Wrought-Pipe Drainage Systems

By J. J. Cosgrove

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J. J. COSGROVE

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"PRINCIPLES AND PRACTICE OF PLUMBING"
"SEWAGE PURIFICATION AND DISPOSAL"
"HISTORY OF SANITATION"
"PLUMBING PLANS AND SPECIFICATIONS"
"PLUMBING ESTIMATES AND CONTRACTS"
"DESIGN OF TURKISH BATHS"

Published by

Standard Sanitary Mfg. Co.

Pittsburgh, U. S. A.

PREFACE

THE subject of Wrought Pipe has long deserved a place in technical literature, and the present little volume is now offered to the public in the hope that it will fill that place and be found an invaluable aid to those who have the installing of iron pipe systems.

The work is much broader in its scope than the name would imply. A more descriptive title, perhaps, would have been "The Manipulation of Wrought Pipe", for the text is applicable to any system of piping whatsoever which is put together with screw threads. Outside of one chapter which deals entirely with the taking of measurements for wrought-pipe drainage systems, the text applies equally to the working of wrought pipe for heating systems, refrigerating systems, pipe lines, drive wells, power plants, or any other use to which iron pipe may be put. It follows, therefore, that the book would be equally valuable to workers in these several allied lines.

The volume was not intended solely for the use of helpers and apprentices. Of course, it should be among the very first books given a beginner to study; but it will be found, likewise, to contain much of value to the Journeyman, Superintendent, Contractor and Engineer.

J. J. COSGROVE.

Philadelphia, Pennsylvania,
December 15, 1909

PUBLISHER'S NOTE

THE primary object of our organization is, as is universally known, to manufacture and market "Standard" Plumbing Fixtures, Brass Goods and other products made in our factories. In the development of an organization to accomplish this result, there has been established an Advertising and Publishing Department of no small proportions, and "Wrought Pipe Drainage Systems" is the outgrowth of the work of this department. This brief statement will, we believe, serve to give the public a clear understanding of our somewhat unique position of being at the same time manufacturer and publisher.

The first serious work of the Publishing Department on a large scale was "Modern Sanitation" (established June, 1904). From this came the publication, first in serial form and later as a book, J. J. Cosgrove's first work, "Principles and Practice of Plumbing" (book published December, 1906). The phenomenal success of the book is a matter of general knowledge, although it may not be widely known that "Principles and Practice of Plumbing" has been adopted as a text book in more than thirty universities and colleges in the United States, and bids fair to be adopted in others. This achievement has been accomplished solely on the merit of the work and without solicitation on the part of either the author or publisher.

"History of Sanitation" (published February, 1909) and "Sewage Purification and Disposal" (published March, 1909) by the same author have in the short time in which they have been offered to the public, duplicated the success of "Principles and Practice of Plumbing" and both the author and publisher feel that "Wrought Pipe Drainage Systems" will be equally successful.

In "Wrought Pipe Drainage Systems", "Sewage Purification and Disposal", "History of Sanitation", and "Principles and Practice of Plumbing" we feel that the literature of the craft has been enriched in an enduring manner, and that we have justified our appearance in the field of publishers as amply as we have our standing as manufacturers of a world-wide known and used product.

Standard Sanitary Mfg. Co.

Publishing Department — Pittsburgh, U. S. A.

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INTRODUCTORY

HISTORICAL.—The wrought-pipe drainage system, formerly known as the Durham System of House Drainage, was first introduced in plumbing practice about the year 1880. In April of that year Caleb W. Durham, C. E., applied for letters patent on a system of house drainage that was independent of the support of the building and could not be affected by a settlement thereof. The most important feature of the Durham System of House Drainage was a recessed threaded fitting, which, when screwed on a pipe, presented at the joints a smooth, continuous inner surface without pocket or projection to impede the flow of sewage. This feature, the recessed drainage fitting, was the most important element in the patent, however, and as soon as the patent expired "Durham Fittings" were made by numerous manufacturers, who gave to them the name "Recessed Drainage Fittings."

Advantages of Wrought-Pipe Systems.—Wrought-pipe drainage systems did not immediately spring into general use. It was only upon the advent of steel-frame skyscraping buildings, when a stronger, more flexible system of piping was needed than could be had with cast-iron pipe, that wrought-pipe drainage systems were adopted. Among the many reasons why wrought pipe, with recessed drainage fittings, was considered better than cast-iron soil pipe, with lead-calked joints, for drainage systems in tall buildings, may be mentioned: greater strength and permanency of the joints, which are not affected by the alternate expansion and contraction of the lines; greater strength of the pipe and fittings; greater flexibility of the pipe and of the system as a whole; greater variety in the size of pipe and fittings, and a less number of joints.

Wrought-pipe drainage systems do not differ, in the principles of installation, from that of any other system of house drainage; it is only in the materials of which the system is constructed, and the manner in which the materials are handled and worked, that the systems differ.

Wrought-Iron and Steel Pipe.—At the present time the name wrought-iron pipe is a misnomer. Formerly all screw pipe was made of wrought iron, but recent improvements in the manufacture of soft Bessemer steel have so cheapened the cost of production that steel pipe has practically driven wrought-iron pipe from the markets. In the early stages of steel-pipe manufacture, chilling of the pipe after welding sometimes left hard spots in the steel that could be detected when cutting and threading the pipe; furthermore, imperfect welding sometimes caused a pipe to split for several feet along the weld when being threaded or screwed in place. Such progress has been made toward improving the temper and weld of pipe steel, however, that to-day wrought-iron pipe can scarcely be distinguished from steel pipe, so far as the cutting, threading and splitting is concerned; in appearance, however, the two materials differ. According to the April, 1906, number of *The Valve World*, published by the Crane Company, wrought-iron pipe can be distinguished from steel pipe by observing the following differences:

"Iron pipe is rough in appearance and the scale on it is heavy, whereas the scale on steel pipe is very light and has the appearance of small blisters or bubbles, underneath which the surface is smooth and somewhat white. Steel pipe seldom breaks when flattened, but if a fracture does occur it will be noticed that the grain is very fine. Iron pipe when subjected to the same flattening test breaks easily, and shows a coarse fracture, due to the long fiber of the material."

Tensile Strength of Wrought Pipe.—Wrought pipes are made much thicker and stronger than is necessary to withstand the internal pressures to which, under ordinary conditions, they are subjected. This additional thickness and strength is necessary to withstand the various stresses incident to cutting and threading pipes and screwing them in place, also the severe strains that pipe lines must withstand when subjected to alternate contraction and expansion.

The tensile strength of a pipe is the resistance it offers to the fiber of its metal being torn apart. Tensile strength of pipe varies with the material of which it is composed, and it would naturally follow that the material which possesses the greatest tensile strength, all other qualities being equal, would make the best pipe material. The tensile strength of soft steel, such as is used in the manufacture of pipe, is about 61,825 pounds per square inch, and the tensile strength of wrought iron is about 34,520 pounds per square inch. It follows, therefore, that for pipes of equal size and thicknesses, steel pipe will withstand a working pressure of almost double that of wrought-iron pipe, and, so far as the strength of the two materials is concerned, it is the better pipe material.

It might be inferred from the fact that steel pipe possesses almost double the tensile strength of wrought-iron pipe, that the walls of steel pipe could be made proportionately thinner, thus saving considerable in the material and weight of steel pipe. Other considerations, however, require that there be no appreciable difference between the thickness of walls of pipe made from the two metals; for instance, as steel pipe is about twice as strong as wrought-iron pipe, the loss from corrosion or other cause of a certain thickness from the walls of a steel pipe would weaken it almost twice as much as would the loss of an equal thickness from the walls of a wrought-iron pipe.

Strength of Seam in Wrought Pipe.—The tensile strength of a pipe metal cannot be taken as the actual strength of the pipe, for just as a chain is only as strong as its weakest link, so a pipe is only as strong as its weakest part, the seam. The strength of a welded seam varies with the amount of lap and the skill of the workman who makes the weld. In the case of wrought-iron pipe, the strength of the seam varies from 49 per cent. to 84 per cent., and will average about 70 per cent. of the tensile strength of the metal. On the other hand, the strength of the welded seams of steel pipe varies from about 50 per cent. to about 93 per cent., and will average about 72 per cent. of the tensile strength of the metal.

So far, then, as the ratio between the strength of seam and tensile strength of the metal is concerned, there is but slight difference between that of wrought iron and steel; it should be remembered, however, that the tensile strength of steel is almost double that of wrought iron, consequently the actual strength of a weld in steel pipe is about double that in a wrought-iron pipe. It may safely be assumed, therefore, that a certain size and weight of steel pipe possesses about twice the strength of an equal size and weight of wrought-iron pipe, and will sustain almost double the working pressure, besides withstanding almost double the torsional stresses without opening at the seam.

Torsional Strength of Wrought Pipe.—As would be expected from the greater tensile strength of steel and from the greater strength of a steel weld, steel pipe will withstand a much greater degree of torsional stress, without failing at the weld or being twisted off, than will equal weights and sizes of wrought-iron pipes.

Corrosion of Wrought Pipes.—The life of wrought pipe buried in earth is materially shortened by chemical action of the earth with which it comes in contact or by stray electric currents. For this reason wrought pipes are never used for the house drain in a building where the pipes must be buried in the soil, although they are sometimes used when the drains are run in underground pipe ducts. Certain kinds of soil are more energetic than others in attacking pipes. This is due to the chemical composition of the soil, which, if impregnated with sulphur, will corrode through the walls of wrought pipe in an incredibly short time.

Soil is not the only material around buildings which has a corrosive effect on wrought pipes. Coal and coal cinders, or ashes, are equally destructive, as also is concrete made from cinders and cement. All coal contains more or less sulphur in the form of sulphide of iron, or iron pyrites, and, if in the process of combustion all sulphur is not driven off from the coal, the portion that remains in the cinder might be sufficient in quantity to form a sulphuric or sulphurous acid, either of which will energetically attack and destroy wrought pipes. In the case of cast-iron pipe there is less damage from such source. In casting soil pipe, a thin silicious scale or film forms on the outside of the pipe and protects it from corrosion, unless the scale is removed by mechanical means or etched away by acid. It is due to this reason that cast-iron pipe is used for the underground portion of drainage systems which otherwise are made up of wrought pipes.

Some brands of cement which contain sulphate of lime are quite destructive to wrought pipes; fortunately, however, most cements are free from sulphates, and when such grades are used and mixed with sand and crushed stones or gravel the resulting concrete will not appreciably injure pipes embedded in it. Good practice, however, requires that pipes which are to be embedded in cement be coated thoroughly with a good preservative, and, where conditions permit, wrapping the pipes in tarred paper will add greatly to the life of the pipe.

So far as wrought iron and steel pipes are concerned, there is no appreciable difference between their length of life under similar conditions of exposure to corrosion, and one can be accepted as equally good as the other.

Galvanized Wrought Pipe.—Wrought pipe is galvanized by pickling it in a bath of acid, then immersing the pipe in a tank of molten zinc, or zinc and tin. When properly prepared, the pipe upon leaving the tank of molten metal is covered with a thin coating of the zinc, or zinc and tin, and this coating will protect the pipe from corrosion, sometimes prolonging its life several times that of ungalvanized-iron pipe. Galvanizing, however, will not protect pipe from pitting, due to electrolysis.

The process of galvanizing, while prolonging the life of the pipe by protecting it from corrosion, at the same time makes the pipe more brittle, so that a length of galvanized pipe will break under a strain which would not break an ungalvanized length of equal size and weight. If large galvanized pipes are to be bent to fit in their respective places in an installation, the better practice is to bend the pipes first and have them galvanized afterward. It will be found much easier to bend the pipe when plain, and, by galvanizing them afterward, no tool marks or bending marks will show on the galvanizing.

Galvanized pipe is the only kind of wrought pipe which is suitable for water supply. When plain wrought pipe is used for water-distributing mains, the iron dissolved by the water often imparts a peculiar disagreeable taste to the water, besides in many instances rendering the water unfit for industrial purposes, on account of the iron it contains.

Coating Wrought Pipes.—Wrought pipes for use in drainage systems are in many instances covered both inside and out with a coating of asphalt or pitch, applied hot. The manner of coating pipes in many respects is similar to the process of galvanizing. The pipes are first heated, then immersed in a vat of molten pitch or asphalt, which adheres to the walls and dries out, leaving a smooth surface. Coating pipes is beneficial in many ways:

it prolongs the life of the pipe by protecting it from contact with earth, air or sewage, and the smooth surface reduces the friction within the pipe.

Electrolysis of Wrought Pipes.—Electrolysis of wrought pipe is a pitting caused by stray electric currents flowing from the pipes to the surrounding earth. Electrolysis takes place only at the points where electric currents leave the pipes, not where they enter or pass along the line. Electrolysis always takes place on the outside of pipes, which is one way of distinguishing electrolysis from corrosion. There are no means of preventing electrolysis except by providing a suitable conductor from the point where the current escapes into the earth back to the dynamo where the electricity is generated. Where suitable return conductors are provided but little damage is caused by electrolysis, while, on the other hand, where the return conductors are inadequate much damage is done by the vagrant currents.

As wrought-iron and steel pipes are practically the same, they will be considered in this work, together with all other pipes of whatever metal or alloy which are put together with screw joints, as wrought pipes.

Butt Welded Pipe.—Small sizes of standard-weight wrought-iron and steel pipe, that is, pipe ranging in size from ⅛-inch to 3 inches in diameter, are made by butting the two edges of metal together, as shown in Fig. 1, and welding them in that position. This method of joining the edges is known as a *butt-weld* and is used only in the manufacture of pipes that are tested to a less pressure than 600 pounds per square inch. Butt-welded pipes, up to 2 inches in diameter, are tested to 600 pounds per square inch, and all other sizes are tested to 1,000 pounds per square inch.

Fig. 1
Butt-Weld Pipe

Lap-Welded Pipe.—All standard-weight wrought pipes 3 inches and more in diameter, and all heavy wrought pipes, are made by lapping one edge of the metal over the other, as shown in Fig. 2, and welding to a smooth cylindrical finish. This form of seam is known as a lap weld, and is used in the manufacture of large sizes of pipe, also for small pipes required for high pressure work where the pressure exceeds 1,000 pounds per square inch.

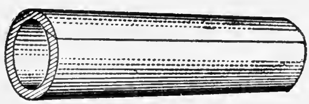

Fig. 2
Lap-Weld Pipe

It is commonly supposed that wrought pipes are sent from the mills without being tested, notwithstanding the fact that the manufacturers state that they test every length. That belief is entirely wrong, however. Each length of wrought pipe, before being shipped, is actually tested by water pressure, and if found defective in any part, the defective portion is cut out, the pipe rethreaded, and again tested before being passed by the inspector.

The process of pipe welding is very simple. In the butt-weld operation, the pipe metal which has been cut to size, is heated in a long furnace to a welding temperature throughout, and is then quickly drawn through a bell-shaped ring which bends the plate into cylindrical shape and forces the edges together thereby forming a weld. The pipe is next passed through suitable rollers to give it the right outside diameter and is then straightened, threaded and tested.

The lap-weld process consists of two operations, bending and welding. The plate is brought to a red heat in a suitable furnace, and then passed through a set of rolls which bevel the edges, that when overlapped and welded the seam will be neat and smooth. It then passes direct to the bending machine where it is bent roughly into shape with the two edges overlapping. The skelp is then heated in another furnace to welding temperature, taken out and passed through the welding rolls.

Weights and Dimensions of Wrought Pipe.— Most iron pipe used for drainage systems and for water supply are subjected to additional stresses besides those due to internal pressure. They sometimes sustain great crushing strains, due to weight of parts of the structure in which they are built, which, by slightly settling, press on all the branches connected with the system. To withstand all possible pressures and stresses to which they might be subjected, wrought pipes are made in three weights—standard, extra strong and double extra strong, only the first of which is

TABLE I

WEIGHTS AND DIMENSIONS OF STANDARD WROUGHT PIPE

Diameter			Thickness	Circumference		Transverse areas			Length of Pipe per sq. foot of		Length of pipe containing 1 cubic foot	Nominal weight per foot	Number of threads per inch of screw
Nominal internal	Actual external	Actual internal		External	Internal	External	Internal	Metal	External surface	Internal surface			
Inches	Inches	Inches	Inches	Inches	Inches	Sq. In.	Sq. In.	Sq. In.	Feet	Feet	Feet	Pounds	
1/8	.405	.27	.068	1.272	.848	.129	.0573	.0717	9.44	14.15	2513.	.241	27
1/4	.54	.364	.088	1.696	1.144	.229	.1041	.1249	7.075	10.49	1383.3	.42	18
3/8	.675	.494	.091	2.121	1.552	.358	.1917	.1663	5.657	7.73	751.2	.559	18
1/2	.84	.623	.109	2.637	1.957	.554	.3048	.2492	4.547	6.13	472.4	.837	14
3/4	1.05	.824	.113	3.299	2.589	.866	.5333	.3327	3.637	4.635	270.	1.115	14
1	1.315	1.048	.134	4.131	3.292	1.358	.8626	.4954	2.904	3.645	166.9	1.668	11 1/2
1 1/4	1.66	1.38	.14	5.215	4.335	2.164	1.496	.668	2.301	2.768	96.25	2.244	11 1/2
1 1/2	1.9	1.611	.145	5.969	5.061	2.835	2.038	.797	2.01	2.371	70.66	2.678	11 1/2
2	2.375	2.067	.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	3.609	11 1/2
2 1/2	2.875	2.468	.204	9.032	7.753	6.492	4.784	1.708	1.328	1.547	30.1	5.739	8
3	3.5	3.067	.217	10.996	9.636	9.621	7.388	2.243	1.091	1.245	19.5	7.536	8
3 1/2	4.	3.548	.226	12.566	11.146	12.566	9.887	2.679	.955	1.077	14.57	9.001	8
4	4.5	4.026	.237	14.137	12.648	15.904	12.73	3.174	.849	.949	11.31	10.665	8
4 1/2	5.	4.508	.246	15.708	14.162	19.635	15.961	3.674	.764	.848	9.02	12.49	8
5	5.563	5.045	.259	17.477	15.849	24.306	19.99	4.316	.687	.757	7.2	14.502	8
6	6.625	6.065	.28	20.813	19.054	34.472	28.888	5.584	.577	.63	4.98	18.762	8
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.501	.544	3.72	23.271	8
8	8.625	7.982	.322	27.096	25.076	58.426	50.04	8.386	.443	.478	2.88	28.177	8
9	9.625	8.937	.344	30.238	28.076	72.76	62.73	10.03	.397	.427	2.29	33.701	8
10	10.75	10.019	.366	33.772	31.477	90.763	78.829	11.924	.355	.382	1.82	40.065	8
11	11.75	11.	....	36.914	34.558	108.434	95.033	13.401	.325	.347	1.51	45.028	8
12	12.75	12.	....	40.055	37.7	127.677	113.098	14.579	.299	.319	1.27	48.985	8
13	14.	13.25	....	43.982	41.626	153.938	137.887	16.051	.273	.288	1.04	53.921	8
14	15.	14.25	....	47.124	44.768	176.715	159.485	17.23	.255	.268	.903	57.893	8
15	16.	15.43	....	50.26	48.48	201.06	187.04	14.02	.239	.248	.77	62.	8
16	17.	16.4	....	53.41	51.52	226.98	211.24	15.74	.225	.233	.68	......	8
17	18.	17.32	....	56.55	54.41	254.47	235.61	13.86	.212	.221	.61	......	8

TABLE II

WEIGHTS AND DIMENSIONS OF EXTRA STRONG WROUGHT PIPE

Nominal Inside Diameter	Actual Inside Diameter	Actual Outside Diameter	Thickness	Internal Circumference	External Circumference	Length of Pipe per Square Foot of Inside Surface	Length of Pipe per Square Foot of Outside Surface	Internal Area	External Area	Nominal Weight per Foot of Length
Inches	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Sq. Inches	Sq. Inches	Pounds
1/8	.20	.40	.10	.64	1.27	18.63	9.43	.03	.12	.29
1/4	.29	.54	.12	.92	1.69	12.98	7.07	.06	.22	.54
3/8	.42	.67	.12	1.32	2.12	9.07	5.65	.13	.35	.74
1/2	.54	.84	.14	1.70	2.63	7.04	4.54	.23	.55	1.09
3/4	.73	1.05	.15	2.31	3.29	5.10	3.63	.45	.86	1.53
1	.95	1.31	.18	2.98	4.13	4.01	2.90	.71	1.35	2.17
1¼	1.27	1.66	.19	3.99	5.21	3.00	2.30	1.27	2.16	3.00
1½	1.49	1.9	.20	4.69	5.96	2.55	2.01	1.75	2.83	3.63
2	1.93	2.37	.22	6.07	7.46	1.97	1.60	2.93	4.43	5.02
2½	2.31	2.87	.28	7.27	9.03	1.64	1.32	4.20	6.49	7.67
3	2.89	3.50	.30	9.08	10.99	1.32	1.	6.56	9.62	10.25
3½	3.35	4.00	.32	10.54	12.56	1.13	.95	8.85	12.56	12.47
4	3.81	4.50	.34	11.99	14.13	1.00	.84	11.44	15.90	14.97
4½	4.25	5.00	.35	13.35	15.71	.90	.76	14.18	19.63	17.60
5	4.81	5.56	.37	15.12	17.47	.79	.68	18.19	24.30	20.54
6	5.75	6.62	.43	18.06	20.81	.66	.57	25.93	34.47	28.58
7	6.62	7.62	.50	20.81	23.95	.58	.50	34.47	45.66	37.60
8	7.50	8.62	.56	23.56	27.10	.51	.44	44.13	58.42	47.85

commonly used for drainage systems, although in very tall buildings extra strong pipe is now frequently used. Wrought iron and steel pipes are made according to the same standards.

The sizes and dimensions of standard-weight wrought pipe can be found in Table I.

Extra Strong Wrought Pipe.—The outside dimensions of extra strong pipe are the same as for corresponding sizes of standard weight pipe. The outside dimensions of the several weights of each size of pipe are made the same sizes, so that stock fittings will fit all sizes of weights of pipe, and so one set of dies can thread the several weights of pipe. As the outside dimensions of standard and extra heavy pipes are the same, and the walls of the extra strong pipe are thicker, the bore of extra strong pipe is smaller, and this reduction in size should be taken into account when pipe of a certain diameter is required. Extra strong pipe is always shipped without threads or couplings, unless otherwise ordered. The weights and dimensions of extra strong wrought pipe can be found in Table II.

Double Extra Strong Wrought Pipe.—Double extra strong pipe, like extra strong pipe, differs from standard wrought pipe only in having thicker walls and a smaller bore. Double extra strong pipe is seldom used in drainage systems, but finds its most extensive application in high-pressure steam work, large hydraulic plants and refrigerator plants. Double extra strong pipe is shipped without threads or couplings, unless otherwise ordered.

TABLE III

WEIGHTS AND DIMENSIONS OF EXTRA STRONG WROUGHT PIPE

Nominal Inside Diameter	Actual Inside Diameter	Actual Outside Diameter	Thick-ness	Internal Circum-ference	External Circum-ference	Length of Pipe per Square Foot of Inside Surface	Length of Pipe per Square Foot of Outside Surface	Internal Area	External Area	Nominal Weight per Foot of Length
Inches	Inches	Inches	Inches	Inches	Inches	Feet	Feet	Sq. Inches	Sq. Inches	Pounds
3/8	.23	.67	.22	.73	2.12	15.69	5.65	.04	.36	.96
1/2	.24	.84	.29	.76	2.63	15.66	4.54	.04	.55	1.50
3/4	.42	1.05	.31	1.32	3.29	9.04	3.63	.13	.86	2.30
1	.58	1.31	.36	1.84	4.13	6.50	2.90	.27	1.35	3.40
1 1/4	.88	1.66	.38	2.78	5.21	4.31	2.30	.61	2.16	5.00
1 1/2	1.08	1.9	.40	3.41	5.96	3.51	2.01	.93	2.83	6.45
2	1.49	2.37	.44	4.68	7.46	2.56	1.60	1.74	4.43	9.48
2 1/2	1.75	2.87	.56	5.51	9.03	2.17	1.32	2.41	6.49	13.30
3	2.28	3.50	.60	7.17	10.99	1.67	1.09	4.09	9.62	17.70
3 1/2	2.71	4.00	.64	8.53	12.56	1.40	.95	5.79	12.56	22.00
4	3.13	4.50	.68	9.85	14.13	1.21	.84	7.72	15.90	24.70
4 1/2	3.56	5.00	.72	11.20	15.71	1.05	.76	9.96	19.64	32.45
5	4.06	5.56	.75	12.76	17.47	.94	.68	12.96	24.30	37.10
6	4.87	6.62	.87	15.31	20.81	.78	.57	18.66	34.47	50.10
7	6.06	7.62	.84	19.04	23.95	.62	.50	28.83	45.66	60.34
8	6.87	8.62	.87	21.60	27.10	.56	.44	37.12	58.43	71.52

The weights and dimensions of double extra strong pipe can be found in Table III.

Merchant and Full-Weight Wrought Pipes.—In addition to the classification of pipe as standard, extra strong and double extra strong, there is a distinction made among manufacturers and dealers between pipes which run within 5 per cent. of specified weights and those which fall below the 5 per cent. limit. Pipes which are within 5 per cent. of card weights are known as *full weight pipe*, while pipes that fall below the 5 per cent. limit are known as *merchant pipe*. There is no difference between the grades of material used for the different classes of pipe, and so far as the full weight and merchant pipes are concerned, they are subjected to the same tests and receive equal care and inspection as to welding and material. Merchant pipe is from 2 to 3 per cent. lighter than full weight pipe and for most uses is sufficiently strong. When, however, the maximum weight and strength is required, *full weight* pipe should be specified.

Wrought pipes are made in random lengths of from 12 to 20 feet, with 17 feet perhaps as a fair average. The smaller pipes, that is those from $\frac{1}{8}$ inch to 1 inch in diameter, are tied up in bundles for shipment, while larger sizes are shipped loose. Very large pipes have their threads protected during shipment by screwing half couplings on the ends.

CHAPTER II

WORKING WROUGHT PIPE

JOINTS FOR WROUGHT PIPE

CUTTING PIPE.—Small wrought pipes, ranging in size from $\frac{1}{8}$-inch to 4 inches in diameter, are usually cut on operations with a hand pipe-cutter. Pipes of larger size and sometimes small pipes of 2 inches in diameter and upward are cut with a cutting attachment to a pipe-threading machine. There are two principal types of hand pipe-cutters commonly used. They are respectively known as wheel-and-roller cutters, and three-wheel cutters. In the wheel-and-roller cutter, Fig. 3, the

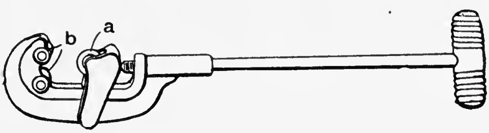

Fig. 3
Wheel-and-Roller Pipe Cutter

cutting is done by the cutting wheel, *a*, while the rollers, *b*, serve only to reduce the friction of the cutter on the pipe, and thus make the cutter more easy to operate. With this type of cutter, the wheel must be revolved completely around the pipe and the stem screwed down at each turn, until the pipe is cut off.

The three-wheel cutter, Fig. 4, differs from a wheel-and-roller cutter principally in having two cutting wheels, *a*, replace the two rollers in the wheel-and-roller cutter. This change reduces the friction of the cutter on the pipe, thereby making it easier to operate, makes less of a burr inside of the pipe, and permits a pipe being cut off by moving the handle backward and forward only about one-quarter turn. Each type of cutter has its own particular field of usefulness and is best suited for certain kinds of work. For general all-

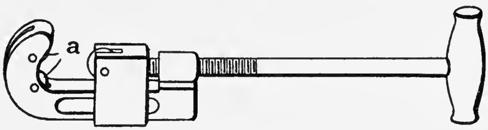

Fig. 4
Three-Wheel Pipe Cutter

around work at the bench, the wheel-and-roller type is best fitted. It is stronger, will wear longer and cut truer under the rough usage incident to such service. On the other hand, a three-wheel cutter is invaluable when cutting out a line of pipe, that already is in place, close to a wall or ceiling; owing to the limited swing the handle requires, it will have room to spare when cutting a pipe where a wheel-and-roller cutter could not be used. When operating a cutter, the wheel should be screwed gently down, the cutting wheel well oiled and the handle revolved. With proper usage a cutter will last for years and always cut true. However, most fitters and helpers screw down the wheel as tight as they conveniently can before revolving the handle. That is a bad practice. It not only breaks the cutter and strains the rollers so the cutting wheel will not run true, but it also forms a deep burr on the inside of the pipe, which, unless removed, partially chokes the pipe and considerably reduces its capacity.

Reaming Iron Pipe.—On all drainage work, the burr formed on the inside of a pipe by the process of cutting must be removed, or an imperfect junction at the joint will result. The rough edges presented by the burrs will catch and hold anything of a fibrous nature coming in contact with them, and in course of time the horizontal portions of pipe might become completely choked. The burr should also be removed from the pipes that are to be used for ventilation purposes or for water supply, otherwise larger sizes of pipes should be used to compensate for the loss of capacity due to the burrs. A convenient tool for reaming the ends of pipes is shown in Fig. 5. It is known as a skeleton reamer. By placing the left hand on the plate *a* and pressing the cutting end into the opening of a pipe, while working the ratchet handle back and forth with the right hand, the burr is quickly removed.

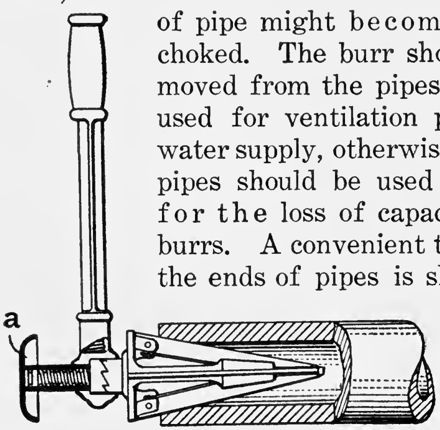

Fig. 5
Pipe Reamer

Standard Pipe Threads.—Wrought pipes are joined together by means of screw threads. The Briggs thread, which differs in coarseness according to the size of pipe, is the standard adopted by the pipe manufacturers' association, and is now generally cut on pipes and tapped in fittings. The number of threads per inch for any size of pipe can be found in the last column of Table I.

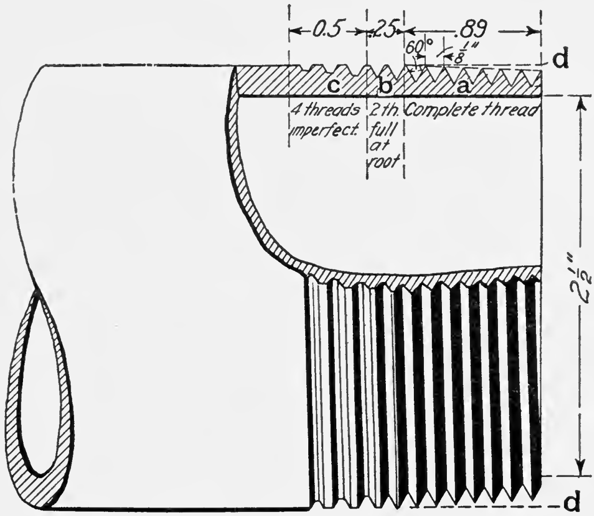

Fig. 6
Perfect 2½-inch thread

Screw threads are classified as male threads and female threads. Male threads are those which are cut on the outside of a pipe or fitting and screw into a corresponding thread inside of a coupling valve or fitting. Female threads are tapped on the inside of couplings, valves and fittings, and screw onto male threads. It takes both a male and a female thread to make a screw joint.

A perfect thread on 2½-inch pipe is shown, slightly reduced, in Fig. 6. The threads have angles of 60 degrees and are slightly rounded off at their tops and bottoms so that the height, or depth of thread, instead of being exactly equal to the pitch x cosine of 30 degrees (pitch x 0.866) is only four-fifths of it, or equal to 0.8 1/n if n. be the number of threads per inch. The screw has about six full or perfect threads, *a*, and two threads, *b*,

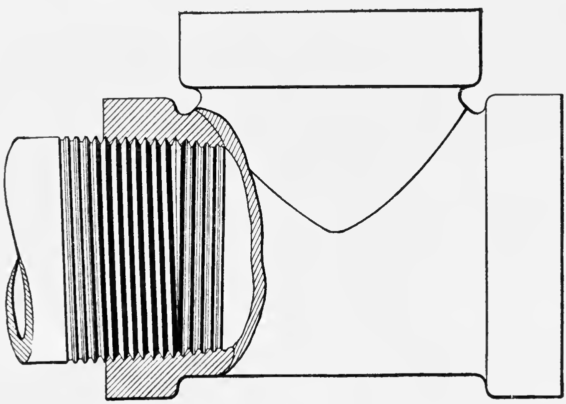

Fig. 7
Male and Female Threads United

that are full at the root, or bottom, but imperfect at the top. The balance of the threads, *c*, are not essential to the screw but are simply imperfections incidental to cutting the thread at a single operation. Pipe threads taper 1 inch in 32 inches to the axis of the tube, as shown by the way the threads pitch from the dotted lines, *d*, *d*, which are parrallel to the sides of the pipe; hence, when a thread is cut to the full depth at *a*, the top of threads, *c* are bound to be more or less flattened and imperfect.

Female threads in valves and fittings are tapped with the same degree of taper as male threads on pipe ends, but taper in the opposite direction, so that when a pipe thread is entered in a fitting the two threads fit together very loosely and are easily entered. As the fitting is screwed on, however, the threads tighten uniformly along the entire engaging surface until a perfectly tight metal-to-metal joint is secured. Such a joint is shown in Fig. 7.

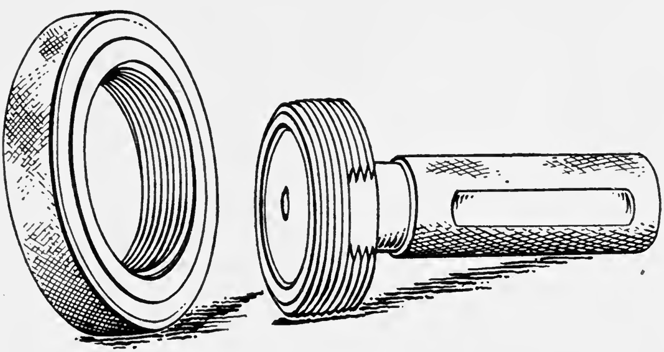

Fig. 8
Pipe Thread Gauges

Pipe Thread Gauges.—Although there is such a thing as a Standard Thread, namely Briggs, even amongst the large manufacturers there appears to be mighty little knowledge of what the standard sizes really are. It is a matter of common observation that fittings from different factories are tapped differently. Some are large and some are small, especially noticeable in the large sizes; and in making up work with either screwed fittings or flanges it is to a large extent necessary to cut and fit in order to make perfect joints to accurate measurements. Irregularity in the small sizes of nipples and malleable fittings for gas and water services is so common as to scarcely cause any comment. It will happen frequently that nipples will enter fittings only a turn or a half a turn. The manufacturer of the fitting will maintain that his tapping is standard, and the manufacturer of the nipple will declare with equal positiveness that his threading is to gauge. The only way for the contractor to satisfy himself on the point is to either measure and caliper the threads to pipe and fittings, or measure them by means of Briggs standard pipe thread gauges, as shown in Fig. 8. These gauges consist of a plug and a ring. On the plug a surface is ground which indicates the depth to which the plug should enter a fitting, to allow for screwing up with tongs to make a tight joint. When the plug is screwed into the ring, the top surface of the two are flush.

Flat Threads.—An imperfect thread, due to a slight flattening of the pipe at the weld, is sometimes cut on a pipe. While the aim should be to have perfect threads on all pipes, still threads need not be rejected on account of slight flatness or broken threads. The raised part of a male thread, which fits into the depressed part of a female thread, plays only a proportional part in making a joint tight. The raised part of the female thread which fits the depressed part of the male thread is the other factor in making a tight joint, and, unless the whole raised part of either a male or female thread is flattened or broken so that water can traverse the circumference of the pipe as many times as there are threads, the joint can be made perfectly water tight and will remain so under high pressure. Another cause of apprehension is the small V-shaped grooves that sometimes occur in threads, due to the weld not finishing perfectly smooth and circular outside. Such a defect in a thread is not necessarily serious, unless the groove is so deep that it extends below the bottom of the thread.

Cutting Pipe Threads.—Pipe threads are cut with dies which may be operated either by hand or by machine. Small sizes of pipe are usually cut with hand stocks, which may be fitted with solid

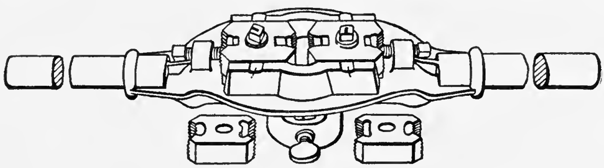

Fig. 9
Armstrong Stock and Dies

or with adjustable dies. Armstrong stocks with adjustable dies, Fig. 9, are more convenient and by far more accurate than block dies for general work. The dies may be adjusted to cut a shallow or a deep thread to fit the tapping of each lot of fittings, and the dies being firmly attached to the stocks permit no movement or shifting to cause the cutting of imperfect threads.

Supplemental Guides for Stocks.—The guides for all makes of stocks are sufficiently loose to easily slip over any weight of pipe, whether galvanized, plain or tar coated. Hence, when cutting standard pipe, particularly if the pipe is slightly under size, the guide is so loose that the resulting play usually produces a slightly crooked thread. This can be prevented by making supplemental guides of different weights of tin, as shown in Fig. 10, to take up the play between the regular stock guide and the pipe.

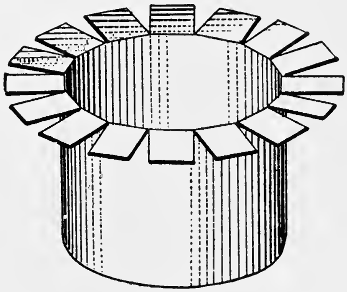

Fig. 10
Tin Brushing for Stock Guide

Cutting Threads to Fit Tappings.—Threads on pipes should be cut so that when screwed into fittings no portion of the threads will be exposed. This requirement is particularly important for galvanized pipes. When a thread is cut on galvanized pipe, the galvanizing is cut through and removed; this leaves an exposed spot, thinner than the average thickness of pipe, which, being bright, will more easily corrode; furthermore, in exposed work the installation looks better when the threads are concealed.

When threading pipe with adjustable dies, by properly setting the dies the threads can be cut so that when screwed into a fitting no portion of the thread will be exposed. With solid dies conditions are different; they cut a certain depth of thread, and cannot be adjusted to cut a deeper or a more shallow one. By the exercise of a little care, however, as deep and uniform threads can be cut with a solid die as with adjustable ones. This is accomplished by placing a piece of tin of the required thickness, as shown at *a*, Fig. 11, over one set of teeth in the die and then cutting a thread on the pipe; or the same result can be obtained by first cutting an ordinary thread on the pipe and then running the thread over with a die on which a piece of tin has been placed, as shown in the illustration. This method of cutting deep threads with solid dies is generally used by experienced fitters when working brass and nickel-plated pipe, so that no thread will be exposed when the fittings are made up.

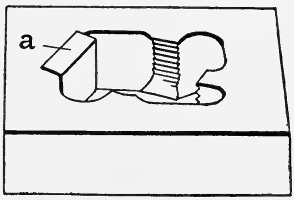

Fig. 11
Die Attachment for Cutting
Deep Threads

Right-Hand and Left-Hand Threads.—Pipe threads, either male or female, can be cut either right-handed or left-handed. Right-hand threads are the kind commonly used, and unless otherwise ordered are cut on the ends of stock pipe and tapped in stock fittings, while left-hand threads are unusual, being cut when wanted on the ends of pipes, and tapped in special stock couplings and elbows which are used for connecting together two pipes that come together from different directions. Fittings are screwed on right-hand threads by turning the fitting to the right. They are screwed on left-hand threads by turning the fittings to the left. The female threads in fittings must correspond with the male threads on pipes, or else they cannot be connected; for instance, a right-hand thread in a fitting will screw on a right-hand thread on a pipe, while a left-hand thread in a fitting is required to screw on a left-hand thread on a pipe. A right-hand thread in a fitting will not screw on a left-hand thread on a pipe. Nor will a left-hand thread in a fitting screw on a right-hand thread. Right and left hand couplings and elbows are not made in sizes larger than 2 inches, consequently left hand threads larger than 2 inches are not required on pipe ends. Right and left threads are not made for large sizes of pipe owing to the great frictional resistance encountered when two sets of threads are being screwed together at the same time. The resistance offered is largely due to the great amount of engaging surface in contact, and to slight crookedness of the threads which necessitates a certain "giving" of the pipes which are being screwed together. The resistance offered by a large right-and-left coupling when being made up calls for such large tongs or wrenches, and imposes such great torsional stresses on the pipe and coupling, that in practice large right-and-left connections have been found unsatisfactory, and some other form of coupling, either a union or flange joint, is used.

Cutting Crooked Threads.—As a rule, too great care cannot be exercised when threading iron pipe, to see that the threads are cut straight.

A deviation of but a slight fraction of an inch, when cutting a thread on a pipe several feet long, will cause a variation of the pipe from its alignment of from $\frac{1}{2}$-inch to 2 inches. There are conditions, however, under which crooked threads not only are permissible but are actually desirable. When a fitting is not tapped true, or when it faces a little off line, the pipe can be brought to a true alignment by cutting a crooked thread on the end of the pipe that screws into the fitting. To do this, it is only necessary to remove the guide from the stock and replace it with another guide from one to two sizes larger, according to the amount of crook wanted on the thread; then, while the thread is being cut, hold the stock so that the guide will press against one side of the pipe; this will cause the die to engage the pipe at a slight angle, as shown in Fig. 12. A crooked thread is shown in Fig. 13. By cutting a crooked thread on each end of a piece of pipe, each thread crooking in opposite direc-

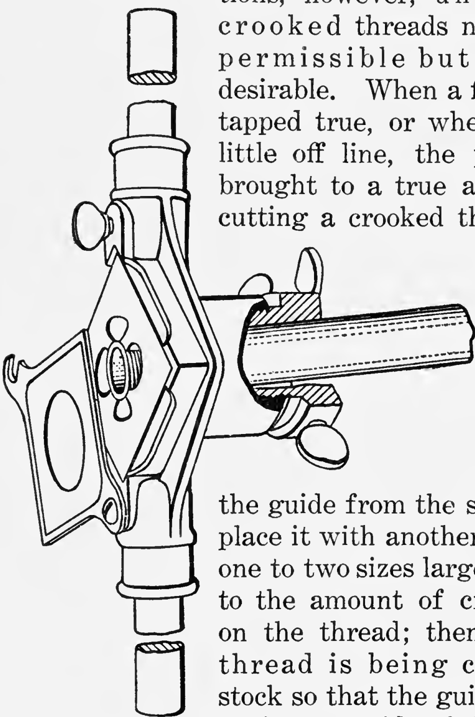

Fig. 12
Method of Cutting
Crooked Threads

tions, a slight offset can be effected, as shown in the illustration. A greater degree of crookedness is shown in this illustration than would be permissible in practice, as sufficient metal would not be

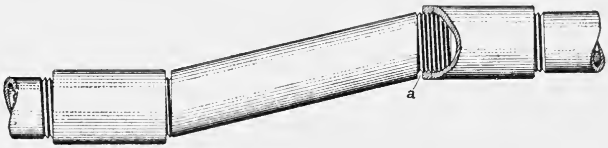

Fig. 13
Crooked Threads Forming Offset in Pipe

left at the point *a* to give the desired length of life to the pipe. The amount of crook in this case is exaggerated to make clear the meaning.

Cutting Nipples.—Nipples are short pieces of pipe from 1 inch to about 6 inches long, threaded on both ends. Small sizes of pipe, six inches and longer, can easily be held in a vise while being cut and threaded. With short nipples, however, it is different; a special devise called a nipple-chuck, Fig. 14, being required to hold them. An ordinary

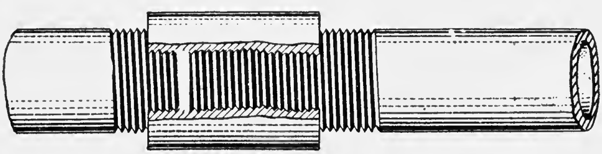

Fig. 14
Nipple Chuck

nipple-chuck is simply a short piece of iron pipe on which a running thread, that is, a screw thread three or more inches long, is cut; on this thread is screwed a coupling to within about $\frac{3}{8}$-inch of the end. The nipple to be threaded, on one end of which a thread has already been cut, is screwed into the coupling until the end of the nipple jams against the end of the pipe forming the nipple-chuck; that holds the nipple firmly in place while the thread is being cut. If the nipple is so short that the guide strikes the coupling before the die reaches the nipple, the guide should be removed and a larger size substituted that will slip over the coupling. If, however, the nipple is a close one, the guide can be placed on the nipple-chuck back of the coupling. After a nipple is threaded and the fitting screwed on, it can be removed from the chuck, by hand, after first loosening the coupling with a wrench.

CHAPTER III

PIPE CUTTING AND THREADING TOOLS

GENERAL Requirements of Fitters' Tools.—The importance, both to journeyman and contractor, of having plenty of the very best tools that money can buy or skill produce, cannot be overestimated, when it is considered that much time is wasted, on large operations, by not having a sufficient number of benches, vises, stocks, dies and cutters, or by having tools which are so worn, dulled or poorly designed and constructed, that men who use them cannot work to the best advantage; and that with poor or insufficient tools, from two to four times as much time is required to perform a certain piece of work as would be required with a sufficiency of good tools. On large operations where a number of workmen are employed installing iron pipe, it is a matter of economy to provide one bench and set of cutting and threading tools for each two journeymen.

The benches should be well made, strong, conveniently situated in a well-lighted place, and securely fastened to the floor or ceiling so they cannot be easily moved from their positions. It is better, where possible, to secure the benches to the floor, as this method of securing them gives a clear deck space to the benches. A very good bench that can be "knocked down" for shipment from place to place can be made by any fitter from iron pipe, with a few flanges and other fittings. A view of such a bench is shown in Fig. 15. The top of the bench should be made of hard pine, maple, oak or other firm wood, to withstand the rough usage

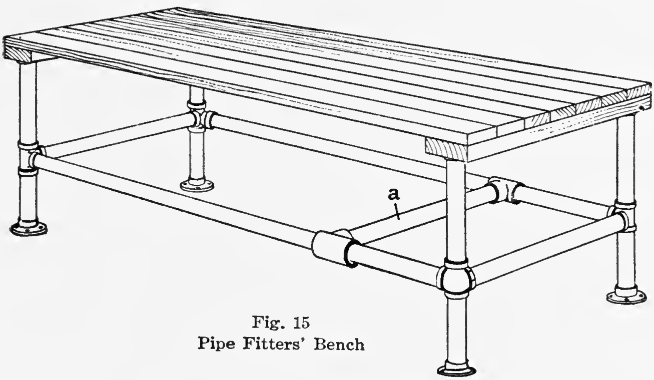

Fig. 15
Pipe Fitters' Bench

it will receive, and an adjustable bending bar, *a*, will be found a convenient attachment for bending small sizes of pipe, as well as forming a rest for holding stocks and dies when not in use. On the under side of the bench-boards, hooks may be screwed in to hold the dies and guides when not in the stocks; and, it might seem needless to remark, that the dies and guides should be wiped with cotton waste when removed from the stocks to keep them from becoming gummed with oil and dirt.

Pipe Vises.—For holding pipe at a bench, while cutting and threading, hinged vises, Fig. 16, will be found by far the most convenient and the quickest to operate. The jaws are renewable and can be replaced at any time they become damaged or they can be removed for sharpening and repairs. This type of vise is made in two sizes. The smaller takes pipes up to 3 inches in diameter, while the larger one, Fig. 17, will hold pipes from $2\frac{1}{2}$ to 8 inches in diameter.

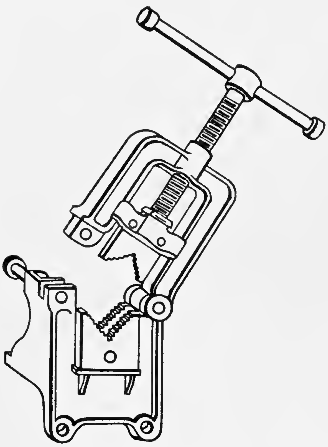

Fig. 16
Small Hinged Vise, Open

Forbes Pipe-Threading Machine.—A pipe-threading machine that is operated by hand power is shown in Fig. 18. This machine is provided with adjustable dies which may be so set as to cut a shallow or deep thread. The machine is light and portable, can be geared to run at different speeds,

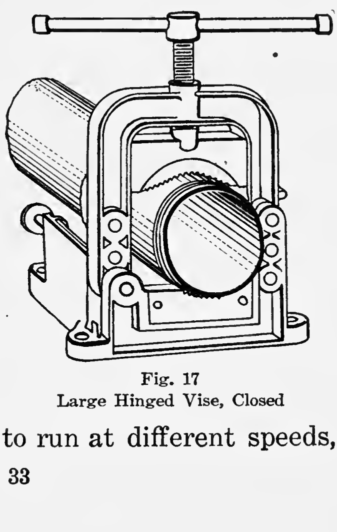

Fig. 17
Large Hinged Vise, Closed

and can be operated with such little power that with it one man can easily cut and thread a 4-inch pipe. Machines of this type can be had that will cut threads on pipes up to 10 inches in diameter. However, smaller sizes that cut threads up to 4 inches give the best service and are more extensively used than are the large sizes.

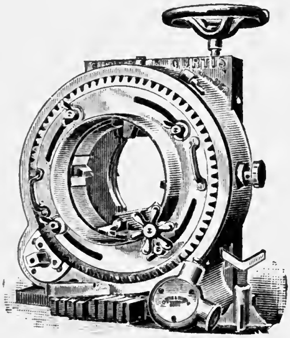

Fig. 18
Forbes Hand Pipe-Threading Machine

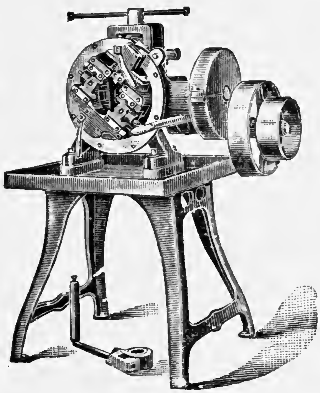

Fig. 19
Armstrong Hand Pipe-Threading Machine

Armstrong Pipe-Threading Machine.—An Armstrong pipe-threading machine, Fig. 19, can be run by hand or by power. It is built very strong and possesses sufficient strength to cut pipe many sizes larger than its rated capacity. It can be detached from its pedestal or stand and secured to a bench. Like the Forbes machine it has adjustable dies which permit any depth of thread being cut, and it is operated so easily that with it one man can cut threads on large sizes of pipe, 4 inches or more in diameter.

Both the Forbes and the Armstrong pipe-threading machines, as in fact are most of the large power pipe cutting and threading machines, are equipped with self centering vise jaws, so that a pipe, when gripped ready for threading will be in perfect alignment and automatically centered with the die.

Crane Pipe-Cutting and Threading Machine.—The Crane pipe-cutting and threading machine,

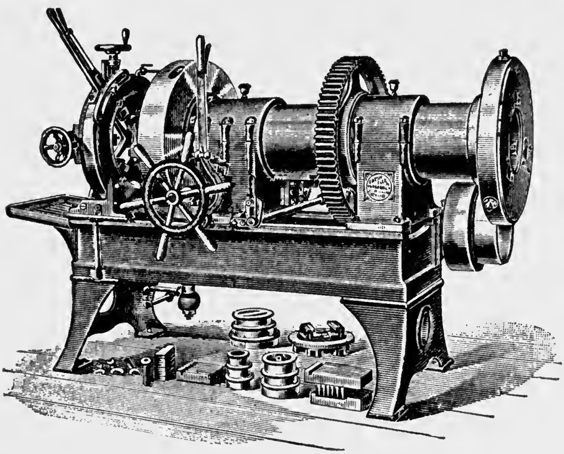

Fig. 20
Crane Power Pipe-Cutting Machine

Fig. 20, is designed for long and severe service in a shop. It is not portable nor can it be operated by hand. The machine is equipped with stationary die-head and sliding spindle, universal gripping chuck, with three steel jaws actuated by cams driven by a worm and segment, automatic oil pump and reversing countershaft. Machines of this type can be operated by any kind of power and are made in size to cut inclusively from 1-inch to 6-inch pipes, which is large enough for the average shop. Larger machines which will cut and thread pipes up to 18 inches in diameter may likewise be had. When a firm has a large quantity of pipe annually to cut and thread it pays to have a power cutting and threading machine in the shop and an Armstrong, Forbes or some equally good hand machine on a job. Power machines are fitted with cut-off attachments for cutting pipe.

The pipe-threading machines enumerated and described in the foregoing paragraphs are illustrated as types of different machines. There are other good machines on the market which give excellent service, among which may be mentioned the Duplex, Saunders, Bignall and Keeler, Borden and the Peerless.

A power threading and cutting machine is a piece of mechanism that requires reasonable care to produce good results. It is as much a machine as a lathe or planer, and an equally good machine hand should have charge of a pipe-threading machine that would be put in charge of a lathe or planer.

With a good man in charge of the machine, good results will be had with almost any good type of pipe-cutting and threading machine, for, after all, the results depend to a great extent on the condition in which the chasers are kept and in having them made with proper rake and relief in the first place. The particular machine used is a matter more of personal opinion; but no machine will cut clean threads unless due attention is paid to the chasers.

Pipe-Threading Dies.—The proper shape of die is now an important consideration, since steel pipe has supplanted wrought-iron pipe. Formerly, when wrought iron pipe was exclusively used, the dies were so shaped and held in the stocks that the cutting edge, *a*, Fig. 21, engaged the tube on the center axis and parrallel to the diameter. This

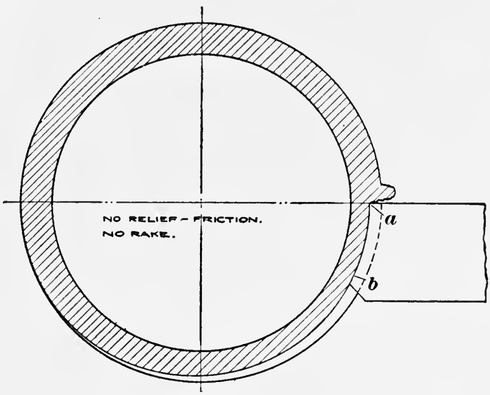

Fig. 21
Old Form of Chaser

shape of die had no relief at *b*, no rake, and scraped the metal away instead of cutting it when forming a thread; nevertheless, the dies were found satisfactory for the purpose, for wrought iron is comparatively weak and so broken up with interspersed cinder that it is readily scraped out by such a tool. Bessemer steel, of the quality best adapted for pipe, however, is tougher and stronger than wrought iron and cannot be cut so easily; hence the necessity for special dies for cutting steel pipes. It may be remarked, in passing, that while dies suitable for cutting wrought-iron pipe are not satisfactory for cutting steel pipe, dies which will cut steel pipe are equally satisfactory for cutting wrought-iron pipe.

For cutting threads on steel pipe, the cutting point of the die must have sufficient front rake, and

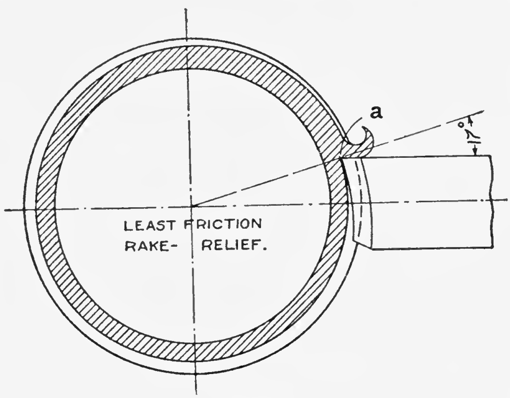

Fig. 22
Correct Form of Chaser

relief, to cut the metal out with a clean finish without waste of power, or unnecessary friction, similar to the working of a lathe tool. This can be accomplished by advancing the cutting edge of the die about 17 degrees beyond the centre axis, or diameter, of the pipe, as shown at *a* in Fig. 22. The cutting edge will then form an acute angle that will cut and not scrape the metal from the pipe when a thread is being formed. The same end may be obtained by grinding ordinary dies that are set on the center axis so the cutting edges, *a*, will have a rake of about 17 degrees, as shown in Fig. 23. The latter method is the simpler

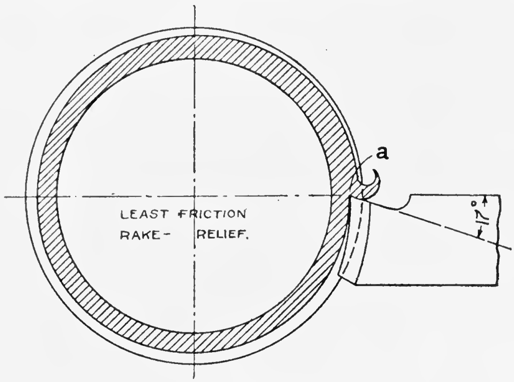

Fig. 23
Correct Form of Chaser

and less expensive one, and any workman that has access to an emery or carborundum wheel can, in a few minutes, change ordinary dies into steel-

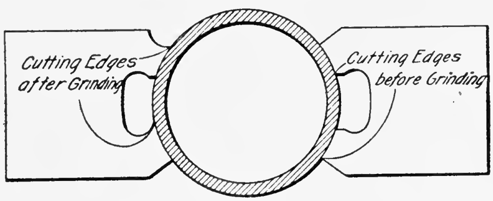

Fig. 24
Armstrong Dies, before and after grinding to correct form

cutting dies without drawing the temper. Armstrong dies can be converted into steel pipe-cutting dies by grinding them to the shape shown in Fig. 24.

In addition to possessing sufficient rake, a die should possess sufficient clearance so that chips of iron or steel from the pipe cannot interfere and clog the chaser, thus causing it to tear the thread. That is, the teeth should bear on the pipe only at the cutting edge, as shown at *a* in Fig. 25, and should be free from the pipe, as shown at *b*, so as to reduce the friction and prevent the tearing of threads by chips.

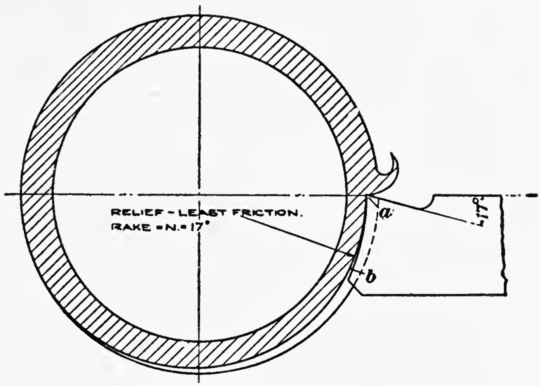

Fig. 25
Chaser Showing Clearance

As tensile strength of a metal is the resistance it offers to its fibres being torn apart, it follows as a natural consequence that steel pipe, which is the stronger and tougher of the two, is harder to thread than is wrought-iron pipe, which, having from 2 to 3 per cent. of cinder intermixed, is so weakened that no difficulty is experienced in scraping out a thread with the form of die commonly used in practice.

The force required to thread steel pipe, with the dies commonly used, is approximately 20 per cent. greater than the force required to thread equal sizes of wrought-iron pipe. For instance, to cut a thread with an ordinary die on a 1¼-inch wrought-iron pipe requires a pull of from 83 to 87 pounds on a stock arm 21 inches long, and to cut a thread on 1¼-inch steel pipe with a similar die requires a pull of from 100 to 111 pounds on a stock arm 21 inches long.

Under ordinary conditions, then, as they obtain in practice, it can be assumed that to thread steel pipe requires an expenditure of 20 per cent. more energy than is required to cut and thread wrought-iron pipe. This waste of energy, however, can be reduced to an amount too small to be considered by using dies of proper design.

The best angle of shear for a die used for threading wrought-iron pipe is 12 degrees; for threading steel pipe, 20 degrees; and for threading either wrought-iron or steel pipe, 17 degrees. With dies of 17 degrees shear, 1¼-inch wrought-iron pipe can be cut by exerting a pull of from 58 to 62 pounds on a stock handle 21 inches long, while with common dies a pull of 83 to 97 pounds would be required.

The saving of energy when threading steel pipe with dies of approved rake and clearance is even greater than the saving of energy when threading wrought-iron pipe with dies of proper rake and clearance. For instance, 1¼-inch steel pipe can be threaded with properly shaped dies by exerting a pull of from 60 to 65 pounds on a 21-

inch die stock, while a pull of from 100 to 111 pounds would be required to thread the same pipe with an ordinary die. It will be observed that a pull of only 2 pounds more is required to thread 1¼-inch steel pipe than is required to thread an equal size of wrought-iron pipe with approved dies and that 1¼-inch steel pipe can be threaded with approved dies with an expenditure of 23 pounds less energy than is required to thread wrought-iron pipe with ordinary dies.

The greater force required to thread pipes with ordinary dies is due entirely to friction caused by the rubbing of the non-cutting part of the chaser, and to the lack of clearance for chips which become wedged between the pipe thread and the chaser, thus adding to the resistance.

Nye Pipe-Threading Dies.—In the Nye dies clearance for chips is provided in a novel manner.

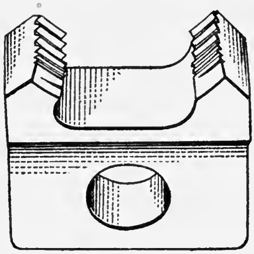

Fig. 26

By referring to illustration, Fig. 26, it will be seen that there is a full set of leading threads, back of which every other tooth is removed from the die, thus leaving a double space between to reduce the friction, provide clearance for chips and room for oil. In addition to the clearance provided by removing every other tooth further clearance is provided and the amount of friction is still further reduced by making the dies so that the teeth bear on the pipe only at their cutting edges, *a,* illustration Fig. 27. Clearance is shown at *b.*

Nye dies are further made according to correct principles by having the chasers so set that the teeth cut on a tangent, thus making a shearing cut instead of scraping out the metal. On account of this latter method of construction Nye dies are particularly suitable for threading steel pipe.

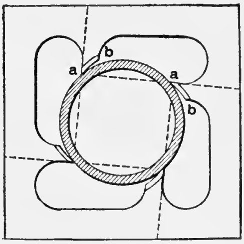

Fig. 27

Pipe of various sizes can be cut with Nye dies with an expenditure of much less force than is required to cut equal sizes of pipe with ordinary dies. Nye dies are made for Armstrong stocks, also for solid block stocks.

Oil for Thread-Cutting.—When cutting or threading pipes, oil must be freely used on the dies or cutter. The oil lubricates the teeth of dies, keeps them cool and seems to make the thread cut with a smoother finish. Economy in the purchase and use of oil is poor economy. The very best of oil should be used and in liberal quantities. When cutting and threading pipe with hand stocks the oil used is lost, but with machines, provision is made to catch the oil and use it over again.

The best oil to use for cutting and threading pipe is lard oil; next to lard oil comes cottonseed oil. When working in an exposed place in cold weather, provision must be made to warm lard oil, which congeals at a comparatively high temperature, and will not then flow.

Care should be exercised by the fitter not to oil the end of a pipe before the die is well started so it cannot strip. For some reason, it seems much easier to start a thread when the pipe is free of oil than it is when the pipe is oily.

Length of Pipe Threads.—The mistake is often made by fitters of cutting exceptionally long threads on the ends of pipes under the impression that the longer the threads the tighter will be the joints. This does not necessarily follow, however, for when long threads are cut they are harder to make up, and when once made up, part of the thread is useless, serving neither to strengthen the joint nor to make it tight. The reason for this is that long threads produce more friction than short ones when being screwed up, which heats the parts so they do not make up well together, and the irregularity of the surfaces of a number of threads in contact prevent the parts adjusting themselves to each other. Further, that portion of a pipe thread which extends through the die plate possesses no taper and when screwed into an ordinary fitting is more than likely to extend beyond the threaded portion into the interior where it does no good. If used with recessed drainage fittings, on the other hand, the straight threads on the end of a pipe will prevent the taper threads further back from coming into use, and the result is very likely to be a leaky joint. There is a right proportion for pipe threads as well as for every thing else, and these proportions may be found in Table IV.

TABLE IV

LENGTH OF PERFECT PIPE THREADS

Nominal Inside Diameter of Pipe Inches	Actual Inside Diameter of Pipe Inches	Actual Outside Diameter of Pipe Inches	Thickness of Pipe Inches	Number of Threads Per Inch	Length of Perfect Thread Inches	Number of Perfect Threads	Diameter of Thread at End of Pipe	
							Outside Inches	At Bottom of Thread Inches
1/8	.270	.405	.068	27	.19	5.13	.393	.342
1/4	.364	.540	.088	18	.29	5.22	.522	.445
3/8	.494	.675	.091	18	.30	5.40	.656	.579
1/2	.623	.840	.109	14	.39	5.46	.816	.717
3/4	.824	1.050	.113	14	.40	5.60	1.025	.926
1	1.048	1.315	.134	11 1/2	.51	5.87	1.283	1.162
1 1/4	1.380	1.660	.140	11 1/2	.54	6.21	1.626	1.505
1 1/2	1.610	1.900	.145	11 1/2	.55	6.33	1.866	1.745
2	2.067	2.375	.154	11 1/2	.58	6.67	2.339	2.218
2 1/2	2.468	2.875	.204	8	.89	7.12	2.819	2.646
3	3.067	3.500	.216	8	.95	7.60	3.441	3.268
3 1/2	3.548	4.000	.226	8	1.00	8.00	3.938	3.765
4	4.026	4.500	.237	8	1.05	8.40	4.434	4.261
4 1/2	4.508	5.000	.246	8	1.10	8.80	4.931	4.758
5	5.045	5.563	.259	8	1.16	9.28	5.491	5.318
6	6.065	6.625	.280	8	1.26	10.08	6.546	6.373
7	7.023	7.625	.301	8	1.36	10.88	7.540	7.367
8	7.982	8.625	.322	8	1.46	11.68	8.534	8.361
9	9.000	9.625	.342	8	1.57	12.56	9.527	9.354
10	10.019	10.750	.366	8	1.68	13.44	10.645	10.472

A careful examination of the table will show that the number of threads for pipe less than 2 inches in diameter, will average about six. This of course, refers to the perfect taper threads. In addition to the perfect threads, it will be remembered that there are a number of imperfect or leading threads which, while they might help some to make a strong joint, play but a very unimportant part in making the joint tight.

When cutting threads on pipe, all that is necessary is to run the die up on the pipe until the end projects about 1-16 inch through the die plate. Dies for the various sizes of pipe are so proportioned in thickness, that when the pipe projects through the die plate a perfect thread of the desired number of turns will be formed, and any further threading of the pipe will cut only a straight intapered thread.

A better idea of the length of threads can be gained, perhaps, by an examination of the column headed "Length of Perfect Thread in Inches". It will be seen by reference to the column that the length of perfect thread on 2 inch pipe is but little over one-half inch, while the lengths gradually decrease with the sizes of pipes so that on $\frac{1}{8}$ inch-pipe the perfect thread is only .19 inch in length.

CHAPTER IV

WROUGHT-PIPE FITTINGS

VENTILATION FITTINGS

TYPES OF FITTINGS.—Ordinary cast-iron or malleable-iron steam or water fittings are generally used for ventilation purposes. These fittings are made to stand a working pressure of 150 pounds per square inch, and will withstand a pressure of from 1,600 to 2,500 pounds per square

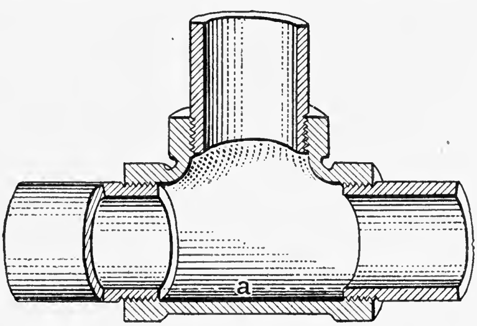

Fig. 28
Section Through Ordinary Pipe Fitting

inch. Steam and water fittings, Fig. 28, are made with enlarged bodies which form pockets, the thickness of the pipe, at *a*. These pockets increase the friction of fluids flowing through the fittings and would serve as numerous cesspools for the retention of sewage if used on drainage pipes. For these reasons they are permitted only in the vent system. Pipe fittings are made plain, beaded and in heavy pattern for steam and water piping. The plain and beaded fit-

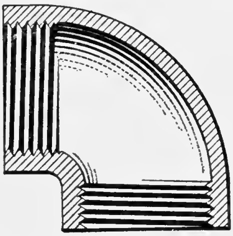

Fig. 29
Section Through Plain Fitting

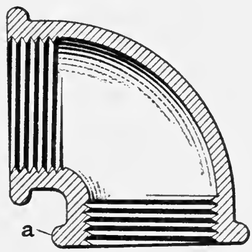

Fig. 30
Section Through Beaded Fitting

tings are made of malleable iron and the heavy steam fittings are made of cast iron.

Plain fittings are suitable only for pipes subjected to light pressure. The metal of the fittings, as may be seen in the illustration, Fig. 29, is approximately the same thickness throughout the entire cross section.

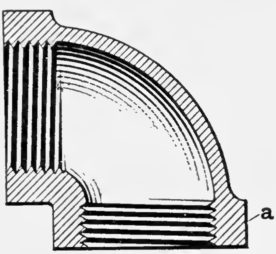

Fig. 31
Section Through Cast-Iron Fitting

Beaded fittings, Fig. 30, on the other hand, have a reinforced bead of metal, *a*, around the outlets to strengthen the fittings so they will not be easily split when pipes are being screwed into place or when subjected to other stresses. Cast-iron fittings, Fig. 31, have a reinforcing ring, *a*, around each outlet, which gives them sufficient strength to withstand any ordinary pressure to which they are subjected.

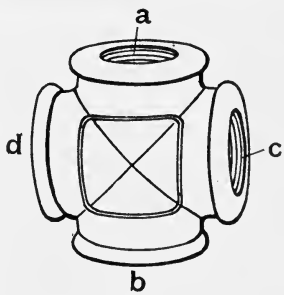

Fig. 32
Cross Fitting

Types of the several fittings generally used in vent systems are shown in the following illustrations. The fitting, Fig. 32, is a cross, and may be had with all the outlets one size or with the different outlets reduced to whatever size desired. Fittings with only one size of outlet are known as straight fittings, while those with different sizes of outlets are known as reducing fittings.

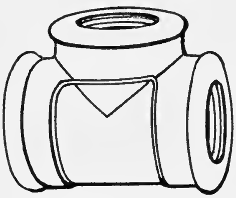
Fig. 33
Tee Fitting

A T fitting is shown in Fig. 33. This fitting, like the cross, can be had with various sizes of outlets, or with the outlets all one size. The fitting shown in Fig. 34 is a 90-degree bend, generally called an elbow. It may be had straight or reducing. The 45-degree bend, Fig. 35, is not made reducing but only with uniform size of outlets. A right-and-left coupling is shown in Fig. 36. It can be distinguished from an ordinary pipe-coupling by the ribs

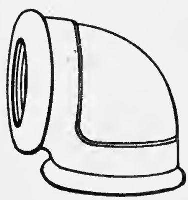
Fig. 34
Elbow

which run along its side. Right-and-left couplings are tapped with taper threads, the same as other fittings, and ordinary pipe couplings such as come with all lengths of pipe, are tapped with straight threads without taper. Special right hand coup-

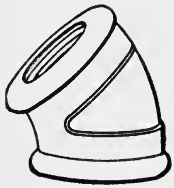

Fig. 35
45-Degree Bend

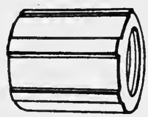

Fig. 36
Right-and-Left Coupling

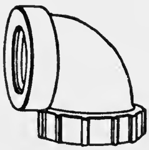

Fig. 37
Right-and-Left Elbow

lings, however, are made with taper threads, as are likewise couplings for pipe-line work. Right-and-left 90-degree bends, Fig. 37, are also made and may likewise be distinguished by short ribs on the end that contains the left thread.

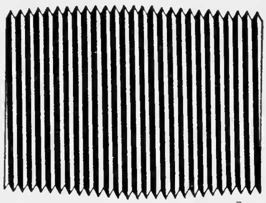

Fig. 38
Close Nipple

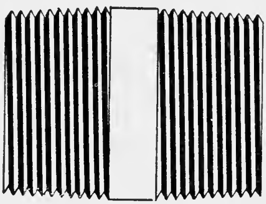

Fig. 39
Shoulder Nipple

A close nipple is shown in Fig. 38. A close nipple is just the length of two threads and has no unthreaded pipe between them.

A shoulder nipple is shown by Fig. 39. This nipple has a short length of pipe between the threads. In drainage work both short nipples and shoulder nipples should be made of extra strong pipe, to compensate for the thickness of metal cut away in making the threads, and for the greater liability of corrosion where part of the thread is exposed.

Nipples may be cut any length by the fitter, but stock nipples of certain sizes, only, can be had from supply houses although nipples of any size or weight can be had on special order. The stock sizes of plain and galvanized right-hand nipples carried by jobbers can be found in Table V.

TABLE V
STOCK SIZES OF RIGHT-HAND NIPPLES

Size Inches	Length of Nipples in Inches					
	Close Nipples	Short Nipples	Long Nipples			
⅛	¾	1½	2	2½	3	3½
¼	⅞	1½	2	2½	3	3½
⅜	1	1½	2	2½	3	3½
½	1⅛	1½	2	2½	3	3½
¾	1⅜	2	2½	3	3½	4
1	1½	2	2½	3	3½	4
1¼	1⅝	2½	3	3½	4	4½
1½	1¾	2½	3	3½	4	4½
2	2	2½	3	3½	4	4½
2½	2½	3	3½	4	4½	5
3	2½	3	3½	4	4½	5
3½	2¾	4	4½	5	5½	6
4	3	4	4½	5	5½	6
4½	3	4	4½	5	5½	6
5	3¼	4½	5	5½	6	6½
6	3¼	4½	5	5½	6	6½
7	3½	5				
8	3½	5				

Right-and-left hand nipples are made in stock sizes up to 4 inches in diameter, but are seldom used over 2½ inches in diameter. Stock sizes of right-and-left hand nipples can be found in Table VI.

TABLE VI

STOCK SIZES OF RIGHT-AND-LEFT HAND NIPPLES

Size Inches	Length of Nipples in Inches					
	Close Nipples	Short Nipples	Long Nipples			
⅛	¾	1½	2	2½	3	3½
¼	⅞	1½	2	2½	3	3½
⅜	1	1½	2	2½	3	3½
½	1⅛	1½	2	2½	3	3½
¾	1⅜	2	2½	3	3½	4
1	1½	2	2½	3	3½	4
1¼	1⅝	2½	3	3½	4	4½
1½	1¾	2½	3	3½	4	4½
2	2	2½	3	3½	4	4½
2½	2½	3	3½	4	4½	5
3	2½	3	3½	4	4½	5
3½	2¾	4	4½	5	5½	6
4	3	4	4½	5	5½	6

The nipples listed in Tables V and VI may be had plain or galvanized, and in Standard, extra strong, and double extra strong weights. They are likewise carried in stock in lengths of 6, 7, 8, 9, 10, 11 and 12 inches respectively for all sizes of pipe listed in the tables. Nipples longer than 12 inches are not made. Above that length the pieces are treated as cut pipe, and are not classed as nipples.

Flange unions, Fig. 40, are used to connect together two sections of pipe, 2 inches or larger in diameter, and are often used in place of right-and-left couplings to connect smaller pipes that have not sufficient end spring to permit the use of a right-and-left coupling.

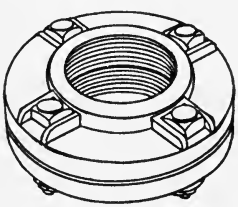

Fig. 40
Flange Union

When used in drainage systems flange unions should be made up with metal gaskets between. For drainage work "Kewanee" flange unions are quite suitable.

A Kewanee union joint is shown in Fig. 41. This type of fitting is used to connect two pieces of pipe which are connected at their opposite ends. The thimbles, *a* and *b*, are screwed onto the two pipes which are to be connected and the two thimbles are then drawn together by means of the ring *c*; the union shown in the illustration is made tight by a metal-to-metal contact; some designs of unions, however, require a gasket to make the joint tight.

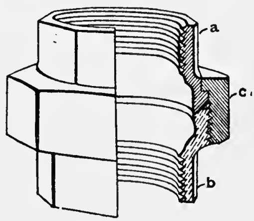

Fig. 41
Pipe Union

Reading Fittings.—Fittings are known and read according to their outlets, always starting with the largest opening. For instance, if the outlet marked *a* on the cross, Fig. 32, were 2 inches; the outlet *b*, 1½ inches; the outlet *c*, 1¼ inches, and the outlet *d*, 1 inch, the fitting would be known and read as a 2x1½x1¼x1 cross. If there were only two sizes of outlets to the cross, one size on the run (*a* to *b*) and one size on the branches (*c* to *d*) the cross would be read by those two sizes of outlets. For instance, if in the run were 2-inch outlets, and in the branches 1½-inch outlets, the fittings would be known as a 2x1½-inch cross.

The run of a cross is always read first, regardless of the size of the other outlets. For instance, if the cross outlets were 2 inch at *a*, 1¼ inch at *b* and 1½ inch at *c* and *d*, starting with the large outlet the run would be read first and then the branches thus—2x1¼x1½x1½ cross.

Other branch fittings, such as T, Y and TY fittings, are read in the same manner. First the run is read, and then the branch, regardless of the size of the side outlets. Usually the branch of a T fitting is smaller than the run, but a certain class of fittings known as bull-head tees have a larger branch outlet than the run.

When mentioning such tees it is usual to state that they are bull headed. Thus, a tee with 1 inch run and 2 inch side outlet would be referred to as a 1x1x2-inch bull headed tee. In reading tees it is customary among fitters to mention only two dimensions when both outlets on the run are the same size. For instance, a tee having two 1¼-inch outlets on the run and a 1-inch side outlet would be referred to as a 1¼x1-inch tee.

Reducing ells are read by naming the larger outlet and then the smaller one. For instance, if a 90-degree bend had one 2-inch outlet and one 1½ inch outlet it would be known as a 2x1½-inch ell.

CHAPTER V

RECESSED DRAINAGE FITTINGS

TYPES of Drainage Fittings.—The distinguishing feature of drainage fittings that makes them particularly suitable for drainage work is the recess in the hubs in which the female threads are tapped. This recess, which is shown at *a a* in Fig. 42, is made of just sufficient depth so that when a pipe is screwed into a fitting the inside of the pipe will finish flush with the inside of the fitting. Drainage fittings may be divided into three groups: traps, branches and bends. Fittings of the first group are shown in illustrations from Fig. 43 to Fig. 45 inclusive.

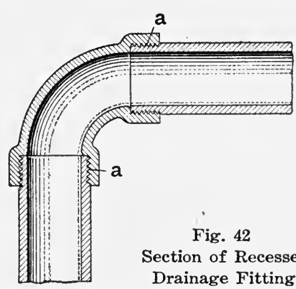

Fig. 42
Section of Recessed
Drainage Fitting

Recessed Drainage Traps.—The fitting Fig. 43 is a running trap and may be used as a main-drain trap, or as a leader, yard or area drain trap. The fitting Fig. 44 is a half-S trap with an outlet for back venting. It is used as a fixture trap, generally for a closet or slop sink. Fig. 45 is a three-quarter S trap, and is used like the half S trap in connection with fixtures.

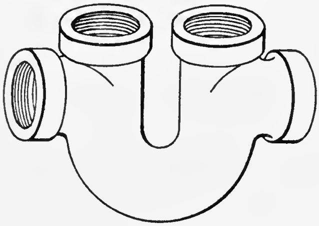

Fig. 43
Running Trap, Two Cleanouts

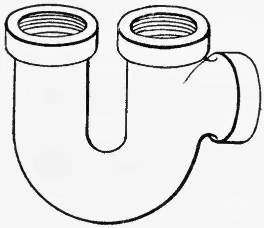

Fig. 44
Half S Trap

Recessed Drainage Branches.—In the second group of fittings a Y branch is shown in Fig. 46. This fitting may be used in any position and on either a vertical or a horizontal line of pipe. It is one of the best types of branch fittings to use on horizontal drains, because it permits sewage to enter the main drain from the branch at such an angle as not to interrupt the flow of sewage in the

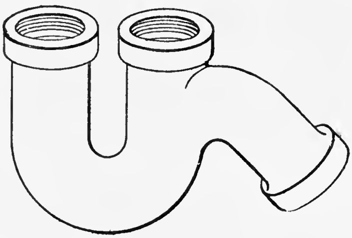

Fig. 45
Three-Quarter S Trap

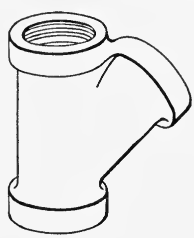

Fig. 46
Y Branch

main. Y fittings are made both single and double pattern and with branch angles of 45 degree and of 60 degree. A double Y branch is shown in Fig. 47.

The branch to both Y and double Y fittings may be had the same size as the run or with reduced outlets. Three-way elbows are shown in Fig. 48.

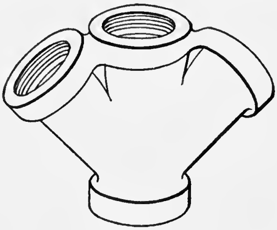

Fig. 47
Double Y Branch

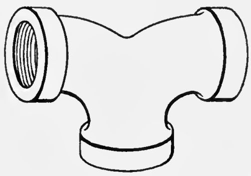

Fig. 48
Three-Way Elbow

The smaller sizes of this type of fitting are used most frequently on vertical pipes as outlet fittings for sink or lavatory wastes. Larger sizes are made bull headed with reducing inlets on the run.

A type of fitting that combines the easy junction of a Y branch with the right angle facings of a T fitting is shown in Fig 49. This is the type of

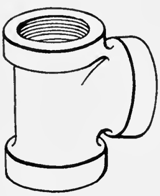

Fig. 49
Short Sweep TY
Fitting

Fig. 50
Long Turn TY
Fitting

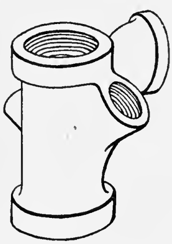

Fig. 51
TY Fitting with
Side Outlets

branch fitting most commonly used for fixture outlets in drainage work. It is known as a short sweep TY fitting and may be had straight or with reducing outlets. The fitting, Fig. 50, is also a TY but of a long turn pattern. On account of its easy sweeping curves it is the better suited for

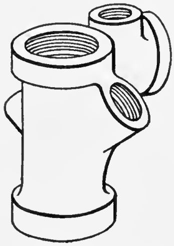

Fig. 52
TY Fitting with Side Outlets and Vent Connection

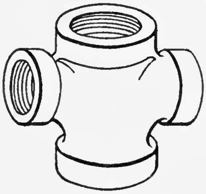

Fig. 53
Double TY Fitting, Short Turn

drainage work, and when space will permit it should be used. This pattern of fitting is generally used on horizontal drains. The short turn fittings, on the other hand, requiring less space, are generally used for branch outlets on vertical soil and waste stacks, but seldom on horizontal drains. A convenient and sanitary type of branch fitting for

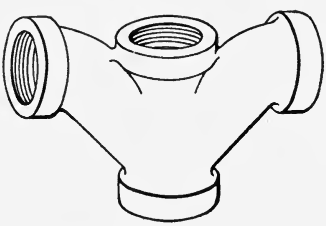

Fig. 54
Double TY Fitting, Long Turn

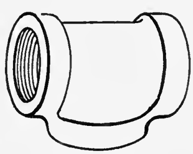

Fig. 55
T Fitting

a bathroom outlet is shown in Fig. 51. This fitting is known as a TY with two side inlets. It provides separate connections for the three usual fixtures in a bathroom, thus doing away with the objectionable practice of connecting the bath tub and basin wastes to the lead closet bend. The fitting shown

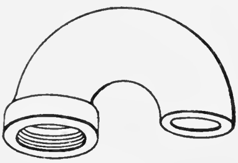

Fig. 56
Return Bend

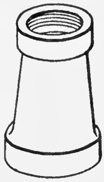

Fig. 57
Increaser

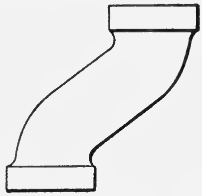

Fig. 58
Offset

at Fig. 52 is similar to the one just described, except that it has, in addition to the two side inlets, an extra opening on top of the closet branch, to be used as a back vent from the closet. In Fig. 53 is shown a double TY fitting of short turn pattern, for use on vertical stacks of soil and waste pipes. This fitting is particularly suitable for closets or other fixtures which are located on opposite sides of a wall.

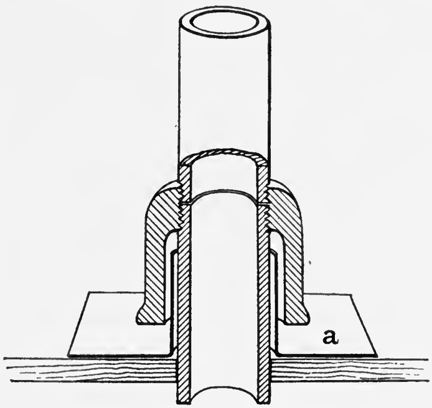

Fig. 59
Roof Connection

A double TY of long-turn pattern is shown in Fig. 54. Like the single pattern long-turn TY it is used principally on horizontal drains, although it is equally suitable for vertical stacks where space will permit its use. Common T fittings, Fig. 55, are used only on vent pipes and on horizontal drains for fresh air inlet connections. Return bends, Fig. 56, are used in drainage work only to cap fresh air inlets and other vent outlets. Hence they are made only in standard sizes from 2 to 5 inches inclusive. Increases, Fig. 57, are made approximately 9 inches over all and in standard sizes from 2x3 inches to 7x8 inches diameters. Offsets are shown in Fig. 58. They are not made with greater offset than 12 inches. When larger offsets are required they must be made up with a piece of pipe and 45-degree, 60-degree or other bends. Roof connections are used for flashing pipes that pass through roofs. The manner of using them is clearly indicated in the illustration, Fig. 59, which shows a roof connection in place covering the flashing *a* on top of the roof.

Recessed Drainage Bends.—Owing to the rigid joints to wrought-iron pipe, greater variety of bends must be used than are required for cast-iron soil pipe. The least angle made by a drainage fitting is 5⅝ degree. The fitting that makes this bend is known as a 5⅝-degree elbow, and a 5⅝-degree elbow turns a line of pipe but slightly from its original direction. Fittings of this type, likewise 11¼-degree elbows, and 22½-degree elbows, 45-degree, 60-degree and 90-degree elbows, are shown comparatively in Fig. 60. All of these types of fittings are extensively used in drainage work, where they are required principally for offsetting lines or giving to them a slight turn in the required direction. On ordinary work the only type of elbow outside of 90-degree bends which is extensively used is the 45-degree bend. These fittings are made long-turn and short-turn patterns. The short-turn fitting is shown in Fig. 61, and the long-turn fitting in Fig. 62. Long turn fittings are of greater radius than short turn bends and should be used wherever space will permit. Bends having angles of 60-degrees, Fig. 63, are also made, but are not so extensively used. Two patterns of 90-degree elbows are made: long turn elbows, Fig. 64, and short turn elbows, Fig. 65. Like the long 45-degree bends, long turn 90-degree elbows are preferable, and should be used wherever space permits. Long turn 45-degree or 90-degree bends will give to a pipe the same angle of pitch as would similar bends of short pattern. Long turn fittings differ from short turn

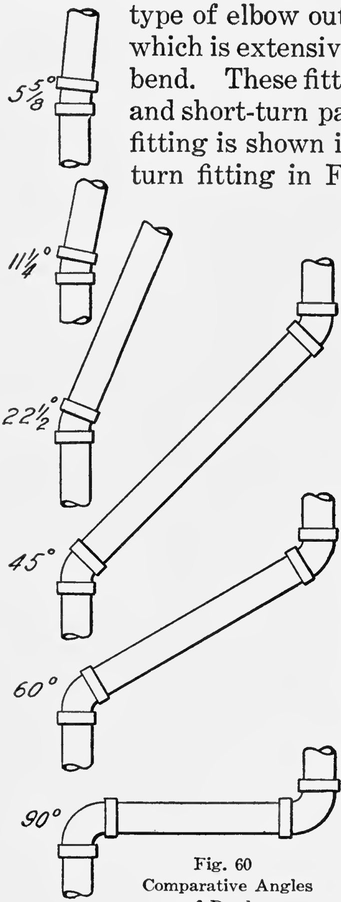

Fig. 60
Comparative Angles
of Bends

fittings only in the length of radius with which they are made, not in the degree of angle. The difference between long and short 45-degree bends

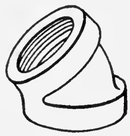

Fig. 61
Short-Turn 45° Bend

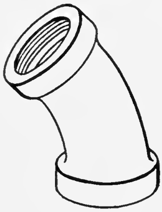

Fig. 62
Long-Turn 45° Bend

Fig. 63
Short-Turn 60° Bend

is comparatively shown in Fig. 66, and the difference between long and short 90-degree bends is shown in Fig. 67.

Ordinarily, for offsetting pipes 45-degree bends are used. These and 45-degree Y fittings are staple stock and are favored because when used together they turn a pipe in almost any direction. This is shown in Fig. 68, where the line of pipe, *a*, intersects the Y branch at an angle of 45 degrees while a 45-degree bend, *b*, turns the branch parallel with the main line, or, as at *c*, turns the line at right angles to the main. If, instead of a 45-degree Y fitting, a 60-degree fitting were used, two different degrees of bends would have to be kept in stock to accomplish what with a 45-degree Y fitting is done with

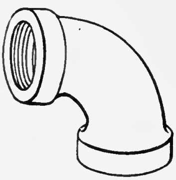

Fig. 64
Long-Turn Elbow

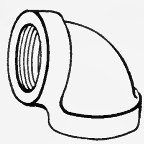

Fig. 65
Short-Turn Elbow

a 45-degree bend. For instance, when a 60-degree Y branch is used a 30-degree bend will turn the branch at right angles to the main, but a 60-degree bend would be required to turn the branch parallel with the main. The same conditions hold true where bends other than 45 degrees are used to offset or change the direction of a pipe. If, for instance, a 30-degree bend be used to turn a line of pipe from its direction, another 30-degree bend will turn the pipe back to its original direction, thus forming an offset. If, however, it is desired to turn the pipe at right angle, a 60-degree bend in addition to the 30-degree bend must be used. In short, the sum of the two angles used must equal 90 degrees.

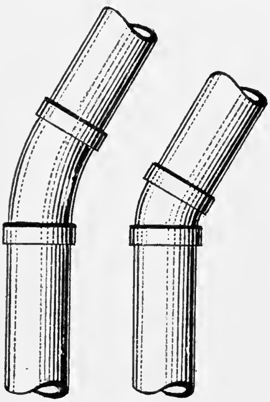

Fig. 66
Comparative Long-Turn and Short-Turn Bends

Closet elbows, Fig. 69, flanged on one end to bolt a closet to, are made but are not used to any great extent in wrought-pipe drainage work. When they are used the joints between the closets and the flanges must be made tight with putty, paste, or gaskets of some

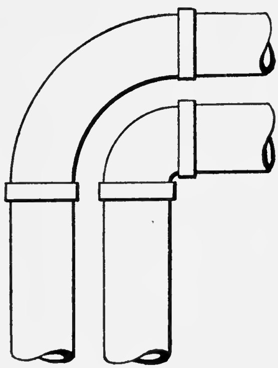

Fig. 67
Comparative Long-Turn and Short-Turn Bends

kind, which is objectionable. Closet floor connections, which are built on the ball and socket principle, and are adjustable and are made tight by means of a metal-to-metal contact, are now made for the same purpose and are so much superior that they should be used. These connections may be had for screw pipe, Fig. 70, or for lead pipe, Fig. 71. Both the iron pipe and the lead pipe connections are made in sizes suitable for 3-inch and 4-inch pipe and may be used in connection with either iron or earthenware closets. Base elbows are shown in Fig. 72. They may be had also as shown in Fig. 73, with one hub end for calking to cast iron pipe. Each of these patterns has a cleanout opening at the throat of the bend.

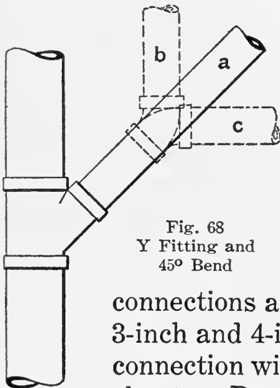

Fig. 68
Y Fitting and
45° Bend

Material and Coating of Drainage Fittings.— Drainage fittings are made of malleable iron and of cast iron. Cast iron drainage fittings are stock fittings and are generally used, while malleable iron fittings are made only to fill orders. Drainage fittings may be had plain, coated with asphaltum or galvanized. Some fittings are electroplated, which deposits on them a thin film of zinc. Such fittings are not coated inside, and are so thinly coated on the outside that the covering does not

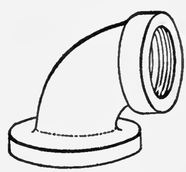

Fig. 69
Closet Elbow

serve as a preservative and will not protect the fittings from corrosion. Electroplated fittings are generally sold as galvanized fittings, whereas they are but little better than plain fittings. For drainage work both pipe and fittings should be coated inside and out with some good preservative. When asphaltum is used it should be applied while the pipe or fittings are hot.

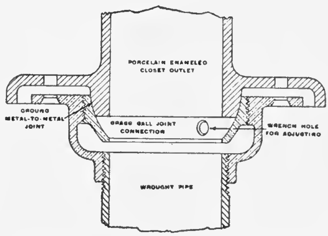

Fig. 70
Ball-Joint Metal-to-Metal Closet Floor Connection—Iron Pipe

Tappings for Drainage Fittings.—Recessed drainage fittings of the TY and 90-degree bend patterns are tapped to give a fall of about ¼-inch per foot to pipes screwed into them.

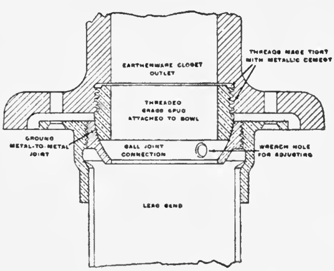

Fig. 71
Ball-Joint Metal-to-Metal Floor Connection—Lead Pipe

For instance, a TY fitting, tapped to provide for fall, if laid in a drain at a grade of about ¼-inch per foot, with the branch turned upright, will give the branch a true perpendicular from the horizontal; and a 90-degree bend or TY fitting, tapped to allow for fall, if placed in a vertical line of pipe will give a fall of $\frac{1}{4}$-inch to the foot to the branches taken off that vertical line. If drainage fittings were not tapped in this manner, so as to allow for fall, the required pitch would have to be obtained either by slightly bending the pipe or by cutting crooked threads on one end of each branch pipe screwed into the fitting.

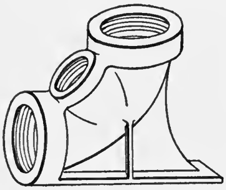

Fig. 72
Base Elbow, for Wrought Iron Pipe

Centre of Fittings.—In measuring piping it is necessary to know how to locate the center of fittings, for most pipe measurements are taken from the center of one fitting to the centre of another. The centers can be found by drawing imaginary straight lines from the centers of the several outlets of a fitting and at right angles to their faces; the point where all the lines intersect is the center of the fitting. This method of locating the centre of fittings will be better understood by a reference to the following illustrations. In Fig. 74 a straight line *a*, drawn at right angles to one face of the 90-degree bend,

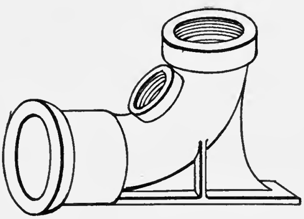

Fig. 73
Base Elbow, for Cast Iron and Wrought Iron Pipe

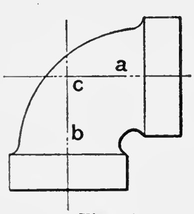

Fig. 74
Center of Elbow

and at the center of the outlet, would intersect the line *b*, drawn from the other outlet, at the point *c*, which is the center of the bend. In Fig. 75, the line *a*, drawn from the upper face of the 45-degree bend, and at right angles to it, would intersect the line *b*, drawn from the opposite outlet, at the point *c*, which is the center of a 45-degree bend. The center of a fitting is really that point which would be the center of various pipes crossing at the angles of the openings. The center, *c*, of the T, Fig. 76, is found by drawing a line *a*, through the center of the run, and intersecting it, at right angles, by a line, *b*, drawn from the center of the branch.

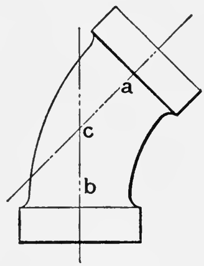

Fig. 75
Center of 45° Bend

For the purpose of finding their centers, TY fittings, Fig. 77, may be considered T's. A line, *a*, drawn through the center of the run would intersect the line *b*, drawn at right angles from the face of the branch, at *c*, which is the center of this fitting. In like manner the center of a double TY fitting, Fig. 78, would be found, at *c*, by drawing a line, *a*, through the center of the run and cutting it with a line, *b*, drawn through the center of the branches. There are two conditions under which the center of Y branch fittings are to be found,

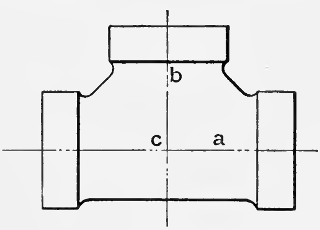

Fig. 76
Center of T Fitting

each way depending upon the manner the fitting is to be used. When the fitting branch is to be continued at an angle of 45 degrees from the main the center would be found as shown in Fig. 79. A line, *a*, drawn through the run would be intersected by the line *b*, drawn at right angles to the face of the branch. The point *c*, where the lines intersect, would be the center of the fitting. The centers of double Y fittings are found in the same manner. The line *a*, Fig. 80, is intersected by lines *b* and *b*, at the point *c*, which is the center of the fitting. When the branch of a Y fitting, by means of a bend, is to be turned at right angles to the main, as shown in Fig. 81, the short nipple and bend must be considered part of the fitting and the center of the combination found. This is done as in the case of TY fittings by intersecting the line *a*, drawn through

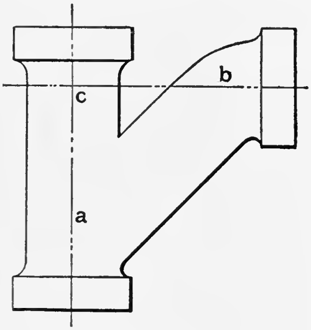

Fig. 77
Center of TY Fitting

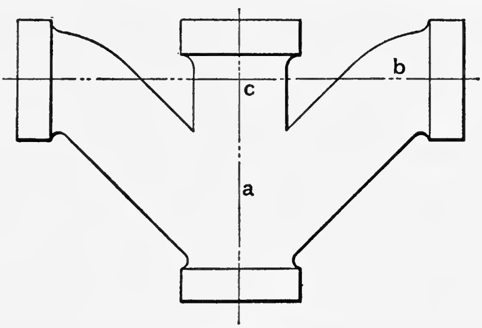

Fig. 78
Center of Double TY Fitting

the run of the fitting, by the line *b*, drawn at right angles to the face of the branch at the point *c*, which is the center of the fitting.

It is necessary for the workman to know the location of the center of fittings, or be able to determine it, for the reason that most pipe measurements are taken from the center of one fitting to the center of another, and in order to determine the exact length of pipe to be cut, allowance must be made for those portions of the measurements taken up by the fittings. Ordinarily, after a little practice, the workman is able to judge the center of a fitting with his eyes, but if in doubt, he can make sure by placing his rule on the center of the various runs, and parallel with them, then marking a chalk or pencil line along the rule, to where the several lines meet. He can then deduct for each fitting an amount equal to the length along the line he is working on, measured from the face to the shoulder in the hub of the fitting. The distance from the center of fitting to shoulder of hub, not to the face of hub is deducted, because the pipe will extend

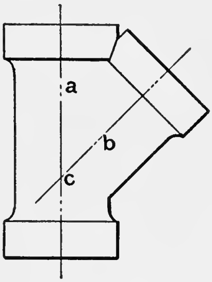

Fig. 79
Center of Y Fitting

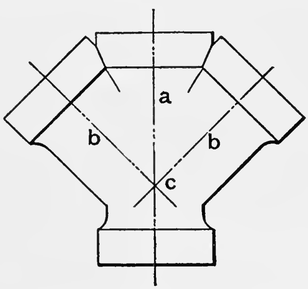

Fig. 80
Center of Double Y Fitting

past the face of the hub, and make up clear to the shoulder within the recess. If however the recesses in the fittings are made deeper than would be required by an ordinary thread, that is, over 1.3 inches for 4-inch pipe, allowing for 8 perfect threads and two full at the root but slightly flattened on top, then instead of allowing for the full depth of the hub, an allowance would simply be made of 1.3 inches, which is the length of a full and perfect 4-inch thread.

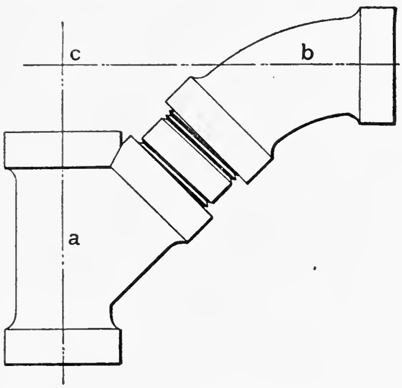

Fig. 81
Center of Y and 45° Bend

CHAPTER VI

BENDING WROUGHT PIPE

TYPES of Pipe Bends.—In many classes of drainage work, particularly car and marine plumbing, pipe bends are extensively used instead of cast-iron or malleable-iron fittings; hence the necessity for a knowledge of what size and kinds of bends can be made. For drainage work there are but three principal types of bends used. The first, Fig. 82, is a quarter bend and is the one which has to be made most frequently. The second, Fig. 83, is a return bend, and the third, Fig. 84, is an offset bend.

Expansion bends, Fig. 85, are used in long lines of steam or hot water pipes to allow for expansion and contraction. Expansion bends of this type may be made of copper or of iron. The one shown in the illustration is made of copper. If made of iron the radius would have to be much larger, as explained in Table VII.

The advisable radius to which pipes can be bent bears a certain relation to the inside diameter and weight of the pipe. It may be stated, as a rule, that the advisable radius of a bend for standard pipe is six times the inside diameter of the pipe. That is, the advisable radius, *r*, Figs. 82, 83, 84, for a 4-inch pipe would be 4x6—24 inches. There is a minimum and a maximum radius for pipe bends above or below which bends cannot conveniently be made. If the radius must be reduced

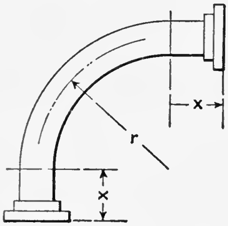

Fig. 82
Quarter Bend in Pipe

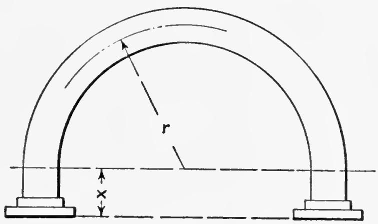

Fig. 83
Return Bend in Pipe

below the minimum a heavier weight of pipe should be used. On the other hand, if the radius is increased above the maximum the bend is apt to look like a series of kinks, owing to the short heats taken by the bender. Galvanizing wrought-iron pipe makes it brittle, which increases the difficulty of bending it; furthermore, heating galvanized pipe to bend it destroys the galvanizing; hence, galvanized pipe for drainage systems should be bent plain and galvanized afterward. In bending pipe there is less liability of it opening along the seams if the weld is placed at the side, and it might be well to note that steel

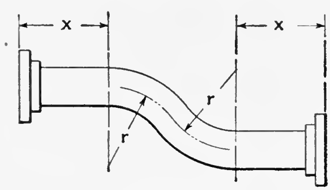

Fig. 84
Offset Bend in Pipe

pipe being softer than wrought-iron and having a stronger weld, is the better material where many bends are to be made.

The minimum, maximum and advisable radius for pipe bends can be found in Table VII.

TABLE VII
RADII FOR PIPE BENDS*

Diameter of Pipes	Minimum Radius	Maximum Radius	Advisable Radius
Inches	Inches	Inches	Inches
2½	10	25	15
3	12	30	18
3½	14	35	21
4	16	40	24
4½	18	45	27
5	20	50	30
6	24	60	36
7	28	70	42
8	32	80	48
9	36	90	54
10	40	100	60
11	44	110	66
12	48	120	72
14 O. D.*	60	140	84
15 "	68	145	90
16 "	76	150	100
18 "	90	165	125
20 "	120	180	150
22 "	132	198	165
24 "	144	216	180

* O. D. means outside diameter.

A straight piece of pipe, that marked x on the illustrations, is required on the ends of all pipe bends to facilitate bending and threading them. The length of straight pipe, x, required for pipes of different diameters can be found in Table VIII.

TABLE VIII
LENGTH OF STRAIGHT PIPE X

2½-inch pipe x - -	4 inches	7-inch pipe x - -	8 inches
3 -inch pipe x - -	4 inches	8-inch pipe x - -	9 inches
3½-inch pipe x - -	5 inches	10-inch pipe x - -	12 inches
4 -inch pipe x - -	5 inches	12-inch pipe x - -	14 inches
4½-inch pipe x - -	6 inches	14-inch pipe x - -	15 inches
5 -inch pipe x - -	6 inches	15-inch pipe x - -	16 inches
6 -inch pipe x - -	7 inches	16-inch pipe x - -	20 inches

* National Tube Co.'s Book of Standards.

Types of Iron Pipe Coils.—Plumbers and fitters are often called upon to furnish heating and cooling coils of various shapes and dimensions,

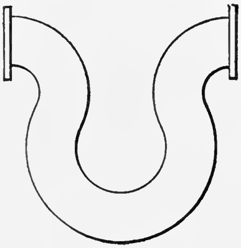

Fig. 85
Expansion Loop

and, while such coils can hardly be considered as related to wrought-pipe drainage systems, it might not be amiss to illustrate a few stock types. Fig. 86 shows a plain spiral coil that can be made in any reasonable length and in sizes of pipe from $\frac{1}{8}$-inch to 4 inches, inclusive, in diameter. The lengths of pipe required to make such a coil are not connected together by means of screw couplings, but are permanently joined by an electric weld. When copper or brass coils are required the joints are brazed. A continuous double coil is shown in Fig. 87. It consists of a left-hand and a right-hand spiral, joined at the top and having no screw joints. This gives a maximum amount of coil in a very compact space. An open pattern conical coil is shown in Fig. 88. This type of coil is extensively used in stoves for heating purposes, particularly in car heaters and water heating stoves. A close conical coil is shown in Fig. 89. Coils of this shape

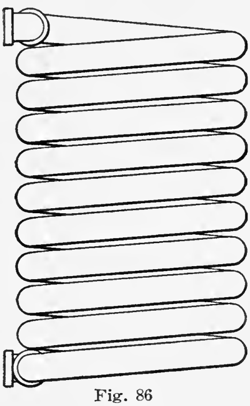

Fig. 86
Spiral Coil

made of tinned copper tubing are used in ice boxes for cooling water and in creameries for cooling cream. The cream falling from above flows in a thin film over both inner and outer surfaces of the cone, while cold water flows through the tube to carry off the heat from the cream.

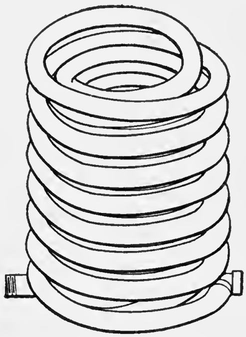

Fig. 87
Continuous Double Coil

A close flat coil is shown in Fig. 90. Coils of this shape are used in ice tanks for cooling water.

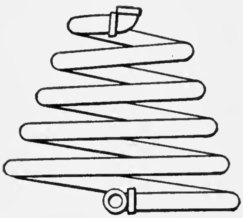

Fig. 88
Open Conical Coil

They are made both open and close patterns, and of iron or copper tubing. Reducing coils, Fig. 91, are used for condenser coils in distilling plants. They are made by commencing with a large size of pipe and welding, end to end, successively smaller sizes until the last size is just what is required to carry the liquid. In Fig. 92 is shown a box coil nested. Nested coils can be made with any number of coils,

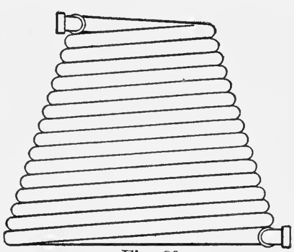

Fig. 89
Close Conical Coil

either round, square or oblong, nested together. The different coils in the nest may be also of different sizes of pipe.

Usually in nested coils the several pipes are connected to a manifold header, *a*, to eliminate friction and reduce the pressure required to force liquids through the coils.

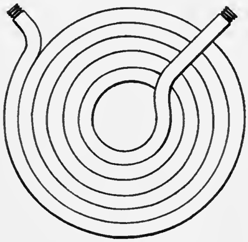

Fig. 90
Close Flat Coil

Pipe bends and coils, particularly when made from large sizes of pipe, are usually made by tube manufacturers or bending companies from sketches and dimensions furnished by the fitter.

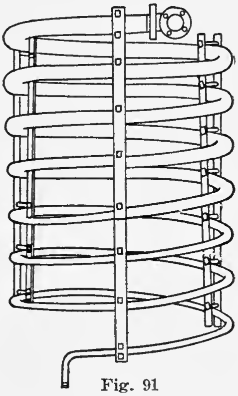

Fig. 91
Reducing Coil

Great care and accuracy should be observed in making sketches and taking measurements, to see that not only will the coil fit the place made for, but that it can be easily put in that place.

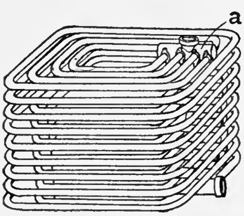

Fig. 92
Box Coil Nested

Pipe-Bending Forms and Machines. — Ordinarily, small size pipe bends, such as are required on all large installations, are made by the workmen in the building. The pipes are bent cold, and, for small pipes, a vise is generally used as a bending form. Larger sizes of pipe, from 1 to 2 inches in diameter, are bent on the job, generally by using a pipe-bending form. A pipe-bending form made of iron and quite convenient for either shop or job is shown in Fig. 93.

Some form of pipe-bending devise is almost indispensable on a large job, where it will save its cost in workman's time searching for a suitable plank from which to improvise a bending form or board. The devise shown in Fig. 93, while very convenient, is limited in its usefulness to the making of simple bends and offsets. When double offsets or compound bends of any kind are to be made, a more improved pipe-bending devise will be found necessary. A pipe-bending machine that answers all requirements is shown in Fig. 94. With this type of machine, by the exercise of a little care and practice, almost any conceivable form of bend can be made. When large sizes of pipe are to be bent into compound curves a templet,

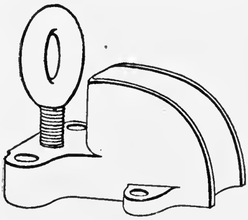

Fig. 93
Pipe-Bending Form

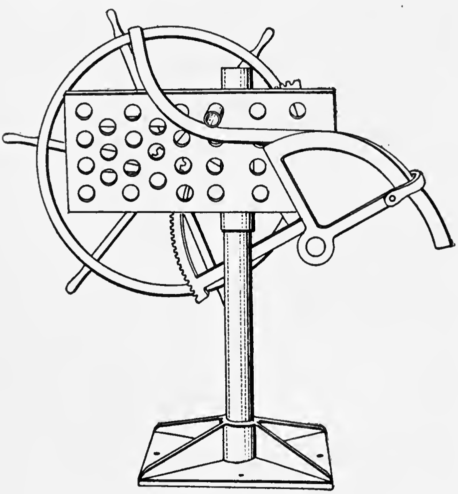

Fig. 94
Pipe-Bending Machine

or pattern, of the bends should be made out of small pipe ($\frac{1}{4}$ inch or $\frac{3}{8}$ inch) to serve as a guide in bending the larger pipe.

With a little practice, a skillful workman can bend small sizes of pipe, that is, anything from $\frac{1}{8}$-inch to 2-inches in diameter, into any desirable form or shape within reason, and the bends can be made without a kink or tool mark showing on the pipe. For pipes up to 2-inches in diameter, ordinarily no heat will be required, indeed, the pipe can be bent better without being heated, unless particularly short bends are to be made. For bending large sizes of pipe, on the other hand, it will be necessary to heat the metal, not so much because heating the pipe causes it to bend better, but because it is easier to handle when hot, and leverage enough could not well be secured to bend large sizes of pipe cold.

CHAPTER VII

MAKING-UP PIPE

USE of Joint Pastes.—To produce a perfectly strong and tight joint in screw pipes it is necessary that the pipe threads be brought to a firm metal-to-metal contact along the entire engaging parts. To do so the threads must be absolutely clean, free from rust, and the metal should be well lubricated, in order to reduce the friction when screwing the pipes together. Friction in pipe joints is due to the large amount of bearing surface, which becomes greater the further the threads are made up; friction produces heat, which causes expansion of the joint, and as the pipe is lighter than the coupling or fitting it expands more, hence is made apparently tight, while the thread is comparatively loose; consequently, when pipe and fitting both cool again the pipe shrinks more than the fitting and a loose thread, liable to leak, results. To secure a good joint, the very best lubricant should be used; grit, paste or any form of gummy material tends to produce friction without, as many believe, filling the interstices of the threads and thus preventing leaks. Red lead, white lead and asphaltum are not as satisfactory for making up pipe threads as are lubricating oils; and graphite is superior to them all, as the graphite not only lubricates the threads, but when the oil dries out the graphite flakes prevent the threads from rusting together, thereby making it easy to disconnect the pipe at any time. If, however, the pipe is to be permanently made up and it is not desired to disconnect it at some future time, the threads can advantageously be made up with Smooth-On elastic cement. This will insure tight joints.

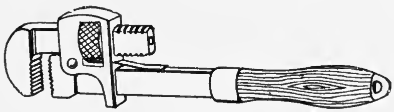

Fig. 95
Stillson Wrench

Fittings are generally made up at the bench before taking the pipe from the vise. Small fittings, not over 2½ inches in diameter, are generally made up by screwing a short piece of pipe in the side outlet of the fitting and using this pipe for a turning lever. Chain tongs are used for making up larger sizes of fittings.

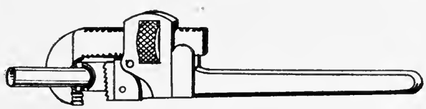

Fig. 96
Trimo Wrench

Pipe Tongs and Wrenches.—Pipes are made up by the aid of pipe wrenches and chain tongs. Of the pipe wrenches used Stillson wrenches, Fig. 95, and Trimo wrenches, Fig. 96, are among the best. These wrenches are made in sizes from 6 inches to 48 inches in length and each size can be adjusted to grip several sizes of pipe. The length and range of various sizes of Stillson and Trimo wrenches can be found in Table IX:

TABLE IX

SIZE AND RANGE OF PIPE WRENCHES

Length when open	6-inch	8-inch	10-inch	14-inch
Takes from . . .	1/4-inch wire to 1/2-inch pipe	1/8-inch wire to 3/4-inch pipe	1/8-inch wire to 1-inch pipe	1/4-inch wire to 1 1/2-inch pipe
Length when open	18-inch	24-inch	38-inch	48-inch
Takes from . . .	1/4-inch wire to 2-inch pipe	1/4-inch wire to 2 1/2-inch pipe	1/2-inch pipe to 3 1/2-inch pipe	1-inch pipe to 5-inch pipe

Chain tongs are made in two patterns, open-link chain tongs and flat-link chain tongs. The

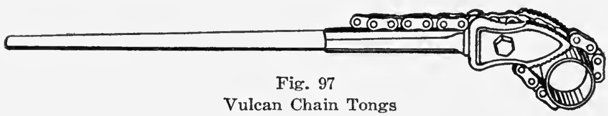

Fig. 97
Vulcan Chain Tongs

Vulcan tongs, Fig. 97, is a type of the latter kind. The jaws of these tongs are drop forged and made reversible and interchangeable, so that they can be

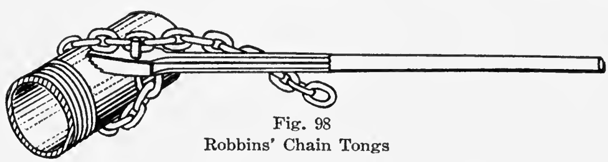

Fig. 98
Robbins' Chain Tongs

reversed, or, in case of injury, at trifling cost, be replaced with new jaws. Robbins' chain tongs, Fig. 98, are a type of open-link chain tongs. They are hand-forged tools and have no interchangeable parts; hence, when the jaws are dulled, or when in other ways the tongs are out of order, they

TABLE X

SIZE OF CHAIN TONGS

Length of lever, inches	27	36	48
Size of chain	5/16	5/16	3/8
Weight, pounds . . .		12	24
For pipe	1 to 2	1¼ to 4	2 to 6
Length of lever, inches	60	72	84
Size of chain	½	⅝	¾
Weight, pounds . . .	33	50	100
For pipe	2½ to 8	4 to 10	4 to 16

must be sent to the blacksmith's for repairs. The size of chain tongs and the diameters of pipes they will turn can be found in Table X.

CHAPTER VIII

MEASUREMENTS AND SKETCHES

EXPLANATION of Signs.—Space will not always permit words to be spelled out in full on a pipe sketch without crowding the measurements to such an extent as to make the characters unintelligible; hence, in writing down measurements, many signs and abbreviations are used, the meaning of which should be perfectly understood by the fitter, to enable him to interpret the sketch.

The sign for feet is a little mark (′) placed at the right upper side of a figure, thus—2′; when so placed it indicates that the dimension referred to is 2 feet. The inch sign is a double mark (″) placed at the upper right side of a figure as in the case with feet. When so placed it indicates that the quantity refers to inches. Thus 4″ would be read 4 inches. When both feet and inches are a part of a quantity the number of feet with the mark annexed is written and followed immediately, without intervening sign, by the number of inches and the inch mark. Thus 2′ 4″ would be read 2 feet 4 inches. Sometimes the feet and inches are written with a dash or hyphen between; thus 2′—4″ would be read 2 feet 4 inches as in the foregoing case, the dash not affecting the values.

Bends in pipes or fittings are measured in degrees, which are indicated thus—°. A degree sign placed after a number indicates that the bend referred to is made at an angle of that many degrees from a straight line. Thus a 45° bend would be read a 45-degree bend.

Reading Measurements.—There are two dimensions which should be marked on pipe sketches—the size of the pipe to be cut and its length. The size of pipe is marked crosswise on the pipe, as shown by the dimension 4″ in Fig. 99,

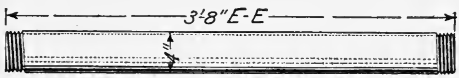

Fig. 99
End-to-End Measurement

or it may be marked alongside of the pipe, but always at right angles to it. When the size marks are omitted on some pieces of pipe on a sketch the large size of pipe is understood to continue up to the point where a smaller size is indicated. The outlets to the run of the fittings on a sketch take their size from the pipes screwed into them, and when marked pipes are screwed into all outlets of a fitting the dimensions of the fitting need not be marked. However, when a reducing fitting is used any outlet into which a marked pipe is not screwed must have the size of outlets marked to indicate the kind of fitting required. When no dimensions are marked on a fitting it is understood to be a straight fitting of the size of the pipe.

End-to-End Measurements.—The method of measuring the lengths of pipe and the way the measurements are indicated on a pipe sketch are shown in Figs. 99, 100 and 101. In Fig. 99 the measurement, which is from end to end, is indicated by the abbreviation E-E. End-to-End measurements may be from the end of a pipe to the end of a fitting screwed thereon; it may be over all from the end of a fitting screwed on one end of a pipe to the end of another fitting screwed on the other end of the pipe, or it may be a measurement over several pieces of pipe and several fittings from extreme end to extreme end.

Center-to-End Measurements.—Center-to-end measurements are shown in Fig. 100, and are abbreviated C-E. In this case the dimension is taken from the center of the fitting to the end of the pipe and would shorten the actual length of pipe to 3 feet 8 inches minus *a*, the distance from

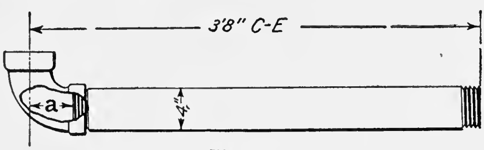

Fig. 100
Center-to-End Measurement

the end of the pipe to the center of the elbow. Like in the case of end-to-end measurements, center-to-end measurements may be for a section of pipe containing several pieces of pipe and fittings.

Center-to-Center Measurements.—Center-to-center measurements, Fig. 101, are abbreviated C-C. They are taken from the center of one fitting to the center of the other. This measurement shortens the actual length of pipe to 3 feet 8 inches, minus *a* and *b*, the distance from the ends of the pipe to the center of the fittings. As in the two preceeding cases, center-to-center measurements may be over several pieces of pipe from the center of one end fitting to the center of another.

In cutting and threading wrought-iron pipe to fit measurements taken from center of fitting to center of fitting, allowance is made for the space

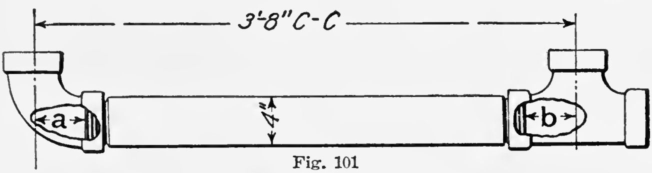

Fig. 101
Center-to-Center Measurement

taken up by the fitting on each end of the pipe, and a proportional length is cut from the pipe to be threaded. The exact length in inches that must be taken off different sizes of pipe to allow for the fittings cannot be stated as a rule, because different types of fittings require different lengths, and even fittings of the same type, but made by different manufacturers, vary so in dimensions that pipe cut for one make of fitting would not fit when used with fittings made by a different manufacturer. Further, in using fittings made by one manufacturer, but tapped at different times, the difference in the tappings will make sufficient difference to throw a close measurement out of true. The best way to allow for fittings is to determine, by finding how far a thread will make up in a fitting, just what distance there will be from the end of the pipe to the center of the fitting, and cut that length off the pipe. This is usually done, in practice, by laying the fitting alongside the pipe in such a position that the end of the pipe will extend along the fitting a distance equal to which the thread will make up in the fitting and measuring from the end of the pipe to the center of the fitting. This distance, on each end, is equal to the length of pipe that must be cut off to allow for a center-to-center measurement.

In handling small sizes of pipe, however, particularly where the measurements need not be exact, the measurements are taken from center to center and the workman, when getting out the pipes, allows a certain amount for fittings. The amount so allowed is generally the average of a number of measurements of the fittings used in that locality. For instance, with most fittings, an allowance of $\frac{3}{8}$-inch for each $\frac{3}{8}$-inch fitting; $\frac{1}{2}$-inch for each $\frac{1}{2}$-inch fitting; $\frac{5}{8}$-inch for $\frac{3}{4}$-inch fittings, and $\frac{3}{4}$-inch for 1-inch fittings will be found sufficiently accurate. In the same way an average can be allowed for fittings up to two inches in diameter, but above that size patterns vary so in design that each fitting should be measured separately for close work.

Explanation of Degrees in Fittings.—There is a unit or standard for measuring the angle of bends and branch fittings, just as there are units for the measurement of time, length, weight and volume. The unit of measurement for fittings is known as a degree and is one of the 360 equal divisions of a circle. For instance, if in Fig. 102, beginning where the vertical line cuts the lower arc, the figure was divided into 360 equal parts, 180 of the divisions would be on each side of the vertical line, and this straight line would therefore represent one-half the number of equal divisions in the circle or 180 degrees. In the naming of fittings, one half the circle is ignored, and the angle 180 degrees is used as a base. This straight line represents a straight piece of pipe which might properly be called a no-degree bend. Likewise, it represents the straight run of a branch fitting, and any branch or bend from that run is measured and named according to the number of degrees it includes between the center of the branch and the straight line. For example, the straight line may represent the run of a Y branch, and the 45-degree line the angle of the branch outlet; or, the straight line may represent a straight run of pipe, and the 45-degree line the angle that would be given the pipe by means of a 45-degree bend. In the same manner, an elbow

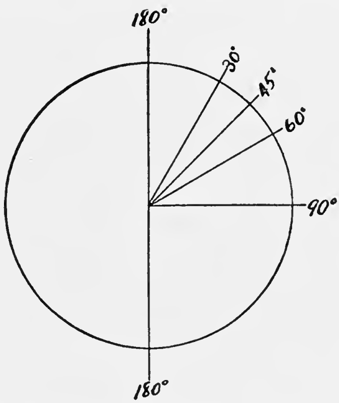

Fig. 102
Diagram Explaining Degrees in Fittings

would form the right angle marked by the 90-degree line; and likewise, this is the direction that would be given the branch to a T fitting, which is really a 90-degree branch, when the run was along the no-degree line.

Measuring for 45-Degree Connections.—The usual method in practice of measuring for a 45-degree connection is shown in Fig. 103. Trial pieces, *a* and *b*, are screwed by hand into a 45-degree bend, and the section thus made is held in such a position that the trial pieces align with the trial piece *c* and the main pipe *d*, or on a line where

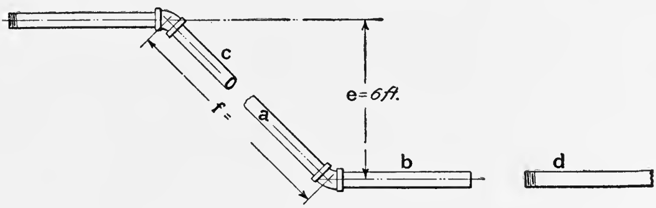

Fig. 103
45° Measurement

the pipe *d* will be run. The measurements are then taken from center of fitting to center of fitting, allowance afterward being made for the threads. A much simpler way is to measure the distance, *e*, from the center of one pipe to the center of where the other one will be run and multiply the distance by 1.41. The product will be the measurement of the 45-degree connection from center to center of the bends. Allowance must then be made for the fittings to find the exact measurement of the pipe. For instance, if the distance, *e*, be 6 feet, the length of pipe, *f*, from center to center of fitting will be 6x1.41=8.46 feet, or 8 feet 6 inches nearly. The reason for this is simple. The connection is the diagonal of a square, the sides of which are 6 feet and the ratio of the diagonal of a square to one of its sides is 1.414; but as two points are as far as a decimal need be carried in practice the constant 1.41 will answer.

In like manner, when the dimension of the short side of a rectangle—that is, the distance the pipe is to be offset—is known, also the angle of fitting to be used, the length of the connection from center to center can be found by multiplying the short end of rectangles by the ratio for that angle. For bends of greater angle than 45-degrees the long side of the rectangle should be taken. The ratio or constant for the various bends used in drainage work can be found in the Table XI:

TABLE XI
RATIOS FOR DIFFERENT ANGLES

Degrees of Bend	Name of Wrought-Iron Fitting	Name of Soil Fitting	Ratio of diagonal to side of Rectangle
	Elbows	Bend	
5⅝	5⅝°	1/64	10.22
11¼	11¼°	1/32	5.12
22½	22½°	1/16	2.61
30	30°	1/12	2 00
45	45°	⅛	1.41
60	60°	⅙	1.15

In all cases due allowance must be made for the length of fittings, as the distance computed will be from center to center of fitting.

Some fitters find it easier to use common fractions and add 5 inches for each foot the line is to be offset, or 5/12-inch for each inch the line is to be offset. Thus, in the foregoing example, adding 5 inches for each foot the line is to be offset would be 5x6=30 inches, which, added to the 6 feet offset, would equal 6 feet plus 2 feet 6 inches (30 inches), or 8 feet 6 inches from center-to-center of bends.

The method of finding the length of a 45-degree bend by adding $\frac{5}{12}$-inch for each inch the line is to be offset is indicated in the following example:

> EXAMPLE.—What will be the length of a 45-degree connection where the line is offset 6 feet?
>
> SOLUTION.—6 feet=72 inches and 72 x $1\frac{5}{12}$ = 8 feet 6 inches. (Answer.)

Sometimes it is necessary to find the length of a 45-degree connection between two pipes that run at right angles to each other, as shown in Fig. 104, instead of parallel to each other, as in the preceding example. When such is the case, from the center of one of the bends, as *a*, measure the distance, *b*, to the center axis, *c*, of the pipe, *d*. The length, *b*, then multiplied by the constant for that angle will give the length of the connection from center to center.

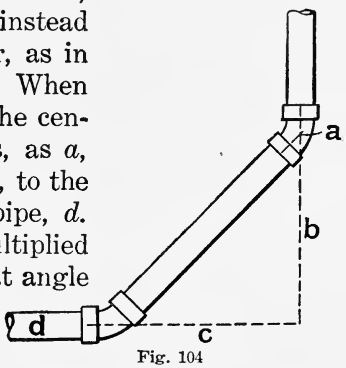

Fig. 104
Measurement for 45° Connection

Measuring Instruments.—For short measurements of pipes, or for laying out work on a job, a two-foot rule is generally used. However, when long lengths of pipe, or long distances in a building, are to be measured, there will be less liability of errors if a longer instrument be employed. For most purposes a ten-foot rod will be found a very convenient instrument. This consists of a wooden rod, 10 feet long, divided up by marks into feet and inches, thus making it really a ten-foot rule. When a tape line is used, for accurate measurements, it should be either a steel tape or a cloth tape with steel strands embedded. An ordinary tape line will stretch sufficiently to cause errors.

Pipe Sketches.—Drainage pipes for small installations, where the sizes of pipes are 4 inches or less in diameter, are usually cut and threaded with hand tools on the premises. The pipe for large installations, however, where pipes larger than 4 inches in diameter are used, also where a large quantity of piping from 2 inches to 4 inches in diameter is to be installed, is cut and threaded at the shop from sketches and measurements taken in the building. In getting out pipe for drainage work it is customary to sketch, measure and cut certain sections at a time; for instance, the house drain would be sketched and measured in one section; the stack of soil, waste and vent pipe in another section, and the branch connections to fixtures in another section. A sketch such as would be sent to a shop from which to get out pipe for an installation is shown in Fig. 105. On this sketch are marked the sizes of the various pipes, which, in turn, give the size of fitting outlets; also the length

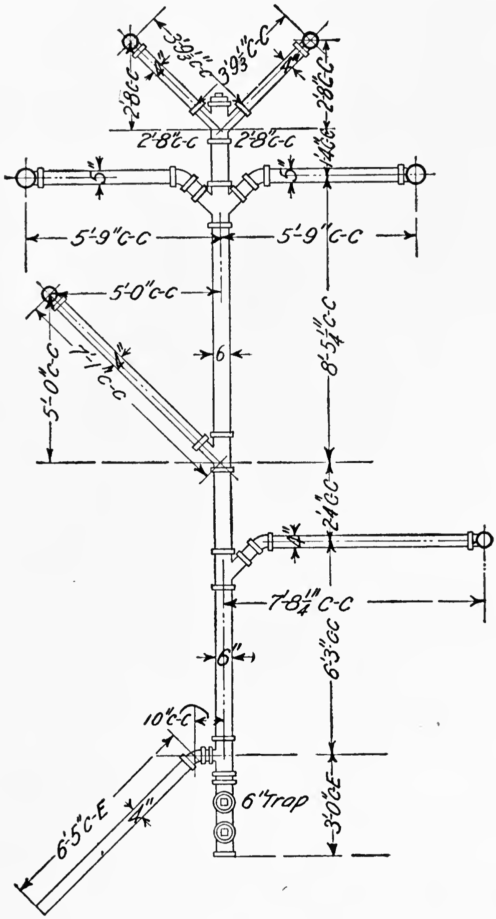

Fig. 105
Pipe Sketch for Sending to Shop

of all pipes measured from center-to-end, from end-to-end or from center-to-center. By following carefully the data furnished on this pipe sketch the pipe can be cut and threaded hundreds of miles away from the work as accurately as though cut on the premises. When pipe is cut and threaded on the premises less pains are taken to make a sketch than when the sketch is to be sent away Usually, in the former case, a line drawing similar to Fig. 106 is deemed sufficient, as the fitter has in mind the layout of the work and only requires a memorandum containing the various measurements. When getting out pipe at the bench from a sketch, the fitting that will be screwed onto the pipe when installed should be used to measure by. The reason for this requirement is that fittings made by different manufacturers differ in length, and a pipe cut to measure with a certain fitting might not fit when used with one of a different make.

In Fig. 107 is shown a plan view of a battery of eight water closets, set back to back, with a space of one foot for pipes left between the compartments. The closets are set 3 feet from center-to-center, and it will be assumed that the distance, *a*, between the center of the tiers of closet outlets is found by measurement to be 3 feet, also that the stack, *b*, is equidistant from a line drawn through each tier of closet outlets; then, to take the measurements of the pipe for this battery of closets, with a chalk line strike two parallel lines, *a*, *b*, Fig. 108, 3 feet apart, and a third line, *c*, midway between them. These three lines then represent,

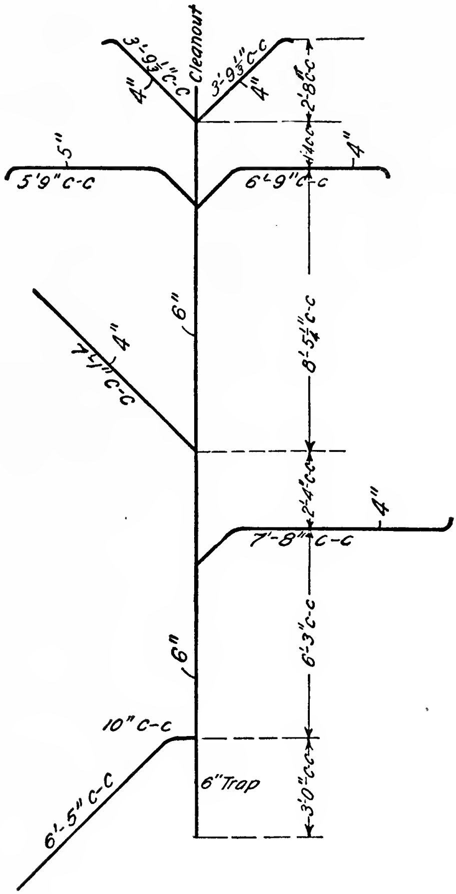

Fig. 106
Pipe Sketch for Workman's Own Use

respectively, the two lines of closet outlets in the two tiers, and the center of the soil stack outlet. Next draw a line, *d*, at right angles to the other

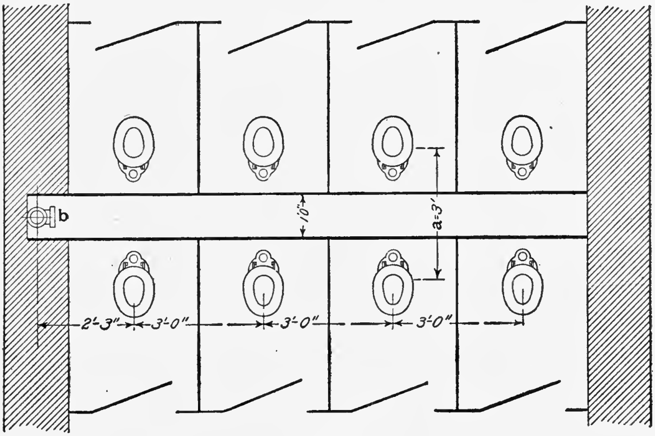

Fig. 107
Plan of Battery of Closets

lines and so as to cut all three of them, then at intervals of 3 feet draw the lines *e*, *f*, *g*, and at a distance of 2 feet 3 inches from the line *g* draw the

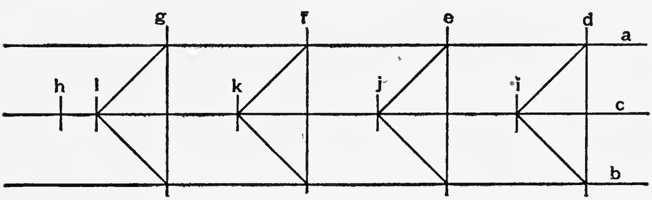

Fig. 108
Laying Out Measurements for Closets

short line *h*. The lines *d*, *e*, *f*, *g*, where they cross the lines *a*, *b*, will mark the center of outlets from the eight water closets. Now 18 inches from the lines *d*, *e*, *f*, *g*, in the direction of the soil stack, draw the lines *i*, *j*, *k*, *l*, and the points where they cross the line *c* will mark the center of the closet

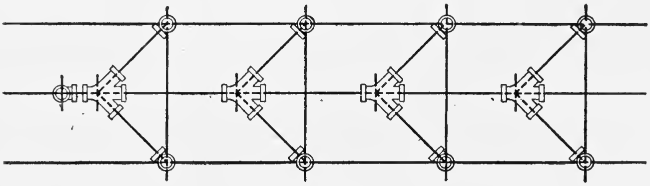

Fig. 109
Measurements for Battery of Closets

double Y branches; by measuring from these points to the center of closets, as, for instance, from *i* to *b*, will give the required length of pipe from center

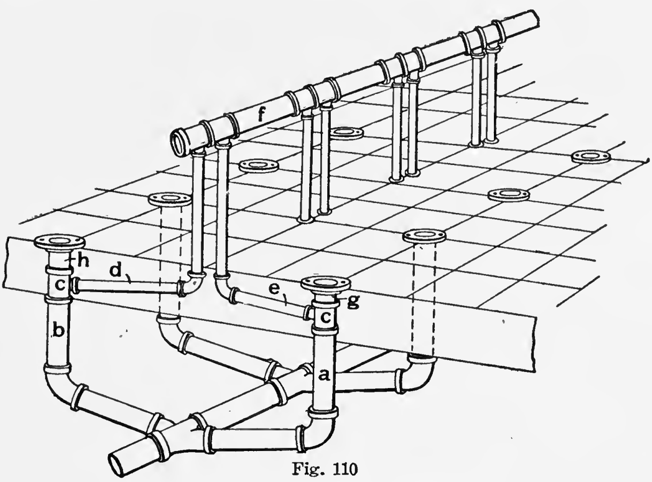

Fig. 110
Taking Back-Vent Measurements

of double Y to center of closet bend. If the pipe is to be cut and threaded where the measurements are taken the respective fittings can be laid in their proper places, as shown in Fig. 109, and the actual lengths of pipe measured.

The drainage and vent pipes, for the battery of closets, are shown installed in Fig. 110. When taking the measurements previously explained, measurements would also be taken for the pieces *a* and *b*, the lengths of which would be determined by measuring from the branch outlet in the soil stack to the height desired for the center of the T's, *c*, *c*, then allowing for the grade of the pipe from the soil stack outlet to the point where the elbows turn up for the closets. The back-vent pipe connections, *d*, *e*, from the soil pipes to the main vent, *f*, being 2 inches in diameter, would be cut and threaded on the premises. They would be made up with right-and-left-hand elbows, or a separate right-and-left coupling could be used. The short pieces of 4-inch pipe, *g*, *h*, would be measured and cut after the rest of the work shown had been installed.

Great care formerly had to be observed in cutting, threading and screwing in these nipples so that the flanges would be perfectly level and all finish flush with the toilet-room floor. The connection was a very difficult one to make for that reason, for a crooked thread on either end of the nipple or in the flange, would throw the fitter's measurements out of true. The ball-joint closet flange previously mentioned now makes this connection simple and easy, for the flange does not have to be screwed down so that it rests perfectly level on the floor, as the ball-joint with adjustable seat compensates for any crookedness in threads or variation in height of the flange. The illustration shows iron pipe extended clear to the closet. In practice, however, connections of lead are more frequently extended to the closet to allow for expansion of the pipes or settling of the building or stacks without injury to the piping or fixtures. The use of an ordinary lead bend, or a short piece of 4-inch lead pipe does not compensate sufficiently for the settlement of walls, floors or stacks, for the reason that lead pipe of itself is not flexible and whatever "give" there is to the lead connections to closets and slop sinks, is due to the kinking, bending, tearing or some other damage to the lead pipe. What is needed is a perfectly flexible connection or fitting which will give without damage to pipe or fixtures under a settlement of the floors, so that the closets will always remain securely seated on the floors; and which under a settlement of the soil stacks, will expand without distortion, damage or injury to pipe, fixture, joints or connection. Such a fitting is now made and can be had either in the form of a bend or as a straight piece of pipe. Small folds, corrugations or convolutions in the pipes like the folds of an accordian, draw out or fold together, according to whether they are subjected to a tension or compression stress; and, if subjected to a sidewise movement, will compress on one side and expand on the other to compensate for the lateral movement. In very tall buildings a greater amount of trouble is experienced from the settlement of floors and stacks, and in such installations, if flexible fittings or bends are not used, it is better to run the horizontal branch for a battery of closets to one side of the tier of outlets, and take the various branch connections from the side of the soil pipe and turn up to the closets with a bend, then to run directly under the tier of outlets, allowing TY fittings, or Y branches and $\frac{1}{8}$ bends to pass straight up to the closet fixtures, this latter method of course is the cheaper one and the better method when flexible connections are used.

When a pipe sketch is sent to the shop to have the pipe cut and threaded a copy should be kept by the fitter by which to check up the pipes and fittings when they are delivered to the building; also as a guide when installing the work. The machine hand in the shop, when getting out pipe to sketch, should screw the proper fitting on each piece of pipe as it is cut, and before shipping it should see that each piece is marked with the proper length and letters and that all threads are protected by screwing short pieces of pipe together or else by having couplings screwed on the threads to protect them in transit.

CHAPTER IX

PLANNING THE WORK

LAYING Out Work from Plans.—The following six illustrations show plan views of the basement, first, second, third and fourth floors of a hospital building, and a detail of the work in one of the bath rooms. In order to intelligently lay out the system of drainage pipes in this building it would first be necessary to plan in the mind the exact layout of each set of fixtures. Often it will be found that by a slight rearrangement of the fixtures in a group the stacks of soil, waste and vent pipes can be more directly run, with less cutting of walls and partitions and with considerable less labor, pipes and fittings.

It must be borne in mind that at the stage of the construction of a building when the plumbing is roughed-in there are but few partitions set; consequently, before any of the rising lines can be located the rooms in which the fixtures are to be installed must be laid out in their proper locations. When groups of fixtures on the several floors are located directly above one another the installation of the system becomes much simplified. In that case the location of the stack for the top group of fixtures is determined, and a plumb-line dropped to the basement to mark the center of the stack, which serves for the several groups of fixtures on all the floors. If the groups of fixtures on the several floors are not set directly above one another, the plumb-line would be dropped from the lowest group of fixtures and provision made for offsetting the line above the outlet for that group.

A simple way to find if the fixtures on the several floors are directly above one another is to arrange the plans together so that the outside lines of the walls all coincide, then stick a pin point through the entire set of plans where the stack for the top set of fixtures will be located and note the location of the pin hole on the lower floor plans.

To illustrate the manner of laying out the work for a group of fixtures in a bath room, take, for example, the main bath room, Fig. 111, on the fourth-story plan of the hospital building shown in subsequent illustrations.

It should be borne in mind, which full-sized plans would show, that the outside walls, *a* and *b*, Fig. 111, are furred, also that the thickness of walls would be indicated. The problem for the fitter is to find the exact location of the finished wall lines, *c* and *d*. To do so he must first learn the thickness of furring strip to be used. Assuming a thickness of furring strip of 2 inches, and allowing 1 inch for lath and plaster, would bring the inside of the walls, *a* and *b*, 3 inches from the inner surfaces of the rough walls. This allowance of 3 inches would properly locate the finished wall,

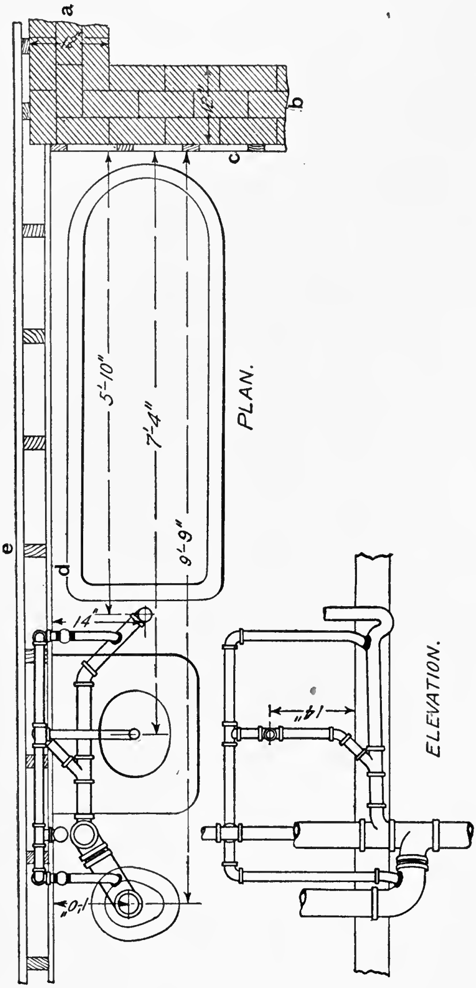

Fig. 111
Taking Measurements for Roughing-in a Bathroom

c, of the bathroom and the finished wall, *e*, of the nurses' room, which adjoins the bathroom. Having the line, *e*, and knowing the dimensions of the partition studs, the line *d* is easily obtained. For instance, if pipes were to be concealed in the partition, the studs would doubtless be 2x6. If no pipes were to be concealed, 2x4 studding would probably be used. Assuming dimensions of 2x6, and allowing 1 inch on each side of the studding for lath and plaster, would bring the line *d* 8 inches from the finished wall line, *e*, or 5 inches back from the face of the rough wall, *a*. The line *d* having been found, a strip of wood should be nailed there to preserve the place.

The location of fixture waste outlets is next in order. These outlets depend entirely on the dimensions and kinds of fixtures and fixture fittings to be used. For instance, a washout closet would have a different outlet measurement than a syphon-jet closet, and even like types of closets made by different manufacturers have different outlet measurements; so that work roughed-in for one make of closet might not be suitable for another make. It is customary, therefore, when roughing-in work to provide the foreman with sketches showing the exact measurements of the fixture to be used. In taking the measurement of bath tub outlets the fittings to be used must be known. This requirement is necessary because a combined waste-and-overflow invariably comes under the rim of a bath tub, and requires no extra space for its use, whereas a unique waste, or bell supply, requires 2 to 3 inches over the length of

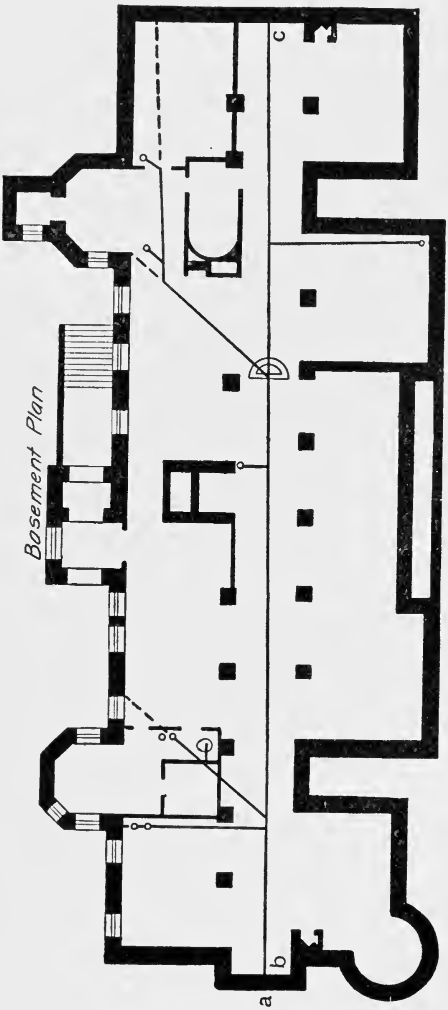

Fig. 112
Basement Plan of Hospital

the tub. Another point which must be considered in setting a bath tub is the distance it will be kept from the wall. In narrow bathrooms, where space is limited, the tub is usually set tight against the wall; while in large bathrooms, where space will permit, the bath tub is kept 6 or more inches from the wall, to allow room for cleaning back of tub.

In the case of the example, assuming a tub 5 feet 6 inches long over all, with an extra allowance of 3 inches for bell supply and waste, and allowing a total width of 2 feet 2 inches, the tub to be set 1 inch from each wall, would make the measurement for the waste outlet to the tub 5 feet 10 inches from the wall *c*, and 14 inches from wall *d*.

The waste outlet from the basin would next be considered. The edge of the basin, where space permits, should be kept at least 6 inches away from the roll rim of the tub. In the present example we will assume a basin 30 inches in width with the outlet located to the center and back, and 3 inches clear space between the edge of the basin and the bath tub. In fitting up the basin an S trap might be used, but as an S trap extends to the floor, thus taking up valuable floor space, besides being an unsightly appendage, always in the way, it is more than likely a good fitter would use a ½ S trap and extend the pipe back to the wall. The distance from the floor to the basin waste outlet must then be found. Ordinarily, a basin is set 2 feet 6 inches above the floor. If in the case of the example a trap connected to the bottom of a basin measures 16 inches to the center of the outlet from the top of basin slab, the 16 inches would

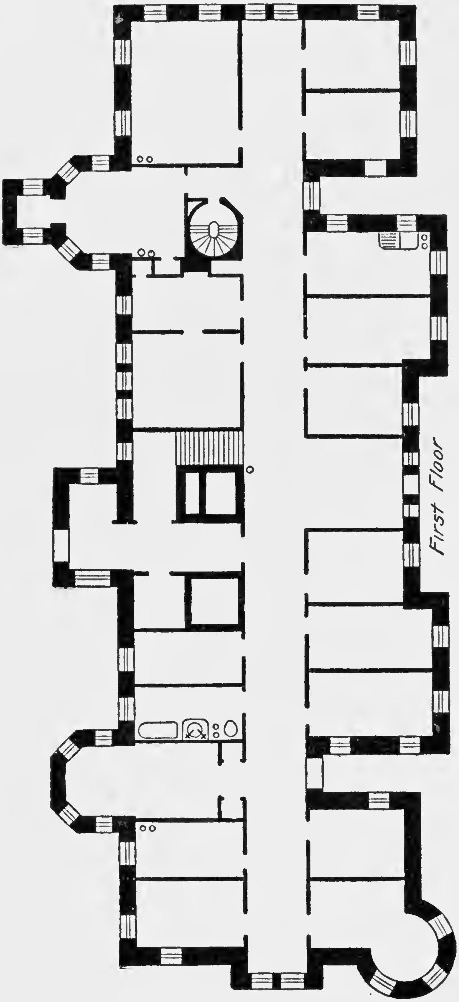

Fig. 113
First Floor Plan of Hospital

have to be deducted from 2 feet 6 inches, which would leave the distance from the floor to the center of the basin waste 14 inches. Allowing a clear space of 3 inches between the basin and the tub, then the outlet to the basin TY would be located 1 inch + 3 inches + 5 feet 9 inches + 1 foot 3 inches =7 feet 4 inches from wall *c*, and 14 inches from the floor to center of outlet.

The closet should have a clear space of at least 14 inches from the edge of the basin to center of closet; where space will permit more room should be allowed. The distance the closet waste will be set from the partition *d* can be found by measuring the closet. In the present example a distance of 1 foot will be assumed. The outlet from the closet would then be located 9 feet 9 inches from the wall *c* and 12 inches from wall *d*.

Having located the outlets to the various fixtures it next becomes necessary to locate the stacks of soil and waste pipe. It might be remarked, in passing, that reversing the order of the fixtures so that the closet would be in the corner where the bath tub now is located, and changing the bath tub to where the closet is located, would bring all the rising lines of soil, vent and waste pipe in the corner, where they would be more out of the way. However, it is not always possible to locate stacks where they would be more convenient for the fitter. He must sometimes locate them where they are least convenient, for a satisfactory layout. In the present example it will be assumed that it was necessary to locate the soil and vent stacks where shown. The branch soil, waste and vent pipes to

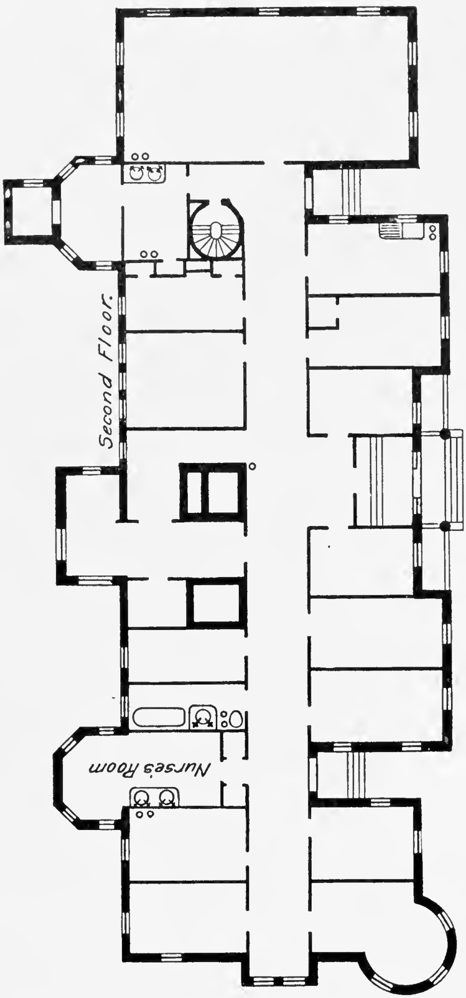

Fig. 114
Second Floor Plan of Hospital

the fixtures in the bathroom under consideration would then be run as indicated on the plan and elevation.

In roughing-in the work in a bathroom or toilet room great care must be exercised to get the proper height of the finished floor level. Should the floor level be calculated too high, part of the waste piping might project above its surface; while should the floor level be calculated too low, the fixture branches might not project through the floor a sufficient distance to be soldered to the fixture connections. All outlets to the drainage system should be securely capped or plugged to prevent the introduction of dirt into the piping and so the system will be ready for testing. Lead pipes or bends should have their ends closed by a round disk soldered in the opening. A round disk not only closes the opening for testing and the exclusion of dirt, but also preserves the shape of the pipe outlet. It is always well to take the precaution to temporarily box in exposed connections in toilet rooms to prevent their being damaged by plasterers or other workmen throwing planks on them.

When the various stacks of soil, waste and vent pipe in the building have been located in the manner indicated in the foregoing example, plumb-lines are dropped to the basement to locate the points where the various lines will intersect the house drain. Usually the run of the house drain is marked on the plans and all the fitter has to do is to follow the plan. In this case, however, it will be assumed that no house drain is shown and the

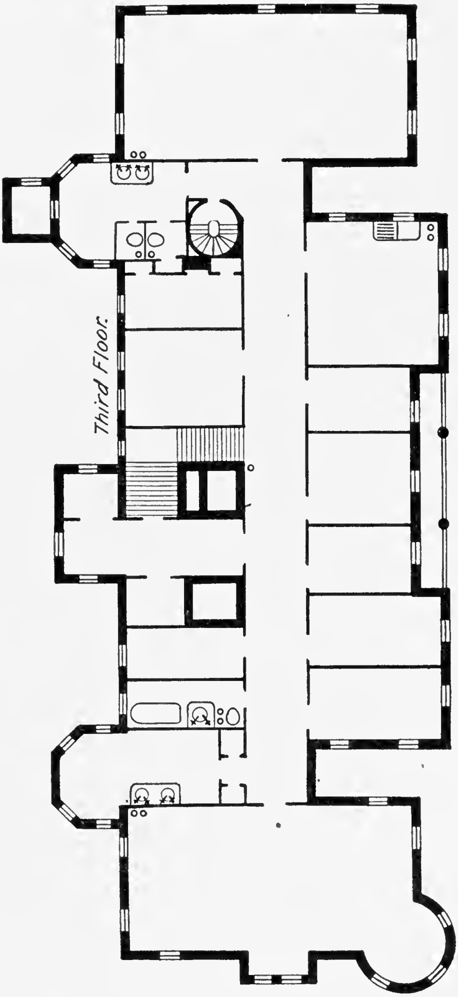

Fig. 115
Third Floor Plan of Hospital

method of laying it out and taking the measurement will be explained. To simplify the example no rain leaders will be included.

The point where the main house drain enters the building governs to a great extent the layout of the house drain in the cellar or basement of that building, and influences somewhat the manner of taking measurements. In the present example it will be assumed that the house drain enters the building at the point marked *a* on the basement plan, Fig. 112, while the rising lines of soil and waste pipe are located at the points marked on the first, second, third and fourth floor plans, Figs. 113, 114, 115 and 116. The problem, then, is to connect the various rising lines to the house drain in the most direct manner possible. The first thing is to locate the main drain. This can be done by stretching a line parallel with the outside walls of the building, from the point *b* to a point *c*. This line represents the main house drain. There are two ways of connecting the stacks to this drain. One way is to use 45-degree angle Y fittings and run the branch pipes diagonally across the building until they intersect the drain; the other is to use TY fittings and run the branch pipes at right angles to, and until they intersect, the house drain.

The kind of connection to be used will depend on local conditions. Some connections might have to be run at right angles to the house drain to avoid obstacles, while other branches might require to be run at angles of 45 degrees for the same reason. When the house drain is suspended from the basement or cellar ceiling it generally is better

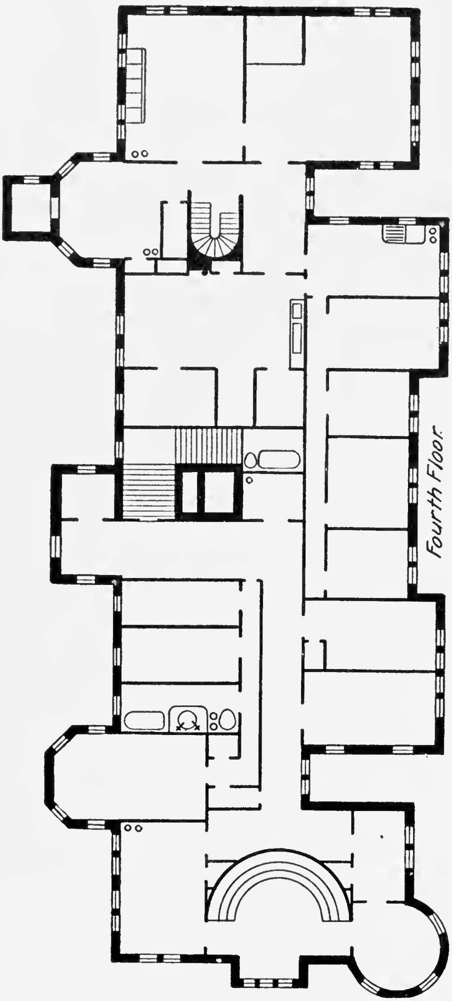

Fig. 116
Fourth Floor Plan of Hospital

to run the branches at right angles, as by this method, where long branch lines are required, they will not pass through more than one room nor cross doors leading to the corridor on the way to the house drain. Furthermore, a right-angle connection requires less pipe than does a 45-degree connection, and as it shortens the distance to be traversed by sewage from the fixture to the main drain it may be considered, in some cases, the better of the two connections. In the example it will be assumed that no structural parts of the building, nor apparatus of any kind, interferes with the use of either right-angle or 45-degree angle connections. The system would then be run as indicated by lines on the plans.

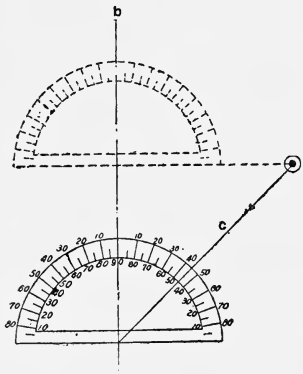

Fig. 117
Protractor

Having the points where the rising stacks turn up and the location of the house drain marked by a line, the measurements of pipe can easily be taken by means of a 10-foot rod or a tape line by following instructions previously given. A good-sized protractor, Fig. 117, will be found convenient when taking the house drain measurements. The protractor can be used to locate the point where a branch connection of any angle used in drainage work will intersect the main house drain. The manner of using the protractor is shown in the illustration. The center line of the protractor is held in line with the cord *a*, *b*, which represents the main house drain, and the protractor is then moved backward or forward until a line, *c*, connected to a nail at the point where the rising line will be located, coincides with the angle to be used. For instance, one end of the line, *c*, in the illustration is connected to the center of the bottom of a stack, and the point where the other end crosses the house sewer line when on the 45-degree angle mark of the protractor indicates where the center of a Y fitting should be located; and a cord tied to the string at this point will mark the location for a Y branch in the house drain. To find where a 90-degree bend from this stack would intersect the drain, the protractor should be moved forward to the position shown by dotted lines, when it would indicate the place or point of connection. A protractor is shown in place on the house drain in Fig. 112, where it illustrates the application, and at the same time shows more nearly its relative size. In Fig. 117 the protractor is made out of proportion to the distances indicated, in order to show in detail what a protractor looks like. This simple little instrument, which need not be longer than 2 feet, will be found useful oftentimes for measuring the degree of angle of bends about which their might be some doubt.

The method of laying out work from plans and taking measurements, given in this chapter, is merely a suggestion and need not be followed literally. The fitter must use his own judgment in each case, and originate a method of his own. For instance, if the basement floor were laid and clear of rubbish, he might strike chalk lines on the floor to represent the several runs of pipe, and take his measurements from those lines. Again, 2x4 studding may be strung along to represent where the pipes will be run, and measurements taken from the studding.

The point to make is that the layout must first be visualized in the mind, then, starting from some definite point, the work laid out and places marked to locate the different runs of pipe and the fittings.

CHAPTER X

INSTALLING WROUGHT-PIPE DRAINAGE SYSTEMS

GENERAL METHODS.—When installing drainage systems in tall steel structures, the plumbers generally work ahead of the masons and carry up their stacks of soil and waste pipe along with the iron work. By thus working ahead of the masons much time can be saved by putting the roughing-in pipes in the wall and floor spaces before the floor and wall tiles are set. Great accuracy, however, must be observed in locating rising and branch lines so they will be in their proper places. A good plan is to take all measurements from the outside walls of the building, as they will be found accurately located, whereas partitions might vary enough from the plans to throw the measurements out of place.

In many buildings it is necessary to put in the rising soil and waste lines before the house drain is installed; when such is the case it becomes necessary, after the house drain is installed, to connect the rising lines to the drain by means of some kind of a union joint.

Reversing Couplings.—Ordinary couplings, such as come with all lengths of small size wrought-pipe, are tapped without taper. This and the fact that the threads in the free end of the couplings are liable to become damaged in transit has led to the practice commonly known to the trade as reversing couplings.

When a coupling, with a straight untapered thread, at the mill is screwed onto a piece of pipe which is threaded with a taper thread, the effect is, not only to slightly expand the coupling, but also to contract the pipe. The first thing an experienced pipe-fitter does to prepare a lot of wrought-pipe for erection, is to unscrew the couplings from the random lengths, turn the couplings around, and screw them on part way again. Then when he comes to install the pipe in the building the expansion in one end of a coupling will be equalized by a previously unused thread on the pipe; and the contraction in the used thread of the pipe will be equalized by the straight thread in the un-expanded end of the coupling. Among users, as a general rule, coupling-joints have a very bad reputation; although in most instances it is merely necessary to turn the coupling around, in the manner described, to make the joint tight and strong. Reversing the couplings is advantageous in another way. Threads in the free end of a coupling are often bent or damaged in handling, so that the male thread on a pipe cannot easily be entered. By reversing the couplings before a pipe is installed, the fitter knows he will have a good thread in the coupling when he comes to use it in the building, and if it be damaged, the threads can easily be straightened at the bench when the coupling is being reversed.

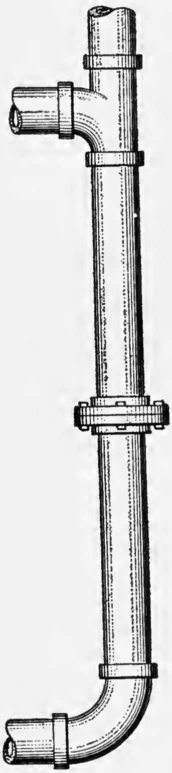

Fig. 118
Single Flange
Connection

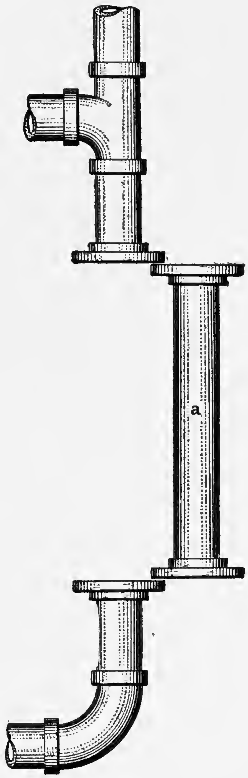

Fig. 119
Double Flange
Connection

Flange Union Joints.—The fitting most commonly used for connecting together two sections of large-size waste or vent stacks is a flange union.

When there is sufficient spring to the separate parts that are to be connected to allow for the length of thread on the last piece of pipe to be screwed in, the connection can be made with a flange union, as shown in Fig. 118. When, however, both the fittings are held rigidly in place two flange unions, as shown in Fig. 119, must be used. This permits the section *a* to be slipped into place without disturbing the other parts of the connection. Gaskets for flange unions used in a drainage system should be of sheet copper, sheet lead or asbestos sheet packing.

Right-and-Left Connections.—Connections between two sections of pipe 2 inches and smaller in diameter are usually made with right-and-left threads when there is sufficient spring to allow the right-and-left coupling or right-and-left nipple to be slipped into place. When making up a right-and-left connection the coupling is first screwed on one thread, for instance the right thread, as far as it can easily be screwed with a wrench. The coupling is then marked, after which it is unscrewed and the number of threads it was made up counted. The coupling is next screwed on the left thread and in like manner the number of threads it made up is counted. The difference between the number of threads it made up on the right threads and left threads then determines the number of turns lead it must have on one thread when being permanently put together. For instance, if the coupling made up four turns on the left thread and six turns on the right thread, in making the joint up permanently, the coupling would be started two turns on the right thread before entering the left thread. Then, when the coupling is permanently screwed on the pipe both threads will make up equally tight. If a right-and-left nipple is used instead of a right-and-left coupling the threads would be screwed up and counted in the same manner. The term right-and-left is marked on plans or pipe sketches and listed in catalogues by the abbreviation R. & L. Right-and-left couplings or nipples of larger diameters than 2 inches are seldom used.

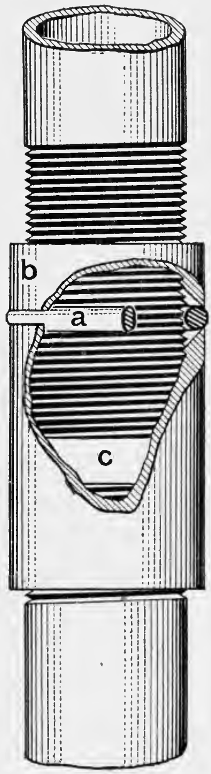

Fig. 120
Running Thread
Connection

Running-Thread Connections.—Connections are often made between pipes in drainage work by means of a running thread and coupling, as shown in Fig. 120. This is not so reliable a connection as a flange joint, but it can sometimes be used more conveniently than flange joints or other connections, and when a metal ring gasket, *a*, is used in the joint between the coupling and the follower, *b*, a perfectly tight and permanent joint is secured. To make a running-thread connection, the last piece of pipe screwed in must be cut short enough so it will slip in between the sections to be joined; then, when screwed into place it leaves a space, *c*, between the ends of the pipes which must be bridged by the coupling. Up to this time the coupling has been screwed onto the running-thread, even with the end of the pipe. When it is now unscrewed to bridge the gap between the pipe and make up on the lower thread it leaves a loose fit on the running-thread which has no taper. This loose thread is then made tight by placing a gasket of lead or soft solder, *a*, in the beveled recess of the coupling and jamming it in tight by screwing down the follower.

Pipe Supports.—All pipes, in both drainage system and water supply, should be well supported, not only to sustain the weight of the pipes and the water contained, but also to prevent the pipes from

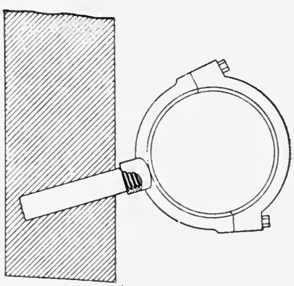

Fig. 121
Netherland Pipe Hanger

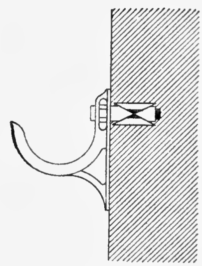

Fig. 122
Wall Bracket for Pipe

vibrating or getting out of alignment, and to withstand any other shocks and strains they might be subjected to. Usually hangers are spaced on horizontal drains about 10 feet apart, while on vertical stacks of soil, waste and vent pipe supports are

TABLE XII

SIZE AND BEARING CAPACITY OF PIPE HANGERS

Size of pipe in inches	Weight of 1 foot of pipe	Weight of pipe on hanger if placed 10 feet centers	Weight of water in 1 foot of pipe	Weight of water on hanger if placed 10 feet centers	Weight of pipe and water for 1 foot of pipe	Weight of pipe and water on hanger if placed 10 feet centers	Breaking load of hanger in lbs.	Safe load 1/4 of breaking load
1	1.67	16.70	.33	3.33	2.00	20.00	819	204
1 1/4	2.25	22.50	.57	5.70	2.82	28.20	804	201
1 1/2	2.69	26.90	.86	8.60	3.55	35.50	699	177
2	3.66	36.60	1.25	12.50	4.91	49.10	1,941	485
2 1/2	5.77	57.70	1.98	19.80	7.75	77.50	1,534	383
3	7.54	75.54	3.00	30.00	10.54	105.40	1,308	327
3 1/2	9.05	90.05	4.25	42.50	13.30	133.00	1,274	318
4	10.72	107.20	5.50	55.00	16.22	162.20	2,820	705
5	14.56	145.60	8.50	85.00	23.06	230.60	3,000	750
6	18.76	187.60	12.25	122.50	31.01	310.10	3,189	797
7	23.41	234.10	16.75	167.50	40.16	401.60	3,280	820
8	28.34	283.40	21.75	217.50	50.09	500.90	3,600	900
9	34.67	346.70	27.50	275.00	62.17	621.70	4,000	1,000
10	40.64	406.40	34.00	340.00	74.64	746.40	4,418	1,104

usually placed at each floor of the building. The strength of hangers for various sizes of pipes and the loads they must sustain when spaced ten feet apart can be found in Table XII.

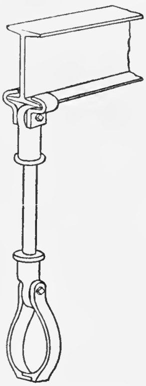

Fig. 123
Pipe Hanger for Iron Beam

Hangers and supports for hot water pipe should be so arranged as to allow for expansion and contraction.

Horizontal pipes that are run close to a wall can be well supported by Netherland hangers, Fig. 121, or by wall brackets, secured to the wall by expansion bolts, as shown in Fig. 122. When pipes are suspended from beams, pipe hangers, Fig. 123, afford a good means of support. This type of hanger is provided with a clamp to attach it to an iron I beam, while the hanger shown in Fig. 124, is provided with a lag screw, to screw into wooden beams. Both of these hangers provide for expansion and contraction, are adjustable and can be put on after the pipe is in place.

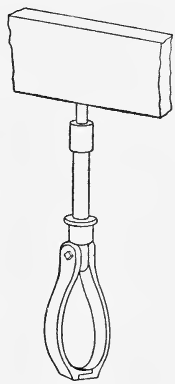

Fig. 124
Pipe Hanger for Wooden Beam

A method of securing vertical pipes to I beams, is shown in Fig. 125; with this form of hanger better results are obtained if a coupling, or fitting, is so located that it rests on the hangers. A figure-eight hanger is shown in Fig. 126. This hanger is likewise used to support vertical pipes, but only when two of them pass up on opposite sides of a beam. The last two hangers illustrated are of special design

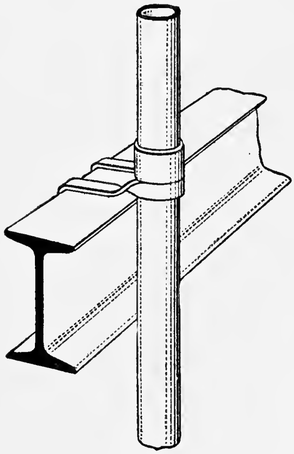

Fig. 125
Strap Iron
Hanger

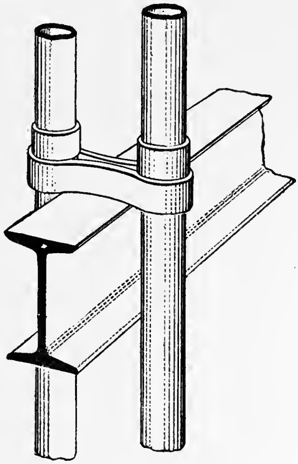

Fig. 126
Figure Eight
Hanger

and must be made by a blacksmith. The others are stock designs that can be purchased at any supply house.

Expansion of Soil and Waste Lines.—When soil and waste stacks are installed in high buildings, local conditions are such that allowance should be made for expansion and contraction; under ordinary conditions, however, in buildings of moderate height provision need seldom be made for expansion of the stacks, the spring of wrought-iron pipe and flexible joints to cast-iron pipe compensating for any variation of length due to temperature. As a matter of fact, the range of temperature during the year should not vary 40 degrees F. It is doubtful if it would vary half that much, but assuming a variation of temperature during the year of 40 degrees F. the expansion of a wrought-iron pipe in a building 200 feet high would be less than one inch. The vertical parts of a building, however, are subject to very much the same range of temperature as the pipes, and the entire building will expand correspondingly with the pipes.

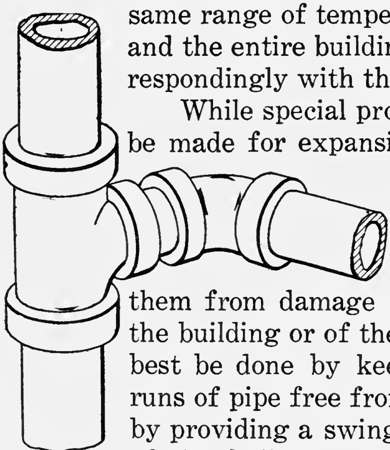

Fig. 127
Swing-Joint for Soil Stacks

While special provision need seldom be made for expansion and contraction of soil, waste or vent pipes, provision should be made to protect them from damage from settlement of the building or of the stacks. This can best be done by keeping all horizontal runs of pipe free from structural beams, by providing a swing joint at each floor of the building where long horizontal runs are taken from a vertical stack, and by providing flexible connection for all closet and slop-sink connections. A swing joint is shown in Fig. 127. It is made by placing the branch fitting in the stack at right angles to its final direction and turning it by means of an elbow and nipple, which provides a swing joint that permits a slight expansion of the stack or settlement of the building without excessively straining either pipe or fittings.

More important, still, than the swing joint, is a flexible connection for water closets and slop sinks. There are but very few buildings in which some settlement of the floors, walls or stacks does not occur. This is noticeable in many buildings when settlement or shrinkage of the floor beams has left the water closets raised from $\frac{1}{8}$ to $\frac{3}{8}$ inch above the finished floor, held in that position by the lead bends, wrought-pipes, or soil pipes, to which they are connected. On the other hand, in tall buildings, settlement of the stacks has often pulled the pipes apart at some point, usually at the closet floor flange. Owing to this liability of being first raised above the floor, and later broken, and the danger of being pulled apart, the closet connections to the drainage system in a building has always been known as the weakest point in the system and the one most liable to cause trouble. This connection can now be made perfectly secure, however, by interposing a flexible connection similar to that shown in Fig. 128, between the closet floor flange and the soil pipe. The con-

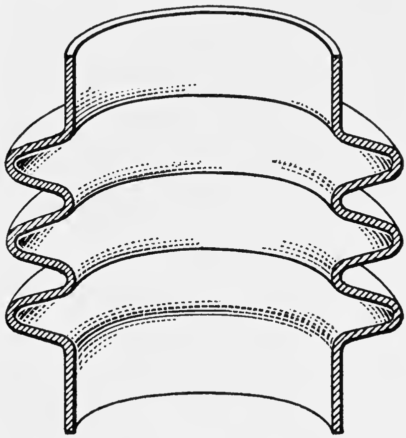

Fig. 128
Flexible Connection for Water Closets

nection can be had in the form of an ordinary lead bend, with the flexible corrugations on the vertical leg, or in the form of a straight piece of pipe. Wherever a connection similar to this is used, in case of a settlement or shrinkage of the floors, the closets will automatically adjust themselves to the new conditions by pressing the folds of the connection together, so that the bases of the closets will always remain on the floor. On the other hand, if the stack settles, instead of breaking the pipe or the closet connection as was formerly the case, the folds of the flexible connection, yielding to the stress, open to compensate for the settlement, without damage to the drainage system or the fixture. In case the soil pipe becomes pulled to one side by the settlement, the flexible connection will still compensate for the derangement, by contracting on one side and expanding on the others.

Expansion of Water Pipes.—Water pipes expand or contract for every change of temperature to which they are subjected. To provide for this variation in length expansion loops are placed in the vertical lines of water and circulation pipes in all tall buildings, to permit of expansion and contraction of the lines without injury to the pipes.

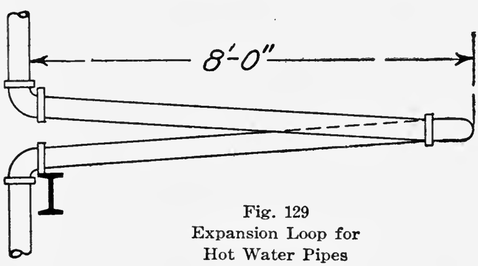

Fig. 129
Expansion Loop for
Hot Water Pipes

The loops are usually from 6 to 8 feet long, made as shown in Fig. 129, and are spaced about 50 feet apart. Usually hot water and circulation pipes are fastened midway between loops and allowed to expand both up and down.

The length that water pipes will expand depends upon the degree to which they are heated and the material of the pipes. Within ordinary ranges of temperature cast iron varies 0.00000617 of its length for each degree F. heated or cooled. Wrought-iron pipe varies 0.00000686 of its length for each degree F. heated or cooled. Hence the expansion or contraction of any pipe, when the length and temperature of water are known, can be found by the following rule:

RULE: Multiply the length of pipe in inches by the number of degrees F. it is heated or cooled, and multiply the product by the coefficient of expansion for the kind of pipe used.

Expressed as a Formula:

$$e = lhc$$

when

l = length of pipe in inches

h = degrees F. the pipe is heated or cooled

c = coefficient of expansion (0.00000617) cast iron, .00000686 wrought iron, .00001037 brass, .00000955 copper, and .00000599 steel

e = elongation of pipe in inches.

EXAMPLE: What will be the expansion of a wrought-iron pipe 100 feet long, when heated from 60 degree to 212 degree temperature?

SOLUTION: 100 feet + 12 = 1,200 inches, and 1,200 inches × 152 = 182,400 × .00000686 = 1.25 inches.

Tables of Linear Expansion.—Tables showing the linear expansion of cast-iron, wrought-iron and brass pipe for each 100 feet length at different temperatures are very convenient for reference, and are incorporated here to save the necessity for calculating the expansion of pipes, the approximate elongation being sufficient for all practical purposes. The expansion of cast-iron pipes can be found in Table XIII; that of wrought pipe is Table XIV; and the expansion of brass pipe can be found in Table XV. By multiplying the expansion in one-hundredth parts of any kind of pipe by the decimal parts of 100 or by any multiple of 100, the total expansion for that length can be determined. Thus, if at a temperature difference of 338 degrees Fahrenheit 100 feet of cast-iron pipe expands 2.5 inches, in 25 feet it would expand .25 × 2.5 = .62 inch, while in 300 feet it would expand 3×2.5=7.5 inches.

Cleaning Exposed Piping.—In the making-up of wrought pipe in the building, if a little care is exercised by the workmen, all exposed pipes can be installed with lines running parallel spaced equal distances apart throughout the entire length of the runs; the hangers put on true and in line with one another; the pipe left free from tool marks when gripped with tongs or wrenches, and all threads screwed in so they will not show where made-up into fittings. If tool marks or threads show in the

TABLE XIII
EXPANSION OF CAST-IRON PIPE

Temperature of air when pipe is fitted	Length of pipe when fitted	Length of pipe when heated to—							
		215° F.		265° F.		297° F.		338° F.	
Degrees F.	Feet	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	100	100	1.59	100	1.96	100	2.20	100	2.50
32	100	100	1.36	100	1.65	100	1.96	100	2.27
64	100	100	1.12	100	1.43	100	1.75	100	2.00

TABLE XIV
EXPANSION OF WROUGHT PIPE

Temperature of air when pipe is fitted	Length of pipe when fitted	Length of pipe when heated to—							
		215° F.		265° F.		297° F.		338° F.	
Degrees F.	Feet	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	100	100	1.72	100	2.21	100	2.31	100	2.70
32	100	100	1.47	100	1.78	100	2.12	100	2.45
64	100	100	1.21	100	1.61	100	1.87	100	2.19

TABLE XV
EXPANSION OF BRASS PIPE

Temperature of air when pipe is fitted	Length of pipe when fitted	Length of pipe when heated to—							
		215° F.		265° F.		297° F.		338° F.	
Degrees F.	Feet	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
0	100	100	2.58	100	3.18	100	3.56	100	4.05
32	100	100	2.19	100	2.79	100	3.18	100	3.67
64	100	100	1.81	100	2.41	100	2.79	100	3.28

finished work, the workmanship cannot be considered first class, nor can it if threads or pipes are crooked so that the lines are not parallel and true. Ordinarily, a good fitter straightens every length of pipe he is going to use in a long run, by taking out waves and crooks received by the pipe after it left the factory. Sometimes a fitting is found which is tapped crooked. In such cases the better plan is to set the fitting aside to use on concealed work, but if no other similar fitting is at hand, a crooked thread can be cut on the pipe to compensate for the crooked thread in the fitting.

Tool marks can generally be removed by going over them gently with a fine file, and following with a piece of fine sand paper or emery cloth.

All wrought pipe is more or less soiled and the galvanizing tarnished from exposure to weather by the time it reaches the workmen for installation, and oil, grease, and lead from the workmens hands do not add any to the appearance of the pipe by the time it is installed. This is of no importance in concealed work, but in exposed piping it is as important to remove the dirt and brighten up the pipe as it is to remove the tool marks. Wrought pipes can be cleaned after they have been installed by scouring them with a wet cloth and fine white sand, or if sand of the right quality is not obtainable, powdered pumice can be substituted, a few cents worth being sufficient for an ordinary building.

CHAPTER XI

WORKING POLISHED BRASS AND NICKEL-PLATED PIPE

BY THE exercise of a little care in handling, nickel-plated and polished brass pipes can be cut, threaded and made-up as quickly as can iron pipe, and without marring or scratching the nickel-plated or polished surface. To do so, however, it is necessary to understand the nature of a brass pipe, the tools required for handling it, and the method of using the tools. Nickel-plated pipes are generally abbreviated N. P. pipes.

Brass pipes, of iron-pipe sizes, are made in stock lengths of 12 feet, although special lengths can be had to order. The lengths are seamless drawn, can be had plain, polished or nickel-plated and tempered hard, soft or medium; the medium temper, sometimes called regular temper, is just sufficiently annealed to make it suitable for plumbing and steam work. Seamless brass pipes, of iron-pipe sizes, are made only up to 6 inches in diameter; up to that size they may be had in standard and extra-heavy weight, which correspond, in safe-working pressure, with standard and extra-heavy wrought iron pipes.

The sizes and weights of iron pipe sizes of brass pipe may be found in Table XVI:

TABLE XVI

SIZES AND WEIGHTS OF SEAMLESS BRASS TUBING

IRON PIPE SIZE Inches	⅛	¼	⅜	½	1	1¼	1½
Weights per lin. foot	.25	.43	.62	.90	1.25	1.70	2.50
IRON PIPE SIZE Inches	2	2½	3	3½	4	5	
Weights per lin. foot	3.00	4.00	5.75	8.30	10.90	12.75	

Brass fittings should correspond in finish with the pipes they join. The fittings are similar in pattern to beaded malleable iron fittings.

Vise Jaws for Nickel-Plated Pipe.—Ordinary vise jaws cannot be used for holding polished brass or nickel-plated pipes on account of the way they would crush the pipe and mar the surface. In place of the toothed jaws of the ordinary vise, friction jaws, which may be held by the jaws of an ordinary vise, are substituted. A common practice is to split along its center axis a piece of brass pipe about 3 inches long and two sizes larger than the pipe to be cut, and place the split piece of pipe in the jaws of the pipe vise, where they serve as friction jaws to hold the nickel-plated pipe. The pipe to be worked is not placed directly in the friction jaws, however,

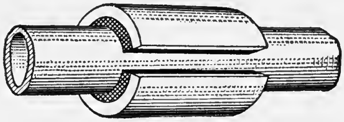

Fig. 130
Vise and Wrench Jaws or Clamp for Brass Pipe

but is imbedded in plaster of paris or powdered rosin, which keeps the pipe from turning and at the same time protects the polished or nickel-plated surface from being scratched if the pipe should accidentally be turned. Powdered rosin holds the stronger, but is harder to remove from the pipe after the thread is cut; for this reason plaster of paris is more commonly used for the friction bed. When rosin is used and clings fast to the pipe, it can be removed by wiping the pipe with a cloth moistened with gasoline.

A better set of clamps for a vise, and a set that can be used also for making up the pipe, is shown in Fig. 130. The clamps are made by splitting in two longitudinally a wrought-iron pipe coupling two sizes larger than the pipe to be held, then casting on the inner side solder linings that just fit the circumference of the pipe. The threads of the coupling hold the solder lining firmly in place, while the solder presents a soft surface to the pipe it holds should the plaster of paris or rosin fall away. Sometimes friction clutches, made either of split pipe or couplings and lined with sheet lead, are used.

A hinged vise is the most convenient to use when working polished brass or nickle-plated pipe. The top part of the vise can then be thrown back, the lower jaw placed in the vise and covered with plaster, more plaster then placed on top of the pipe, the top jaw placed in position, the vise closed, tightened, and the pipe is ready to cut, thread and screw a fitting on.

Cutting and Threading Brass Pipe.—For cutting brass pipe a good, sharp cutter should be used. Brass pipe is much softer than wrought-iron and steel pipe, and a much larger burr will be formed on the inside of brass pipe if a dull cutter be used. When the pipe is cut the end should be reamed to remove the burr. For threading brass pipes adjustable dies are most suitable. The thread can then be gauged to suit the tapping of the fittings, so that when the fittings are made-up no portion of the thread will show, and the pipe and fittings will present a smooth, continuous surface unbroken by patches of brass showing through the nickel-plating. Water must be used freely when cutting brass threads to keep chip from becoming hot and cleaving with rough edges. Water, used when cutting brass pipe, takes the place of lard or cottonseed oil used when cutting iron-pipe threads. Care must be taken when cutting threads on brass pipe to wrap paper around the pipe where the guide presses against its surface. The paper not only guides the die truer, so as to make a more perfect thread, but also protects the nickel-plating from abrasion of the iron guide. The number of threads on the end of a brass pipe are usually less than on an iron pipe. On a brass pipe five or six threads including the imperfect threads generally are sufficient.

Bending Brass Pipe.—Brass pipe or nickel-plated brass pipe can be bent into any reasonable shape much easier than can iron pipe and almost as easily as can lead pipe; furthermore, the bending can be accomplished without in any way injuring the finished surface of the pipe. The best way to bend brass pipe is to drill a hole through a short two-inch plank of hardwood or yellow pine, Fig. 131, and use the hole in this plank for a bending form. The soft edges of the wood give under the pressure of the pipe without in any way injuring it. Annealed pipe, generally called regular temper pipe, is the best kind for bending.

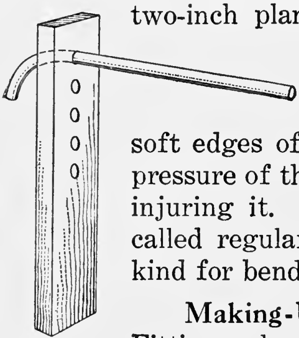

Fig. 131
Plank for
Bending
Brass Pipe

Making-Up Nickel-Plated Pipe.—Fittings should be made-up on nickel-plated pipe before the pipe is removed from the vise. This can be done by screwing a short piece of pipe in a side outlet of the fitting and using the pipe to make-up the fitting. To make-up pipe in place, special brass pipe wrenches or a Stillson wrench with pipe clamps must be used. The clamps used in the jaws of the Stillson wrench may be the same ones that are used in the pipe vise and which are shown in Fig. 130. This combination makes a very satisfactory wrench for making-up brass or nickel-plated pipe; it is inexpensive, easy to operate and possesses greater strength of grip than any other kind.

Wrenches for Nickel-Plated Pipe.—A friction pipe wrench suitable for making-up brass and nickel-plated pipes, which can be made by any fitter in a few minutes, is shown in Fig. 132. A piece of heavy canvas, or a section of light, pliable linen hose about 2 feet long, is securely bolted to a hardwood handle made of hickory, maple, ash or oak. The under side of the canvas or hose is rubbed with rosin or plaster of paris and is then ready for

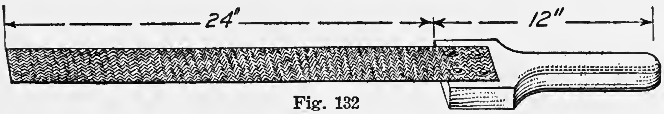

Fig. 132
Wrench for Brass and Nickel-Plated Pipe

use. The manner of using this type of wrench is shown in Fig. 133. The flexible tailpiece is wrapped around the pipe and then doubled under, so that the loop *a*, is pinched between the pipe and the handle end. Any pressure on the handle in the direction of the arrow will then tighten the tailpiece and make it more firmly grip the pipe, while an opposite pressure on the handle releases the friction clutch so that the wrench can be moved back for another grip. For making-up pipes not larger than ¾-inch in diameter a handle 12 inches long with a tailpiece 20 or 24 inches will be found the most convenient. For larger sizes of pipe longer and heavier handles and tailpieces are required. For general all-round use a wrench with 24-inch tailpiece will be found satisfactory.

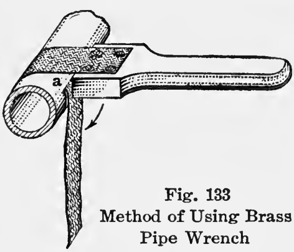

Fig. 133
Method of Using Brass Pipe Wrench

Wrenches for making up nickel-plated pipe can now be purchased from dealers in plumbing and heating supplies. One of such wrenches is shown in Fig. 134. It is a modification of the wrench shown in Fig. 132, over which it possesses no advantage except that it may be purchased ready made. The split-coupling clamps used in a vise for holding nickel-plated pipe while

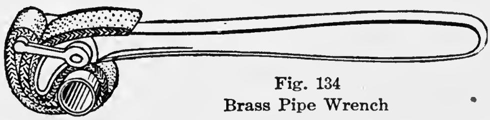

Fig. 134
Brass Pipe Wrench

being cut and threaded may likewise be used in connection with a Stillson wrench for making-up pipe. The clamps are put on the pipe to be made up with plaster of paris or rosin on the jaws, and the clamps are then gripped in the jaws of a Stillson wrench the same as would be an ordinary coupling.

Making-up Brass Pipe.—In making-up brass or nickel-plated pipes, particular care must be exercised not to stretch or split the fittings. The fittings are cast, and cast brass fittings do not possess the strength of malleable iron fittings, so that the threads cannot be screwed home until they encounter equal resistance. The best way to do is to set the dies, if adjustable, so they will cut threads of the right size to make-up perfectly tight in the fittings when the thread is all concealed. If solid dies are used, select pieces of tin of just the right weight so that when put on the teeth of the die it will cut a thread of the required size. No trouble will then be experienced in making joints perfectly tight and without any of the thread part showing. In screwing the pipes into fittings, a little lubricating oil, graphite or lead may be put on the male threads on the pipes. Never put the joint paste in the fitting as it does no particular good, and may later find its way into the water. Sometimes, when threads are a little loose they are made-up with lamp-wick. That is, a single strand of lamp-wick is wound around the thread on the end of a pipe, being placed in the depressed part, and wound so the fiber will be drawn-in not pushed out when the two parts come together. When the joint is finally made-up, this lamp-wick insures tight threads. It is much more workmanlike however, to cut the threads to a perfect fit and not depend upon paste or fiber of any kind to make the joints tight.

Brass and copper pipes, are sometimes put together with sweat-joints. To sweat joints together, a soldering salt or fluid of some kind is put on the male and female threads, which are then tinned with half-and-half solder. The fitting and pipe end are then heated until the solder is soft, and while in that condition the threads are screwed together. When the pipe and fitting cool, the joint is not only held together and made tight by a thread, but also with solder.

APPENDIX

WELDING WROUGHT PIPES BY THE THERMIT PROCESS.

IN pipe fitting practice, wrought pipes are often required to be welded end to end, instead of being connected with the usual threaded pipe couplings. Continuous pipe coils are required in creameries; well casings in oil regions are often continuous; refrigeration pipes and coils may often be welded advantageously into complete systems, and steam and water pipes aboard ship are often required to be welded. The welding of pipes, however, finds its greatest field of usefulness in connecting large sizes of pipe in the installation of refrigeration, steam and hot water service mains, buried in the streets or located in tunnels or pipe ducts. Notwithstanding the extent to which this method of connecting pipes has been carried within recent years, how many are there who know that the pipes can be welded almost as easily as a plumber wipes a solder joint on lead pipe, and by a process almost analogous. Up to within comparatively recent times the welding together of wrought pipes, end to end, in place, was almost impossible, or at all events so costly as to be almost out of reason; lately, however, the process has been made both simple and inexpensive by the introduction of Thermit into practice.

And what is Thermit?

It is simply a physical mixture of finely pulverized aluminum and iron oxide. In its original state, aluminum is found as a constituent of common gray clay. When it is separated from the clay in the heat of an electric furnace, it forms the metal aluminum, which has a marked avidity for oxygen. If it is then finely pulverized and mixed with the proper proportion of peroxide of iron, commonly called rust, it forms the reagent, Thermit. In this state it remains inert, waiting for the proper temperature to free the oxygen from the iron, when it will again unite with the aluminum with an evolution of intense heat. To start a reaction, the Thermit is ignited in one spot by the aid of about a teaspoonful of ignition powder. The combustion is then communicated throughout the mass without the aid of heat or power from the outside; and during the process of combustion, which occupies about 15 seconds, the burning mixture produces the intense temperature of approximately 5400 degrees Fahrenheit.

The intensity of this heat can better be imagined by comparing it with the fusing points of iron and steel. At a temperature of 2520 degrees Fahrenheit, or less than one-half that of Thermit, steel is reduced to a molten state. Wrought iron, which is more refractory than steel, fuses at the higher temperature of 2912 degrees Fahrenheit, which is slightly over one-half the temperature of Thermit.

It is due to this great heat produced by the combustion of Thermit, that welding of iron and steel by the process is made possible, as the excess heat is transmitted to the metals to be welded, thus raising the temperature to the welding point. During the reaction or combustion which takes place, the oxygen contained in the iron oxide combines with the pulverized aluminum to form a highly superheated liquid slag of aluminum oxide, or liquid clay. The iron, which is set free by the combining of the oxygen with the aluminum, and is heated to the same high temperature as the slag, sinks to the bottom of the crucible. Thus superheated molten iron and slag is poured around the pipes to be welded and when the required temperature is attained, the ends of the pipes are forced together and the weld is made.

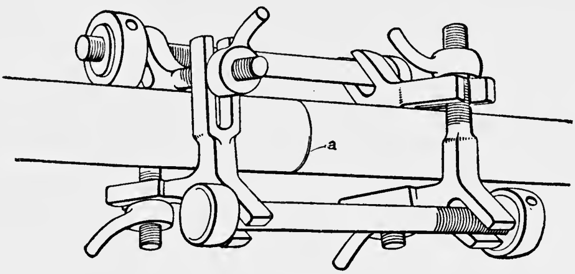

Fig. 135

Skilled labor is not necessary for this process, nor are expensive and cumbersome tools. An outfit consisting of mold, clamps, crucible and necessary wrenches is all that is required, and the process is as simple as it is quick and easy. A better idea of the manner of connecting pipes by means of a Thermit weld, will be had by referring to Fig. 135, which shows how the joints are prepared for welding. The ends of the pieces to be welded are filed perfectly true and the ends are then butted carefully together, as shown at *a*. A set of clamps, such as shown in the illustration, is then placed on the pipes, which are arranged in perfect alignment. When the pipes are ready, a cast-iron mold, similar to that shown in Fig. 136, is placed in position. This mold is made in two parts, the upper part having a gate or opening, *a*, to admit the superheated metal. In a flat-bottom crucible, held in a pair of tongs, the Thermit is ignited. After the reaction has taken place, the upper part of the vessel is filled with the slag, which occupies three times the space of the superheated liquid iron. When the whole mass is in a liquid state, the iron collects at the bottom of the crucible. Then all is ready, and the superheated liquid mass is poured into the mold through the gate. The slag flows in first, and coming into contact with the walls of the mold and the pieces of pipes to be welded, adheres in a thick layer to those surfaces, thus protecting them from contact with the liquid metal, which runs in last. When the liquid mass in the mold has softened the ends of the pipes, and raised them to a welding temperature, the pipes are forced together by means of the clamps, thus completing the weld. After the weld has chilled, the mold and clamps may be removed and the layer of slag and metal knocked off. The joint will then be found to be almost as strong as the pipe elsewhere, and the weld evidenced only by a slight up-setting of the pipe at this point.

The crucible and tongs used for firing and pouring Thermit are shown together in Fig. 137. The man who handles the tongs, as well as all his helpers, wear blue goggles to prevent being momentarily blinded by the incandescence of the liquid Thermit steel and slag.

Vertical pipes are welded as easily as those in a horizontal position, but a different shaped mold box is used for the purpose.

Thermit powder is put up in paper bags, each bag containing the quantity necessary to weld a given size of pipe; each bag is called a welding

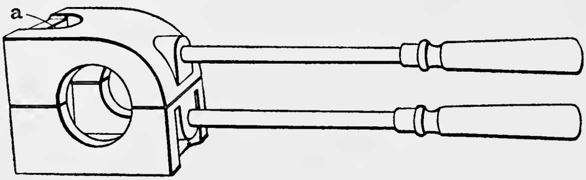

Fig. 136

portion for the size designated, so that nothing in the way of judgment in the mixing of a charge is left to the workman, who, by following instructions knows he will get a definite result from every bag of powder.

Thermit is not used exclusively but only incidentally for welding pipes. The greatest field of

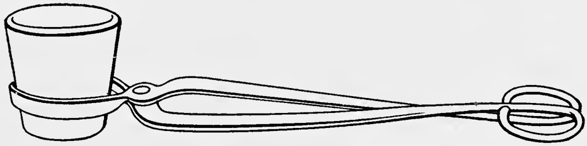

Fig. 137

usefulness is welding parts of heavy structures in place, which require great strength at the weld, and cannot be removed for repairs without great expense. It is used extensively for making repairs to steamships, locomotives and machinery of all kinds.

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