

CONTENTS

	Page
<i>CHAPTER I</i>	
SOURCE OF WATER SUPPLY	1
Surface Supplies	1
Self-Purification	2
Storage	3
Reservoir Size	4
Clearing of Reservoir Area	6
Ground Water Supplies	6
Quantity of Water Required	9
Variations from Annual Average	10
Fire Demand	11
Future Demand Based on Population Forecast	12
<i>CHAPTER II</i>	
METHODS OF WATER PURIFICATION	14
Purification by Storage	14
Slow Sand Filtration	14
Straining	15
Rapid Sand Filtration	16
Aeration	18
Desalination	19
Chemical Treatment and Application	20
Lime Slaking and Feeding	27
Direct Feed of Powdered Quicklime	30
Measurement of Water	30
<i>CHAPTER III</i>	
COAGULATION AND SEDIMENTATION	33
Coagulation	33
Aluminum Sulfate	34
Ferrous Sulfate and Lime	34
Ferric Sulfate	35
Chlorinated Copperas	35
Ferric Chloride	35
Sodium Aluminate	35
Lime	36
Other Coagulants	36
Laboratory Jar Tests	36
Mixing, Agitation, or Flocculation	38
Sedimentation	41
Sludge Blanket Filtration Devices	45
The Spiractor	46

	Page
<i>CHAPTER IV</i>	
FILTERS AND FILTRATION	50
Gravity or Rapid Type Filters	50
Loss of Head	53
Rate of Flow Control.....	53
Filter Underdrain or Strainer System	55
Filter Gravel	56
Filter Sand	58
Anthrafilt	58
Multimedia Filters	58
Mixed Media Filter	59
Wash-water Troughs or Gutters	59
Cleaning of Filter Bed	60
Pressure Filters	61
Diatomaceous Earth Filters	61
Insulating and Painting of Filters, Piping, and Pumps to Minimize Sweating	62
<i>CHAPTER V</i>	
DISINFECTION OR STERILIZATION	64
Sterilization with Chlorine	64
Chlorine Gas	64
Operation of V-Notch Chlorinator	65
Operation of Fischer-Porter Chlorinator	66
Operation of BIF Chlorinizer	69
Operation of Advance Gas Chlorinator	70
How Chlorine Kills Bacteria	71
Amount of Chlorine Required	71
Ammonia-Chlorine	73
Break-point Chlorination	74
Dechlorination	75
Chlorine dioxide	75
Sterilization with Lime	76
Conclusions Regarding Bactericidal Action of Lime	77
<i>CHAPTER VI</i>	
FLUORIDATION OF WATER	79
Fluoridation Chemicals	79
Application	80
Feeders	80
Hazards	80
Bulk Storage of Dry Fluorides	81
Status of Fluoridation	81
<i>CHAPTER VII</i>	
TASTES AND ODORS	82

CHAPTER VIII

Page

PREVENTION OF RED WATER AND CORROSION	86
---	----

CHAPTER IX

WATER SOFTENING	88
Lime and Soda Ash Process	88
What Is Hard Water?	88
Where Hard Water Is Found	88
How Hard Water Is Softened	90
History of the Lime-Soda Ash or Chemical Process	91
Explanation of Lime Treatment	93
Water Not "Doped" with Chemicals	93
Does Softening Water Affect the Taste?	94
Economic Aspects of Water Softening	95
Why Soften Water	95
Softeners in the Home	98
Cisterns	98
Other Advantages of Softening	98

CHAPTER X

CHEMISTRY OF LIME-SODA ASH PROCESS OF WATER SOFTENING....	102
Application of Analyses to Plant Operation	104
Determination of Proper Quantity of Lime	104
Determination of Proper Quantity of Soda Ash	105
Determination of Proper Quantity of Caustic Soda	106
Expression of Water Softening Results	107

CHAPTER XI

SOFTENING WATER FOR MUNICIPALITIES	109
Lime and Soda Ash Process	109
Application of Softening Chemicals	109
Mixing and Settling	112
Overcoming Limitations and Reducing Operating Costs of Process....	113
1. Excess Treatment	113
2. Split Treatment	115
3. Excess Lime Followed by Recarbonation	115
4. Addition of Aluminum Compounds	115
5. Substitution of Ion Exchanger for Soda Ash to Remove Non-Carbonate Hardness	115
6. Excess Lime, Recarbonation, and Secondary Stirring	117
7. Sludge Reclamation	118
8. Return Sludge in Lime-Soda Ash Water Softening	119
9. Sludge Disposal	119

	Page
<i>CHAPTER XII</i>	
REMOVAL OF IRON, MANGANESE, SILICA, HYDROGEN SULFIDE, AND FLUORIDES	122
Iron and Manganese Removal	123
Silica	125
Hydrogen Sulfide	125
Fluorides	126
Removal of Fluorides	126
Household Fluoride Removal Units	126
<i>CHAPTER XIII</i>	
RECARBONATION OF LIME SOFTENED WATER	127
Recarbonation Not Always Necessary	129
Comparison of Fuels for Carbon Dioxide Production	129
Apparatus Required	130
Types of Carbonation Plants	131
New Developments in Carbonation Equipment	132
Spray Impingement on CO ₂ Gas	134
Calculation of Carbon Dioxide Requirements	134
Capacity of Compressor or Blower Required	135
Carrying Capacity of Various Sizes of Pipe	136
Point of Application of Carbon Dioxide	136
Dry Ice, or Liquid Carbon Dioxide, Carbonation	136
Recarbonation with Sodium Bicarbonate	136
<i>CHAPTER XIV</i>	
ION EXCHANGE (ZEOLITE) PROCESS OF WATER SOFTENING	138
Silicious Type Ion Exchange Minerals	139
Softening Capacity of Ion Exchange Minerals	139
Polystyrene Base Exchangers	140
Ion Exchange Water Softening Units	141
Upflow versus Downflow—Channeling	143
Salt Storage and Brine Measuring Tank	143
Regenerating the Softening Unit	144
Salt Saving Scheme	144
Automatic Regeneration	145
Specifications for Salt	145
Ion Exchange Materials Used as Filtering Medium	146
Iron Removal	146
Iron Fouling	147
Control of Hardness	147
Adjustment of Calcium Carbonate Content and pH Value	150
Study of Water Supply	151
Choice between Lime-Soda Ash and Ion Exchange Softening	151
Ion Exchange Household Soft Water Service	152
Organic Ion Exchange Units	152
Cation Exchanger	152
Anion Exchanger or Adsorbent	153

<i>CHAPTER XV</i>		Page
TREATMENT OF BOILER FEED WATER		154
Boiler Scale		154
Lime-Soda Ash Softening for Boiler Feed Water (Hot Process)		157
Silica Removal		158
Sodium Ion Exchange Softening for Boiler Feed Water		160
Organic Ion Exchange Materials		160
Lime-Ion Exchange Softening for Boiler Feed Water		160
Condensate for Boiler Feed		161
The Use of Boiler Compounds or Internal Treatment		163
Phosphate Treatment of Boiler Feed Water		164
Boiler Corrosion		164
Boiler Plate (Caustic) Embrittlement		165
Foaming and Priming		165

CHAPTER XVI

TREATMENT OF WATER FOR MISCELLANEOUS USES	167
Water for Making Ice	167
Water for Brewing	168
Water for Other Uses	170

CHAPTER XVII

WATER DISTRIBUTION	172
--------------------------	-----

CHAPTER XVIII

SKELETON METHODS OF ANALYSIS	174
Water Analysis	174
Turbidity	174
Color	174
Hydrogen-ion Concentration (pH) (Potential of Hydrogen)	175
Alkalinity to Phenolphthalein and Methyl Orange	178
Acidity-Free Carbon Dioxide	178
Total Acidity	178
Free Mineral Acids	178
Mineral Acids and Sulfates of Iron and Aluminum	179
Total Hardness	179
Versenate Method	179
Soap Method	179
Non-Carbonate Hardness	180
Magnesium	180
Calcium	180
By Titration of Oxalate with KMnO_4	180
Calcium, by Versenate	181
Calcium and Magnesium	181
Total Dissolved Solids	182

	Page
Silica	182
Gravimetric	182
Colorimetric	182
Alumina	183
Iron	183
Manganese	184
Carbonate	184
Bicarbonate	184
Sulfates	184
Chlorides	185
Nitrates—U.S. Geological Survey Method	185
Hydroxide	185
Sodium Polyphosphate	186
Fluorides	187
Waters Requiring Preliminary Distillation Treatment	188
Microscopic Examination of B. Coli Group	188
Procedure for Gram-Staining B. Coli	189
Preparation of Staining Solution	189
Completed Coli-Form Organisms	190
Presumptive Test	190
Partially Confirmed Test on Eosin Methylene Blue Stroke Plates	190
Confirmed Test, Using Brilliant Green Bile	190
Completed Test	191
Membrane Filter Procedure for Coli-Form Group	191
Reporting Results of Water Analysis	191
Graphic Scheme	194
Calculating Hypothetical Combinations	195
Residual Chlorine	197
Calcium Carbonate Chemical Balance or Stability Test	197
Quantitative Determination of Odor	199
Outline of Laboratory Odor Experiments	200
Break-Point Chlorination Treatment	200
Carbon Treatment	201
Permanganate Treatment	201
Procedure for Determination of Algae and Micro-organisms	201

CHAPTER XIX

MISCELLANEOUS ANALYSES, TESTS, AND STANDARDS.....	203
Analysis of Lime	203
Rapid Sugar Test	203
Complete Chemical Analysis	203
Slaking Rate Test	203
Specifications for Lime	203
Analysis of Soda Ash	203
Specification for Soda Ash	204
Analysis of Aluminum Sulfate	204
Specification for Aluminum Sulfate	205
Analysis of Filter Sand for Effective Size and Uniformity Coefficient... ..	205

	Page
Preparation of Reagents for Laboratory Experiments	206
Drinking Water Standards	207
Useful Equivalents	211
Weight of Chemicals	212
Pump Power Requirements	213
Manometer Conversion Table	213
Temperature Conversion	213
Useful Formulae	214
Table of Atomic Weights	215