	24.00	....	....
	4	61.4	459	435	30.00	....	....
	5	78.8	589	520	35.00	....	....
	6	96.1	718	620	42.00	....	....
	7	113.4	847	700	47.00	....	....
	9	148.0	1106	870	59.00	....	....
6	2	39.3	294	360	25.00	....	....
	3	64.8	485	445	30.00	....	....
	4	90.3	675	545	36.00	875	$51.00
	5	115.8	866	645	43.00	1035	60.00
	6	141.4	1058	760	51.00	1205	70.00
	7	166.9	1248	860	57.00	1365	79.00
	8	192.4	1439	960	64.00	1520	89.00
	9	217.9	1630	1060	70.00	1680	98.00
	10	243.4	1820	1160	77.00	1840	107.00
7	3	89.6	670	565	37.00	....	....
	4	124.8	933	680	45.00	1080	63.00
	5	160.1	1196	795	53.00	1265	73.00
	6	195.3	1460	910	60.00	1420	84.00
	7	230.6	1725	1025	68.00	1635	94.00
	8	265.8	1987	1140	75.00	1815	105.00
	9	301.1	2251	1260	83.00	2000	116.00
	10	336.3	2515	1375	90.00	2185	126.00
8	3	118.3	884	670	44.00	....	....
	4	164.8	1233	805	53.00	1290	74.00
	5	211.4	1580	935	61.00	1495	86.00
	6	258.8	1935	1070	70.00	1705	98.00
	7	304.5	2278	1200	78.00	1915	110.00
	8	351.1	2625	1335	87.00	2125	122.00
	9	397.7	2975	1465	96.00	2335	135.00
	10	444.2	3320	1600	104.00	2545	147.00
	12	537.4	4015	1860	121.00	2960	171.00
	14	630.5	4760	2125	139.00	3380	195.00
	16	713.6	5360	2390	156.00	3795	219.00
9	3	151.0	1130	760	50.00	1220	70.00
	4	210.4	1575	905	59.00	1455	83.00
	5	269.9	2018	1055	69.00	1690	97.00
	6	329.3	2462	1200	78.00	1925	110.00
	7	389	2910	1350	88.00	2150	124.00
	8	448	3350	1500	98.00	2390	137.00
	9	508	3800	1645	107.00	2620	151.00
	10	567	4240	1795	117.00	2930	165.00
	12	686	5130	2090	136.00	3330	192.00
	14	805	6020	2385	156.00	3790	219.00
	16	924	6900	2680	175.00	4490	258.00
10	4	262	1960	1040	67.00	1670	95.00
	5	336	2510	1205	78.00	1930	110.00
	6	408	3050	1370	88.00	2190	125.00
	7	482	3600	1530	99.00	2450	141.00
	8	556	4160	1695	110.00	2710	156.00
	9	630	4710	1860	121.00	2970	171.00
	10	704	5260	2025	131.00	3230	186.00
	12	852	6370	2355	153.00	3750	216.00
	14	1000	7480	2680	174.00	4270	246.00
	16	1147	8570	....	....	4795	276.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Out-side Diam. Feet	Out-side Height Feet	Cap-acity Cubic Feet	Approx. Capac-ity Gallons	Two-inch Stock		Three-inch Stock	
				Approx. Weight	List Price	Approx. Weight	List Price
10	18	1295	9670	....	....	5330	$ 307.00
	20	1443	10760	....	....	5920	343.00
11	4	317	2370	1180	$76.00	1905	108.00
	5	407	3040	1360	88.00	2190	125.00
	6	497	3710	1540	99.00	2470	141.00
	7	587	4390	1720	111.00	2760	158.00
	8	677	5030	1900	123.00	3040	174.00
	9	767	5740	2080	135.00	3330	192.00
	10	857	6410	2260	146.00	3630	207.00
	12	1037	7760	2620	170.00	4190	240.00
	14	1217	9100	2980	193.00	4980	285.00
	16	1396	10430	....	....	5330	306.00
	18	1576	11780	....	....	5990	347.00
	20	1756	13130	....	....	6650	387.00
12	4	381	2850	1340	87.00	2150	123.00
	5	488	3650	1530	100.00	2470	141.00
	6	596	4450	1730	113.00	2780	160.00
	7	703	5260	1930	126.00	3100	178.00
	8	811	6060	2130	139.00	3410	196.00
	9	918	6860	2330	152.00	3720	214.00
	10	1026	7680	2520	165.00	4040	232.00
	12	1241	9280	2910	191.00	4660	269.00
	14	1456	10890	3320	217.00	5290	305.00
	16	1671	12500	....	....	5970	347.00
	18	1886	14100	....	....	6710	392.00
	20	2101	15700	....	....	7430	437.00
13	4	448	3350	1490	96.00	2410	138.00
	5	575	4300	1710	110.00	2750	157.00
	6	702	5260	1920	124.00	3090	177.00
	7	828	6190	2130	139.00	3430	197.00
	8	955	7140	2350	152.00	3770	216.00
	9	1082	8090	2560	167.00	4110	236.00
	10	1208	9040	2780	181.00	4440	255.00
	12	1462	10930	3200	209.00	5120	294.00
	14	1715	12820	....	....	5870	340.00
	16	1969	14700	....	....	6590	383.00
	18	2223	16600	....	....	7420	435.00
	20	2475	18500	....	....	8220	486.00
14	4	522	3900	1680	108.00	2700	154.00
	5	669	5000	1910	123.00	3060	175.00
	6	816	6100	2140	139.00	3430	196.00
	7	964	7200	2370	154.00	3790	217.00
	8	1011	8300	2600	169.00	4260	239.00
	9	1259	9400	2830	184.00	4520	259.00
	10	1406	10500	3060	199.00	4890	281.00
	12	1701	12700	3520	229.00	5620	323.00
	14	1996	14900	....	....	6450	374.00
	16	2291	17100	....	....	7260	423.00
	18	2585	19300	....	....	8170	481.00
	20	2880	21500	....	....	9040	536.00
15	4	561	4200	1850	119.00	3190	181.00
	5	726	5400	2080	135.00	3360	191.00
	6	892	6600	2330	150.00	3740	214.00
	7	1057	7900	2570	166.00	4130	236.00
	8	1222	9100	2820	182.00	4520	259.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Out-side Diam. Feet	Out-side Height Feet	Cap-acity Cubic Feet	Approx. Capac-ity Gallons	Two-inch Stock		Three-inch Stock	
				Approx. Weight	List Price	Approx. Weight	List Price
15	9	1387	10400	3060	$198.00	4900	$281.00
	10	1552	11600	3300	214.00	5290	303.00
	12	1882	14100	....	....	6070	348.00
	14	2213	16500	....	....	6970	403.00
	16	2543	19000	....	....	7960	467.00
	18	2873	21500	....	....	9050	532.00
	20	3203	24000	....	....	9750	578.00
16	4	642	4800	2020	130.00	3260	185.00
	5	820	6100	2280	147.00	3680	209.00
	6	1009	7500	2530	164.00	4090	233.00
	7	1198	9000	2800	181.00	4500	257.00
	8	1386	10400	3060	198.00	4910	281.00
	9	1575	11800	3320	215.00	5320	304.00
	10	1764	13200	3600	233.00	5760	330.00
	12	2151	16000	4120	267.00	6600	378.00
	14	2528	18500	....	....	7590	440.00
	16	2906	21900	....	....	8570	501.00
	18	3283	24500	....	....	9550	563.00
	20	3660	27300	....	....	10600	630.00
17	4	736	5500	....	....	3580	204.00
	5	952	7100	....	....	4020	229.00
	6	1169	8700	....	....	4460	255.00
	7	1385	10300	....	....	4900	280.00
	8	1601	12000	....	....	5340	306.00
	9	1818	13600	....	....	5780	332.00
	10	2034	15200	....	....	6240	359.00
	12	2467	18400	....	....	7200	416.00
	14	2900	21700	....	....	8240	482.00
	16	3333	24900	....	....	9310	549.00
	18	3766	27900	....	....	10440	622.00
	20	4200	31200	....	....	11560	695.00
18	4	827	6200	....	....	3900	222.00
	5	1071	8000	....	....	4360	249.00
	6	1314	9800	....	....	4830	275.00
	7	1558	11600	....	....	5290	302.00
	8	1801	13500	....	....	5770	339.00
	9	2044	15300	....	....	6230	356.00
	10	2288	17100	....	....	6720	385.00
	12	2773	20700	....	....	7810	453.00
	14	3260	24400	....	....	8920	523.00
	16	3747	28000	....	....	10040	593.00
	18	4233	32300	....	....	11240	671.00
	20	4720	36600	....	....	12430	748.00
19	4	924	6900	....	....	4230	240.00
	5	1196	8900	....	....	4720	268.00
	6	1467	11000	....	....	5210	297.00
	7	1739	13000	....	....	5700	325.00
	8	2011	15000	....	....	6190	353.00
	9	2282	17000	....	....	6710	384.00
	10	2554	19100	....	....	7230	413.00
	12	3098	23100	....	....	8350	484.00
	14	3641	27200	....	....	9520	557.00
	16	4184	31300	....	....	10780	638.00
	18	4728	35300	....	....	12030	718.00
	20	5272	39300	....	....	13370	806.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Outside Diam. Feet	Outside Height Feet	Capacity Cubic Feet	Approx. Capacity Gallons	Two-inch Stock Approx. Weight	Two-inch Stock List Price	Three-inch Stock Approx. Weight	Three-inch Stock List Price
20	4	1026	7700			4570	$ 259.00
	5	1328	10000			5090	289.00
	6	1629	12100			5600	319.00
	7	1931	14400			6120	348.00
	8	2233	16700			6640	378.00
	9	2531	18900			7180	410.00
	10	2836	21200			7730	443.00
	12	3440	25700			8960	519.00
	14	4043	30200			10210	598.00
	16	4646	34700			11530	686.00
	18	5250	39200			12850	767.00
	20	5853	43700			14240	859.00
21	4	1133	8500			4930	278.00
	5	1466	11000			5470	310.00
	6	1800	13500			6010	341.00
	7	2133	16000			6550	372.00
	8	2466	18400			7100	404.00
	9	2800	20900			7670	437.00
	10	3133	23400			8330	479.00
	12	3800	28400			9620	559.00
	14	4466	33400			10920	640.00
	16	5133	38400			12300	729.00
	18	5800	43400			13700	824.00
	20	6466	48300			15210	918.00
22	4	1246	9300			5290	299.00
	5	1612	12000			5860	332.00
	6	1979	14800			6430	364.00
	7	2345	17500			7000	397.00
	8	2712	20300			7620	436.00
	9	3078	23000			8220	470.00
	10	3444	25800			8820	506.00
	12	4177	31200			10200	592.00
	14	4910	36700			11480	682.00
	16	5643	42200			13080	776.00
	18	6376	47700			14650	878.00
	20	7109	52200			16220	982.00
23	4	1364	10200			5680	321.00
	5	1765	13200			6280	356.00
	6	2166	16200			6870	390.00
	7	2567	19200			7470	425.00
	8	2969	22200			8070	459.00
	9	3370	25200			8730	499.00
	10	3771	28200			9490	548.00
	12	4573	34200			10930	639.00
	14	5375	40200			12370	730.00
	16	6178	46200			13980	836.00
	18	6980	52200			15600	942.00
	20	7782	58200			17300	1056.00
24	4	1487	11100			6070	343.00
	5	1924	14400			6700	379.00
	6	2361	17600			7320	415.00
	7	2799	20900			7940	451.00
	8	3236	24200			8730	491.00
	9	3673	27600			9290	531.00
	10	4111	31400			10040	582.00
	12	4986	37300			11550	674.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Outside Diam. Feet	Outside Height Feet	Capacity Cubic Feet	Approx. Capacity Gallons	Two-inch Stock Approx. Weight	Two-inch Stock List Price	Three-inch Stock Approx. Weight	Three-inch Stock List Price
24	14	5861	43900			13130	$ 776.00
	16	6736	50200			14810	886.00
	18	7611	56900			16560	1004.00
	20	8485	63400			18360	1123.00
25	4	1616	12100			6480	365.00
	5	2091	15600			7130	402.00
	6	2567	19100			7770	440.00
	7	3042	22700			8420	477.00
	8	3517	26300			9140	521.00
	9	3992	29900			9820	561.00
	10	4468	33400			10610	610.00
	12	5418	40500			12370	716.00
	14	6369	47600			13920	823.00
	16	7319	54700			15660	937.00
	18	8270	61800			17500	1059.00
	20	9221	69000			19340	1183.00
26	4	1750	13100			6890	390.00
	5	2265	16900			7570	427.00
	6	2779	20800			8240	466.00
	7	3294	24600			8910	505.00
	8	3809	28500			9660	547.00
	9	4324	32300			10470	601.00
	10	4838	36200			11290	652.00
	12	5868	43900			12900	753.00
	14	6898	51600			14710	872.00
	16	7927	59200			16520	990.00
	18	8957	67000			18430	1116.00
	20	9986	74700			20440	1252.00
27	4	1889	14100			7320	411.00
	5	2445	18300			8020	452.00
	6	3001	22400			8720	492.00
	7	3557	26600			9420	532.00
	8	4112	30700			10200	580.00
	9	4668	34900			11130	632.00
	10	5224	39200			11880	685.00
	12	6335	47400			13650	798.00
	14	7447	55700			15550	921.00
	16	8558	64000			17400	1043.00
	18	9670	72300			19380	1174.00
	20	10781	80600			21560	1323.00
28	4	2034	15200			7770	437.00
	5	2632	19700			8500	479.00
	6	3231	24200			9220	521.00
	7	3829	28600			9990	567.00
	8	4427	33200			10880	623.00
	9	5026	37800			11760	679.00
	10	5624	42400			12640	733.00
	12	6820	51000			14490	853.00
	14	8017	60000			16350	973.00
	16	9214	69000			18420	1112.00
	18	10410	78000			20600	1249.00
	20	11607	87000			22780	1407.00
29	4	2184	16300			8210	462.00
	5	2827	21100			8960	509.00
	6	3469	25900			9710	548.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Outside Diam. Feet	Outside Height Feet	Capacity Cubic Feet	Approx. Capacity Gallons	Two-inch Stock		Three-inch Stock	
				Approx. Weight	List Price	Approx. Weight	List Price
29	7	4111	30700			10540	$ 598.00
	8	4754	35500			11410	652.00
	9	5396	41100			12320	710.00
	10	6039	45200			13220	766.00
	12	7324	54800			15130	889.00
	14	8608	64200			17160	1022.00
	16	9893	73800			19290	1165.00
	18	11178	83500			21530	1317.00
	20	12463	93100			23890	1479.00
30	4	2340	17500			8670	487.00
	5	3028	21600			9450	531.00
	6	3716	27800			10220	576.00
	7	4404	32900			11040	625.00
	8	5092	38000			12110	695.00
	9	5780	43200			12920	743.00
	10	6468	48300			13830	801.00
	12	7845	58600			15940	938.00
	14	9221	69000			18030	1075.00
	16	10597	79200			20230	1222.00
	18	11974	89600			22550	1379.00
	20	13350	100000			24980	1546.00
31	4	2500	18700			9150	513.00
	5	3236	24100			9950	559.00
	6	3971	29700			10750	606.00
	7	4707	35600			11720	667.00
	8	5442	40700			12560	716.00
	9	6178	46100			13650	788.00
	10	6913	51600			14610	848.00
	12	8384	62600			16650	978.00
	14	9855	73600			18900	1130.00
	16	11325	84700			21190	1281.00
	18	12796	95700			23690	1453.00
	20	14267	106700			26200	1624.00
32	4	2667	19900			9640	540.00
	5	3451	25800			10440	587.00
	6	4235	31600			11290	635.00
	7	5019	37500			12290	698.00
	8	5804	43400			13290	761.00
	9	6588	49300			14280	823.00
	10	7372	55100			15270	885.00
	12	8941	65900			17490	1030.00
	14	10409	77800			19830	1185.00
	16	12078	90100			22160	1339.00
	18	13646	101800			24740	1517.00
	20	15215	113700			27440	1704.00
33	4	2838	21200			10140	568.00
	5	3673	27400			10990	617.00
	6	4507	33600			11880	670.00
	7	5342	40000			12870	730.00
	8	6177	46200			13900	795.00
	9	7011	52400			14920	859.00
	10	7846	57600			16060	933.00
	12	9515	71200			18220	1071.00
	14	11185	83600			20630	1231.00
	16	12854	96000			23160	1401.00
	18	14524	107500			25810	1583.00
	20	16193	121200			28590	1775.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Outside Diam. Feet	Outside Height Feet	Capacity Cubic Feet	Approx. Capacity Gallons	Two-inch Stock		Three-inch Stock	
				Approx. Weight	List Price	Approx. Weight	List Price
34	4	3015	22500			10670	$ 598.00
	5	3901	29200			11550	648.00
	6	4788	35800			12470	703.00
	7	5675	42400			13490	767.00
	8	6561	49000			14570	834.00
	9	7448	55700			15710	912.00
	10	8335	62300			16830	979.00
	12	10108	75600			19180	1134.00
	14	11882	88400			21680	1301.00
	16	13655	102200			24320	1480.00
	18	15428	115400			27080	1670.00
	20	17202	128600			30100	1883.00
35	4	3197	23900			11190	626.00
	5	4137	30900			12090	679.00
	6	5077	38000			13190	748.00
	7	6017	45000			14100	800.00
	8	6958	52000			15200	869.00
	9	7898	59000			16420	949.00
	10	8838	66000			17500	1017.00
	12	10719	73000			20070	1189.00
	14	12599	81600			22640	1360.00
	16	14480	108200			25350	1543.00
	18	16360	122400			28320	1750.00
	20	18241	136500			31290	1956.00
36	4	3384	25300			11700	655.00
	5	4380	32800			12640	708.00
	6	5375	40200			13710	775.00
	7	6370	47700			14840	846.00
	8	7366	55100			15960	907.00
	9	8361	62500			17070	986.00
	10	9356	70100			18330	1068.00
	12	11347	85000			20830	1232.00
	14	13338	99900			23610	1419.00
	16	15329	114800			26380	1607.00
	18	17320	129700			29430	1820.00
	20	19310	144500			32610	2041.00
37	4	3577	26700			12270	686.00
	5	4629	34600			13230	741.00
	6	5681	42500			14340	810.00
	7	6733	50400			15490	882.00
	8	7785	57300			16640	954.00
	9	8838	65100			17780	1025.00
	10	9890	72900			19070	1110.00
	12	11994	89800			21780	1290.00
	14	14097	105500			24490	1470.00
	16	16201	122000			27470	1674.00
	18	18305	136800			30590	1891.00
	20	20410	153300			34000	2132.00
38	4	3775	28200			12840	717.00
	5	4886	36600			13820	774.00
	6	5996	44800			14950	844.00
	7	7106	53100			16140	918.00
	8	8217	61400			17320	992.00
	9	9327	69700			18770	1090.00
	10	10437	78000			19950	1164.00
	12	12658	89800			22580	1335.00

LIST PRICES FEDERAL STANDARD TANKS

Price List No. 26 (Continued)

Outside Diam. Feet	Outside Height Feet	Capacity Cubic Feet	Approx. Capacity Gallons	Two-inch Stock		Three-inch Stock	
				Approx. Weight	List Price	Approx. Weight	List Price
38	14	14879	111400	....	....	25500	$1532.00
	16	17100	127800	....	....	28560	1741.00
	18	19320	144500	....	....	31910	1975.00
	20	21541	161000	....	....	35250	2210.00
39	4	3979	29700	....	....	13420	750.00
	5	5149	38600	....	....	14430	809.00
	6	6319	47300	....	....	15600	881.00
	7	7489	56000	....	....	16820	956.00
	8	8660	64900	....	....	18040	1034.00
	9	9830	73700	....	....	19400	1124.00
	10	11000	82100	....	....	20770	1213.00
	12	13440	100500	....	....	23630	1405.00
	14	15781	117800	....	....	26660	1610.00
	16	18121	135400	....	....	29830	1828.00
	18	20162	153000	....	....	33300	2073.00
	20	22802	170500	....	....	36920	2330.00
40	4	4188	31300	....	....	14000	782.00
	5	5419	40500	....	....	15040	842.00
	6	6651	49600	....	....	16240	916.00
	7	7882	58900	....	....	17500	995.00
	8	9114	68200	....	....	18890	1087.00
	9	10346	77100	....	....	20140	1165.00
	10	11577	86800	....	....	21530	1254.00
	12	14041	105000	....	....	24470	1452.00
	14	16504	123400	....	....	27710	1675.00
	16	18967	141700	....	....	30960	1898.00
	18	21430	160300	....	....	34510	2147.00
	20	23894	178500	....	....	38210	2411.00

Staves and bottom planks for tanks made from 2″ stock would be finished 1⅝″ thick; those made from 3″ stock would be finished 2⅝″. The use of 2″ stock is ordinarily limited to tanks not larger than 14 feet diameter x 10 feet high. For certain purposes even smaller tanks should be made from heavier than 2″ stock.

Prices have been included for sizes up to 40′ outside diam. x 20′ stave length, made from 3″ stock. For some purposes, tanks of the largest diameters included in the above price list, and for moderate heights, may properly be made from 3″ stock. In general, however FEDERAL recommends that tanks larger than 35′ outside diam. x 20′ high should be made from not less than 4″ stock finished 3⅝″ thick. Prices for such tanks, in sizes up to about 60′ diam. x 30′ high, will be quoted on request.

U. S. GALLONS IN STANDARD DIMENSION WOOD STAVE TANKS FOR ONE FOOT IN DEPTH

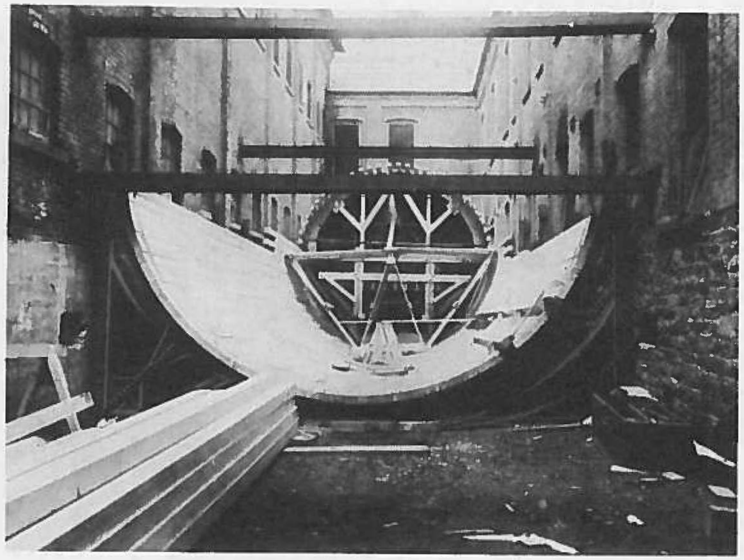
(2″ stock finished 1⅝″ and 3″ stock finished 2⅝″ thick)

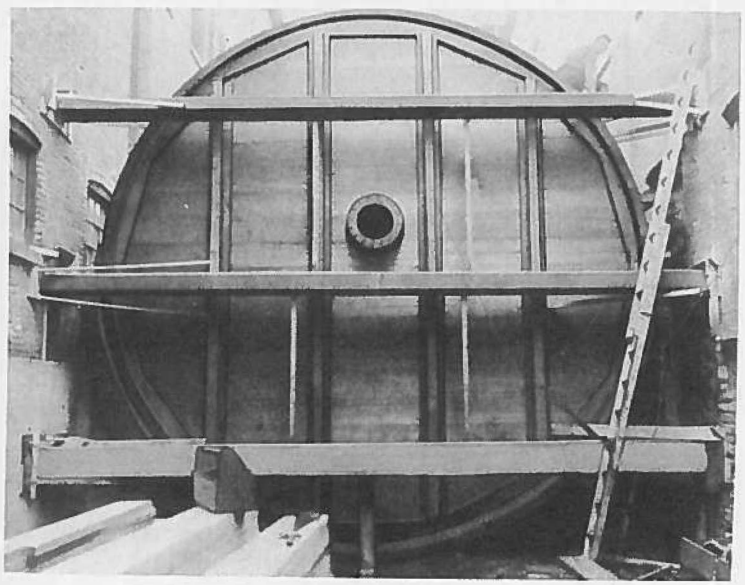
Table No. 47

Outside Diameter Feet	Thickness of Lumber Stock, Inches	Inside Diameter		Number U. S. Gallons	Cubic Feet and Area Square Feet
		Feet	Inches		
3	2	2	8¾	43.76	5.85
4	2	3	8¾	81.68	10.92
5	2	4	8¾	131.42	17.57
6	2	5	8¾	192.83	25.78
6	3	5	6¾	181.76	24.30
7	2	6	8¾	265.99	35.56
7	3	6	6¾	252.97	33.82
8	2	7	8¾	350.96	46.92
8	3	7	6¾	336.00	44.92
9	2	8	8¾	447.68	59.85
9	3	8	6¾	430.70	57.58
10	2	9	8¾	556.06	74.34
10	3	9	6¾	537.21	71.82
11	2	10	8¾	676.27	90.41
11	3	10	6¾	655.40	87.62
12	2	11	8¾	808.21	108.05
12	3	11	6¾	785.40	105.00
13	2	12	8¾	951.90	127.26
13	3	12	6¾	927.15	123.95
14	2	13	8¾	1107.3	148.04
14	3	13	6¾	1080.6	144.47
15	3	14	6¾	1245.9	166.56
16	3	15	6¾	1422.8	190.22
17	3	16	6¾	1611.6	215.45
18	3	17	6¾	1812.0	242.25
19	3	18	6¾	2024.2	270.62
20	3	19	6¾	2248.5	300.6
21	3	20	6¾	2484.1	332.1
22	3	21	6¾	2731.7	365.2
23	3	22	6¾	2990.5	399.8
24	3	23	6¾	3262.	436.1
25	3	24	6¾	3544.	473.8
26	3	25	6¾	3837.	513.
27	3	26	6¾	4144.	554.
28	3	27	6¾	4466.	597.
29	3	28	6¾	4795.	641.
30	3	29	6¾	5131.	686.
31	3	30	6¾	5490.	734.
32	3	31	6¾	5849.	782.
33	3	32	6¾	6564.	833.
34	3	33	6¾	6620.	885.
35	3	34	6¾	7016.	938.

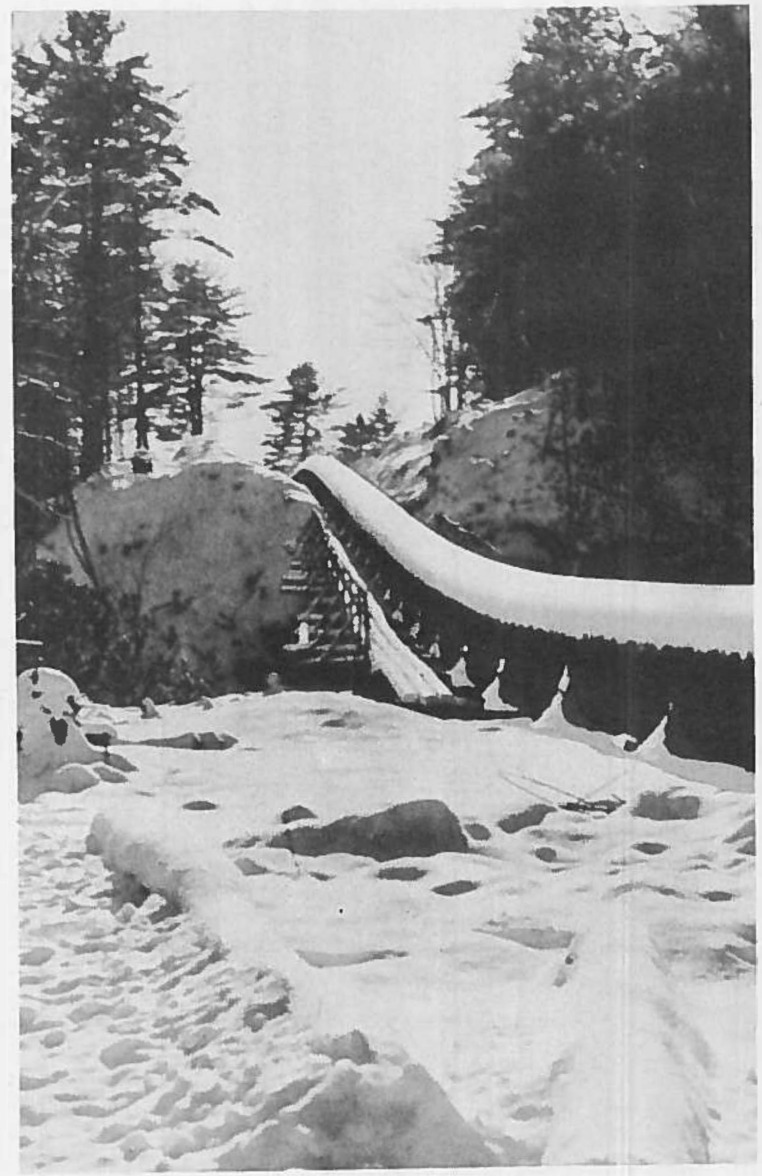
Deduct from outside height of tank in feet as follows to determine inside depth in feet.

Stock	Deduct in Feet
2″	0.51
3″	.64
4″	.84





Horizontal Tank under construction and nearing completion



Winter in upstate New York