

Fundamentals of POWER PLANT ENGINEERING

by

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Dedicated to my wife
Carolyn Perkins Remp
and to my son
George E. Remp, Jr.

ERRATA AND REVISIONS
FUNDAMENTALS OF POWER PLANT ENGINEERING

by
GEORGE E. REMP

Page 9, first line after Table I: "load" should read "demand."

Page 10, second line in solution of Example 1: "load" should read "demand."

Page 11, equation in 3rd line from bottom of page: "5.3" should read "5.9."

Page 37, last paragraph on page should read:

Make a block meter rate which will recover the fixed element in the first 8 kwh per customer per month; the customer element in the next 15 kwh per customer per month; and the energy and profit elements from the excess over 23 kwh per customer per month.

Page 39, load table in Example 4: "11.2" in hours from 6 - 7 and 7 - 8 AM should read "12.2."

Page 39, 15th line from bottom of page: Annual fuel cost "\$363" should read "\$3630."

Page 39, 10th line from bottom of page: Total annual energy element "\$10803" should read "\$14070."

Page 40, section E of Example 4 should read:

E. Block meter rate:

First block:

$$\text{rate} = \frac{\$18730}{12(8000)} = \$0.195/\text{kwh for first 8 kwh}$$

Second block:

$$\text{rate} = \frac{\$27855}{12(15000)} = \$0.155/\text{kwh for next 15 kwh}$$

(continued next page)

Third block:

$$\text{rate} = \frac{\$14070 + \$15750}{12\left[\frac{365(1653)}{12} - 23000\right]} = \$0.091/\text{kwh for excess over 23 kwh}$$

Page 41, section B of Example 5: Total annual energy element "\$10803" should read "\$14070."

Page 41, section E of Example 5 should read:

E. Block meter rate:

First block:

$$\text{rate} = \frac{\$19148}{12(8000)} = \$0.199/\text{kwh for first 8 kwh}$$

Second block:

$$\text{rate} = \frac{\$28235}{12(15000)} = \$0.157/\text{kwh for next 15 kwh}$$

Third block:

$$\text{rate} = \frac{\$14070 + \$15750}{12(27300)} = \$0.091/\text{kwh for excess over 23 kwh}$$

Page 43, 10th line from bottom of page: Machine shops "7 AM to 5 PM" should read "8 AM to 5 PM."

Page 44, last paragraph should read:

(e) Set up a block meter rate which will recover the fixed element in the first 30, the customer element in the next 40 and the energy and profit elements in the excess over 70 kwh per customer per month.

Page 46, Figure IV-2: Designations of points 5_a and 5_b should be reversed.

Page 98, solution of Example 9: Last term in denominator of expression for U, " $\frac{0.75}{0.652}\left[\frac{1}{3000}\right]$ " should read " $\frac{C.75}{C.652}\left[\frac{1}{1615}\right]$ "

Page 115, 5th line from bottom of page: "on of the" should read "one of the."

Page 136, solution of Example 18: Last term in equation for M_{gd} , "0.025" should read "0.038."

Page 150, solution of Example 20: Numerator of equation for SH, "497" should read "407" and "0.24[535 - 70]" should read "0.24[535 - 70][14.82]." Add the following note: See Example 24 for determination of $M_{gs} = 14.82$.

Page 161, 5th line from bottom of page: "~~29(12)~~/4.5" should read "20(12)/4.5."

Page 162, solution of Example 22-A beginning at the third line from the top of the page should read:

If the superheater is disposed in two of three boiler passes, each pass will be 20 ft wide by 6.67 ft deep. Then the area for gas flow between the superheater tubes will be $(53 - 1)(4.5 - 2)(6.67)/12 = 72.3$ sq ft.

The mass flow of gas between the tubes will be:

$$v_g = \frac{291000}{3600(72.3)} = 1.12 \text{ lbs/sec/sq ft}$$

$$\text{and, } h_g = \frac{0.41(1.12)^{0.855} (2048)^{0.315}}{(2.0/12)^{0.415}} = 10.12$$

Then, the overall coefficient of heat transfer is:

$$U = (0.90) \frac{1}{\frac{1}{10.12} + \frac{4.0}{2.0 + 1.67} \left[\frac{0.165}{12(20)} \right] + \frac{2.0}{1.67} \left[\frac{1}{236} \right]} = 8.65$$

Superheater area is:

$$A = \frac{50,600,000}{8.65(260)} = 6800 \text{ sq ft}$$

Each foot of superheater tube has an area of $2\pi/12 = 0.523$ sq ft. There will be $6800/0.523 = 13000$ linear feet of tube, and the length of each element will be $13000/53 = 246$ feet.

Page 186, solution of Example 26-A: Viscosity " $\mu = 0.025$ " should read " $\mu = 0.022$ " and Reynolds' number " $r = 1,485,000$ " should read " $r = 1,690,000$."

Page 188, solution of Example 26-B, add at top of page:

$$\Delta h = 0.745 \frac{(0.041)(682)(2.91)^3}{3.548} = 49.5 \text{ ft of oil}$$

Page 207, Example 30, add the following:

Note: The above method of expressing entrance and exit losses is often used. Another method would be to express the entrance and exit losses as equivalent lengths of straight pipe added to the fittings, etc., when calculating the friction losses.

Page 239, 12th line from bottom of page: "states in" should read "stated in."

Page 246, equation for draft produced by a stack should read:

$$h = 0.254 B H \left(\frac{1}{T_a} - \frac{1}{T_g} \right) - 1.49 \times 10^{-5} \frac{f H W_g^2}{\rho D_i^5}$$

where: W_g = weight of flue gas, lb per hr

"f = 0.0013" for steel stacks should read "f = 0.013"

"f = 0.0018" for brick lined stacks should read

"f = 0.018."

Page 248, last part of solution of Example 34 should read:

Then, by trial in the equation for stacks:

$$0.6 = 0.00384 H - 43.4 \frac{H}{D_i^5}$$

H	160	170	180	190	200	210
D_i	13.60	10.70	9.68	9.11	8.76	8.50
HD_i	2180	1810	1740	1730	1750	1785
D_i/H	0.085	0.063	0.054	0.048	0.044	0.041

It can be seen that the product HD_i has reached a minimum at a stack height of 190 ft. This stack height by chance produces a diameter which falls within the stability range for the parameter D_i/H .

PREFACE

This book is the outgrowth of the author's experience in operating power plants and in teaching power plant engineering to students in mechanical, electrical and chemical engineering. The principal portion of the material is confined to steam power plants and is presented in what the author has found to be a logical sequence, beginning with a study of load curves and power plant economics and progressing through vapor cycles and a detailed examination of the fundamental principles of the various plant components. Chapters are added, as a matter of interest, on the subjects of the economics of load division and Diesel-electric, hydro-electric and gas turbine power plants. No attempt is made to treat the subject of power plant wiring, as this subject properly belongs to the field of the electrical engineer.

The presentation of the material in this book is based on the assumption that it will be presented as a one-semester course, and that the student is familiar with the fundamentals of engineering thermodynamics. The author prefers the project method of presentation of problems to the student because he has found that the method has the advantage of making it possible to integrate the problems into a whole which has meaning to the student. Examples are given in the text in sufficient quantity and detail to guide the student in the execution of the projects. Only one series of projects is given in the text as an aid to the instructor in preparing additional projects from materials out of his own experience.

In order to hew to the line of fundamentals, it has been found necessary to say little about the minor details of design and operation, because these only serve to obscure the job at hand, which is to give a broad picture of power plant engineering in a limited time. It is expected that the instructor will make free use of visual aids, such as motion pictures and plant inspection trips, to supplement and clarify the presentation in the text. A bibliography of selected references is given at the end of each chapter for the benefit of those students who would delve more deeply into this extremely important and intensely interesting subject.

It is a pleasure for the author to acknowledge with thanks the encouragement and assistance of Professors Newton C. Ebaugh, John A. Dent and Paul C. Hoffman of the Mechanical Engineering Department of the College of Engineering of the University of Florida; Mr. Robert B. Cowan, Engineer-Manager of the Utilities Department of the City of Jacksonville, Florida; and Mr. J. H. White, Vice-President of the Florida Power and Light Company of Miami, Florida. Thanks are also due to Mr. L. N. Rowley, Executive Editor of *Power* for permission to use many of the illustrations which originally appeared in that excellent magazine, and to Mr. L. K. Gaventa for his capable aid in making the many drawings necessary in a work of this type.

The author wishes to thank the many manufacturers and engineers who have contributed illustrations and information. An effort has been made to see that proper credit lines are attached.

George E. Remp

Gainesville, Florida
July, 1949

CONTENTS

	page
<i>Preface</i>	v
CHAPTER I	
Introduction.....	1
Growth of Power Generation in the United States. Improvement in Thermal Efficiency of Steam Power Plants. Progress in Hydro and Internal Combustion Power. Power Systems. Public Utility Organization.	
CHAPTER II	
Load Curves.....	8
Demand and Diversity. Load Curves. Factors Used in Operation Analysis. Determination of Size of Equipment.	
CHAPTER III	
Economics of Power Production.....	25
Power Plant Income. Public Utilities as Monopolies. Rates. The Fixed Element. The Energy Element. The Variable Load Element. The Customer Element. The Investor's Profit. Types of Rates. Project I.	
CHAPTER IV	
Vapor Power Cycles.....	45
Carnot Cycle. Rankine Cycle. Engine Efficiency. Reheating Cycle. Regenerative Cycle. Reheating-Regenerative Cycle. Field Cycle. Superposed Cycle. Binary Cycles.	
CHAPTER V	
Prime Movers.....	67
Steam Engines. Estimation of Steam Engine Dimensions. Steam Turbines. Engine Efficiencies and Willans' Line for Steam Turbines.	
CHAPTER VI	
Condensers, Feed-Water Heaters and Evaporators.....	89
Condensers. Mixing Condensers. Surface Condensers. Heat Transfer in Surface Condensers. Commercial Heat Transfer Standards for Surface Condensers. Feed-Water Heaters. Open Heaters. Closed Heaters. Vacuum Pumps.	

Water Cooling Equipment. Evaporators. Project II.	
CHAPTER VII	
Fuels and Combustion.....	117
Coal. Fuel Oil. Natural Gas. Combustion. Heating Value of Fuels. Flue Gas Analysis.	
CHAPTER VIII	
Steam Generators.....	130
Steam Generator Efficiency. Fire-Tube Boilers. Water-Tube Boilers. Heat Transfer in Boilers. Water-Cooled Furnaces. Furnace Refractories and Insulation.	
CHAPTER IX	
Superheaters, Reheaters, Economizers and Air Heaters.....	156
Superheaters. Heat Transfer in Superheaters. Reheaters. Economizers. Heat Transfer in Economizers. Air Heaters. Heat Transfer in Air Heaters. Apportionment of Heating Surface.	
CHAPTER X	
Piping and Duct-Work.....	175
Piping. Friction in Condensers and Feed-Water Heaters. Duct-Work. Pipe and Duct Insulation. Project III.	
CHAPTER XI	
Water Handling Equipment.....	200
Types of Pumps. Head and Work Relations in Pumps. Pump Efficiencies. Laws of Similarity for Centrifugal Pumps. Water Treatment. Precipitation Softening. Base Exchange Softening. Boiler Water Treatment.	
CHAPTER XII	
Fuel Handling Equipment.....	221
Gas Burning Equipment. Fuel Oil Burning Equipment. Coal Burning Equipment. Stokers. Pulverizers. Pulverized Coal Burners. Horizontal Cyclone Burner. Furnace Bottoms. Multiple Fuel Burning Installations. Ash Removal Systems. Dust Collectors.	
CHAPTER XIII	
Draft Equipment.....	236
Fans. Head and Work Relations in Fans. Fan Speeds. Draft Losses. Stacks.	
CHAPTER XIV	
Supervisory and Control Equipment.....	249
Temperature. Pressure. Speed. Fluid Level. Combustion. Chemical Characteristics. Fluid Flow.	

CONTENTS

ix

CHAPTER XV

The Complete Power Plant.....265
Details of Design. Power Plant Buildings. Project IV.

CHAPTER XVI

Economics of Load Division.....280
The Incremental Rate Theory. Division of Load. Load-
ing Schedules. Applications of the Incremental Rate
Method.

CHAPTER XVII

Diesel-Electric Power Plants.....286
Two-Stroke Diesel Cycle. Four-Stroke Diesel Cycle.
The Ideal Diesel Cycle. Supercharging. Diesel Engine
Efficiencies. Diesel Engine Auxiliaries.

CHAPTER XVIII

Hydro-Electric Power Plants.....295
Impoundment Methods. Water Storage. Hydraulic Tur-
bines.

CHAPTER XIX

Gas Turbine Power Plants.....:...303
Gas Turbine Cycles. Gas Turbine Plants.

Appendix.....307

Index.....339

LIST OF TABLES

Table	Page
I. Demand and Diversity Factors.....	9
II. Approximate Power Plant Capital Costs.....	29
III. Probable Life of Power Plant Components.....	31
IV. Design Data for Steam Engines.....	71
V. AIEE-ASME Standardized Turbine Generator Units.....	76
VI. Thermal Conductivity of Metals.....	95
VII. Standard Condenser Tube Data.....	96
VIII. Analyses of Typical American Coals.....	118
IX. Analyses of Typical Fuel Oils.....	119
X. Analyses of Typical Natural Gases.....	119
XI. Heating Value of Coal Based on Proximate Analysis.....	127
XII. Furnace Heat Release.....	147
XIII. Radiation Coefficients.....	152
XIV. Gas Mass Flows and Coefficients of Heat Transfer for Steam Generator Components.....	172
XV. Pipe Line Velocities.....	175
XVI. Dimensions of Pipe.....	176
XVII. Pipe Fittings.....	183
XVIII. Duct Velocities.....	190
XIX. Equivalent Lengths of Duct Bends.....	192
XX. Centrifugal Pump Data.....	205
XXI. Fuel Burning Rates for Stokers.....	225
XXII. Pulverizer Power Requirements.....	229
XXIII. Power Plant Fan Data.....	241
XXIV. Water Conditioning Chemistry Data.....	320
XXV. Steam Tables.....	323

TABLE XVII
continued

300-Pound Malleable Iron Fittings

WORKING PRESSURES

300 pounds steam or oil, 550° F.

- $\frac{1}{4}$ to 1-inch — 2000 pounds cold water, oil, or gas, non-shock
- $1\frac{1}{4}$ to 2-inch — 1500 pounds cold water, oil, or gas, non-shock
- $2\frac{1}{2}$ and 3-inch — 1000 pounds cold water, oil, or gas, non-shock

Dimensions, in Inches



90° Elbow



Tee



Cross



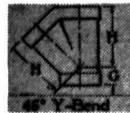
45° Elbow



90° Street Elbow



45° Street Elbow



45° Y-Bend



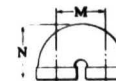
Reducer



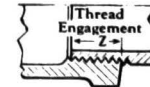
Cap



Coupling



Return Bend



Thread Engagement

APPENDIX

307

Size	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
A—Center to end	$\frac{19}{16}$	$\frac{11}{16}$	$1\frac{1}{4}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{11}{16}$	$2\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{11}{16}$	$3\frac{3}{8}$
B—Center to end, 45° Elbows	$\frac{13}{16}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{11}{16}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
C—Center to end, 90° Street Elbows	$\frac{13}{16}$	$\frac{15}{16}$	$1\frac{1}{4}$	$1\frac{7}{16}$	$1\frac{1}{2}$	$1\frac{11}{16}$	$2\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{11}{16}$	$3\frac{3}{8}$
D—Center to end, 90° Street Elbows	$\frac{17}{16}$	$1\frac{3}{8}$	2	$2\frac{3}{16}$	$2\frac{9}{16}$	$2\frac{7}{8}$	$3\frac{1}{8}$	$3\frac{11}{16}$	$4\frac{1}{2}$	$5\frac{1}{8}$
E—Center to end, 45° Street Elbows	$\frac{3}{4}$	$\frac{11}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{11}{16}$	2		
F—Center to end, 45° Street Elbows	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{9}{16}$	$1\frac{13}{16}$	$2\frac{1}{8}$	$2\frac{5}{16}$	$2\frac{11}{16}$		
G—Center to end, 45° Y-Bends			$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	2
H—Center to end, 45° Y-Bends			2	$2\frac{1}{8}$	$3\frac{1}{4}$	$3\frac{11}{16}$	$3\frac{1}{2}$	$5\frac{1}{4}$	$6\frac{1}{8}$	$6\frac{7}{8}$
J—End to end, Reducers		$\frac{17}{16}$	$\frac{11}{16}$	$1\frac{3}{4}$	2	$2\frac{3}{8}$	$2\frac{11}{16}$	$3\frac{3}{16}$	$3\frac{11}{16}$	$4\frac{1}{16}$
K—Height, Caps	$2\frac{5}{32}$	$\frac{7}{8}$	$1\frac{1}{16}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{11}{16}$	$1\frac{13}{16}$	$2\frac{1}{8}$	$2\frac{1}{4}$
L—End to end, Couplings	$1\frac{3}{8}$	$1\frac{1}{8}$	$1\frac{7}{8}$	$2\frac{1}{8}$	$2\frac{3}{8}$	$2\frac{7}{8}$	$2\frac{7}{8}$	$3\frac{5}{8}$	$4\frac{3}{8}$	$4\frac{1}{8}$
Z—Thread Engagement	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$1\frac{1}{16}$	$1\frac{1}{16}$	$1\frac{1}{16}$	$\frac{3}{4}$	$1\frac{1}{16}$	1

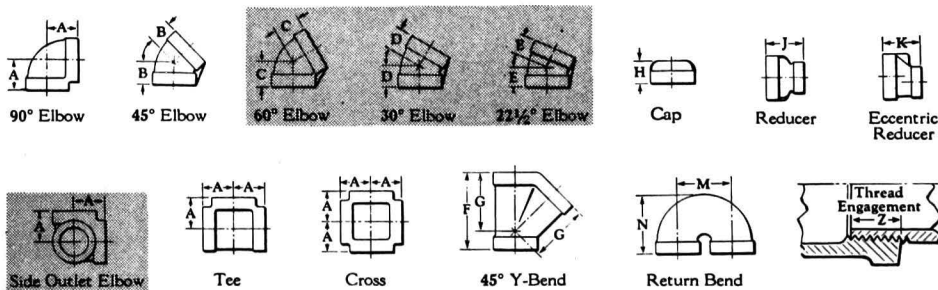
Return Bends

Size	1	1	1	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{2}$	2	2	2	2	
M—Center to center	$1\frac{3}{4}$	$2\frac{1}{2}$	3	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{8}$	$4\frac{1}{8}$	$5\frac{1}{8}$	$6\frac{1}{8}$	$7\frac{1}{8}$	8	$9\frac{1}{8}$	$10\frac{1}{8}$	$11\frac{1}{8}$	12
N—Height	$2\frac{7}{8}$	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{9}{16}$	$3\frac{11}{16}$	$3\frac{13}{16}$	$4\frac{1}{16}$	$4\frac{1}{8}$	$4\frac{1}{4}$	$4\frac{3}{8}$	$4\frac{5}{8}$	$5\frac{1}{8}$	$5\frac{3}{8}$	$5\frac{5}{8}$	$6\frac{1}{8}$	$6\frac{3}{8}$

TABLE XVII
continued

Standard Cast Iron Fittings

WORKING PRESSURES
125 pounds steam
175 pounds cold water, oil, or gas, non-shock
Dimensions, in Inches



Size	A	B	C	D	E	F	G	J	K	H	Z	Return Bends													
												Close Pattern			Open Pattern			Wide Pattern							
Size	M	N	Size	M	N	Size	M	N	Size	M	N	Size	M	N											
1/4	13/16	3/4																							
3/8	15/16	13/16																							
1/2	1 1/8	7/8	1	13/16	3/4	2 1/8	1 1/8																		
3/4	1 5/16	1	1 1/16	1 1/8	7/8	3	2 1/4	1 1/2				9/16													
1	1 1/2	1 1/8	1 1/4	1	1	3 1/2	2 3/4	1 7/8				1 1/16													
1 1/4	1 3/4	1 5/8	1 3/4	1 3/8	1 1/4	4 1/4	3 1/4	2 1/8	2 1/8			1 1/16													
1 1/2	1 15/16	1 7/8	1 3/4	1 1/2	1 1/8	4 7/8	3 13/16	2 1/4	2 1/4			1 1/8													
2	2 1/4	1 11/16	1 7/8	1 3/4	1 1/8	5 3/4	4 1/2	2 7/16	2 7/16			3/4													
2 1/2	2 11/16	1 15/16	2 1/16	1 33/16	1 1/2	6 3/4	5 1/8	2 9/16	2 11/16			1 5/16													
3	3 1/8	2 3/8	2 1/2	1 13/16	1 3/4	7 7/8	6 1/8	2 7/8	2 15/16			1													
3 1/2	3 7/16	2 3/4				8 1/2	7 1/2	3 1/8	3 1/8			1 1/16													
4	3 3/4	2 5/8	3	2 3/8	2 1/8	9 3/4	7 3/8	3 3/8	3 3/8	2 1/16	1 1/8														
5	4 1/2	3 1/16	3 3/4	2 5/8	2 1/4	11 3/4	9 3/4	3 7/8	3 7/8	2 3/8	1 1/4														
6	5 1/8	3 7/16	4 1/16	2 7/8	2 1/4	13 7/8	10 3/4	4 3/8	4 3/8	2 5/8	1 5/8														
8	6 9/16	4 1/4				16 1 5/16	13 3/4	5 1/4	5 1/4	3 1/8	1 7/16														

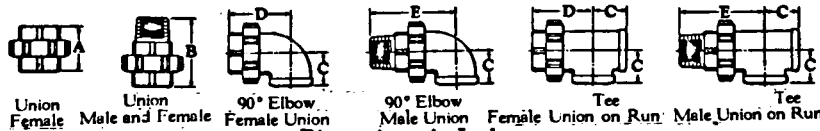
TABLE XVII
continued

Malleable Iron Unions and Union Fittings

WORKING PRESSURES

150 pounds steam

300 pounds cold water, oil, gas or gasoline, non-shock



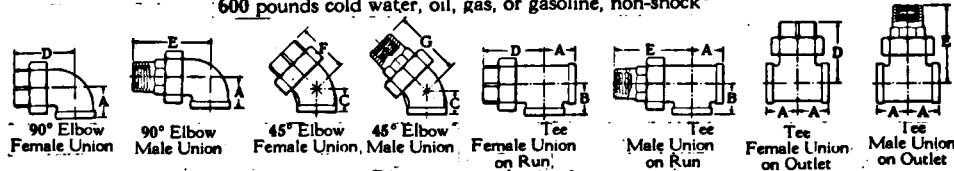
Union Female Union Male and Female 90° Elbow Female Union 90° Elbow Male Union Tee Female Union on Run Tee Male Union on Run

Dimensions, in Inches

Size	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3
A	1 1/8	1 1/2	1 11/16	1 7/8	2 1/4	2 5/8	2 3/4	2 7/8	3 1/4	3 9/16
B	2 3/16	2 3/8	2 3/4	3	3 5/8	3 3/4	3 11/16	4 1/4	4 13/16	5 1/4
C	1 3/16	1 5/8	1 1/2	1 5/8	1 1/2	1 3/4	1 11/16	2 1/4		
D	1 11/16	1 7/8	2 1/8	2 1/4	2 7/8	3 1/8	3 3/8	3 3/4		
E	2 7/8	2 3/4	3	3 3/8	3 11/16	4 1/8	4 7/8	5 1/4		

300 pounds steam, 550° F.

600 pounds cold water, oil, gas, or gasoline, non-shock



90° Elbow Female Union 90° Elbow Male Union 45° Elbow Female Union 45° Elbow Male Union Tee Female Union on Run Tee Male Union on Run Tee Female Union on Outlet Tee Male Union on Outlet

Dimensions, in Inches

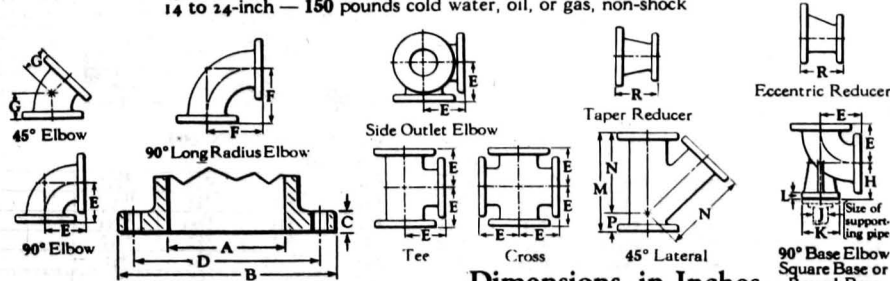
Size	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	1 x 3/4	1 x 1/2	1 x 3/8
A	1 5/16	1 1/8	1 1/4	1 7/16	1 5/8	1 11/16	2 1/8	2 1/2	2 11/16	3 3/8	1 5/8	1 7/16	1 1/2
B	1 1/8	1 1/16	1 3/8	1 7/16	1 5/8	1 11/16	2 1/8	2 1/2	2 11/16	3 3/8	1 7/16	1 1/2	1 1/16
C	1 3/16	7/8	1	1 1/8	1 5/16	1 1/2	1 11/16	2	2 1/4				
D	2	2 1/4	2 7/16	2 3/8	3 3/16	3 11/16	3 11/16	4 1/2	5 1/4	5 11/16	2 3/4	2 7/8	3
E	2 3/16	2 7/8	3 3/16	3 3/4	4 1/8	4 3/8	4 7/8	5 3/8	6 7/16	7 3/16	3 11/16	3 13/16	3 11/16
F	1 5/8	1 3/4	1 11/16	2 3/16	2 1/2	2 7/8	3 1/8	3 11/16	4 3/16				
G	2 3/16	2 7/16	2 11/16	3 1/16	3 7/16	3 13/16	4 1/8	4 3/8	5 3/16				

TABLE XVII
continued

125-Pound Cast Iron Flanged Fittings

14 to 24-inch — 100 pounds steam

WORKING PRESSURES
 1 1/2" to 2" — 125 pounds steam
 2" to 12-inch — 175 pounds cold water, oil, or gas, non-shock
 14 to 24-inch — 150 pounds cold water, oil, or gas, non-shock



Dimensions, in Inches

Size	A	B	C	D	No. of bolts	Dia. of bolts	E	EE	F	G	H	J	K	L	M	N	P	R
1 1/2	1 1/2	5	9/16	3 7/8	4	1/2	4	8	5	2 1/4	3 3/4	1	4 1/4	3/8	9	7	2	
2	2	6	5/8	4 3/4	4	5/8	4 1/2	9	6 1/2	2 1/2	4 3/4	1 1/4	4 3/4	1/2	10 1/2	8	2 1/2	8
2 1/2	2 1/2	7	1 1/16	5 1/2	4	5/8	5	10	7	3	4 3/4	1 1/4	4 3/4	1/2	12	9 1/2	2 1/2	5 1/2
3	3	7 1/2	3/4	6	4	5/8	5 1/2	11	7 3/4	3	4 3/4	1 1/4	5	5/8	13	10	3	6
3 1/2	3 1/2	8 1/2	1 3/16	7	8	5/8	6	12	8 1/2	3 1/2	5 1/4	1 1/4	5	5/8	14 1/2	11 1/4	3	6 1/2
4	4	9	1 5/16	7 1/2	8	5/8	6 1/2	13	9	4	5 1/2	2	6	3/4	15	12	3	7
5	5	10	1 5/16	8 1/2	8	3/4	7 1/2	15	10 1/4	4 1/2	6 1/4	2 1/2	7	1 1/4	17	13 1/2	3 1/2	8
6	6	11	1	9 1/2	8	3/4	8	16	11 1/2	5	7	2 1/2	7	1 1/4	18	14 1/2	3 1/2	9
8	8	13 1/2	1 1/8	11 3/4	8	3/4	9	18	14	5 1/2	8 3/4	4	9	1 5/8	22	17 1/2	4 1/2	11
10	10	16	1 3/16	14 1/4	12	7/8	11	22	16 1/2	6 1/2	9 3/4	4	9	1 5/8	25 1/2	20 1/4	5	12
12	12	19	1 1/4	17	12	7/8	12	24	19	7 1/2	11 1/4	6	11	1	30	24 1/2	5 1/2	14
14	14	21	1 3/8	18 3/4	12	1	14	28	21 1/2	7 1/2	12 1/4	6	11	1	33	27	6	16
16	16	23 1/2	1 7/16	21 1/4	16	1	15	30	24	8	13 3/4	6	11	1	36 1/2	30	6 1/2	18
18	18	25	1 9/16	22 3/4	16	1 1/8	16 1/2	33	26 1/2	8 1/2	15	8	13 1/2	1 1/8	39	32	7	19
20	20	27 1/2	1 1 1/16	25	20	1 1/8	18	36	29	9 1/2	16	8	13 3/4	1 1/8	43	35	8	20
24	24	32	1 5/8	29 1/2	20	1 1/4	22	44	34	11	18 1/2	8	13 1/2	1 1/4	49 1/2	40 1/2	9	24

TABLE XVII
continued

250-Pound Cast Iron Flanged Fittings

WORKING PRESSURES

250 pounds steam

400 pounds cold water, oil, or gas, non-shock



90° Elbow



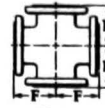
45° Elbow



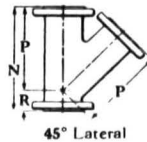
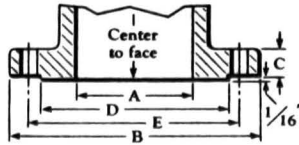
Taper Reducer



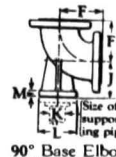
Tee



Cross



45° Lateral



90° Base Elbow
Square Base or
Round Base

Dimensions, in Inches

Size	A	B	C	D	E	No. of bolts	Dia. of bolts	Dimensions, in Inches														
								F	FF	G	H	J	K	L	M	N	P	R	S			
2	2	6 1/2	7/8	4 3/16	5	8	5/8	5	10	6 1/2	3	4 1/2	1 1/4	5 1/4	3/4	11 1/4	9	12 1/4	8			
2 1/2	2 1/2	7 1/2	1	4 15/16	5 7/8	8	3/4	5 1/2	11 1/2	7	3 1/2	4 3/4	1 1/4	5 3/4	3/4	12	10 1/4	13 1/4	5 1/2			
3	3	8 1/4	1 1/8	5 1 1/16	6 5/8	8	3/4	6	12	7 3/4	3 1/2	5 1/4	1 1/4	6 1/4	13/16	14	11	3	6			
3 1/2	3 1/2	9	1 3/16	6 5/16	7 1/4	8	3/4	6 1/2	13	8 1/4	4	5 5/8	1 1/2	6 1/8	1 13/16	15 1/2	12 1/2	3	6 1/2			
4	4	10	1 1/4	6 15/16	7 3/4	8	3/4	7	14	9	4 1/2	6	2	6 1/2	1 3/8	16 1/2	13 1/2	3	7			
5	5	11	1 3/8	8 5/16	9 1/4	8	3/4	8	16	10 3/4	5	6 3/4	2 1/2	7 1/2	1	18 1/2	15	3 1/2	8			
6	6	12 1/2	1 7/16	9 1 1/16	10 5/8	12	3/4	8 1/2	17	11 1/4	5 1/2	7 1/2	2 1/2	7 1/2	1	21 1/2	17 1/2	4	9			
8	8	15	1 5/8	11 5/16	13	12	7/8	10	20	14	6	9	4	10	1 1/4	25 1/2	20 1/2	5	11			
10	10	17 1/2	1 7/8	14 1/16	15 1/4	16	1	11 1/2	23	16 1/2	7	10 1/2	4	10	1 1/4	29 1/2	24	5 1/2	12			
12	12	20 1/2	2	16 7/16	17 3/4	16	1 1/8	13	26	19	8	12	6	12 1/4	1 1/16	33 1/2	27 1/4	6	14			

TABLE XVII
continued

125-Pound Cast Iron Flanges 250-Pound

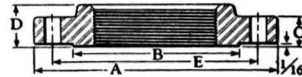
WORKING PRESSURES

- 1 to 12-inch — 125 pounds steam
- 14 to 24-inch — 100 pounds steam
- 1 to 12-inch — 175 pounds cold water, oil, or gas, non-shock
- 14 to 24-inch — 150 pounds cold water, oil, or gas, non-shock



Size of pipe Inches	Dimensions, in Inches					
	A	B	C	D	No. of Bolts	Dia. of Bolts
1	4 1/4	7/16	1 1/16	3 3/8	4	1/2
1 1/4	4 5/8	1/2	1 3/16	3 1/2	4	1/2
1 1/2	5	9/16	7/8	3 7/8	4	1/2
2	6	5/8	1	4 3/4	4	5/8
2 1/2	7	1 1/16	1 3/16	5 1/2	4	5/8
3	7 1/2	3/4	1 1/4	6	4	5/8
3 1/2	8 1/2	13/16	1 1/4	7	8	5/8
4	9	1 5/16	1 5/16	7 1/2	8	5/8
5	10	1 5/16	1 7/16	8 1/2	8	3/4
6	11	1	1 9/16	9 1/2	8	3/4
8	13 1/2	1 1/8	1 3/4	11 3/4	8	3/4
10	16	1 3/16	1 15/16	14 1/4	12	7/8
12	19	1 1/4	2 3/16	17	12	7/8
14 OD	21	1 3/8	2 1/4	18 3/4	12	1
16 OD	23 1/2	1 7/8	2 1/2	21 1/4	16	1
18 OD	25	1 9/16	2 11/16	22 3/4	16	1 1/8
20 OD	27 1/2	1 11/16	2 7/8	25	20	1 1/8
24 OD	32	1 7/8	3 1/4	29 1/2	20	1 1/4

- ### WORKING PRESSURES
- 250 pounds steam
 - 400 pounds cold water, oil, or gas, non-shock

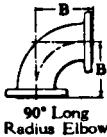
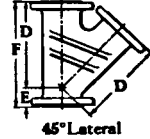
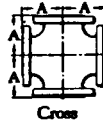
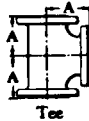


Dimensions, in Inches						
A	B	C	D	E	No. of Bolts	Dia. of Bolts
4 1/2	2 11/16	1 1/16	7/8	3 1/2	4	5/8
5 1/8	3 1/16	3/4	1	3 5/8	4	5/8
6 1/8	3 9/16	1 3/16	1 1/8	4 1/2	4	3/4
6 1/2	4 3/16	7/8	1 1/4	5	8	5/8
7 1/2	4 15/16	1	1 7/16	5 5/8	8	3/4
8 1/4	5 11/16	1 1/8	1 9/16	6 5/8	8	3/4
9	6 5/16	1 3/16	1 5/8	7 1/4	8	3/4
10	6 15/16	1 1/4	1 3/4	7 5/8	8	3/4
11	8 5/16	1 3/8	1 7/8	9 1/4	8	3/4
12 1/2	9 11/16	1 7/16	2	10 5/8	12	3/4
15	11 15/16	1 5/8	2 3/16	13	12	7/8
17 1/2	14 1/16	1 7/8	2 3/8	15 1/4	16	1
20 1/2	16 7/16	2	2 9/16	17 3/4	16	1 1/8
23	18 11/16	2 1/4	2 11/16	20 1/4	20	1 1/4
25 1/4	21 1/16	2 1/4	2 7/8	22 1/4	20	1 1/4
28	23 9/16	2 3/4	3 1/8	24 1/4	24	1 1/4
30 1/2	25 5/16	2 1/2	3 1/16	27	24	1 1/4
36	30 1/16	2 3/4	3 11/16	32	24	1 1/2

TABLE XVII
continued

Cast Steel Flanged Fittings

Dimensions, in Inches



Class	Size	A	B	C	D	E	F	G	H	J	K
150 Pound	1	3½	5	1¾	5¾	1¾	7½				
	1¼	3¾	5½	2	6¼	1¾	8				
	1½	4	6	2¼	7	2	9				
	2	4½	6½	2½	8	2½	10½	5	4½	4¾	½
	2½	5	7	3	9½	2½	12	8½	4½	4¾	½
	3	5½	7¾	3	10	3	13	6	4¾	5	¾
	3½	6	8½	3½	11¼	3	14½	6½	5¼	5	¾
	4	6½	9	4	12	3	15	7	5½	6	¾
	5	7½	10¼	4½	13½	3½	17	8	6¼	7	1½
	6	8	11½	5	14½	3½	18	9	7	7	1½
	8	9	14	5½	17½	4½	22	11	8¾	9	1½
	10	11	16½	6½	20½	5	25½	12	9¾	9	1½
	12	12	19	7½	24½	5½	30	14	11¼	11	1
	14	14	21½	7½	27	6	33	16	12¾	11	1
	16	15	24	8	30	6½	36½	18	13¾	11	1
	18	16½	26½	8½	32	7	39	19	15	13½	1¼
	20	18	29	9½	35	8	43	20	16	13½	1¼
	24	22	34	11	40½	9	49½	24	18½	13½	1¼
300 Pound	1	4	5	2¼	6½	2	8½	4½			
	1¼	4¼	5½	2½	7¼	2¼	9½	4½			
	1½	4½	6	2¾	8½	2½	11	4½			
	2	5	6½	3	9	2½	11½	5	4½	5¼	¾
	2½	5½	7	3½	10½	2½	13	5½	4¾	5½	¾
	3	6	7¾	3½	11	3	14	6	5¼	6¼	1¼
	3½	6½	8½	4	12½	3	15½	6½	5¾	6½	1½
	4	7	9	4½	13½	3	16½	7	6	6½	¾
	5	8	10¼	5	15	3½	18½	8	6¾	7½	1
	6	8½	11½	5½	17½	4	21½	9	7½	7½	1
	8	10	14	6	20½	5	25½	11	9	10	1¼
	10	11½	16½	7	24	5½	29½	12	10½	10	1¼
12	13	19	8	27½	6	33½	14	12	12½	1½	

TABLE XVII
continued

Cast Steel Flanged Fittings

Dimensions, in Inches (Cont.)

Class	Size	A	C	D	E	F	G
600 Pound	1/2	3 1/4	2	5 1/4	1 1/4	7 1/2	5
	3/4	3 3/4	2 1/2	6 3/4	2	8 3/4	5
	1	4 1/4	2 1/2	7 1/4	2 3/4	9 1/2	5
	1 1/4	4 1/2	2 3/4	8	2 1/2	10 3/4	5
	1 1/2	4 3/4	3	9	2 3/4	11 3/4	5
	2	5 3/4	4 1/4	10 1/4	3 1/2	13 3/4	6
	2 1/2	6 1/2	4 1/2	11 1/2	3 1/2	15	6 3/4
	3	7	5	12 3/4	4	16 3/4	7 1/4
	3 1/2	7 1/2	5 1/2	14	4 1/4	18 1/4	7 3/4
	4	8 1/2	6	16 1/2	4 1/2	21	8 3/4
	5	10	7	19 1/4	6	25 1/2	10 1/4
	6	11	7 1/2	21	6 1/2	27 1/2	11 3/4
8	13	8 1/2	24 1/2	7	31 1/2	13 3/4	
10	15 1/2	9 1/2	29 1/2	8	37 1/2	16 3/4	
12	16 1/2	10	31 1/2	8 1/2	40	16 3/4	
900 Pound	3	7 1/2	5 1/2	14 1/2	4 1/2	19	7 1/4
	3 1/2	8 1/2	6	16 1/2	4 1/2	21	8 3/4
	4	9	6 1/2	17 1/2	5 1/2	23	9 1/4
	5	11	7 1/2	21	6 1/2	27 1/2	11 1/4
	6	12	8	22 1/2	6 1/2	29	12 1/4
	8	14 1/2	9	27 1/2	7 1/2	35	14 1/4

Class	Size	A	C	D	E	F	G
1500 Pound	1 1/2	6	4 1/4	11	3 1/2	14 1/2	6 1/4
	2	7 1/4	4 3/4	13 1/4	4	17 1/4	7 1/4
	2 1/2	8 1/4	5 1/4	15 1/4	4 1/2	19 3/4	8 1/4
	3	9 1/4	5 3/4	17 1/4	5	22 3/4	9 1/4
	3 1/2	9 3/4	6 1/4	18 1/4	5 1/2	23 3/4	9 3/4
	4	10 3/4	7 1/4	19 1/4	6	25 1/4	10 3/4
	5	13 1/4	8 1/4	23 1/4	7 1/2	30 3/4	13 1/4
	6	13 3/8	9 3/8	24 3/8	8 1/8	33	14 3/8
8	16 3/8	10 3/8	29 3/8	9 3/8	39	17	
2500 Pound	1 1/2	5 3/16					
	3/4	5 3/8					
	1	6 1/16	4				
	1 1/4	6 7/8	4 1/4				
	1 1/2	7 9/16	4 3/4				
	2	8 7/8	5 3/4	15 1/4	5 1/4	20 1/2	9 1/2
	2 1/2	10	6 1/4	17 1/4	5 3/4	23	10 1/2
	3	11 3/8	7 1/4	19 3/4	6 3/4	26 1/2	11 3/4
	4	13 1/4	8 1/2	23	7 3/4	30 3/4	13 1/2
	5	15 5/8	10	27 1/4	9 1/4	36 1/2	15 3/4
	6	18	11 1/2	31 1/4	10 1/2	41 3/4	18
	8	20 3/8	12 3/4	35 1/4	11 3/4	47	20 1/2
10	25	16	43 1/4	14 3/4	58	25 1/2	
12	28	17 3/4	49 1/4	16 1/4	65 1/2	29	

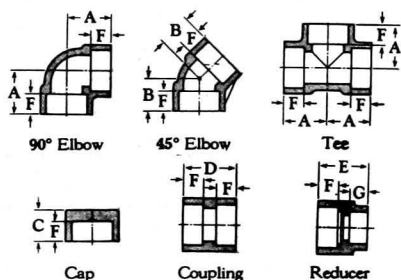
FORGED STEEL SOCKET WELDING
FITTINGS

DIMENSIONS, IN INCHES
(For Standard and Extra Strong Fittings)

WORKING PRESSURES

Pounds per Square Inch — Non-Shock

Temp. Deg. F.	Crane Carbon Steel Fittings		No. 4 Carbon-Molybdenum Steel Fittings (Made to order)	
	Stand-ard	Extra Strong	Stand-ard	Extra Strong
100	2000	3000	2000	3000
150	1900	2850	1900	2850
200	1800	2700	1800	2700
250	1700	2550	1700	2550
300	1600	2400	1600	2400
350	1500	2250	1500	2250
400	1400	2100	1400	2100
450	1300	1950	1300	1950
500	1200	1800	1200	1800
550	1120	1680	1150	1725
600	1040	1560	1100	1650
650	960	1440	1050	1575
700	880	1320	1000	1500
750	800	1200	950	1425
800	740	1100	900	1350
850	670	1000	850	1275
900	600	900	800	1200
950	530	795	640	960
1000	380	570	540	810

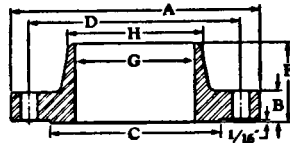


Size	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2
A	1 3/16	1 3/32	1 1/2	1 5/16	1 1/2	1 3/4	2	2 3/8
B	1 1/16	1 3/16	7/8	1	1 1/8	1 5/16	1 7/16	1 11/16
C	3/4	7/8	1	1 1/8	1 1/8	1 3/4	1 3/8	1 1/2
D	1 3/8	1 1/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/4
E		1 3/8	1 1/2	1 5/8	1 3/4	2	2 1/8	2 1/4
F	7/16	9/16	5/8	1 1/16	3/4	1 3/16	7/8	1
G	Depth same as "F", depending on pipe size; e.g. 1/4" has socket 1/8" deep.							

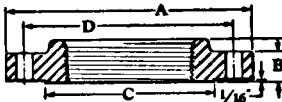
TABLE XVII
continued

Forged Steel Flanges

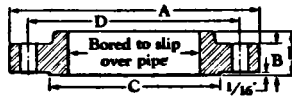
Dimensions, in Inches



Welding Neck Flange
150 and 300-Pound



Screwed Flange
150 and 300-Pound



Slip-On Welding Flange
150 and 300-Pound

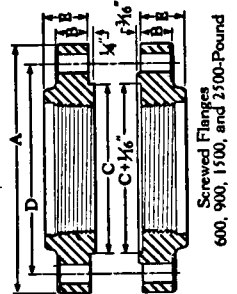
Class	Pipe Size	A	B	C	D	Bolts No.	Dis.	E	F	G	H
150 Pound	1	4 1/4	5/16	2	3 1/2	4	1 1/2	3/4	2 3/16	1.05	1.32
	1 1/4	4 5/8	3/8	2 1/2	3 1/2	4	1 1/2	13/16	2 1/4	1.38	1.66
	1 1/2	5	11/16	2 3/4	3 3/4	4	1 1/2	1/2	2 7/16	1.61	1.90
	2	6	3/4	3 3/8	4 3/4	4	1 1/2	1	2 1/2	2.07	2.38
	2 1/2	7	7/8	4 1/4	5 1/2	4	1 1/2	1 1/8	2 3/4	2.47	2.88
	3	7 1/2	15/16	5	6	4	1 1/2	1 1/4	2 3/4	3.07	3.50
	3 1/2	8 1/4	1 1/16	5 3/4	7	4	1 1/2	1 1/2	2 5/8	3.58	4.08
	4	9	1 1/8	6 3/8	7 1/2	4	1 1/2	1 1/2	3	4.03	4.50
	5	10	1 1/4	7 1/8	8 1/2	4	1 1/2	1 1/2	3 1/2	5.05	5.56
	6	11	1 1/2	8 1/4	9 1/2	4	1 1/2	1 1/2	3 3/4	6.07	6.63
	8	13 1/2	1 5/8	10 3/4	11 3/4	4	1 1/2	1 3/4	4	7.98	8.63
	10	16	1 3/4	12 3/4	14 1/4	12	1 1/2	2 1/8	4	10.02	10.75
	12	19	1 7/8	15	17	12	1 1/2	2 3/8	4 1/2	12.00	12.75
	14 OD	21	1 7/8	16 3/4	18 3/4	12	1	2 1/4	5		14.00
16 OD	23 1/2	1 7/8	18 1/2	21 1/4	16	1	2 1/2	5	Bore as ordered	16.00	18.00
18 OD	25	1 7/8	21	22 3/4	16	1 1/2	2 11/16	5 1/2		18.00	20.00
20 OD	27 1/2	1 7/8	23	25	20	1 1/2	2 7/8	5 11/16		20.00	24.00
24 OD	32	1 7/8	27 1/4	29 1/2	20	1 1/4	3 1/4	6		24.00	
300 Pound	1	4 7/8	1 1/16	2	3 1/2	4	1 1/2	1 1/8	2 7/16	1.05	1.32
	1 1/4	5 1/4	3/8	2 1/2	3 3/8	4	1 1/2	1 1/8	2 9/16	1.38	1.66
	1 1/2	6 1/4	1 3/16	2 3/4	4 1/4	4	1 1/2	1 3/8	2 11/16	1.61	1.90
	2	6 1/2	1/2	3 3/8	5	4	1 1/2	1 5/8	2 3/4	2.07	2.38
	2 1/2	7 1/2	1	4 1/4	5 5/8	4	1 1/2	1 1/2	3	2.47	2.88
	3	8 1/4	1 1/8	5	6 3/4	4	1 1/2	1 11/16	3 1/4	3.07	3.50
	3 1/2	9	1 1/4	5 3/4	7 1/2	4	1 1/2	1 3/4	3 1/2	3.58	4.08
	4	10	1 1/2	6 3/8	7 3/4	4	1 1/2	1 7/8	3 3/4	4.03	4.50
	5	11	1 3/4	7 1/8	9 1/4	4	1 1/2	2	3 3/4	5.05	5.56
	6	12 1/2	1 7/8	8 1/2	10 3/4	12	1 1/2	2 1/8	3 3/4	6.07	6.63
	8	15	1 5/8	10 3/4	13	12	1 1/2	2 7/8	4 3/4	7.98	8.63
	10	17 1/2	1 3/4	12 3/4	15 1/4	16	1	2 3/4	4 3/4	10.02	10.75
12	20 1/2	2	15	17 3/4	16	1 1/2	2 7/8	5 1/4	12.00	12.75	

TABLE XVII
continued

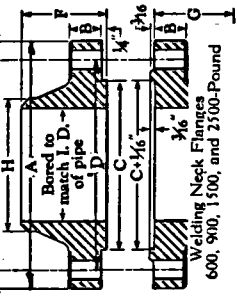
Forged Steel Flanges

Dimensions, in Inches (Cont.)

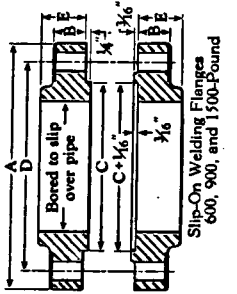
Class	Pipe Size	A	B	C	D	Bolts No. | Dia.		E	F	G	H	
600 Pound	1/2	3 3/4	9/16	1 3/8	2 1/8	4	1/2	7/8	2 5/16	2 1/16	0.84	
	3/4	4 5/8	5/8	1 11/16	3 1/4	4	5/8	1	2 1/2	2 3/4	1.05	
	1	4 7/8	1 1/16	2	3 1/2	4	5/8	1 1/16	2 1 1/16	2 7/8	1.32	
	1 1/4	5 1/4	1 3/16	2 1/2	3 7/8	4	5/8	1 1/8	2 7/8	2 5/8	1.66	
	1 1/2	6 1/8	7/8	2 7/8	4 1/2	4	3/4	1 1/4	3	2 3/4	1.90	
	2	6 1/2	1	3 3/8	5	8	3/4	1 7/16	3 3/8	2 7/8	2.38	
	2 1/2	7 1/2	1 1/8	4 1/8	5 7/8	8	3/4	1 7/8	3 1/2	3 1/8	2.88	
	3	8 1/4	1 1/4	5	6 5/8	8	3/4	1 13/16	3 1/2	3 1/4	3.50	
	3 1/2	9	1 3/8	5 1/2	7 1/4	8	7/8	1 13/16	3 3/4	3 3/8	4.06	
	4	10 3/4	1 1/2	6 1/16	8 1/2	8	7/8	2 1/4	4 1/4	4	4.50	
	5	13	1 3/4	7 5/16	10 1/2	8	1	2 3/8	4 3/4	4 1/2	5.56	
	6	14	1 7/8	8 1/2	11 1/2	12	1	2 5/8	4 7/8	4 5/8	6.63	
900 Pound	8	16 1/2	2 3/16	10 5/8	13 3/4	12	1 1/8	3	5 1/2	5 1/4	8.63	
	10	20	2 1/2	12 3/4	17	16	1 1/4	3 3/8	6 1/4	6	10.75	
	12	22	2 5/8	15	19 1/4	20	1 1/4	3 3/8	6 3/8	6 1/2	12.75	
	3	9 1/2	1 1/2	5	7 1/2	8	7/8	2 1/8	4 1/4	4	3.50	
	3 1/2	10 3/4	1 5/8	5 1/2	8 1/4	8	7/8	2 3/16	4 3/8	4 1/4	4.06	
	4	11 1/2	1 3/4	6 1/16	9 1/4	8	1 1/8	2 3/8	4 3/4	4 1/2	4.50	
	5	13 3/4	2	7 5/16	11	8	1 1/4	3 3/8	5 1/4	5	5.56	
	6	15	2 1/8	8 1/2	12 1/2	12	1 1/4	3 3/8	5 5/8	5 1/2	6.63	
	8	18 1/2	2 1/2	10 5/8	15 1/2	12	1 1/4	4	6 3/8	6 3/8	8.63	
	1 1/2	7	1 1/4	2 7/8	4 7/8	4	1	1 3/4	3 1/2	3 1/4	1.90	
	2	8 1/2	1 1/2	3 3/8	6 1/2	8	7/8	2 1/8	4 1/4	4	2.38	
	2 1/2	9 5/8	1 5/8	4 1/8	7 1/2	8	1	2 1/2	4 3/8	4 1/8	2.88	
1500 Pound	3	10 1/2	1 7/8	5	8	8	1 1/4	2 7/8	4 7/8	4 3/8	3.50	
	3 1/2	11	2	5 1/2	8 1/4	8	1 1/4	3 1/16	5	4 3/4	4.06	
	4	12 3/4	2 1/8	6 1/16	9 1/2	8	1 1/4	3 5/16	5 1/8	4 7/8	4.50	
	5	14 3/4	2 3/8	7 5/16	11 1/2	8	1 1/2	4 1/8	6 3/8	6 1/8	5.56	
	6	15 1/2	3 1/4	8 1/2	12 1/2	12	1 1/4	4 1/16	7	6 3/4	6.63	
	8	19	3 5/8	10 5/8	15 1/2	12	1 1/4	5 3/8	8 3/8	8 3/8	8.63	
	2500 Pound	1 1/2	5 1/4	1 3/16	1 3/8	3 1/2	4	3/4	1 1/16	3 1/8	2 7/8	0.84
		3/4	5 1/2	1 1/4	1 11/16	3 3/4	4	3/4	1 1/16	3 3/8	3 3/8	1.05
		1	6 1/4	1 3/8	2	4 1/4	4	7/8	1 1/8	3 3/4	3 1/2	1.32
		1 1/4	7 1/4	1 1/2	2 1/2	5 1/4	4	1	2 1/16	4	3 3/4	1.66
		1 1/2	8	1 3/4	2 7/8	5 3/4	4	1 1/2	2 3/8	4 5/8	4 3/8	1.90
		2	9 1/4	2	3 3/8	6 3/4	8	1	2 3/4	5 1/4	5	2.38
2 1/2		10 1/2	2 1/4	4 1/8	7 3/8	8	1 1/8	3 3/8	5 7/8	5 5/8	2.88	
3		12	2 5/8	5	9	8	1 1/4	3 3/8	6 3/8	6 3/8	3.50	
4		14	3	6 3/16	10 3/4	8	1 1/2	4 1/4	7 3/4	7 1/2	4.50	
5		16 1/2	3 3/8	7 5/16	12 3/4	8	1 3/4	5 1/8	9 1/4	9	5.56	
6		19	4 1/4	8 1/2	14 1/2	8	2	6	11	10 3/4	6.63	
8		21 3/4	5	10 5/8	17 1/4	12	2	7	12 3/4	12 1/2	8.63	
10	26 1/2	6 1/2	12 3/4	21 1/4	12	2 1/2	9	16 3/4	16 1/2	10.75		
12	30	7 1/4	15	24 3/4	12	2 3/4	10	18 1/2	18 1/4	12.75		



Screwed Flanges
600, 900, 1500, and 2500-Pound



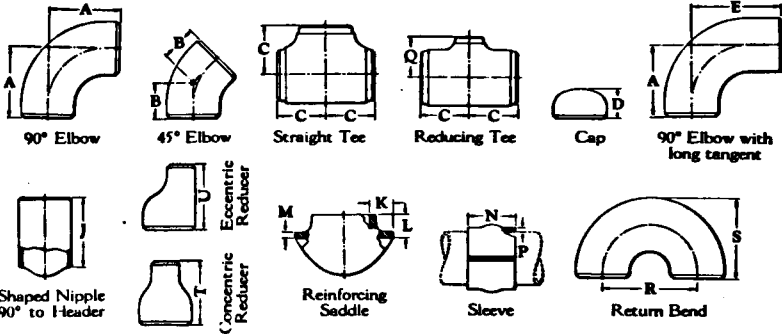
Welding Neck Flanges
600, 900, 1500, and 2500-Pound



Slip-On Welding Flanges
600, 900, and 1500-Pound

TABLE XVII
continued
Steel Butt-Welding Fittings
Dimensions, in Inches

Standard and Extra Strong Fittings have the same outside dimensions.



Elbows, Straight Tees, Caps, Nipples, Saddles, and Sleeves

Size	A	B	C	D	E	J	K	L	M	N	P
3/4	1 1/8	1 1/8	1 1/8	1 1/8	1 1/8	...	...	...	...	...	...
1	1 1/2	1 1/2	1 1/2	1 1/2	1 1/2	...	...	...	...	...	...
1 1/4	1 3/4	1 3/4	1 3/4	1 3/4	1 3/4	6	6	...	...	...	...
2	3	1 3/4	2 1/4	1 3/4	4 1/4	6	1 3/4	1 1/4	1/2	3	1/4
2 1/2	3 3/4	1 3/4	2 1/4	1 3/4	5	6	1 3/4	1 1/4	1/2	3	1/4
3	4 1/4	2	3 3/4	2	5 3/4	6	2	1 3/4	1/2	3	1/4
3 3/4	4 3/4	2 3/4	3 3/4	2 3/4	6 3/4	6	2	1 3/4	1/2	3 3/4	3/4
4	6	2 1/2	4 3/4	2 1/2	7 1/2	6	2	2	1/2	4	3/4
5	7 1/4	3 1/4	4 3/4	3	9	8	2	2	1/2	5	3/4
6	9	3 3/4	5 3/4	3 1/2	10 3/4	8	2 1/2	2 1/4	1/2	6	3/4
8	12	5	7	4	13 3/4	8	3	3	3/4	8	3/4
10	15	6 1/4	8 1/4	5	17	10	3 1/2	3 1/4	3/4	10	1/2
12	18	7 1/2	10	6	20 1/2	10	4	4	3/4	12	1/2
14 OD	16	7 3/4	...	6 1/2	...	...	4	4	3/4	14	1/2
16 OD	18	8 1/4	...	7	...	...	4	4	3/4	16	1/2
18 OD	20	9 1/4	...	8	...	...	4	4	3/4	18	1/2
20 OD	25	...	...	9	...	...	5	5	3/4	20	1/2
24 OD	30	...	...	10 1/2	...	...	5	5	3/4	24	1/2

Return Bends

Size of pipe	R	S
1	3	2 3/4
1 1/4	2 1/2	2 3/4
1 1/2	3 3/4	2 3/4
1 3/4	3	2 1/2
2	4	3 1/4
2 1/2	6	4 1/4
3	7 1/2	5 1/4
3 3/4	9	5
4	10 1/2	6 1/4
4 1/2	12	8 1/4
5	15	10 3/4
6	18	12 3/4
8	24	16 3/4
10	30	20 3/4
12	36	24 3/4

Reducing Tees

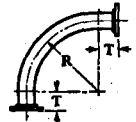
Size	C	Q	Size	C	Q
1 1/4 x 1 1/4 x 3/4	1 7/8	1 7/8	4 x 4 x 3	4 1/4	3 3/4
1 1/2 x 1 1/2 x 1 1/4	2 1/4	2 1/4	4 x 4 x 2 1/2	4 3/4	3 3/4
1 1/2 x 1 1/2 x 1 1/2	2 1/4	2 1/4	4 x 4 x 2	4 3/4	3 1/2
1 3/4 x 1 3/4 x 1 1/4	2 3/4	2 3/4	5 x 5 x 4	4 7/8	4 5/8
2 x 2 x 1 1/2	3 1/4	3 1/4	5 x 5 x 3	4 7/8	4 1/2
2 x 2 x 1 3/4	3 1/4	3 1/4	5 x 5 x 2 1/2	4 7/8	4 1/4
2 1/2 x 2 1/2 x 2	4	4	6 x 6 x 5	5 1/4	5 1/4
2 1/2 x 2 1/2 x 1 1/2	3	2 3/4	6 x 6 x 4	5 1/4	5 1/4
2 1/2 x 2 1/2 x 1 1/4	3	2 3/4	6 x 6 x 3	5 1/4	4 7/8
3 x 3 x 2 1/2	3 3/4	3 3/4	8 x 8 x 6	7	6 3/4
3 x 3 x 2	3 3/4	3 3/4	8 x 8 x 5	7	6 3/4
3 x 3 x 1 1/2	3 3/4	2 7/8	8 x 8 x 4	7	6 1/4
			10 x 10 x 8	8 1/2	8
			10 x 10 x 6	8 1/2	7 1/4
			12 x 12 x 10	10	9 1/2
			12 x 12 x 8	10	9
			12 x 12 x 6	10	8 3/4

Reducers

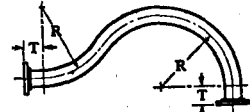
Size	T	U	Size	T	U	Size	T	U
1 1/4 x 3/4	2	2	3 x 2 1/2	3 1/2	3 1/2	6 x 5		
1 1/2 x 1 1/4	2 1/2	2 1/2	3 x 2	3	3	6 x 4		
1 3/4 x 1 1/2	3	3	4 x 3	4	4	6 x 3 1/2	5 1/2	5 1/2
2 x 1 1/2	3 1/2	3 1/2	4 x 2 1/2	4	4	6 x 3		
2 1/2 x 2	4	4	4 x 2	4	4	8 x 6		
3 x 2 1/2	4 1/2	4 1/2	5 x 4	5	5	8 x 5		
3 1/2 x 3	5	5	5 x 3	5	5	8 x 4	6	6
4 x 3 1/2	5 1/2	5 1/2	6 x 4	6	6	10 x 8		
4 1/2 x 4	6	6	6 x 3 1/2	6	6	10 x 6		
5 x 4 1/2	6 1/2	6 1/2	8 x 4	8	8	10 x 8	7	7
5 1/2 x 5	7	7	8 x 3 1/2	8	8	12 x 10		
6 x 5 1/2	7 1/2	7 1/2	10 x 4	10	10	12 x 8		
6 1/2 x 6	8	8	12 x 6	12	12	12 x 6	8	8

TABLE XVII
continued

Standard Types of Pipe Bends



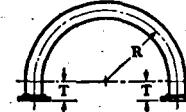
No. 1
Quarter Bend, 90°



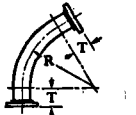
No. 2, Single Offset Quarter Bend



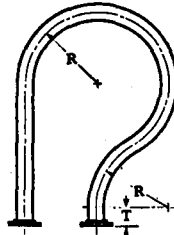
No. 4, Crossover Bend



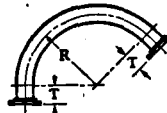
No. 7, U-Bend — 180°



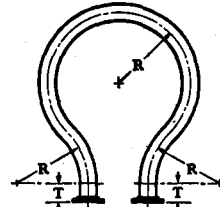
No. 11½
Angle Bend, 46° to 89°



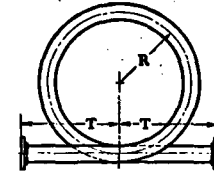
No. 6
Single Offset U-Bend



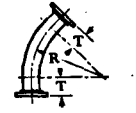
No. 7½
Angle Bend
91° to 179°



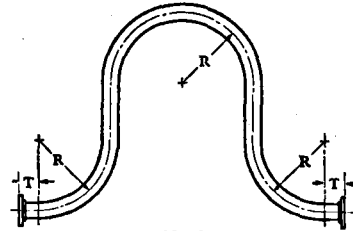
No. 8
Double Offset U-Bend



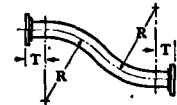
No. 11
Circle Bend



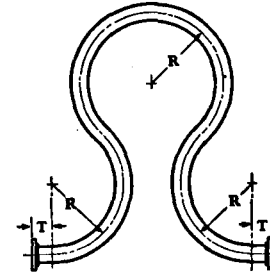
No. 3
45° Bend



No. 9
Expansion U-Bend



No. 5
Offset Bend



No. 10
Double Offset Expansion U-Bend

TABLE XVII
continued
Standard Types of Pipe Bends

Radii and Tangents of Pipe Bends, in Inches

Size of Pipe	Column "A"	Column "B"								Column "C"	
	R Minimum Recommended Radius Steel or Genuine Wrought Iron Pipe Standard or Extra Strong Weight	R Shortest Radii to which pipe can be bent								T Minimum Length of Tangent	
		Steel Pipe Only				Genuine Wrought Iron Pipe				Steel or Genuine Wrought Iron Pipe Standard or Extra Strong Weight	
		Threaded Ends, Screwed, or Welded Flanges		Cranelap Joints		Threaded Ends, Screwed, or Welded Flanges		Cranelap Joints			
Stand-ard Weight Pipe	Extra Strong Weight Pipe	Stand-ard Weight Pipe	Extra Strong Weight Pipe	Stand-ard Weight Pipe	Extra Strong Weight Pipe	Stand-ard Weight Pipe	Extra Strong Weight Pipe	Threaded Ends or Screwed Flanges	Cranelap Joints		
1/4	1 1/4	1	5/8			1 1/4	1			1	
3/8	1 3/8	1 1/4	3/4			1 3/8	1 1/2			1 1/4	
1/2	2 1/2	1 1/2	1	2	2	2 1/2	2	2 1/2	2	1 1/2	2
3/4	3 3/4	1 3/4	1 1/4	3	3	3	2 3/4	3	3	1 3/4	2
1	5	2	1 1/2	4	4	4	3	4	4	2	2
1 1/4	6 1/4	2 1/4	1 3/4	4	4	5	4	5	4	2	2 1/2
1 1/2	7 1/2	2 1/2	2	5	5	6	5	6	5	2 1/2	3
2	10	3	2 1/2	6	6	8	5	8	6	3	4
2 1/2	12 1/2	5	4 1/4	10	10	10	8	10	10	4	5
3	15	8	6	12	12	12	10	12	12	4	6
3 1/2	17 1/2	10	8	12	12	14	12	14	12	5	6
4	20	12	10	14	14	16	12	16	14	5	6
5	25	18	14	18	14	20	15	20	15	6	7
6	30	22	15	22	15	26	18	26	18	7	7
8	40	30	23	30	23	30	28	30	28	9	8
10	50	36	30	36	30	36	32	36	32	12	10
12	60	46	36	46	36	46	42	46	42	14	10
*14 OD	70	60	48	60	48	60	54	60	54	16	14
*16 OD	96	80	60	80	60	80	70	80	70	18	16
*18 OD	108	90	66	90	66	90	80	90	80	18	18
*20 OD	120	100	72	100	72	100	90	100	90	18	18
*24 OD	144	144	108	144	108	144	122	144	122	18	20

*For sizes 14-inch O.D. and larger, the radii shown are based upon pipe with a wall thickness of 1/2-inch or lighter under the "Standard Weight Pipe" column, and a wall thickness of 3/4-inch or heavier under the "Extra Strong Weight Pipe" column.

TABLE XXIV

**FORMULAS AND MOLECULAR AND EQUIVALENT WEIGHTS OF
SUBSTANCES FREQUENTLY APPEARING IN THE CHEMISTRY
OF WATER CONDITIONING**

<i>Substance</i>	<i>Formula</i>	<i>Weight of Molecule or Radical</i>	<i>Eq. Wt.</i>
Aluminum	Al	27.0	9.00
Aluminum chloride (crystal)	AlCl ₃	133.0	44.33
Aluminum chloride (anhydrous)	AlCl ₃ · 6H ₂ O	241.0	80.33
Aluminum sulphate (crystal)	Al ₂ (SO ₄) ₃ · 18H ₂ O	666.4	111.06
Aluminum sulphate (anhydrous)	Al ₂ (SO ₄) ₃	342.1	57.01
Ammonia	NH ₃	17.0	17.00
Ammonium alum	Al ₂ (SO ₄) ₃ (NH ₄) ₂ SO ₄ · 24H ₂ O	906.6	151.10
Potassium alum	Al ₂ (SO ₄) ₃ K ₂ SO ₄ · 24H ₂ O	948.8	158.13
Aluminum hydrate	Al(OH) ₃	78.0	26.00
Ammonium chloride	NH ₄ Cl	53.5	53.50
Ammonium (ion)	NH ₄	18.0	18.00
Ammonia water	NH ₄ OH	35.1	35.10
*Alumina	Al ₂ O ₃	102.0	17.00
Sodium aluminate	Na ₂ Al ₂ O ₄	164.0	27.33
Ammonium sulphate	(NH ₄) ₂ SO ₄	132.0	66.00
Barium	Ba	137.4	68.70
Barium carbonate	BaCO ₃	197.4	98.70
Barium chloride	BaCl ₂ · 2H ₂ O	244.3	122.15
Barium sulphate	BaSO ₄	233.4	116.70
Barium hydrate	Ba(OH) ₂	171.0	85.50
Barium oxide	BaO	153.0	76.50
Calcium	Ca	40.1	20.05
Calcium bicarbonate	Ca(HCO ₃) ₂	162.1	81.05
Calcium carbonate	CaCO ₃	100.1	50.05
Calcium chloride	CaCl ₂	111.0	55.50
Calcium hydrate (pure)	Ca(OH) ₂	74.1	37.05
Calcium hydrate (90%)	Ca(OH) ₂	....	41.10
Calcium oxide (pure)	CaO	56.1	28.05
Calcium oxide (90%)	CaO	....	31.17
Calcium sulphate (anhydrous)	CaSO ₄	136.2	68.08
Calcium sulphate (gypsum)	CaSO ₄ · 2H ₂ O	172.2	86.10
Calcium nitrate	Ca(NO ₃) ₂	164.1	82.05
Calcium phosphate	Ca ₃ (PO ₄) ₂	310.3	51.71
Carbon	C	12.0	3.00
Chloride (gas)	Cl ₂	70.9	35.45

Courtesy of the Cochrane Corp.

TABLE XXIV
continued

<i>Substance</i>	<i>Formula</i>	<i>Weight of Molecule or Radical</i>	<i>Eq. Wt.</i>
Copper	Cu	63.6	31.80
Copper sulphate	CuSO ₄	160.0	80.00
Iron (ferric)	Fe'''	55.8	18.60
Iron (ferrous)	Fe''	55.8	27.90
*Ferric oxide	Fe ₂ O ₃	159.6	26.60
*Iron oxide and alumina	R ₂ O ₃	109.0	18.20
Ferrous sulphate (copperas)	FeSO ₄ · 7H ₂ O	278.0	139.00
Ferric chloride	FeCl ₃	162.0	54.00
Ferric hydrate	Fe(OH) ₃	107.0	35.66
Ferric sulphate	Fe ₂ (SO ₄) ₃	400.0	66.66
Ferrous carbonate	FeCO ₃	116.0	58.00
Ferrous hydrate	Fe(OH) ₂	89.9	44.95
Ferrous oxide	FeO	71.8	35.90
Fluorine (gas)	F ₂	19.0	19.00
Hydrogen (gas)	H ₂	2.02	1.01
Hydrogen sulphide (gas)	H ₂ S	34.1	.....
Lead	Pb	207.0	103.50
Magnesium	Mg	24.3	12.15
Magnesium oxide	MgO	40.3	20.15
Magnesium bicarbonate	Mg(HCO ₃) ₂	146.3	73.15
Magnesium carbonate	MgCO ₃	84.3	42.15
Magnesium chloride	MgCl ₂	95.2	47.60
Magnesium hydrate	Mg(OH) ₂	58.3	29.15
Magnesium nitrate	Mg(NO ₃) ₂	148.3	74.15
Magnesium phosphate	Mg ₃ (PO ₄) ₂	263.0	43.83
Magnesium sulphate	MgSO ₄	120.4	60.20
Nitrogen (gas)	N ₂	28.0	.....
Oxygen (gas)	O ₂	32.0	8.00
Potassium	K	39.1	39.10
Potassium carbonate	K ₂ CO ₃	138.0	69.00
Potassium chloride	KCl	74.6	74.60
Potassium hydrate	KOH	56.1	56.10
Potassium iodide	KI	166.0	166.00
Potassium nitrate	KNO ₃	101.0	101.00
Potassium oxide	K ₂ O	94.2	47.10
Potassium permanganate	KMnO ₄	158.0	158.00
Potassium sulphate	K ₂ SO ₄	174.0	87.00
Silicon	Si	28.1	7.03
Silver	Ag	108.0	108.00
Silver chloride	AgCl	143.3	143.30
Silver nitrate	AgNO ₃	169.9	169.90
Silica	SiO ₂	60.1	30.05
Sodium	Na	23.0	23.00
Sodium bicarbonate	NaHCO ₃	84.0	84.00

TABLE XXIV
continued

<i>Substance</i>	<i>Formula</i>	<i>Weight of Molecule or Radical</i>	<i>Eq. Wt.</i>
Sodium carbonate	Na_2CO_3	106.0	53.00
Sodium chloride	NaCl	58.5	58.50
Sodium hydrate	NaOH	40.0	40.00
Sodium nitrate	NaNO_3	85.0	85.00
Sodium oxide	Na_2O	62.0	31.00
Sodium sulphite	Na_2SO_3	126.0	63.00
Sulphur dioxide (gas)	SO_2	64.1	32.05
Trisodium phosphate	$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ (18.7% P_2O_5)	380.2	126.73
Trisodium phosphate (anhydrous)	Na_3PO_4 (43.3% P_2O_5)	164.0	54.66
Disodium phosphate	$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ (19.8% P_2O_5)	358.2	119.40
Disodium phosphate (anhydrous)	Na_2HPO_4 (50.0% P_2O_5)	142.0	47.33
Monosodium phosphate	$\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ (51.4% P_2O_5)	138.1	46.03
Monosodium phosphate (anhydrous)	NaH_2PO_4 (59.1% P_2O_5)	120.1	40.03
Metaphosphate (Hagan)	NaPO_3 (69.5% P_2O_5)	102.0	34.00
Sodium sulphate	Na_2SO_4	142.0	71.00
Water	H_2O	18.0	9.00
ACID RADICALS			
Bicarbonate	HCO_3	61.0	61.00
Carbonate	CO_3	60.0	30.00
Carbon dioxide	CO_2	44.0	22.00
Chloride	Cl	35.46	35.46
Nitrate	NO_3	62.0	62.00
Hydrate	OH	17.0	17.00
Phosphate	PO_4	95.0	31.66
Phosphorous oxide	P_2O_5	142.0	23.67
Sulphate	SO_4	96.06	48.03
Sulphite	SO_3	80.1	40.05
ACIDS			
Hydrogen	H_2	2.0	1.00
Acetic acid	$\text{HC}_2\text{H}_3\text{O}_2$	60.0	60.00
Carbonic acid	H_2CO_3	62.0	31.00
Hydrochloric acid	HCl	36.46	36.46
Phosphoric acid	H_3PO_4	98.0	32.67
Sulphuric acid	H_2SO_4	98.1	49.05
Nitric acid	HNO_3	63.0	63.00
Sulphurous acid	H_2SO_3	82.1	41.05

* Al_2O_3 and Fe_2O_3 are commonly reported together as R_2O_3 , which for purpose of computation is given a mol. wt. of 109 and eq. wt. of 18.2 on the basis of 88% Al_2O_3 and 12% Fe_2O_3 .

TABLE XXV
continued

Saturated Steam Temperature Table—(Concluded)

Temp. Fahr. t	Abs. Press. Lb./Sq. In. p	SPECIFIC VOLUME			ENTHALPY			ENTROPY			Temp. Fahr. t
		Sat. Liquid v _l	Evap. v _{lg}	Sat. Vapor v _g	Sat. Liquid h _l	Evap. h _{lg}	Sat. Vapor h _g	Sat. Liquid s _l	Evap. s _{lg}	Sat. Vapor s _g	
800	506.12	0.0200	0.7972	0.8172	464.37	739.8	1204.2	0.6646	0.7872	1.4519	800
805	503.28	0.0201	0.7585	0.7786	470.18	733.6	1203.8	0.6708	0.7766	1.4472	805
810	521.44	0.0202	0.7219	0.7421	476.01	727.3	1203.3	0.6767	0.7658	1.4425	810
815	530.59	0.0203	0.6872	0.7075	481.90	720.8	1202.7	0.6827	0.7550	1.4377	815
820	539.80	0.0204	0.6544	0.6748	487.80	714.2	1202.0	0.6888	0.7442	1.4330	820
825	712.10	0.0206	0.6230	0.6436	493.8	707.5	1201.3	0.6949	0.7334	1.4283	825
830	744.55	0.0207	0.5932	0.6139	499.8	700.6	1200.6	0.7009	0.7225	1.4224	830
835	777.90	0.0209	0.5651	0.5859	505.8	693.6	1199.4	0.7070	0.7116	1.4166	835
840	812.68	0.0209	0.5382	0.5591	511.9	686.5	1198.4	0.7132	0.7007	1.4139	840
845	848.37	0.0210	0.5128	0.5338	518.0	679.2	1197.3	0.7192	0.6898	1.4090	845
850	885.20	0.0212	0.4885	0.5097	524.2	671.9	1196.1	0.7253	0.6789	1.4042	850
855	923.45	0.0213	0.4654	0.4867	530.4	664.6	1194.8	0.7314	0.6679	1.3993	855
860	962.80	0.0214	0.4433	0.4647	536.6	656.7	1193.3	0.7375	0.6569	1.3944	860
865	1003.6	0.0216	0.4222	0.4438	542.9	648.9	1191.8	0.7436	0.6458	1.3895	865
870	1045.6	0.0218	0.4021	0.4239	549.3	640.9	1190.2	0.7498	0.6347	1.3845	870
875	1088.6	0.0219	0.3830	0.4049	555.7	632.8	1188.3	0.7559	0.6234	1.3793	875
880	1133.4	0.0221	0.3648	0.3869	562.2	624.1	1186.3	0.7622	0.6120	1.3742	880
885	1179.3	0.0222	0.3472	0.3694	568.8	615.4	1184.2	0.7684	0.6006	1.3690	885
890	1226.7	0.0224	0.3304	0.3528	575.4	606.5	1181.9	0.7737	0.5890	1.3637	890
895	1275.7	0.0226	0.3143	0.3369	582.1	597.4	1179.6	0.7810	0.5774	1.3584	895
900	1326.1	0.0228	0.2989	0.3217	588.9	588.1	1177.0	0.7872	0.5658	1.3528	900
905	1378.1	0.0230	0.2840	0.3070	595.7	578.6	1174.2	0.7936	0.5538	1.3474	905
910	1431.5	0.0232	0.2699	0.2931	602.6	568.8	1171.4	0.8000	0.5419	1.3419	910
915	1486.5	0.0234	0.2563	0.2797	609.7	558.7	1168.4	0.8065	0.5297	1.3362	915
920	1543.2	0.0236	0.2432	0.2668	616.8	548.4	1165.2	0.8130	0.5175	1.3305	920
925	1601.5	0.0239	0.2306	0.2546	624.1	537.7	1161.8	0.8196	0.5050	1.3246	925
930	1661.6	0.0241	0.2185	0.2426	631.5	526.6	1158.1	0.8263	0.4923	1.3186	930
935	1723.4	0.0244	0.2068	0.2312	638.9	515.3	1154.2	0.8330	0.4795	1.3125	935
940	1787.9	0.0247	0.1958	0.2202	646.5	503.7	1150.2	0.8398	0.4666	1.3063	940
945	1852.4	0.0250	0.1845	0.2095	654.3	491.5	1145.8	0.8467	0.4531	1.2998	945
950	1919.0	0.0253	0.1740	0.1993	662.2	478.8	1141.0	0.8537	0.4394	1.2931	950
955	1989.0	0.0256	0.1638	0.1894	670.4	465.5	1135.9	0.8609	0.4252	1.2861	955
960	2060.3	0.0260	0.1539	0.1799	678.7	452.0	1130.7	0.8681	0.4110	1.2791	960
965	2133.6	0.0264	0.1441	0.1705	687.3	437.8	1124.9	0.8756	0.3961	1.2717	965
970	2208.8	0.0268	0.1348	0.1616	696.0	422.7	1118.7	0.8832	0.3809	1.2641	970
975	2286.4	0.0273	0.1256	0.1530	705.2	407.0	1112.2	0.8910	0.3651	1.2561	975
980	2366.2	0.0278	0.1167	0.1445	714.4	390.5	1104.9	0.8991	0.3488	1.2478	980
985	2448.0	0.0283	0.1079	0.1362	724.5	372.1	1096.6	0.9074	0.3320	1.2382	985
990	2532.4	0.0290	0.0991	0.1281	734.6	353.3	1087.3	0.9161	0.3127	1.2286	990
995	2619.2	0.0297	0.0904	0.1201	745.5	332.8	1078.3	0.9253	0.2933	1.2186	995
1000	2708.4	0.0306	0.0810	0.1116	757.3	310.0	1067.2	0.9352	0.2730	1.2072	1000
1005	2800.4	0.0316	0.0719	0.1032	770.1	284.5	1054.6	0.9459	0.2485	1.1944	1005
1010	2895.0	0.0328	0.0631	0.0948	784.2	254.9	1039.1	0.9579	0.2217	1.1798	1010
1015	2992.7	0.0345	0.0551	0.0858	801.3	219.1	1020.4	0.9730	0.1897	1.1617	1015
1020	3094.1	0.0369	0.0389	0.0758	823.9	171.7	995.6	0.9904	0.1481	1.1325	1020
1025	3198.1	0.0440	0.0167	0.0597	870.2	77.6	947.3	1.0305	0.0661	1.0906	1025
1025.04*	2308.2	0.0641	0	0.0641	910.3	0	910.3	1.0645	0	1.0645	1025.04*

* Critical temperature

TABLE XXV
continued

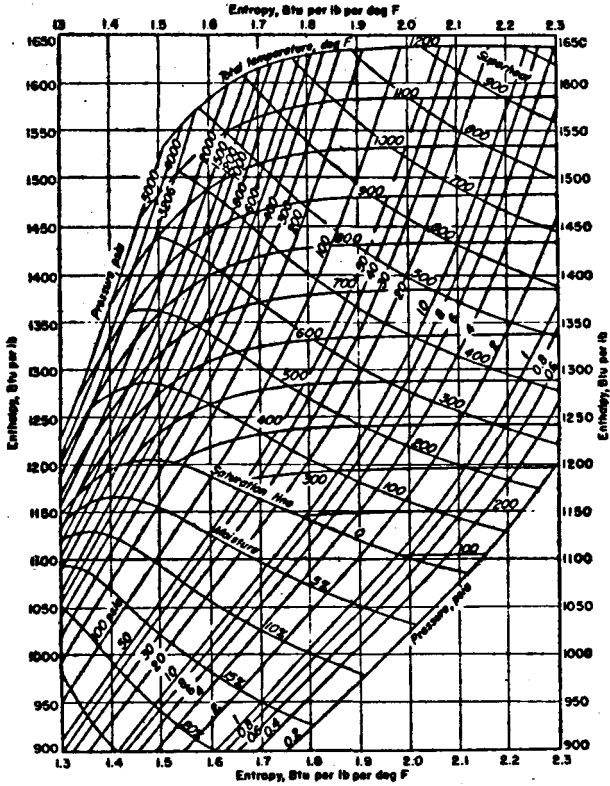
Superheated Steam—(Continued)

Table with columns for Abs. Press (Lb./Sq. In.), Sat. Temp. Water, Sat. Steam, Temperature in Degrees Fahrenheit (500, 520, 540, 560, 600, 650, 700, 750, 800, 900, 1000, 1100, 1300), and rows for various pressure levels (540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690) including subcooled liquid (v), saturated liquid (h), and saturated vapor (s) properties.

heat, deg. F.
ic volume, cu. ft. per lb.

h = enthalpy, B.t.u. per lb.
s = entropy, B.t.u. per deg. F. per lb.

TABLE XXV
continued
Mollier Diagram for Steam



(Power)

INDEX

References are to pages

- A
- Air-cooled wall, 153
Air ejector, condenser, 105
 capacity, 105
 characteristics, 105
Air, Diesel engine scavenging, 286
 excess, 120
 total, 120
Air heaters, economic surface, 169
 heat transfer, 166
 plate type, 166
 recuperative, 165
 regenerative, 166
 tubular, 166
Air horsepower, 239
Altitude, Diesel engine rating, 291
Analysis, coal, 117
 fuel oil, 117
 gas, 117
 proximate, 117
 ultimate, 117
 water, 210
Architecture, power plant, 273
Arithmetic mean temperature difference, 96
Ash handling, hydraulic, 233
 mechanical, 233
Ash fusion temperature, 146
Automatic combustion controls, 256
- B
- Babcock and Wilcox equation, 144
Balance, steam generator heat, 131
Barometric condenser, *see* Condenser
Binary vapor cycle, mercury-steam, 63
 miscellaneous, 64
Blading, turbine, impulse, 74
 impulse-reaction, 75
 reaction, 74
Block Hopkinson demand rate, 35
Block meter rate, 34
Boiler feed pumps, *see* Pumps
Boilers, economical surface, 169
Boiler heat balance, *see* Steam generators
Boiler heat transfer, 141
Boiler horsepower, 130
Bomb calorimeter, 128
Bonds, 6
Brake horsepower, 68
Buildings, power plant, 273
Burners, fuel oil, 221
 gas, 221
 pulverized coal, 229
- C
- Calorimeter, bomb, 128
 gas, 128
Capacity factor, 19
Carnot cycle, 45
Carryover, boiler, 219
 evaporator, 218
Caustic embrittlement, 218
Centrifugal pumps, *see* Pumps
Chain grate stokers, 225
Chimneys, *see* Stacks
Cinder trap, 233

- Circulating water pump, *see* Pumps.
- Closed heaters, 55, 101
 design, 103
 heat transfer, 102
 water velocity in tubes, 102
- Coal, analysis, 117
 calorimeter, 128
 classification, 117
 heating value, 126
 proximate analysis, 117
 ultimate analysis, 117.
- Coal handling, pulverizer system, 223
 stoker system, 224
 storage system, 222
- Collectors, dust, bag type, 234
 centrifugal, 233
 electrostatic, 233
 wet scrubber, 234
- Combustible, basis for analysis, 126
- Combustion, coal, 120
 fuel oil, 120
 gas, 121
- Combustion controls, automatic, 256
- Common stocks, 6
- Compression ratio, Diesel engine, 290
- Condensate pump, *see* Pumps
- Condensers, 89
 design, 97
 friction, tube, 188
 water boxes, 188
 heat transfer, 93
 mixing, barometric, 89
 jet, 89
 surface, 90
- Conductivity, electrolytic, 258
 thermal, gas film, 160
 insulation, 151, 194
 metals, 95
 refractories, 151
 scale, 95
 vapor film, 94, 160
 water film, 95
- Construction costs, power plant, 29
 index, 29
- Cooling ponds, 107
- Cooling towers, forced draft, 108
 induced draft, 108
- Corrosion, boiler, 218
- Correction, for engine efficiency, 79
- Costs, collection, 34
 distribution system, primary, 28
 secondary, 34
 engines, 71
 index, 28
 maintenance, 33
 power plants, 28
 steam generators, 141
 turbo-generators, 79
- Cotterill, 52
- Counterflow engine, 67
- Curtis, C. G., 73
- Customer element, 33
- Cutoff, steam engine, 69
- Cycle, binary vapor, 63
 Carnot, 45
 Diesel, 289
 Field, 56
 gas turbine, 303
 Rankine, 46
 closed, 46
 open, 47
 regenerative, 52
 reheating, 50
 reheating-regenerative, 56
 superposed, 59
 topping, *see* superposed
- Cyclone burner, horizontal, coal, 229
- D
- Dams, types, 295
- Deaerators, *see* Open heaters
- DeLaval, 73
- Demand factor, 8
 table, 9
- Depreciation, 30
- Design, station, 265
- Diagram factor, engine, 70

- Diesel cycle, 289
 Diesel engines, auxiliaries, 292
 four-stroke, 287
 fuel injectors, 287
 scavenging, 286
 supercharging, 291
 two-stroke, 286
 Diesel, Rudolph, 286
 Distribution system, primary, 4
 secondary, 4
 Diversity factor, 8
 table of, 9
 Division of load, 281
 Draft, fans, forced, 242
 induced, 242
 losses, air heater, 242
 burner, 243
 duct-work, 191
 economizers, 244
 fuel beds, 243
 steam generators, 242
 Drainage, heater, 102
 Drips, heater, *see* Drainage, heater
 Duct-work, design, 190
 draft losses, 191
 insulation, 194
 Duration curve, river flow, 297
 load, 14
 Dust collectors, bag type, 234
 centrifugal, 233
 electrostatic, 233
 wet scrubber, 234
- E
- Economics, insulation thickness, 196
 load division, 280
 power production, 25
 surface apportionment, steam generators, 169
 Economizers, arrangement, 163
 economical surface, 169
 heat transfer, 164
 Edison, Thomas, 1
 Efficiency, boiler, *see* Steam generator efficiency
 Efficiency, engine, internal, 49
 overall, 50
 steam engines, 73
 steam turbines, 75
 generator, 80
 mechanical, Diesel engines, 291
 hydraulic turbines, 299
 steam engines, 67
 steam turbines, 75, 80
 thermal, Diesel cycle, 291
 gas turbine cycle, 303
 vapor cycles, 46 *et seq.*
 Ejector, air, 105
 Embrittlement, caustic, 218
 Enclosed plant, 274
 Energy element, 32
 Engines, Diesel, 286, 287
 steam, cost, 71
 counterflow, 67
 cutoff, 69
 diagram factor, 70
 engine efficiency, 68
 indicator, 67
 mechanical efficiency, 67
 uniflow, 67
 Equipment, determination of size, 20
 Equivalent length, pipe fittings, 178
 duct bends, 191
 Evaporators, location in vapor cycle, 109
 long tube, forced circulation, 110
 natural circulation, 110
 multiple effect, 110
 shell and tube, 110
 Excess air, 120
 Expansion lines, 82
 Expansion ratio, steam-engine, 69
 Extraction, *see* Regenerative cycle
- F
- Factors, capacity, 19
 demand, 8
 diversity, 8

- Factors, friction, 178
 - load, 19
 - use, 19
 - Fans, characteristics, 236
 - laws, 236
 - speeds, 240
 - types, 236
 - Federal utility, 7
 - Feed-water hardness, residual after treatment, 212
 - Feed-water heaters, closed, 55, 101
 - open, 53, 100
 - Feed-water treatment, cold lime and alum process, 211
 - cold lime-soda and alum process, 211
 - hot lime-soda process, 212
 - objectives, 212
 - zeolite processes, 215
 - Ferranti, 50
 - Field cycle, 56
 - Field, J. F.
 - Fire-tube boilers, 138
 - Fixed carbon, *see* Coal, proximate analysis
 - Fixed element, 27
 - Flue gas analysis, 128
 - Fluid meters, 258
 - Flyash, 233
 - Franchise, 26
 - Friction factor, 178
 - Fuel bed resistance, 243
 - Fuel handling equipment, 221
 - coal, 222
 - fuel oil, 221
 - gas, 221
 - see also specific equipment*
 - Fuel oil, analyses, 117
 - calorimeter, 128
 - heating value, 127
 - Furnaces, bottoms, fuel oil, 231
 - gas, 231
 - pulverized coal, 231
 - heat release, 147
 - walls, air-cooled, 153
 - insulated, 151
 - water-cooled, 146
 - Fusion temperature of ash, 146
- G
- Gages, pressure, 249
 - Gas, flue, analysis, 128
 - fuel, analyses, 117
 - calorimeter, 128
 - heating value, 127
 - Gas turbine cycles, 303
 - closed, 305
 - open, 303
 - Generator efficiency, 80
 - Governors, speed, 252
 - Grates, dumping, 225
 - travelling, 225
- H
- Hardness of water, 21C
 - Head, dynamic, 203
 - fan, 239
 - friction, 178
 - pressure, 203
 - pump, 203
 - static, 203
 - velocity, 203
 - Heat balance, Diesel engine, 291
 - steam generator, 131
 - Heat conductivity, *see* Conductivity; thermal
 - Heat transfer, air heaters, 166
 - boilers, 141
 - coefficients, steam generator components, 172
 - condensers, 93, 99
 - economizers, 164
 - feed-water heaters, 101
 - furnaces, 146
 - superheaters, 157
 - Heaters, closed, 55, 101
 - deaerating, 100
 - volume, 100
 - drainage, 102
 - heat transfer, 101
 - open, 53, 100
 - terminal difference, 101
 - venting, 103
 - Heating surface, apportionment of, 169
 - Heating value, fuel, higher, 126
 - lower, 126

- Historical background of power, 1
 Folding company, 6
 Horizontal cyclone burner, 229
 Horsepower, air, 239
 boiler, 130
 brake, 68
 indicated, 49, 68
 water, 203
 Hot lime-soda process, 212
 Hotwell, condenser, 97
 heater, 102
 Hydraulic turbines, Francis, 299
 impulse, 299
 Kaplan, 299
 Nagler, 299
 Pelton, 299
 reaction, 299
 Hydro-electric plants, run-of-river, 295
 storage, 295
 Hydrogen zeolite, 217
 Hydrograph, river, 297
 Hypothetical combinations, salts, 213
- I
- Impulse-reaction turbines, steam, 75
 Impulse turbines, hydro, 299
 steam, 73
 Income, power plant, 25
 Incremental rate theory, 280
 applications of, 282
 Index, cost, 28
 Indicated horsepower, 49, 68
 Indicator, engine, 49, 67
 Indicator diagram, Diesel engine, 287
 steam engine, 69
 Injector, fuel, Diesel engine, 287
 Installed capacity, power plants in U.S., 1
 Instruments, supervisory and control, 249
 Insulation, duct, 194
 economical thickness, 196
 Insulation, furnace, 151
 pipe, 194
 Insurance, 30
 Investors' profit, 34
 Investment, distribution system, primary, 28
 secondary, 34
 plant, 28
- J
- Jet condenser, ~~see~~ Condenser
- K
- Kitteredge, A. E., 103
- L
- Level control, fluid, 253
 Life expectancy, power plant components, 30
 Lime and alum process, 211
 Lime-soda process, hot, 212
 Lime-soda and alum process, 211
 Load curves, daily, 9
 duration, 14
 growth, 13
 extension of, 24
 peak, 13
 Load factor, 19
 Logarithmic mean temperature difference, condensing vapors
 96
 counterflow, 157
 parallel flow, 159
 Losses, friction, ducts, 191
 pipe, 178
 pipe fittings, 178
 radiation, steam generators, 134
 furnace walls, 151
 Lubricating oil, economy, Diesel engines, 291
 steam turbines, 33.
- M
- Maintenance, 33
 capitalized, 32
 Management, cost of, 32
 Mass flow, gases, 144
 river, 297

- Maximum demand, 19
 Mean effective pressure, engine, 68
 Mean temperature difference, arithmetic, 96
 logarithmic, *see* Logarithmic mean temperature difference
 Mechanical efficiency, Diesel engines, 291
 hydraulic turbines, 299
 steam engines, 67
 steam turbines, 75, 80
 Mercury-steam binary vapor cycle, 63
 Mercury vapor, Mollier diagram, 65
 Mills, coal pulverizing, *see* Pulverizers
 Mixing condensers; barometric, 89
 jet, 89
 Mixing heaters, *see* Heaters, open
 Mollier diagram, mercury vapor, 65
 steam, 338
 Municipal utility, 6
- N
- Natural draft, 246
 Natural gas, analyses, 117
 combustion, 121
 Net assured capacity, 24
 Newcomen, 67
 Nusselt's equations, 95, 160
- O
- Oil, fuel, *see* Fuel oil
 Open heater, 53, 100
 Orsat flue gas analysis apparatus, 128
 Outdoor plant, 273
 Overfeed stoker, 224
- P
- Paper mill chemical recovery boiler, 233
 Parsons, C. A., 73
 Pearl Street Station, 1
 Permanent hardness, water, 210
 Petroleum, *see* Fuel oil
 pH, boiler water, 218
 controllers, 258
 Phosphates, 219
 Piping, 175
 fittings, 178
 equivalent lengths, 178
 friction, 178
 insulation, 194
 pressure drop, 178
 schedule number, 176
 size determination, 175
 Piston speed, steam engine, 70
 Plant buildings, enclosed, 274
 outdoor, 273
 semi-outdoor, 273
 Ponds, cooling, 107
 Power, Diesel, 3
 gas turbine, 303
 hydro, 3
 steam, 1
 Power plants, buildings, 273
 construction, 274
 design, 273
 Preferred standards, steam turbo-generators, 76
 Pressure compounded impulse steam turbine, 73
 Pressure gages, 249
 Pressure head, 203
 Primary air, 228
 Private utility, 6
 Production costs, 27
 Products of combustion, 128
 Profit element, 34
 Proximate analysis, coal, 117
 Public utilities, 5, 25
 Public Utilities Holding Company Act, 6
 Pulverized coal, firing systems, 223
 furnace bottoms, 231
 Pulverizers, coal, 228
 power requirements, 228
 Pumps, centrifugal, 200
 boiler feed, 205

- Pumps, centrifugal, circulating water, 205
 condensate, 205
 efficiencies, 204
 general purpose, 205
 laws of similarity, 205
 performance characteristics, 206
 speeds, 205
 duplex steam driven, 200
 gear, 200
 multiplex plunger, 200
 screw, 200
 turbine, 200
 Purifiers, steam, 219
- Q
- Quality of steam at end of expansion, 63
- R
- Radiation coefficients, 151
 Radiation losses, steam generator, 134
 calculation of, 151
 Rankine, W. J. M., 46
 Rankine cycle, 46
 efficiency ratio, 49
 ratio, 49
 Rateau, 73
 Rates, steam, 49
 requirements, 27
 types, 34
 Ratio of expansion, steam engine, 69
 Reaction turbines, hydro, 299
 steam, 73
 Reciprocating pumps, 200
 Refractories, 151
 Refrigeration, hotwell, condenser, 97
 heater, 102
 Regenerative cycle, 52
 extraction, 52
 feed-water temperatures, 52
 Regulators, feed-water, 254
 Reheaters, 50, 163
 Reheating cycle, 50
 Reheating-regenerative cycle, 56
- Reserve, spinning, 21
 standby, 21
 Resin, acid adsorbing, 218
 Retirement reserve, 30
 Revenue certificates, 6
 Reynolds' number, 178
 Reynolds, R. L., 52
 Room rate, 35
 Rotating pumps, 200
- S
- Scale, boiler, 210, 219
 condenser tube, 95
 Scales, coal weighing, 223
 Scavenging pumps, Diesel engines, 291
 Schedule number, pipe, 176
 Secondary air, 229
 Selection of number and size of units, 20
 Semi-outdoor plant, 273
 Sinking fund for bond retirement, 30
 Slagging, furnace, 148
 superheater, 16C
 Sodium zeolite, 216
 Speed control, 252
 Spinning reserve, 21
 Spray ponds, 107
 Spreader stoker, 225
 Stacks, design, 246
 draft produced, 246
 Standby reserve, 21
 Static head, 203
 Station design, 265
 Steam engines, *see* Engines
 Steam generators, 130
 convection surface, 141
 cost of, 141
 efficiency, 130
 fire-tube, 138
 heat balance, 131
 heat transfer, *see specific component*
 radiant surface, 148
 water-tube, 138
 Steam jet air pump, capacity, 105
 characteristics, 105
 Stefan-Boltzman relation, 151

Stocks, common, 6
 Stokers, coal, chain grate,
 225
 overfeed, 224
 spreader, 225
 travelling grate, 225
 underfeed, 225
 fuel burning rate, 225
 Superheaters, 156
 convection, 156
 heat transfer, 157
 radiant, 157
 temperature control, 156
 Superposed cycle, 59
 Surface condenser, *see* Con-
 denser
 Surface, heating, apportion-
 ment of, 169
 Surge tanks, hydro plant, 299
 steam plant, 101
 Systems, power, 4

T

Tanks, surge, hydro plant, 299
 steam plant, 101
 Taxes, ad valorem, 26, 29
 income, 34
 Temperature difference, mean,
see Mean temperature differ-
 ence
 Temporary hardness, water, 210
 Terminal difference, condenser,
 97
 heater, 101
 Thermal conductivity, *see* Con-
 ductivity, thermal
 Thermal efficiency, *see* *specif-
 ic cycle*
 Thermometers, 249
 Topping turbines, *see* Super-
 posed cycle
 Total air, 120
 Towers, cooling, forced draft,
 108
 induced draft, 108
 Transmission systems, 4
 Treatment, water, 210
 Tubes, condenser, 96
 Turbines, hydro, 298
 impulse, 299

Turbines, hydro, reaction,
 299
 governing, 252
 impulse, hydro, 299
 steam, 73
 impulse-reaction, steam,
 75
 reaction, hydro, 299
 steam, 73
 steam, engine efficiency,
 75
 large condensing, 79
 mechanical drive, 75
 small condensing, 76
 small non-condensing,
 76
 superposed, 59
 topping, *see* superposed
 Turbo-generators, preferred
 standards, 76
 cost of, 79
 TVA, 3.

U

Ultimate analysis, fuel, *see*
 Fuel
 Underfeed stoker, 225
 Uniflow engine, 67
 United States, cost and use of
 domestic electric service,
 25
 electrical production, 1
 heat rate of power plants,
 1
 installed capacity, 1
 standard of living, 1
 Use factor, 19
 Useful life of power plant
 components, 30
 Utility organization, 5

V

Vacuum, engine efficiency
 correction for, 79
 Vacuum pumps, 105
 Valves, steam engine, 67
 Valves, power plant, 178
 Vapor power cycles, 45
 Variable load element, 33
 Velocity compounded impulse
 steam turbine, 73

Velocity, duct, 19C
 pipe, 175
 tube, condenser, 95
 heater, 102
Viscosity, gases, 191
 petroleum oils, 178
 steam, 178
 water, 178
Volatile matter in fuels,
 see Fuels, analysis
Volume, furnace, 146
 open feed-water heaters,
 100

W

Walls, furnace, air-cooled,
 153

Walls, furnace, insulated,
 151
 water-cooled, 146
Water, boiler, 218
 treatment, 31C
 horsepower, 203
Water-tube boilers, 138
Watt, 67
Work relations, fans, 239
 pumps, 203

Z

Zeolite, hydrogen, 217
 sodium, 216
 softening processes, 215