

A HISTORIC CONTEXT FOR THE TRANSMISSION OF HYDROELECTRICITY

BY THE BONNEVILLE POWER ADMINISTRATION, 1939-1945

by

CHRISTINE ANN CURRAN

*Roll on Columbia, roll on...*

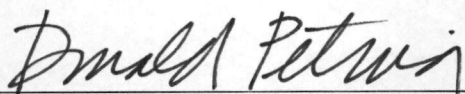
*Christine A. Curran*

A THESIS

Presented to the Interdisciplinary Studies Program: Historic Preservation  
and the Graduate School of the University of Oregon  
in partial fulfillment of the requirements  
for the degree of  
Master of Science

June 1998

"A Historic Context for the Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945," a thesis prepared by Christine A. Curran in partial fulfillment of the requirements for the Master of Science degree in the Interdisciplinary Studies Program: Historic Preservation. This thesis has been approved and accepted by:



---

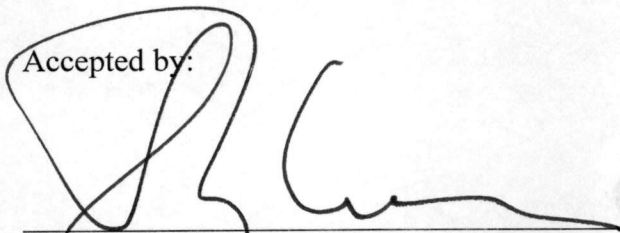
Professor Donald Peting, Chair of the Examining Committee

27 May 1998

Date

Committee in charge: Professor Donald Peting, Chair  
Professor Mary Gallagher  
Dr. William Willingham

Accepted by:



---

Vice Provost and Dean of the Graduate School

An Abstract of the Thesis of

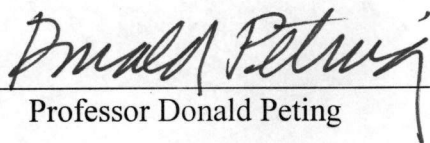
Christine Ann Curran for the degree of Master of Science

in the Interdisciplinary Studies Program: Historic Preservation

to be taken June 1998

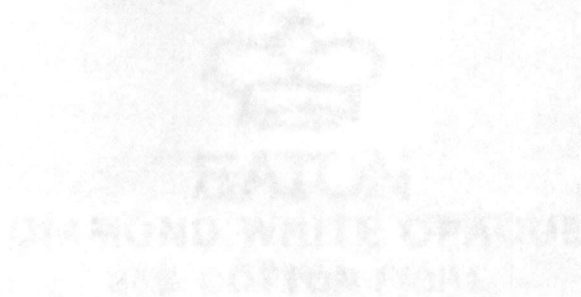
Title: A HISTORIC CONTEXT FOR THE TRANSMISSION OF  
HYDROELECTRICITY BY THE BONNEVILLE POWER ADMINISTRATION,  
1939-1945

Approved:

  
Professor Donald Peting

The Bonneville Power Administration (BPA) was created in 1937 to market power from Bonneville Dam and later, Grand Coulee Dam, two New Deal relief projects on the Columbia River. Between 1939 and 1945 the BPA built a long-distance, high-voltage electrical transmission network that connected Bonneville and Grand Coulee Dams with population centers in Oregon's Willamette Valley and Washington State's Puget Sound area. Known as the "master grid," the original transmission system included 2,736 circuit miles of transmission line and fifty-five electrical substations. This study provides a historic context for the properties that comprise the master grid. It also identifies and describes the grid's two main property types: the electrical substation and the transmission line, discussing ranges of variation and distribution patterns for each

type. This study also sets forth registration requirements and evaluation criteria for the master grid properties, as well as treatment recommendations and mitigation measures for their preservation.



## CURRICULUM VITA

NAME OF AUTHOR: Christine Ann Curran

PLACE OF BIRTH: Portland, Oregon

DATE OF BIRTH: May 13, 1965

## GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon  
Lewis and Clark College

## DEGREES AWARDED:

Master of Science in Historic Preservation, 1998, University of Oregon  
Bachelor of Arts in Art, 1987, Lewis and Clark College

## AREAS OF SPECIAL INTEREST:

Preservation of historic industrial and engineering resources

## PROFESSIONAL EXPERIENCE:

Architectural Historian, Hess, Roise and Company, Minneapolis, Minnesota,  
1996-present

Cultural Resources Assistant, Oregon Department of Transportation, Salem, 1994

Research Assistant, Heritage Research Associates, Eugene, Oregon, 1993

Graduate Intern, Museum of Art, University of Oregon, Eugene, 1992-94

Research Assistant, Demuth Glick Consultants, Ltd., Portland, Oregon, 1991

Research Associate, Janus Associates, Inc., Phoenix, Arizona, 1990

AWARDS AND HONORS:

Oregon Laurel Award, 1992-93

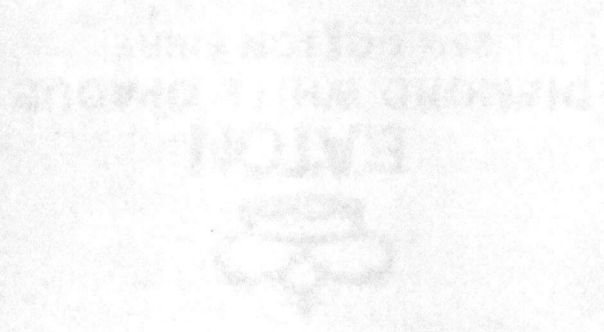
Oregon Laurel Award, 1993-94

## ACKNOWLEDGEMENTS

This project would not have been possible without the assistance of several people at the Bonneville Power Administration. In particular, Sue Ludeman, Robert Hasibar, and Susie Sivyer went out of their way to provide me with crucial information and contacts. Substation operators and building managers gave their time and knowledge, patiently answering questions and lending their hard hats. Thanks to Bob Presser, Salem; Bill Haden, Eugene; John Straub and Marlin Lewis, Vancouver; Janice Sushereba, Ellensburg; and the staff at Troutdale. I also want to express my appreciation to my thesis committee: Don Peting, Mary Gallagher, and Bill Willingham. Their thoughtful comments and professional guidance were made all the more significant by the miles that separated all of us. I want to thank my family and friends for their patience, support, and encouragement when I needed it the most. Finally, I am grateful to JR Vanderburg, for remaining interested, insightful, and understanding all the way through this long process.

DEDICATION

For my parents



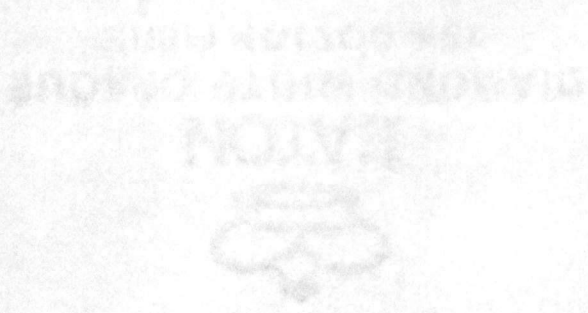
## TABLE OF CONTENTS

	Page
INTRODUCTION .....	1
Chapter	
I. HISTORICAL OVERVIEW .....	4
Early Electrical Transmission, 1873 - 1899 .....	4
Development of Alternating Current .....	6
A Precedent is Set: Niagara Falls .....	10
Electrical Transmission in the Pacific Northwest .....	13
Interconnected Systems in the Pacific Northwest .....	16
Planning for Power: The Evolution of Integration .....	19
Superpower Realized: Conowingo and the PNJ Interconnection .....	22
The Great Depression .....	25
"Talking Columbia" .....	26
The Boulder Canyon Project Act .....	29
The Federal Government in the Power Business .....	32
"The Biggest Thing That Man Has Ever Done" .....	34
The Marketing Dilemma .....	37
The Bonneville Project Act .....	43
The Bonneville Power Administration .....	46
Planning for the Master Grid .....	47
Nuts, Bolts, and Substations: Design Issues of the Master Grid .....	51
Building the Big Line .....	56
A Second Leader and a Second War .....	62
The Northwest Power Pool .....	71
Conclusion .....	74
II. IDENTIFICATION .....	79
Purpose and Methodology .....	79
Property Type: Electrical Substation .....	81
Property Type: Transmission Line .....	117

	Page
III. EVALUATION.....	171
Property Type: Electrical Substation.....	172
Property Type: Transmission Line .....	178
IV. TREATMENT .....	183
Survey Needs.....	183
Research Needs.....	185
Treatment Strategies and Mitigation Measures .....	186
SUMMARY .....	190
BIBLIOGRAPHY .....	196

### LIST OF TABLES

Table	Page
1. Substations Identified .....	124
2. Transmission Lines Identified.....	128



## LIST OF FIGURES

Figure	Page
1. Map of the Master Grid, 1938 .....	61
2. Map of the Master Grid, 1944.....	76
3. Map of the Master Grid, 1946.....	123
4. Control House, Eugene Substation .....	138
5. Control House, Eugene Substation .....	139
6. Control House, Eugene Substation .....	140
7. Control Room, Eugene Substation.....	141
8. Control House Plan, Eugene Substation .....	142
9. Control House, Troutdale Substation.....	143
10. Control House, J. D. Ross Substation.....	144
11. Control House, J. D. Ross Substation.....	145
12. Control House, Ellensburg Substation.....	146
13. Control House/Untanking Tower, Salem Substation.....	147
14. Control House, Astoria Substation .....	148
15. Control House, Astoria Substation .....	149
16. Untanking Tower, Salem Substation .....	150
17. Interior of Untanking Tower, Salem Substation .....	151

	Page
18. Interior of Untanking Tower, Salem Substation .....	152
19. Untanking Tower, J. D. Ross Substation .....	153
20. Oil House, Troutdale Substation.....	154
21. Switchyard, Troutdale Substation.....	155
22. Switchyard, J. D. Ross Substation .....	156
23. Buswork, Ellensburg Substation.....	157
24. Gas Circuit Breaker and Transformers, Eugene Substation .....	158
25. Oil Circuit Breakers, Salem Substation .....	159
26. Capacitor Banks, Astoria Substation .....	160
27. Disconnecting Switch, Troutdale Substation.....	161
28. Switchyard Lighting Fixture, Ellensburg Substation.....	162
29. Transformer Fans, Troutdale Substation.....	163
30. Double-Circuit Suspension Tower, Bradford Island.....	164
31. Single-Circuit Crossing Towers, Bradford Island .....	165
32. Transmission Line Corridor, Bonneville Dam.....	166
33. Drawing, Single-Circuit Suspension Tower .....	167
34. Drawing, Single-Circuit Crossing Tower .....	168
35. Drawing, Single-Circuit Lattice Pole Tower .....	169
36. Drawing, Double-Circuit Suspension Tower.....	170

## INTRODUCTION

The Bonneville Power Administration (BPA) is a hydroelectric power marketing agency whose genesis was concurrent with the Federal government's commitment to promoting hydroelectric power in the western United States during the 1930s. Over nearly 15,000 circuit miles of their own high-voltage transmission lines, the BPA brings to market power generated by twenty-nine federal dams on the Columbia and Snake Rivers and their tributaries. The BPA's service area stretches across 300,000 square miles, encompassing the states of Oregon, Washington, Idaho, western Montana, and parts of California, Wyoming, Nevada, Utah, and eastern Montana.<sup>1</sup>

The BPA was established in 1937 to market power from Bonneville Dam, the first federal dam on the Columbia River. In 1938, J. D. Ross, the BPA's first administrator, unveiled a master plan for a transmission network that would connect Grand Coulee and Bonneville Dams with the population centers of Portland and Puget Sound. Known as the "master grid," this network would link together Pasco, Yakima, Spokane, and Ellensburg, Washington; then join with Washington and Oregon coastal areas and extend down the Willamette Valley to the California border. This master plan proposed in 1938 did indeed

---

<sup>1</sup> Department of Energy, "Bonneville Power Administration 1994 Fast Facts," March 1995.

govern the construction of the BPA main transmission grid that exists today.

The power that traveled along the transmission lines built by the BPA between 1939 and 1945 triggered an industrial transformation in the Pacific Northwest. By constructing nearly 3,000 circuit miles of its own transmission lines and interconnecting with existing public, private and municipal distribution systems, the BPA grid brought cheap Columbia River power to rural communities and attracted large industry to the region.

New Pacific Northwest industries used Bonneville power to produce material for ships and planes and explosives during World War II. More than twenty-five percent of the total aluminum output in the United States during 1943 was produced in the Pacific Northwest, using power transmitted by the BPA.<sup>2</sup> Perhaps BPA's most significant, if not infamous, contribution to the war effort was the provision of power to the Hanford, Washington plant for the production of plutonium used to create the atomic bomb that ended World War II.

This study will provide a historic context for the events that shaped the history of BPA's transmission grid between 1939 and 1945. In addition, this study will provide guidance for the preservation of resources directly linked to the historic context of hydroelectric power transmission by the BPA. It will serve as a starting point from which

---

<sup>2</sup> Gene Tollefson, *BPA and the Struggle for Power at Cost* (Portland: Bonneville Power Administration, 1987), 172.

further research, survey and inventory can be directed to assist in evaluation and treatment programs.

There are four components within this historic context: (1) a *historical overview chapter*, which discusses the history of electrical transmission in the Pacific Northwest and the development of transmission facilities by the Bonneville Power Administration during the years 1939 through 1945; (2) an *identification chapter*, which presents property types associated with the development; (3) an *evaluation chapter*, where parameters are set and registration requirements are presented for the assessment of the property types; and (4) a *treatment chapter*, which includes an initial list of mitigation measures and strategies for the preservation of these resources.

This historic context will be a thematic study focusing on the research topics of Industry, 20th Century Architecture and Engineering, Social History, and Politics/Government. The context will discuss the range of variability, character-defining features, evaluation criteria and protection/treatment activities for identified property types that represent the transmission of hydroelectricity by the BPA. The *temporal* boundaries of the study are from 1939 to 1945. The transmission of power over the first lines of the master grid defines the start date. All the features comprising the original plan of the master grid were in place by the time World War II ended in 1945, thus providing the end date. The *spatial* boundaries of the study comprise the states of Oregon and Washington. These are the states that contain the identified property types.

## CHAPTER I

### HISTORICAL OVERVIEW

#### Early Electrical Transmission, 1873 - 1899

The first practical demonstration of electric power transmission was made by Belgian scientist Zenobe Gramme at the 1873 Vienna Exposition. Using a steam engine-driven motor as a dynamo, he transmitted electricity approximately 550 yards, and used it to power a motor-driven pump.<sup>3</sup> By the late 1870s and the early 1880s, electricity was being used for arc and incandescent lighting, generated by coal, steam or water-driven dynamos. Both lighting systems depended on direct-current transmission for the distribution of electricity.<sup>4</sup> Direct-current transmission worked well for transmission of electricity over short distances, but was problematic for long-distance use. During transmission, resistance from the copper conductors converted much of the electrical

---

<sup>3</sup> Generators were called "dynamos" until 1892 (Tollefson, 14); Duncan Hay, *Hydroelectric Development in the United States, 1880-1940* (Washington, D.C.: Edison Electric Institute, 1991), 6.

<sup>4</sup> Direct current refers to the flow of electricity through a current in which electrons travel in only one direction, like water through a pipe. For an excellent discussion of basic principles of electricity, please see William B. Steinberg and Walter B. Ford's *Electricity and Electronics - Basic* (Chicago: American Technical Society, 1961).

energy to heat before it reached the other end of the line. There was also a corresponding loss of pressure, or voltage, in the electrical current, between the time it was generated by the dynamo and the time it reached its destination.<sup>5</sup> If the transmission route was short, there was less resistance, and the loss of voltage was minimal. However, the longer the transmission route, the greater the resistance, and the voltage loss could be quite substantial by the time the electrical current reached the end of the transmission line. The power demand at the end of a transmission line is equal to the voltage multiplied by the current of the electrical energy. Because of this directly proportional relationship, a heavy current flow accompanied the relatively low voltages that early systems generated. Transmitting a heavy current required large, expensive conductors, and it also meant lots of heat in the lines, which resulted in line losses.<sup>6</sup> Maintaining constant voltage over many miles of transmission lines would have required an enormous generator capable of producing several times the amount of voltage needed on the receiving end of the line, as well many miles of huge conductors to accommodate the heavy currents. Because of these technological restrictions, lighting operations in the 1870s and the early 1880s could not extend more than a mile beyond the generating station. Consequently, generating plants were centrally located in settled urban areas, close to the homes,

---

<sup>5</sup> John J. O'Neill, *Prodigal Genius: The Life of Nikola Tesla* (New York: Ives Washburn, Inc., 1944), 70.

<sup>6</sup> Steinberg and Ford, 113.

factories, and streets that comprised the market for arc and incandescent lighting companies. Households in suburban or rural districts were forced to remain dependent on candles and oil lamps for illumination.<sup>7</sup>

### Development of Alternating Current

In an effort to make electricity available for wider use, inventors in the early 1880s worked with urgency to find a way to transmit high voltage electrical current over long distances. Research all over the world focused on a type of electrical current called alternating current (AC).<sup>8</sup> The scientific principles behind alternating current electricity allowed the introduction of a transformer into the system.<sup>9</sup> The transformer made voltage adjustments possible along the transmission route; electricity could be generated at low voltage, stepped up by a transformer to a high voltage for transmission, then stepped down again to accommodate differing industrial, commercial and residential loads at the end of the line.

---

<sup>7</sup> Hay, 6.

<sup>8</sup> Alternating current always flows first one way through a circuit and then reverses and starts flowing in the other direction.

<sup>9</sup> For a good description of the relationship between alternating current and transformers, please see O'Neill's *Prodigal Genius*.

Scientists had been working with alternating current for years, but it was the invention of the transformer that made the application of alternating current feasible for use in a long-distance transmission system. Frenchman Lucien Gaulard and his English business partner, John Gibbs are credited with inventing the transformer. Gaulard and Gibbs were the first to patent a complete system that combined alternating current with transformers as an economical means of long-distance transmission. The two inventors received their first British patent for "A New System of Distributing Electricity for the Production of Light and Power" in 1881-1882, but it took several more years to develop a fully functional system. Gaulard and Gibbs demonstrated their alternating-current transformer at the Inventions Exposition in London in 1885. Upon hearing of the demonstration and consequent work with a ten-mile-long transmission line near Turin, Italy, George Westinghouse rushed to secure American rights to their patents.

Westinghouse, along with inventor William Stanley, proceeded to develop a means of manufacturing transformers that was much less expensive than the Gaulard and Gibbs process. In March 1886, Stanley installed a 500-volt Siemens alternating-current motor (alternator) and steam engine on the outskirts of Great Barrington, Massachusetts and led a one-mile-long transmission line from there into the center of the village where six transformers stepped voltage down for distribution. By the end of that year, alternating-

current incandescent lighting systems were in commercial operation.<sup>10</sup> Westinghouse's system generated power at 2,200 - 2,400 AC volts and transformed it up to 11,000 volts for transmission. Voltages were then stepped down to 110 or other useable low voltages for consumers at the end of the line. Alternating-current transmission offered many far-reaching advantages over direct current. Since voltages were high during transmission, the accompanying currents were low, which meant smaller conductors could be used. The savings in copper costs were dramatic. In addition, the ability to transmit electricity long distances freed generating plants from their mile-wide radius restrictions. Plants could extend operations to rural districts that had been previously unreachable, and the plants themselves could be located far from urban areas. The latter was particularly liberating for western generating plants that used hydropower to operate their generators. Hydropower plants could finally take advantage of the steep waterfalls and numerous rivers in the western United States, development of which had been hindered by remoteness from urban centers.<sup>11</sup>

More improvements to the Westinghouse system came in 1888, when Serbian immigrant Nikola Tesla sold his patented poly-phase (3-phase) AC system to Westinghouse. Previous to Tesla's invention, AC systems operated on a single-phase

---

<sup>10</sup> Hay, 10-12.

<sup>11</sup> Tollefson, 36.

system. Tesla multiplied the effectiveness of the original system by making it operate on three or more alternating currents simultaneously.<sup>12</sup> The implications of Tesla's new "Universal system" spanned all technological and socio-economical boundaries. BPA historian Gene Tollefson explains,

The [polyphase] system was capable of supplying incandescent lamps, arc lights, direct current motors, single-phase alternating current motors, polyphase motors, and energy for thermoelectrical, and electrochemical uses - all from a common transmission line. It set off a shockwave of institutional reorganization that did not end until after WWII, more than 40 years later. Mines, mills, manufacturing and commercial establishments became more productive. Electric motors were adapted to drills, saws, printing presses, food processing plants, and other uses. In the home, sewing machines and electric kitchen appliances made their first appearances.<sup>13</sup>

Westinghouse successfully demonstrated Tesla's polyphase Universal system at the Columbian Exposition during the Chicago World's Fair in 1893. The famous "City of Lights," the spectacular illumination of all the fair buildings and grounds at night, was made possible by polyphase alternating-current electricity, generated by Westinghouse alternators.<sup>14</sup>

Hydroelectric projects at Willamette Falls in Oregon City, Oregon (1890), and

---

<sup>12</sup> O'Neill, 51.

<sup>13</sup> Tollefson, 42.

<sup>14</sup> Hay, 21.

Snoqualmie Falls in Washington State (1899) were among the first to provide a test of the new alternating current transmission system. In addition, dramatic projects, built in the early 1890s in the Rockies and the Sierra mountains of California, used newly available long-distance transmission lines to bring power to mining operations, where fuel scarcity was becoming a serious problem due to their remote locations. The 1890s saw inventive minds, especially in the West, taking advantage of alternating current to build pioneering transmission networks, shattering the technological impasses that had tethered the region for decades. While many of the early applications of alternating current occurred in the frontier west, it took a highly visible eastern project, at Niagara Falls, New York, to firmly establish the electrical generation and transmission standards that guide the industry today.

#### A Precedent is Set: Niagara Falls

The hydroelectric development at Niagara Falls presented George Westinghouse with an opportunity to demonstrate his Universal system on a far larger scale than any previous electrical project he had undertaken. The scale of the Niagara plant was unprecedented, and Westinghouse and other engineers found themselves designing electrical components specifically for Niagara operations. When the plant went on line for the first time in 1895, it served only local loads. The following year, electricity from Niagara Falls began serving Buffalo, New York, traveling twenty miles along an 11,000-

volt transmission line. Soon, demand by electrochemical industries located at Niagara Falls exceeded that of Buffalo. Pittsburgh Reduction Company (later named Aluminum Corporation of America - ALCOA) quickly became one of Niagara's largest customers.

Other companies followed, including Carborundum Company, a producer of silicon carbide, and Union Carbide, which manufactured calcium. By 1898, two-thirds of the electric power produced by Niagara Falls was being used by electrochemical manufacturers.

Duncan Hay suggests that Niagara's significance was primarily symbolic:

Niagara demonstrated both the technical and economic viability of generating electricity in enormous quantities as a commodity that could be sold to a variety of users, many of whom were located some distance from the point of generation. Technical features such as 3-phase AC generation and transmission, step-up and step-down transformers, and the use of rotary converters for changing AC to DC, had been used at previous sites but the size of the Niagara Project gave them a visibility and legitimacy that overshadowed alternative systems. Beyond the equipment, Niagara proved to the financial community that hydroelectricity could be a means of making money.<sup>15</sup>

Bernard Finn talks about the impact Niagara had on the field of electrical engineering in a broader sense:

The full potential of the electrical revolution began to be realized at Niagara Falls. Here was shown the immense promise of water-powered electrical generation. Here was made clear the great future of electricity applied to chemistry. Here was proven the great value of high-voltage

---

<sup>15</sup> Hay, 25.

alternating current for the transmission of power. Here was schooled a whole generation of electrical engineers, who, having solved the problem of harnessing Niagara, went on to bring electricity within the reach of everyone.<sup>16</sup>

The technological and economic trends that began at Niagara Falls had a profound effect on the electrical industry. Power plants across the United States adopted modified or elaborated versions of the principles developed at Niagara for the next twenty-five years.<sup>17</sup>

The diversity of solutions to electrical transmission problems reached their pinnacle in the years that followed initial operations at Niagara Falls. Innovations and experimentation continued to mark transmission developments in the west, but with the added technical knowledge and initiative spawned by the plant at Niagara Falls.

States west of the Rockies continued to see some of the longest transmission distances in the country, as water resources with the most hydroelectric potential were typically located hundreds of miles from load centers. In addition, transmission facilities in western states did not have to withstand the humidity, ice, and snow that characterized the weather in the East and Midwest. Climatic conditions in California, Colorado, Nevada and Utah were comparatively arid, inflicting less damage to long spans of

---

<sup>16</sup> Bernard S. Finn, *Lighting a Revolution: The Beginning of Electric Power* (Washington, D.C.: Smithsonian Institution, 1979), 80-81, quoted in Hay, 25.

<sup>17</sup> Hay, 25.

transmission line, which resulted in lower maintenance costs. Thirdly, much of the west was unsettled territory, making it was much easier to secure many continuous miles of rights-of-way than it was east of the Rockies where populations were dense.<sup>18</sup>

### Electrical Transmission in the Pacific Northwest

The advent of alternating-current transmission found several private lighting companies operating in the Pacific Northwest, most of them founded in the mid-1880s. U.S. Electric Lighting and Power Company (predecessor of Portland General Electric) of Portland, the Seattle Electric Lighting Company of Seattle, the Tacoma Light and Water Company of Tacoma, and Washington Water Power of Spokane, were all distributing direct current electricity from central stations. In 1889, transmission of direct-current electricity from Willamette Falls in Oregon City, Oregon, fourteen miles to the city of Portland, initiated long-distance electrical transmission systems in the Pacific Northwest. The following year, the Oregon City plant switched successfully to alternating current. The installation at Snoqualmie Falls in Washington State, completed in 1899, used a vertical drop of 270 feet to generate electricity, which was then distributed by parallel transmission lines to Seattle (thirty-two miles away) and Tacoma (forty-four miles

---

<sup>18</sup> Ibid., 31.

distant). As with the Buffalo line at Niagara, Westinghouse's 3-phase, universal system was used.<sup>19</sup>

During this time, the major cities in the region were establishing streetcar systems. In addition to providing a market for electricity beyond illumination, the streetcar systems, in some cases, served as a means of extending municipal electrical distribution grids. In these instances, railway companies would contract with private lighting companies for use of the transmission lines built to service the streetcars.<sup>20</sup>

Private companies were not the only entities developing electrical operations in the late 1890s. Soon after the Civil War, a series of fatal epidemics caused by water-borne disease prompted many U.S. cities to acquire and operate their own water systems. Cities that owned their own systems were likely to develop a subsequent electrical generating plant to supply themselves with cheap electricity for pumping operations. Subsequently, many city-owned systems expanded their distribution networks and began to provide electricity in their municipality where service by private companies was insufficient. Seven cities in the Pacific Northwest operated electrical distribution systems by 1900: McMinnville, Milton-Freewater, and Forest Grove, Oregon and Tacoma,

---

<sup>19</sup> Tollefson, 28-33.

<sup>20</sup> Ibid.

Centralia, Port Angeles and Ellensburg, Washington.<sup>21</sup>

After the turn of the century, the federal government entered the electricity market on a limited scale. In 1902, Congress passed the Reclamation Act to encourage settlement of the western United States. The Act created the Reclamation Service, an agency charged with irrigating the arid regions of the west by constructing large water storage projects and pumping plants. During the construction of Reclamation's first two projects, the Theodore Roosevelt Dam at Arizona's Tonto basin, and the Minidoka Project on Idaho's Snake River, the government realized the commercial potential of the hydroelectricity that was being generated at both sites to support construction activities. Subsequently, Congress passed the 1906 Townsite Act, which authorized the Reclamation Service to sell surplus power from irrigation projects, with preference given to municipalities. Revenue from would be used to pay for the irrigation project. At Roosevelt Dam, the Reclamation Service built transmission lines to the city of Phoenix, where the power was purchased by Pacific Gas and Electric Company. At Minidoka, Reclamation built transmission lines to three towns, Heyburn, Rupert and Burley. In turn, the towns organized cooperative utility companies, which built distribution networks inside the town, and arranged sales to individual customers. By 1920, over 1,100 Idaho farm families were obtaining electricity from approximately twenty mutual power

---

<sup>21</sup> Gus Norwood, *Columbia River Power for the People: A History of Policies of the Bonneville Power Administration* (Portland: Bonneville Power Administration, 1980), 95-103.

companies that maintained 290 miles of distribution lines. In this way, the Reclamation Service became an unlikely mechanism for the expansion of electric power transmission networks in some western states.<sup>22</sup>

### Interconnected Systems in the Pacific Northwest

By the time the Minidoka Project began providing electric power to rural Idaho towns, electricity had become commonplace in the major cities of the Pacific Northwest. Portland's Lewis & Clark Exposition of 1905 had exposed over three million people to a brilliant display of interior and exterior electric lighting, demonstrating that electricity was "no longer a novelty in the cities."<sup>23</sup> By the end of that year, power distribution systems of public and privately owned utility companies served most of the towns and cities in the Pacific Northwest.

In 1910, American Power and Light, a subsidiary of an eastern holding company known as Electric Bond and Share, incorporated Pacific Power and Light (PP&L) in Portland, Oregon. PP&L was the first of many Pacific Northwest utilities that was formed

---

<sup>22</sup> Leah S. Glaser, "Historic American Engineering Record, Eastern Mining Area Transmission Line (The 115kV System), HAER No. AZ-6-B, Gila County, Arizona." Salt River Project, Phoenix, Arizona, June 1996, 4-10; Jeffrey Hess and Demian Hess, "The Minidoka Project," typed manuscript, 1991.

<sup>23</sup> Tollefson, 55.

or acquired by large eastern-based holding companies between 1910 and 1930. The trend toward holding company ownership in the utility industry began nationally just after the turn of the century. Holding companies acquired small, underdeveloped operating utilities, financed their improvement, and provided expert advice in the areas of generation, transmission and distribution of electricity. As the operating companies grew, so did the profits, and control, of the holding companies. Although the power and influence of the holding companies would peak in the Pacific Northwest and the rest of the country in the 1920s, the trend began to shape the development of transmission and distribution systems in Oregon and Washington before the First World War.

After incorporating PP&L, Electric Bond and Share proceeded to acquire several small utilities in Oregon and Washington. Historian Thomas P. Hughes illuminates the strategy behind the holding company's actions:

When the companies acquired [by the holding company] were in the same geographical area. . . they were united by transmission lines into a continuous system and were often merged to form larger operating companies. As a result, small, inefficient plants could be shut down, load factor could be improved, varied energy sources mixed, and diversity exploited.<sup>24</sup>

The small utilities that Bond and Share acquired were subsequently interconnected and absorbed by PP&L, providing the newly formed company with an instant customer base,

---

<sup>24</sup> Thomas P. Hughes, *Networks of Power* (Baltimore: The Johns Hopkins University Press, 1983), 399.

several generating facilities, and 388 miles of transmission lines. In 1911, one year after its incorporation, PP&L acquired and interconnected eight more neighboring systems.<sup>25</sup>

Available technology and demonstrated success prompted similar interconnections between disparate electrical systems. Spokane's Washington Water Power (WWP) was another private utility that took an early lead in consolidating systems in central and eastern Washington and Idaho. However, unlike PP&L, WWP was not owned by a holding company. It was a large, independently owned utility that supplied much of the inland region with electricity over 600 miles of 66,000-volt transmission lines from its numerous and powerful generating plants. WWP sold power wholesale to small town utilities until 1913, when it began acquiring them. Operating under a single owner, the WWP system of generating plants and transmission lines evolved over several years to cover 20,000 square miles. After World War I, the WWP system interconnected with other privately owned electrical systems in Washington, Oregon, Idaho and Montana, forming one of the largest regional interconnections in the country.<sup>26</sup>

---

<sup>25</sup> Tollefson, 63; John Dierdorff, *How Edison's Lamp Helped Light the West* (Portland: Pacific Power and Light Company, 1971), 16.

<sup>26</sup> Tollefson, 65.

### Planning for Power: The Evolution of Integration

Across the country, regionally interconnected networks proved more efficient, more capacious, and more dependable than isolated distribution systems. However, most utilities were still able to meet their load requirements profitably while operating independently. Therefore, interconnected electrical systems were still in the minority as the United States prepared to enter the First World War. As the war effort geared up, many utilities found they could not meet the enormous demands for electricity needed to produce war materiel. A survey of the country's generating plants sponsored by the War Industries Board revealed that using interconnection technology could greatly increase the generating capacity of existing plants. The results of the survey prompted the federal government to build giant steam and hydroelectric power plants to augment existing transmission systems. The high productivity of these systems boosted American generating capacity by more than two million horsepower between the spring of 1917 and the fall of 1918. Despite this increase, however, demand by war industries continued to outpace production. In July 1917, the War Industries Board predicted that if hostilities continued through the winter of 1918-1919, the nation would suffer a massive power shortage. As historian Duncan Hay explains, to avert the shortage, the War Industries Board "and other government agencies actively encouraged, and in some cases ordered,

interconnection of electric generation and distribution systems."<sup>27</sup>

World War I marked the first time interconnections had been used successfully on such a large scale in the United States. In addition, the end of the war left government and industry planners with the task of developing new markets for several giant federal power plants. Through these efforts was born the notion of the "integrated system," in which the existing facilities of independent utilities were combined with new generating facilities and high-voltage transmission lines to create a huge "power pool" that was centrally controlled and operated. The difference between standard interconnection practices and integration was,

a simple interconnection tied together at one juncture or a limited number of points only two utility systems; often the capacity of the tie line was small, permitting transfer of only a limited amount of excess power. Control of each system remained independent. By contrast, integration would bring two formerly independent systems under common control. No longer would it be possible to distinguish the boundaries of these systems by their tie lines, for these would become part of the transmission-line network of the integrated systems. Institutional merger did not follow immediately, however.<sup>28</sup>

Integration was the technological key to the "planned systems" that emerged after the war. Historian Thomas Hughes explains the concept:

The purpose of these new systems, established according to master plans,

---

<sup>27</sup> Hay, 115.

<sup>28</sup> Hughes, 296.

was to knit together, on a regional scale, utilities that had formerly evolved independently. The planned networks, or grids, usually took the form of high-voltage lines ringing a supply region, or polygon, the sections of which met at major load centers. The planned grids represented the pooling of energy from utilities that preserved their legal identities, primarily as distributors of the pooled energy. In some instances, a separate corporate entity owned and managed the grid; in others, the utilities presided over the grid, or pool, using a committee structure. . . . Under some plans, the utilities or power companies fed the pool from their own power plants. Under others, the grid took power both from its own plants and from the plants of participating utilities.<sup>29</sup>

Alarmed by the power shortages during World War I, planners and engineers increasingly looked toward the idea of huge regional planned grids, or power pools, to solve the problem of future nationwide power shortages. Industry leaders agreed that a comprehensive system was an appropriate solution, but disagreements erupted over whether the nationwide network should be should be publicly or privately owned. Politicians and government officials brought the issue to the forefront of public debate in the early 1920s, when secretary of interior Franklin Knight Lane emerged in support of a privately owned and operated system known as "superpower." In theory, the system, which would be owned and managed by private holding companies, would combine huge new thermal and hydroelectric generating plants with existing facilities under a new master grid of superhigh-voltage transmission lines. Opposition to this plan was led by Pennsylvania governor Gifford Pinchot, who envisioned a scheme similar to superpower,

---

<sup>29</sup> Ibid., 324.

but publicly owned. In further contrast to superpower, "giant power" included a distribution plan to service rural areas, a market long neglected by private utilities and unreachable by municipal systems. The year 1926 was a definitive year for the public versus private power debate. Pinchot's giant power failed in the Pennsylvania legislature, as the Federal Power Commission authorized the construction of the nation's first superpower project on the Susquehanna River near Conowingo, Maryland.<sup>30</sup>

#### Superpower Realized: Conowingo and the PNJ Interconnection

Built by the Philadelphia Electric Company, the Conowingo plant was designed specifically to feed into a regional transmission grid, formed when Philadelphia Electric's existing facilities were interconnected with those of two neighboring utilities, the Public Service Electric and Gas Company of New Jersey and the Pennsylvania Power and Light Company. The construction of a high-voltage grid and the Conowingo hydroelectric plant completed the integration of the three utilities, forming what was the world's largest power pool at that time, with 1.5 million kilowatts of centrally controlled power. The Conowingo project did not introduce new technology to the industry. Its uniqueness lay in the way the power pool was administered. While Conowingo was still under

---

<sup>30</sup> Tollefson, 76; Hughes, 303-304.

construction, the three companies formed a new entity known as the PNJ Interconnection, which operated the power pool from a central dispatcher. Historian Thomas Hughes highlights some of the reasons the PNJ power pool was so unique in the industry:

The integrated and centrally controlled PNJ power pool differed from the mergers and utility holding-company structures that were then proliferating. The utility managers and engineers who operated the power pool began to see the PNJ as electrically one company, but financially and organizationally a committee of peers negotiating planning and operations. The PNJ brought the economic benefits of a large system and at the same time preserved the utilities' corporate identities.<sup>31</sup>

The success of the PNJ venture gave credibility to the superpower notion. The project "served as a model for other utility confederations and for cooperation among peers in general. Contemporaries recall that during the early years of its operation, managers and engineers from the world over came to inspect the PNJ grid."<sup>32</sup>

Across the country, other integrated regional systems began drawing attention from the engineering press. Networks in Alabama, Georgia, South Carolina and California were featured as smaller-scale examples of the superpower concept.<sup>33</sup> In contrast to these planned systems, however, most of the electrical networks in the nation were evolving under the manipulations of eastern-based holding companies. Hughes

---

<sup>31</sup> Hughes, 330.

<sup>32</sup> Ibid., 333.

<sup>33</sup> Hay, 116.

estimated that by 1924, two-thirds of the generating capacity of the national electric industry were controlled by holding companies.<sup>34</sup>

In 1928, virtually all of the private electric utilities in the Pacific Northwest were "absentee owned" by eastern holding companies.<sup>35</sup> Subsidiary companies of Electric Bond and Share owned most of the utilities servicing Washington, Idaho, Montana and parts of Oregon, including Pacific Power and Light, Northwestern Electric, Inland Power and Light, Washington Water Power, Idaho Power, Montana Power and Utah Power and Light.<sup>36</sup> By 1930, subsidiaries of Standard Gas and Electric and Central Public Service Corporation, both of Chicago, serviced much of Oregon. In addition, Stone and Webster, the large eastern concern that built the Conowingo project, established its presence in the Pacific Northwest when it built the first hydroelectric dam on the Columbia River. Constructed between 1928 and 1932, Rock Island Dam created a huge surplus of power and triggered a flurry of interconnections among the Electric Bond and Share companies and subsequently, between those companies and Stone and Webster's Northwestern subsidiary, Puget Sound Power and Light. The interconnected facilities of these and other private and municipal utilities created the electrical transmission and distribution

---

<sup>34</sup> Hughes, 390

<sup>35</sup> Norwood, 24.

<sup>36</sup> Tollefson, 56.

networks that crisscrossed the Pacific Northwest in the late 1920s and early 1930s. These were evolving systems; interconnections that were made over a long period of time, based on proximity, ownership, and corporate machinations.

### The Great Depression

When the national economy crashed in October 1929, so did the stocks of many large holding companies. Because virtually all private electrical utilities in the Pacific Northwest were owned by holding companies, the region and its utility industry were hit particularly hard by the Great Depression. Investments in hydroelectric generation dropped, construction ceased, and power sales plummeted as businesses and factories went out of business.<sup>37</sup> Hostility toward private utility had been spreading throughout the nation, even before the Depression. A 1927 Federal Trade Commission Report on the extent of monopolization in the electric utility industry had prompted an investigation of utility holding companies. The investigation revealed "unfair attacks on municipally owned electric systems, corruption of legislatures and public officials, financial manipulation, and neglect of operating utility companies."<sup>38</sup> These revelations "adversely

---

<sup>37</sup> Norwood, 32.

<sup>38</sup> Norwood, 24.

affected the public image of utilities" and added fuel to the frustration of farmers and other rural citizens who were already bitter because holding-company-owned utilities either would not extend service to rural areas, or would do so under financially unreasonable conditions.<sup>39</sup> When New York governor and presidential candidate Franklin Delano Roosevelt came to Portland to deliver a campaign speech in 1932, his attack on electric utility holding-company monopolies found a receptive audience.

### "Talking Columbia"

Governor Roosevelt also spoke to another topic of great interest to the attentive crowd, when he addressed the issue of Columbia River development:

We have, as all of you in this section of the country know, the vast possibilities of power development on the Columbia River. And I state, in definite and certain terms that the next great hydroelectric development to be undertaken by the Federal Government must be that on the Columbia River.<sup>40</sup>

Roosevelt called for federally controlled public power, to insure that "there will exist forever a national yardstick to prevent extortion against the public and to encourage the

---

<sup>39</sup> Norwood, 101.

<sup>40</sup> Samuel I. Rosenman, comp., *The Public Papers and Addresses of Franklin D. Roosevelt*, New York: Russell and Russell, 13 vol., 1938-1960, as quoted in Norwood, 26.

wider use of that servant of the American people - electric power."<sup>41</sup> Roosevelt subscribed to the ideology long-held by the Bureau of Reclamation: that multi-purpose projects were more efficient and cost-effective than single-purpose projects, and that this type of undertaking should exist as part of a carefully controlled, comprehensive river development program.

Franklin Roosevelt was not the first to acknowledge the industrial potential of the Columbia River. State and private interests had been sponsoring surveys and commissioning preliminary studies on the development potential of the upper and lower Columbia River since before 1920. Fears that there would not be a big enough market for the enormous amount of power that would be generated, and cost estimates pushing \$30 million kept these early initiatives from becoming realities.<sup>42</sup>

In March 1925, Congress authorized the Rivers and Harbors Act of 1925. The Act directed the Corps of Engineers to prepare cost estimates for investigations of "those navigable streams of the United States, and their tributaries, whereon power development appears feasible and practicable. . . ," and from these investigations, formulate a plan for multipurpose development of those rivers.<sup>43</sup> In 1926, cost estimates and recommendations

---

<sup>41</sup> Ibid.

<sup>42</sup> William F. Willingham, *Water Power in the Wilderness: The History of Bonneville Lock and Dam* (Portland: U.S. Army Corps of Engineers, Portland District, 1987), 1.

<sup>43</sup> The River and Harbor Act of 1925 expressly excluded investigations of the Colorado River

for comprehensive surveys were submitted to Congress as House Document No. 308-69/1, more commonly referred to as the "308 Report." Surveys of the Columbia, Tennessee, Missouri, and other rivers were authorized in the River and Harbor Act of 1927, resulting in extensive reports on each river. The report on the Columbia River recommended a system of eight dams, including Grand Coulee and Bonneville, as the basis of their "general plan for the improvement of the Columbia River and minor tributaries for the purposes of navigation and efficient development of water power, the control of floods, and the needs of irrigation."<sup>44</sup> In Washington, D.C., the Board of Engineers for Rivers and Harbors of the U.S. Army Corps of Engineers changed the number of proposed dams on the Columbia from eight to ten. They also recommended that the development of the river be undertaken by states, municipalities, or private concerns; not the federal government. However, by the time the Board of Engineers completed their recommendations, the Great Depression had made the notion of a locally developed Columbia River an impossibility. As the Depression deepened, the future of development on the Columbia River looked increasingly bleak. For Franklin Roosevelt, the stalled Columbia River development plan fit perfectly into his New Deal picture. His plan to fund Bonneville and Grand Coulee dams as relief measures would not only

---

(Norwood, 45).

<sup>44</sup> Norwood, 45.

provide for their construction, but would put thousands of men back to work in the process. The New Deal was to become the instrument that turned a decade of planning into reality.<sup>45</sup>

As Roosevelt revealed his plan for the Columbia River, a Bureau of Reclamation project on the Colorado River was setting the stage for the policies and attitudes that would allow him to make good on his promises to the Pacific Northwest. The authorization, construction, and operation of Boulder (later, Hoover) Dam established a level of federal involvement that had heretofore never been seen in the United States. The project would set precedents for federal development of the nation's river systems that would last for the next 25 years.

#### The Boulder Canyon Project Act

Like Bonneville and Grand Coulee Dams, Boulder Dam had its genesis before the Great Depression brought Franklin Roosevelt and his New Deal to the White House. The dam was authorized in 1928 primarily as a flood control measure for the southern valleys of California. Located in the Black Canyon on the Colorado River, it was a component of the Boulder Canyon Project Act, which also provided for irrigation of California's

---

<sup>45</sup> Willingham, 2-7.

Imperial and Coachella valleys by way of an All-American Canal.<sup>46</sup> The Bureau of Reclamation (USBR) project was to be paid for by the sale of electricity generated by a powerhouse at the dam, in accordance with the 1906 Townsite Act. While these functions mirrored those of previous USBR irrigation projects across the western states, the immense scale and the politics surrounding the Boulder Canyon Project Act quickly distinguished it from its predecessors.

Because of the Colorado River's unique interstate and international character, the federal government made early efforts to mediate potential conflicts of use. In 1921, in anticipation of the river's eventual development, Congress passed an act authorizing the Colorado River Compact, an agreement designed to provide for equitable distribution of the water supply among the states of California, Nevada, Arizona, New Mexico, Colorado, Wyoming, and Utah. Later, planning for the Boulder Canyon Project Act brought the complexities of interstate and international negotiations to the forefront, prompting legislators to include an unprecedented provision in the Boulder Canyon Project Act that "forbade the approval of any power permits on the Colorado River or its tributaries until the act had become effective."<sup>47</sup> The government did not want other

---

<sup>46</sup> The site chosen for Boulder Dam was one of two that were under consideration by the Department of the Interior. The winning site was called Black Canyon, while the other was known as Boulder Canyon. The legislation process began before the site was chosen, and therefore carries the misleading name of the Boulder Canyon Project Act.

<sup>47</sup> Paul L. Kleinsorge, *The Boulder Canyon Project* (Stanford: Stanford University Press, 1941), 91.

projects on the river that would "interfere with the interstate water allocation agreements."<sup>48</sup> This policy remained in place until after the Boulder Canyon Project Act was declared effective in June 1929. However, even after the provision was no longer in effect, most permit applications were rejected. By refusing to allow private power projects on the Colorado River, the Federal Power Commission was sending a strong message about the government's desire to pursue the development of the river as a unified system.<sup>49</sup> That intention was further emphasized by an additional provision of the Boulder Canyon Project Act, which authorized the use of \$250,000 to "investigate the feasibility of irrigation, power, and other projects in the Colorado River Basin."<sup>50</sup>

With the government firmly entrenched on the Colorado River, the continuity of federal presence became essential to the success of the Boulder Canyon Project. The interstate and international character of the Colorado River presented challenges unlike any previous USBR projects, and in most cases, the solutions to these challenges required the presence of federal authority. Each of the seven states of the Colorado Compact had their own political agendas and conflicting ideas on how to distribute and utilize the river's water. Power and irrigation interests needed to be regulated, and agreements with

---

<sup>48</sup> Ibid., 54.

<sup>49</sup> Ibid., 52.

<sup>50</sup> Ibid., 102.

Mexico on the division of waters on the lower Colorado had to be negotiated. In addition, it was clear that some sort of centralized management would be necessary in order to operate the one powerhouse at the plant and to market the electricity.

### The Federal Government in the Power Business

In an effort to prevent private monopolization of the regional power industry, the Department of Interior decided to retain control over the operation of the power plant at Hoover Dam, and sell the power themselves to contractors who would fill the greatest public need. No provisions would be made for the transmission of the electricity by the government - transmission facilities would be built by the contracting agencies, and local distribution would occur over existing lines. There were to be three principal contractors for Hoover Dam power: the City of Los Angeles, Metropolitan Water District, and Southern California Edison Company. Provisions were also included for future power use by Arizona and Nevada. According to historian Paul L. Kleinsorge, since these fifty-year contracts "will account for over \$327,000,000 in revenues during the fifty-year period, they represent one of the largest power transactions in the history of the world."<sup>51</sup>

The power marketing activities at Hoover Dam were, indeed, a far cry from any

---

<sup>51</sup> Ibid., 154.

previous USBR efforts. Government-built plants at projects, such as Roosevelt Dam in Arizona or Idaho's Minidoka, were much smaller in scale than the Boulder Canyon Project. Construction and operation costs, as well as revenues, were so much smaller at these projects that they were not considered precedents for the government's entrance into the power industry on the huge scale exhibited at Hoover Dam. As historian Kleinsorge surmised,

That the government has kept control of the power-production facilities in order to assure reaping the greatest social benefits is an unusual step away from the traditional policy of reserving such activity to private enterprise; but, as an unusual step, it may serve as a precedent which will have far-reaching effects upon the future economic development of the power industry.<sup>52</sup>

The success of the Hoover Dam project elevated the level of acceptance of federal involvement in private industry. In addition, the project gave rise to a new confidence in the federal government, a confidence that led to a social and political environment that would enable Franklin D. Roosevelt to establish his public power policies in the Pacific Northwest with authority.

---

<sup>52</sup> Kleinsorge, 300.

"The Biggest Thing That Man Has Ever Done"

President Franklin D. Roosevelt took office in January 1933, two years into the construction of Boulder Dam. By May of that year, he had approved the first public power legislation as part of his New Deal reforms. The Tennessee Valley Authority (TVA) was created with a broad mandate to develop the resources of the Tennessee Valley, an area that included most of the state of Tennessee, parts of Alabama and Mississippi, and areas of Virginia, North Carolina, Kentucky, and Georgia. In addition to the generation of electric power, the dams and power plants authorized by the Act were to provide for flood control and the improved navigation along the Tennessee River and its tributaries. However, unlike previous federal multipurpose initiatives, the TVA Act responded to the specific social and environmental problems of a particular region. Reflecting the Depression era's New Deal agenda, the TVA Act included provisions for reforestation and proper use of the land, as well as the manufacturing of fertilizers to boost the agricultural and industrial economies in the region. Roosevelt's commitment to public power inspired a key component to the plan for the region's economic revival: a TVA directive to sell any surplus power generated by the dams in a way that assured the widest possible use of electricity for the lowest possible cost. To that end, Congress authorized the TVA to construct transmission facilities to bring the power to market. The TVA transmission network would evolve over time, through two principle means: a massive acquisition program, whereby the TVA purchased the existing distribution

facilities of private utilities in the region; and, the construction of transmission lines that would connect TVA power plants, as well as bring the power to customers. Preferred customers, which were identified as municipalities and rural electric cooperatives, would build or acquire the distribution facilities that would transmit TVA electricity to the ultimate consumer. The TVA transmission network was somewhat reminiscent of the pre-war evolving systems, in that it developed over time. However, the integration of existing systems with new high-voltage transmission lines; the establishment of a central dispatch point; and the emphasis on regional distribution had all the markings of the kind of planned, integrated regional system that had its genesis during the first world war. Combined with its federal mandate and New Deal social agenda, the TVA transmission network would ultimately bear a striking resemblance to Gifford Pinchot's giant power scheme of the 1920s.<sup>53</sup>

Federal power was poised to enter its heyday. Boeyed by a compliant Congress, Roosevelt introduced the National Industrial Recovery Act (NIRA) in June 1933. Among its many provisions, the NIRA authorized the "development of water power" and "transmission of electric energy," and provided for the Public Works Administration under the Department of the Interior. Under the direction of Interior secretary and

---

<sup>53</sup> Roscoe C. Martin, ed., *TVA: The First Twenty Years* (Knoxville: The University of Tennessee Press, 1956), 109-113; The Tennessee Valley Authority, *Annual Report* (Washington: USGPO, 1936), 24-28; *Tennessee Valley Authority, 1933-1937* (Washington: USGPO, 1937), 27-34; Victor C. Hobday, *Sparks at the Grassroots* (Knoxville: The University of Tennessee Press, 1956), 14-15.

administrator of Public Works Harold Ickes, the PWA was the initial funding source for countless federal building projects undertaken during the Depression. In 1933, Ickes authorized Public Works Administration Federal Project No. 9 and Public Works Administration Federal Project No. 28, known more commonly as Grand Coulee Dam and Bonneville Dam, respectively. Construction began on both dams that same year.

Bonneville Dam was the first in the 308 Reports' ten-dam chain on the Columbia River. It was built by the Corps of Engineers at a site located about thirty-seven miles upstream from Portland, Oregon. Bonneville was designed as a "run-of-river" dam, which meant that it would have limited storage capacity, and little ability to control the flow of the river. Although the dam was intended to improve navigation on the river, its primary function was the production of electric power. The original powerhouse at Bonneville Dam was constructed to hold two, 43,200-kilowatt hydroelectric generating units, with a substructure that would accommodate four additional units.<sup>54</sup>

In contrast to the run-of-river dam being built at Bonneville, north central Washington's Grand Coulee Dam was eventually designed as a high storage dam capable of impounding huge quantities of water and regulating the flow of the river. Constructed by the Bureau of Reclamation, Grand Coulee was primarily an irrigation project, with a directive to generate electricity to finance the project. When completed, Grand Coulee's

---

<sup>54</sup> Willingham, 12-13.

original two powerhouses would contain nine 108,000-kilowatt generators each, for a combined output of 1.9 million kilowatts of electricity. The generator units planned for Grand Coulee Dam were the largest that had ever been built anywhere in the world.<sup>55</sup>

As the dams rose on the Columbia, anticipation ran high in Oregon and Washington. Together, the dams triggered the long-awaited development of the Columbia River, and promised to transform the economy of the region. Because the dams were authorized as New Deal relief measures, construction began immediately. The Bonneville project alone put over 3,000 people back to work. The Grand Coulee project was so gigantic in scale that it became, even more so than Hoover Dam, a national symbol of better days to come. "It was colossal and magnificent," wrote Marc Reisner in *Cadillac Desert*, "a purgative of national despair."<sup>56</sup>

### The Marketing Dilemma

In 1934, as construction on both dams progressed, regional planning officials turned their attention to the issue of how to sell the power that would soon be available. In 1934, a seven-member "Bonneville Commission" presented split opinions in a report

---

<sup>55</sup> Paul C. Pitzer, *Grand Coulee: Harnessing a Dream* (Pullman: Washington State University Press, 1994), 208.

<sup>56</sup> Marc Reisner, *Cadillac Desert* (New York: Penguin Books USA Inc., 1993), 156.

to the Oregon legislature on the transmission issue. Four members favored the idea of a trunk line running from Bonneville Dam to the Portland-Vancouver area, where it would connect with existing local distribution systems and new lines built to service anticipated large industrial loads. By contrast, the Bonneville Commission's remaining three members, insisting that "the market area for Bonneville power is taken as the entire Northwest region," urged the United States "to construct the interstate power transmission system, connecting all public and private plants in the Northwest."<sup>57</sup> Beginning in January 1935, several bills were introduced before Congress, presenting options such as: the Bureau of Reclamation taking control of Bonneville Dam and marketing the power of both Bonneville and Grand Coulee; the establishment of a Columbia Valley Authority that would take over Bonneville Dam from the Corps of Engineers and Grand Coulee from the Bureau of Reclamation; and the Corps retaining control over Bonneville Dam and selling the power from main transmission trunk lines. Although pressure was mounting for the establishment of a TVA-type system in the west, President Roosevelt remained open-minded about the type of organization that should be chosen. Roosevelt encouraged a regional approach, and in the spring of 1935, he discussed options at length with members of the Pacific Northwest Regional Planning Commission (PNWRPC), an organization created the previous year by the National

---

<sup>57</sup> Norwood, 53.

Planning Board.<sup>58</sup> In July 1935, Secretary Ickes wrote a letter to the PNWRPC enlisting its assistance in the preparation of a report by the National Resources Committee to the President on "the future of the Columbia Basin, which he is hoping will be helpful in determining the type of organization which would be set up for the planning, construction, and operation of certain public works in that area."<sup>59</sup>

In preparation for the report, the PNWRPC held public hearings on the transmission issue in September 1935 in cities all over Oregon, Washington, and Idaho. Among the many opinions offered during these meetings, the voice of Professor Carl Edward Magnusson emerged to provide critical information, educated opinion, and direction to the decision-making process. Magnusson, a professor of engineering at the University of Washington, was a vocal, educated proponent of interconnected electrical transmission systems and a long-time advocate of a regional transmission grid. In his many speeches, lectures and articles, he emphasized the important role that ownership played in the administration of a transmission network, stating that "ownership and control of the transmission lines form the basis for establishing and maintaining regional monopoly of the electric power business." Respected by his professional peers,

---

<sup>58</sup> The National Planning Board was established by the Public Works Administration, having been authorized to do so by the National Industrial Recovery Act of June 16, 1933. The PNWRPC was made up of a small group of private citizens and representatives from the planning boards of Oregon, Washington, Idaho, and Montana (Richard Lowitt, *The New Deal and the West* (Bloomington: Indiana University Press, 1984), 138).

<sup>59</sup> Norwood, 55.

Magnusson was able to communicate the complexities of the transmission issue to the public in a way they could understand. He was very much in favor of a new federal power marketing agency that would market Bonneville power over a federally-built regional transmission network. Magnusson's opinions held a lot of weight in the Pacific Northwest and he was an active participant in the hearings held by the PNWRPC in 1935.

The PNWRPC submitted their report to the National Resources Committee in December, 1935. In the report, the Commission endorsed the establishment of a federal power marketing corporation; the adoption of a uniform-rate policy throughout the region; and a TVA-style three-man board.<sup>60</sup> The report also recommended the construction of "a central grid to link the principal centers of existing and future public power generation by means of high-tension lines capable of supplying power reliability and uniformity."<sup>61</sup> The volume also included a large, fold-out map of the proposed "master grid," showing a closed triangular loop that began at Grand Coulee Dam, dropped southwest to Bonneville Dam and Portland, ran northeast to Seattle, then back to Grand Coulee. 230,000-volt backbone lines radiated east to Montana, south through Idaho to Utah, north to Vancouver, B.C. and south to California.<sup>62</sup> The map was prepared

---

<sup>60</sup> Norwood, 59; Tollefson, 127.

<sup>61</sup> Vera Springer, *Power and the Pacific Northwest: A History of the Bonneville Power Administration* (Washington DC: USDI, 1976), 8.

<sup>62</sup> Norwood, 237.

by Charles E. Carey, an electrical engineer and member of the PNWRPC. The report received a strong endorsement from the National Resources Committee. It was published in May 1936, as Bonneville Dam neared completion out west on the Columbia River.

Under normal political conditions, it would have been virtually impossible for a federal power marketing agency to enter the marketplace in the Pacific Northwest, a region historically dominated by holding-company-owned private power. Opposition from a strong utility lobby, whose monopolistic agenda was regarded by Roosevelt as "private socialism," would have made it very difficult for public power legislation to pass through Congress. During the 1930s, however, conditions across the nation were far from normal. Conditions caused by the Depression gave public power a foot in the national door, and step by step, New Deal reforms whittled away the power and influence of private electric utility interests in the Pacific Northwest. This gradual process received a substantial boost in 1935, when Senator Burton Wheeler of Montana and Congressman Sam Rayburn of Texas introduced legislation targeting electric utility holding companies. In August 1935, President Roosevelt signed the Public Utility Holding Company Act, which "limited holding companies to a single utility property with a contiguous service area," and provided for the "elimination of non-contiguous holding companies within five years."<sup>63</sup> The effect of this legislation on the Pacific Northwest and across the nation was

---

<sup>63</sup> Tollefson, 122, 262.

gradual but decisive. As BPA historian Gene Tollefson explained:

Between 1935 and 1950, 759 companies were separated from the holding company systems. Between 1938 and 1958, the number of holding companies declined from 216 to 18. With passage of the Public Utility Holding Company Act of 1935, the electric utility industries emphasis shifted from razzle-dazzle finance and enrichment by questionable means, to providing service to the customer at a reasonable profit.<sup>64</sup>

As was the President's intention, the Public Utility Holding Company Act considerably weakened the influence of private interests in the electric utility industry. The elections of 1936 dealt another blow to private power in the Pacific Northwest, as voters in Washington State approved the establishment of public utility districts (PUDs) in fifteen counties. Although Oregon and Idaho did not follow suit, this represented a substantial contingent of public power supporters in the region. In the same election, Oregon and Washington voters turned down a proposal for state-constructed transmission grids to carry Bonneville and Grand Coulee power, "eliminat[ing] the alternative of State-owned transmission systems and thus clarif[ying] the transmission option as simply either Federal or private."<sup>65</sup> Although the reaction against State-owned transmission systems could not be interpreted as a mandate for federal power transmission in the

---

<sup>64</sup> Ibid., 267.

<sup>65</sup> Norwood, 50.

region, the decisive reelection of President Roosevelt made it a likely option.

### The Bonneville Project Act

By early 1937, Roosevelt knew a decision on the marketing of Bonneville power would need to be made soon. Despite the endorsement of the PNWRPC report by the National Resources Committee, months of hearings, and the introduction of bill after bill, agreement on the logistics of marketing power in the Pacific Northwest had failed to materialize. Since January 1935, over thirty bills had been introduced. The ongoing debate had added fuel to the long-standing feud between the Corps of Engineers and the Bureau of Reclamation, and proponents of a Columbia Valley Authority continued to be vocal and insistent. Oregon's two Republican senators, Charles McNary and Frederick Steiwer; Washington's two Democratic senators, Homer T. Bone and Lewis Schwellenbach; and Idaho's Democratic senator, James P. Pope all introduced opposing legislation during this time. Roosevelt, apparently weary of the "increased bickering, turf guarding, and mutual suspicions," appointed Secretary Ickes as head of an informal committee on National Power Policy, and gave him two weeks to report back.<sup>66</sup> The President was anxious to make a decision; it would be several years before Grand Coulee

---

<sup>66</sup> Pitzer, 236.

Dam would be ready to produce power, but Bonneville Dam was almost finished. The Committee on National Power Policy presented to their findings to the President, endorsing the report by the PNWRPC with some exceptions. They wanted a bureau instead of a corporation to market the power, and they wanted it under Secretary Ickes' Department of Interior. This bureau would develop, generate, and market electricity. It would also guarantee uniform, or "postage-stamp" rates all over the region, as opposed to rates that would vary according to the distance between a customer and the generating source. After considering the committee's recommendations, Roosevelt suggested creating a temporary agency, leaving the controversial question of rates, and the marketing of Grand Coulee power, for future consideration. After several revisions, a bill creating "an independent administration, under the Interior Department, controlling the sale and distribution of power generated at Bonneville Dam" was introduced by Representative Joseph Mansfield of Texas and steered through Congress by Senator McNary.<sup>67</sup> The Bonneville Project Act was passed and signed by the President on August 20, 1937, just weeks before Bonneville Dam was dedicated. It was authorized as a temporary measure, as stated directly in the legislation: "The form of administration herein established for the Bonneville Project is intended to be provisional pending the establishment of a permanent administration for Bonneville and other projects in the

---

<sup>67</sup> Pitzer, 236; Willingham, 42.

Columbia River Basin."<sup>68</sup>

Although plans for a Columbia Valley Authority were on hold, the legislation that created the Bonneville Project Act drew much precedent from that which created the Tennessee Valley Authority. Although not as comprehensive as the TVA Act's conservation mandate, the Bonneville Project Act clearly committed the Bonneville Project to encourage diversification of the Pacific Northwest economy by soliciting large industry. In addition to actively promoting regional economic development, both BPA and TVA Acts gave preference, in the sale of power, to municipalities and rural electric cooperatives; they also authorized the construction of federal transmission lines.

Historian Gus Norwood boiled down the basic provisions of the Bonneville Project Act:

Basically, the Bonneville Project Act establishes the Bonneville Power Administration [the agency was known as the Bonneville Project until 1940] and serves as BPAs charter or organic law. The Act assigns responsibilities: the Corps of Engineers generates the power. The Corps installs and operates generators requested by the Administrator. The Administrator builds and operates transmission facilities, markets and exchanges power, negotiates power contracts, and proposes rate schedules. FPC makes the cost allocations and approve rates. These constitute the structural decisions of the Act.<sup>69</sup>

---

<sup>68</sup> Lowitt, 161.

<sup>69</sup> Norwood, 63.

### The Bonneville Power Administration

With policy in place, President Roosevelt traveled to Oregon to dedicate Bonneville Dam on September 28, 1937. At the dam Roosevelt assured the crowd that the cost of the dam "will be returned to the people of the United States many times over in the improvement of navigation and transportation, the cheapening of electric power, and the distribution of this power to hundreds of small communities within a great radius." It must have been difficult to believe that the \$83,000,000-pricetag of Bonneville Dam could ever pay for itself in a region that held only three million people; where just over thirty percent of its farms were electrified; where the primary economic bases, lumber and agriculture, remained devastated by the Depression; and where there was virtually no industrial development. Roosevelt's words at the dedication ceremony belied the foresight that distinguished him as an outstanding leader. The man Roosevelt favored to administer the new Bonneville Project was also a man of vision. On October 10, 1937, Secretary Ickes appointed Roosevelt's good friend and consummate public power man, James Delmage McKenzie (J. D.) Ross as Administrator of the Bonneville Project.<sup>70</sup>

J. D. Ross worked for Seattle City Light as an electrical engineer from 1903 until 1911, when he was promoted to lighting superintendent. During his long tenure with

---

<sup>70</sup> Lowitt, 162.

Seattle City Light he was an outspoken proponent of public power. Later he served as a consultant on the Saint Lawrence River Project for then New York Governor Franklin D. Roosevelt. Over the course of his career, Ross was a consultant for the Federal Power Commission, an advisory engineer for the Public Works Administration, and a commissioner on the Securities and Exchange Commission. Ross kept his job as Seattle's lighting superintendent after he was tapped to head the Bonneville Project. He served part-time for both agencies. Ross died unexpectedly in 1939, after just 17 months as Bonneville Project Administrator. In that short time, he launched all the major policy directives of the Bonneville Project Act. With a hand-picked administrative staff, Ross tackled the controversial rate issue, initiated efforts to actively promote local PUDs, and insisted on the earliest possible construction of the master grid transmission network. "He served vigorously as the instrument of change," Gus Norwood recounted. "He was able to facilitate change because he had wide support among the people of the Pacific Northwest. He also had the confidence and support of the President."<sup>71</sup>

#### Planning for the Master Grid

SEC.2. (b) In order to encourage the widest possible use of all electric energy that can be generated and marketed and to provide reasonable

---

<sup>71</sup> Norwood, 103.

outlets therefor, and to prevent the monopolization thereof by limited groups, the administrator is authorized and directed to provide, construct, operate, maintain, and improve such electric transmission lines and substations, and facilities and structures appurtenant thereto, as he finds necessary, desirable, or appropriate for the purpose of transmitting electric energy, available for sale, from the Bonneville project to existing and potential markets, and, for the purpose of interchange of electric energy, to interconnect the Bonneville project with other Federal projects and publicly owned power systems now or hereafter constructed.<sup>72</sup>

Such was the directive, one of many, faced by J. D. Ross when he accepted the job of Administrator of the Bonneville Project. Approximately one month after his appointment, Ross and a small staff established the BPA headquarters in Portland, Oregon. Early planning efforts for the transmission grid were broad-based. Historian Craig Holstine wrote that, once they were settled in their new offices, "Ross and his staff began their investigation of the region's power needs and potentials. They examined metropolitan areas likely to demand the heaviest loads of power; rural electrification systems and power requirements for irrigation; railway electrification needs; natural resource development plans; and the forthcoming interconnection of the federal network with previously existing power systems."<sup>73</sup> In addition, Ross spent those early months preparing a budget, which he submitted to the Bureau of the Budget late in 1937.<sup>74</sup>

---

<sup>72</sup> Norwood 63.

<sup>73</sup> Craig Holstine, "National Register of Historic Places Inventory Nomination Form: Bonneville Power Administration Master Grid," 1987.

<sup>74</sup> Norwood, 112.

As Ross continued to gear up the building program through early 1938, a sense of urgency began to emanate from the White House. President Roosevelt was becoming increasingly concerned by events taking place overseas. Germany had been rearming its military forces since 1935. Hitler's 1936 reoccupation of the Rhineland and Mussolini's invasion of Ethiopia the same year served as warnings of serious unrest in western Europe. The expansionist tendencies of Italy and Germany became even more threatening when they forged an alliance during their involvement in the Spanish Civil War (1936-1939). Japan's aggressive move into China in 1937 prompted Roosevelt to speak openly of the need to "'quarantine' aggressor nations."<sup>75</sup> The Roosevelt administration had been watching events in Europe closely, but any efforts to prepare for possible involvement were minimal. Congress and much of the country had been in a very isolationistic mood since the first World War, and Roosevelt was not anxious to alienate either faction.

However, after Hitler's invasion of Austria on March 12, 1938, Roosevelt took steps to secure the nation's electric supply. To him, involvement in the war seemed imminent, whether the people wanted it or not, and he was not about to let power shortages hamper a potential war effort as they had in World War I.<sup>76</sup> On March 18, the

---

<sup>75</sup> Doris Kearns Goodwin, *No Ordinary Time* (New York: Simon & Schuster, 1994), 22.

<sup>76</sup> Roosevelt was Assistant Secretary of the Navy during World War I. His knowledge of the power shortages experienced during World War I led to his proactive efforts to avoid a similar situation should the U.S. go to war again (Norwood, 120).

president directed the Federal Power Commission and the War Department to survey the nation's power capacity. In July a report was made to the president, concluding that the situation was "so serious as to require immediate attention."<sup>77</sup> Roosevelt counted on J. D. Ross and the Bonneville grid to dramatically boost the nation's power capacity. As administrator of the nascent BPA, Ross was in a unique position to create, from the ground up, a transmission system designed to accommodate defense production as well as serve domestic and commercial needs. In his 1938 annual report, Ross emphasized the importance of utilizing Bonneville power for defense production:

It is logical to expect these [war] industries to make increasing demands upon the installed capacity of the Pacific Northwest. Bonneville's output will therefore stand as a safeguard against acute power shortage. . . Modern warfare is fought in the factory as much as in the air or trenches. America must be ready to meet not only peacetime needs of power for home, farm, and industry, but must be assured of her ability to cope with emergency demands for large blocks of electricity. In the hydroelectric streams of the Pacific Northwest is potential power far in excess of that available in other regions of the Nation. It should be developed at an economical rate to meet mounting peacetime needs and the equally important possibilities of emergency drains. . . Preparedness requires foresight.<sup>78</sup>

Under the threat of war, the regional Bonneville grid acquired national importance. What began as a system to connect two New Deal projects to improve a

---

<sup>77</sup> Norwood, 107.

<sup>78</sup> Bonneville Power Administration, *Annual Report* (Washington, D.C.: GPO, 1938), quoted in Norwood, 108.

regional economy became a means for a nation's collective security. So began a crash construction program that took a transmission grid planned for a ten-year development period to one that was completed in just over five years.<sup>79</sup>

#### Nuts, Bolts, and Substations: Design Issues of the Master Grid

One of the first people J. D. Ross hired in November, 1937, was engineer Charles E. Carey, formerly with the PNWRPC. Carey had designed the map depicting a proposed master grid transmission system included in the PNWRPCs 1935 report to the National Resources Committee. Ross adopted Carey's plan as the basis of BPA's transmission grid, and hired him to carry it out. In developing the master grid, Carey had looked closely at the British Electricity Grid, England's national transmission system built between 1927-1933, and Ontario, Canada's publicly owned regional system, which also began operating in the mid-1920s. Both were high-voltage transmission grids overlaying and connecting to existing regional distribution systems. He also looked at the experiences of the TVA.<sup>80</sup> Once he was recruited by Ross, Carey hired engineering consultant Dr. E.C. Starr, who had begun his career on the Conowingo superpower project in 1927, to help develop the

---

<sup>79</sup> BPA, *Annual Report*, 1944, 41.

<sup>80</sup> Norwood, 202.

grid. Much of the technological data used to build the Bonneville grid originated at Conowingo. According to Dr. Starr, "It was pretty much the same thing. I mean, we were using data developed for the design on the Conowingo transmission lines when we designed our first lines here. The data had been produced in Dr. Peek's laboratory and elsewhere and lines had been built and operated successfully and consequently we followed those designs quite closely."<sup>81</sup> Engineers utilized industry standards in designing the line's steel towers, modifying their structural components to account for a variety of factors, such as "function, voltage level, number of circuits, safety requirements, topography, and financial considerations." Topography was an especially important factor for tower design along the BPA grid. Towers designed for heavily forested, mountainous terrain required special specifications to handle up to 8 pounds per square inch of wind and ice loads; lightning; and unusually narrow right-of-ways through mountain passes. American Bridge Company of Pittsburgh, PA, supplied the first steel towers for the grid.<sup>82</sup>

Designs for substation components evolved in-house. On high-voltage, long-distance transmission systems, substations were placed at strategic locations to "route and

---

<sup>81</sup> Dr. E.C. Starr, personal interview as quoted in Tollefson, 136. Dr. Frank W. Peek, Jr. was a famous high-voltage engineer who directed the development of insulation for a 230kv transmission line that ran from the Conowingo plant to Philadelphia.

<sup>82</sup> Holstine; Norwood, 116, 173.

control electrical power flow; transform a voltage to a higher or lower level; and function as a delivery point to an individual customer, such as a private or publicly owned utility, or an industry such as an aluminum plant."<sup>83</sup> Buildings typically found at a substation would include a control house, which held crucial operating equipment; an untanking tower, where giant oil transformers and circuit breakers were cleaned and serviced; an oil house, which held pumping equipment; and a condenser building, used to house a large piece of equipment known as a synchronous condenser. A substation, depending on its size and function, might have only one of these buildings ( in which case that would be a control house), or all of the buildings mentioned. Many substations on the master grid didn't have any buildings at all. Large electrical components of a substation, such as transformers, circuit breakers, and capacitor banks, were located outdoors, contained within an area known as a switchyard. Every substation had a switchyard, in which equipment and apparatus were found in combinations, "depending upon voltage, station function, [and] customers served."<sup>84</sup> In a switchyard, aluminum tubes called buses carried high-voltage currents between the equipment in the yard. Giant steel towers supporting conductor cables served as the end of the line for transmission lines entering the

---

<sup>83</sup> Holstine, sec. 7, p. 1.

<sup>84</sup> Ibid., sec. 7, p. 5.

substation.<sup>85</sup>

Historian Craig Holstine notes the division of labor in the substation design process at BPA:

The System Engineering Section drew up general plans for the first. . . substations to be installed in the original Master Grid. System Engineering then turned to the Substation Engineering Section, which prepared the specifications for heavy equipment and fittings needed for each station. Finally, after the grand scheme had been determined, the Architectural and Drafting Section was given the task of preparing individual building designs.<sup>86</sup>

According to a 1939 BPA Engineering Division report, the task of designing the substation buildings was difficult because there were no other BPA buildings from which to use as a template. These were the Bonneville Project's first buildings. Engineers and designers began by establishing a reference file, "consisting of catalogues, drawings, specifications, and technical information from various other substations and construction jobs in all parts of the country." Men such as John M. Rathburn, Chief of Substation Design from 1939-1942, Franz Maas, Dean Wright, Glen Dunbar, H.R. Stevens and Clarence Frenke were involved in designing the substation buildings on the master grid

---

<sup>85</sup> Specific information about buildings and structures along the master grid obtained on substation site visits conducted by Christine Curran in 1995-1996; and from construction drawings dating from 1939 found at various substations.

<sup>86</sup> Holstine, sec. 8, p. 8.

between 1939-1945.<sup>87</sup>

Designers established a basic building form early on, described in BPA's 1939

Annual Report:

The substation buildings are designed on a unit basis so that each unit will present a complete and appropriate structure that may have additional units added as the needs of the substation increase. . . . From an architectural viewpoint the most interesting feature of a substation is the control house, where plain wall surfaces are interrupted only by carefully proportioned window and door openings. . . . Particular attention is being given to the selection of materials on basis of durability and low expense of upkeep. . . . Landscaping has been made an integral part of the design of the substations to achieve natural, dignified, and pleasing structures.<sup>88</sup>

The substation control houses took on a very recognizable style. Almost of all them were one-story with either a basement or generous crawl space. Characterized by symmetrical facades, flat roofs and enormous multiple-pane, steel-sash windows, almost all of the control houses were designed in the stripped-classical style prevalent among government buildings built during the 1930s. Most of them were of reinforced concrete covered with stucco, although two had brick-sheathed steel frames. Some of the smaller ones had wood frames covered with wood or aluminum siding and hipped metal roofs. Exterior decoration was minimal, consisting primarily of brass, cast stone, and glass block. The larger, more critical substations on the line received the most elaborate

---

<sup>87</sup> Ibid., sec. 8, p. 9; Norwood, 115-116.

<sup>88</sup> BPA, *Annual Report*, 1939, quoted by Holstine, sec. 8, p. 10.

decoration. Interior finishings ranged from simple brass radiator grilles and light fixtures to marble wainscot and granite window sills. Some had skylights. Most had metal lath and plaster over structural tile walls and floors of asphalt tile.

Untanking towers and oil houses followed the same stylistic tendencies over different forms. The towers rose upwards of 50 feet, while the oil houses were small and between 60 and 80 percent below grade.

### Building the Big Line

May 1938 saw the first congressional appropriation of \$3.5 million distributed to the BPA. Initial monies were used for supplies and manpower, property acquisition, and preliminary surveys for a two-circuit, 220-kilovolt (lines were soon upgraded to 230 kilovolts), thirty-seven-mile line from Bonneville Dam to Vancouver, Washington, and a 230-kv line from Bonneville to Grand Coulee Dam. Ross felt these lines were the most critical of the system. The Bonneville-Vancouver line would bring power immediately to a population center, which would bring in needed revenue. As for the Bonneville-Grand Coulee line, even though the BPA was only authorized to market power from Bonneville Dam, Ross had always felt that linking the two dams was crucial. Once the dams were connected, no matter who marketed the power in the future, the potential would exist for a combined output. In 1938, as war clouds gathered, the tie between the two dams and the huge amounts of power it symbolized became increasingly significant. In addition to the

two backbone lines, surveys were funded for a 115-kv. line from Vancouver to Eugene, Oregon; a 230-kv. line from Vancouver to Kelso, Washington; a 230-kv. line from Kelso to Chehalis, Washington; a 115-kv. line from Chehalis to Raymond, Washington; and a 115-kv. line from Bonneville Dam to the Dalles, Oregon.<sup>89</sup>

Property acquisition along these lines was accomplished by means of a mass condemnation program, initiated by J. D. Ross to expedite the construction of the master grid. The program served its purpose, allowing corridors 300 to 375-feet-wide to be surveyed and cleared through forest and farmland in Oregon and Washington in record time. However, the condemnation suits resulted in extensive litigation that didn't let up until second BPA administrator, Dr. Paul J. Raver abandoned the contentious policy, in October 1939, in favor of purchasing easements.<sup>90</sup>

Although actual construction wouldn't begin on the major lines of the master grid until 1939, one small line did materialize during the planning year of 1938. The BPA used \$10,000 of its first appropriation to fund a 13.8-kv., 4.6-mile line from Bonneville Dam to Cascade Locks, a small Oregon community just upstream from the dam. Cascade

---

<sup>89</sup> Holstine, sec. 8, p. 7; *Electrical West* 81 (August 1938): 60.

<sup>90</sup> "Dam Line Buys Halt," *Oregonian*, October 28, 1939. Raver's easement policy meant that the BPA could erect structures, poles and lines wherever necessary, but the property would remain in the landowner's name, and could be used by the landowner. The landowners got paid for their land much more quickly through this voluntary agreement plan than they did through the process of condemnation.

Locks became BPA's first customer when this line was energized on July 9, 1938.<sup>91</sup>

During the summer of 1938, BPA received \$10,750,000 from the PWA for the construction of four transmission lines and their requisite substations. Covering a total of 550 miles, the four lines ran from Bonneville to Grand Coulee; from Bonneville to The Dalles; from Vancouver to Aberdeen, and from Vancouver to Eugene. An additional WPA grant of \$1,080,988 allowed right-of-way clearing to begin on the Bonneville-Vancouver line. Hundreds of workers from the Works Progress Administration provided manpower for right-of-way clearing and the building of maintenance roads on this and other lines along the master grid.<sup>92</sup>

By late 1938, J. D. Ross was administrator of a staff of 700 and a WPA crew of 550. Preparation and planning for the construction project was in high gear: hundreds of miles of land had been condemned and cleared; \$4 million-worth of contracts had been let for materials, and the design of the master grid was in full-scale production. In November, Ross disclosed the routes of the five initial lines in the transmission network, and the location of the principal substations. Originally, sixteen substations were planned for placement along the first five transmission lines. In Oregon they were to be located at Portland (St. John's), Oregon City, Salem, Albany, Eugene, Hood River and The Dalles.

---

<sup>91</sup> *Electrical West* 81 (July 1938): 44.

<sup>92</sup> *Electrical West* 81 (August 1938): 60; Tollefson, 136; Norwood, 113-114.

Washington substations were to be located at Vancouver, Kelso, Cathlamet, Chehalis, Raymond, Aberdeen, Yakima, North Bonneville, and Grand Coulee Dam.<sup>93</sup>

The placement of substations along the grid depended on several factors. Substations were located at the generating sources to immediately step up voltage for transmission, hence the substations at North Bonneville and Grand Coulee Dam. Most were located at points where the federal grid interconnected with private, municipal or PUD distribution systems; or where lower-voltage federal "finger lines" broke off from the main grid. Ross' original plan for substation placement on the early lines was followed with minor exceptions. The Yakima substation was eliminated after Yakima County voters failed to pass a measure establishing a public utility district. In addition, a major substation was added to regulate voltage on the extraordinarily long 234-mile line from Bonneville to Grand Coulee. Known as Midway substation, its name reflected its location halfway between the dams.<sup>94</sup>

---

<sup>93</sup> "Bonneville Lines and Substations Disclosed," *Electrical West*, 81 (December 1938): 53; there were actually eight Oregon substations in the planning stages at this time. BPA constructed a South Bank substation in 1939 at Bonneville Dam on the south shore of the Columbia River specifically to service the line from Bonneville Dam to Cascade Locks. In contrast with other BPA substations that operated at voltages from 115 kv. to 230 kv., South Bank substation had an operational capacity of 13.8 kv. Because of its limited voltage capacity, and its design for local use only, South Bank substation was not considered a key substation on the original grid. The substation was demolished in the late 1980s when new locks were constructed at Bonneville Dam. For more information on South Bank substation, see "Bonneville Power Administration South Bank Substation," Report HAER No. OR-4 for the Historic American Engineering Record, National Park Service, 1987.

<sup>94</sup> BPA again planned for a substation at Yakima in 1940 after election results called for the establishment of a PUD in Yakima County. However, materials shortages brought on by the war postponed construction of a distribution system, and in 1942 a subsequent election overturned the vote to form a PUD

In January 1939, Ross publicly presented the blueprint for the new federal transmission system (Figure 1). Although more fully developed, it was essentially the system that Charles Carey designed in 1935. Depicted was a loop that ran from Bonneville Dam east to Portland-Vancouver, north through Chehalis to Tacoma and Seattle, northeast to Grand Coulee Dam, then southwest down to Bonneville Dam. In addition, high-voltage loops connected the Washington towns of Kelso, Raymond, Aberdeen and Chehalis; Grand Coulee Dam with Spokane, Lewiston, Idaho, Walla Walla and Pasco; and the Oregon towns of Albany, Waldport and Astoria. Circuits ran from Vancouver to the California border; from The Dalles, Oregon to Bend; from Pasco south through Pendleton to Boise, Idaho and east to Pocatello. Commonly called a "grid," it was really a series of interconnecting loops. It was so comprehensive, realistic, and efficient that it made the transition from a map to reality with little alteration. Changes that did occur were a result of shifting priorities driven by the United States' entry into World War II; construction of certain circuits was rushed, material shortages delayed others, and an influx of industrial users into the region prompted the addition of new

---

(Tollefson, 202); Midway substation was in such an isolated spot that BPA built a small town to house the men who operated the facility. The town was dismantled in 1991. Houses were sold and moved from the site (Juanita Jenson, Midway substation, interview by Christine Curran, January 23, 1998).



lines and substations previously unplanned.<sup>95</sup>

### A Second Leader and a Second War

The BPA experienced a change in leadership after the untimely death of J. D. Ross on March 14, 1939. The agency spent six months under the direction of Charles Carey, then Frank Banks, chief construction engineer for Grand Coulee Dam, before Dr. Paul J. Raver was appointed permanent administrator on September 15, 1939. Following in Ross' footsteps would not be easy. Historian Gus Norwood recounts that "Raver faced the many and continuing challenges of reorganization, conducting studies, building facilities, quadrupling the BPA work force, formulating power marketing policies, and typing BPA firmly to the war effort."<sup>96</sup> Events during the fall of 1939 were to dictate the focus of Raver's leadership during the years 1939-1945, a period characterized by an astonishing increase in regional industrial development. Just days before Raver's official appointment, President Roosevelt declared a limited national emergency following Hitler's blitzkrieg of Poland. The United States was officially in a war economy. The very next month, Raver talked openly about "the possibility of a speedup in generating and

---

<sup>95</sup> "Master Power Plan for Northwest Announced," *Electrical West* 82 (February 1939): 62.

<sup>96</sup> Norwood, 122.

transmission line construction at both Bonneville and Grand Coulee and probability of a major power change that would place emphasis upon industrial rather than commercial and domestic development." The fact that there was virtually no heavy industry in the Pacific Northwest at this time did not stop Raver. His successful efforts to establish new industries in the region and provide them with power defined the development of the master grid between 1940 and the end of the war.<sup>97</sup>

The day before J. D. Ross died, Charles Carey presided over the erection of the first steel tower on the Bonneville-Vancouver line, which marked the beginning of construction on the master grid. By June, construction was in progress at BPA's small South Bank substation and the Eugene and North Vancouver substations. The North Vancouver facility was to be the largest and most important substation on the grid, as it was the central dispatching point for the entire BPA system. Later known as Ampere substation, it was renamed for the third time in 1941 in honor of J. D. Ross.<sup>98</sup> Later that summer, an Interior Department appropriation of \$13.4 million, plus \$2 million from the WPA, assured construction on the master grid would continue uninterrupted through 1940. By October 1939, more than 2,000 WPA workers were clearing rights-of-way and building maintenance roads for the BPA, making the project the "largest single WPA

---

<sup>97</sup> "Bonneville Line Speedup Talked," *Oregon Journal*, October 20, 1939.

<sup>98</sup> For detailed information about equipment and engineering relating to J. D. Ross Substation, see Donald G. Worth, "J. D. Ross Substation is Northwest's Largest," *Electrical West* 89 (August 1942): 41-44.

payroll in the state at present."<sup>99</sup> In December, the twin-circuit Bonneville-Vancouver line was energized.<sup>100</sup>

With the construction program on track, administrator Raver turned his attention to creating large markets for Bonneville power. By the end of 1939, Raver had secured contracts to sell Bonneville power to Canby's municipal system and Portland General Electric Company, a major private utility that served the Portland metropolitan area. The BPA also held contracts with a few public utility districts and small municipalities throughout Oregon and Washington. However, bigger markets were crucial to the success of the BPA system. Congress was anxious to see a financial return on the project, and President Roosevelt needed large industrial production facilities to prepare the country for war. A December 1939 contract with the Aluminum Company of America (ALCOA) to provide power for a planned Vancouver reduction plant was just the beginning of a BPA-led industrial transformation of the Pacific Northwest.

It had always been the intention of New Deal planners and public-power advocates to establish industrial markets in the Pacific Northwest concurrent with the development of the Columbia River. New industries were expected to provide a market for Bonneville and Grand Coulee power, and in the process, stabilize and develop the

---

<sup>99</sup> "2,000 Working on Bonneville Power Lines," *Seattle Post-Intelligencer*, October 24, 1939.

<sup>100</sup> BPA, "Transmission Line One-Line Diagrams-Cross Index," April 15, 1991, 1-36.

regional economy. BPA policy and directive encouraging industrial customers had been in place since its beginning. For this reason, when the United States shifted to a war economy in September 1939, the BPA stood poised to play a key role in meeting national defense requirements "without impairment of the Government's long-time program for development of the Pacific Northwest in accordance with sound conservation practice." According to BPA's *Annual Report* for 1941, "All that remained to put the Northwest on a full defense footing was the execution of contracts with new defense industry," and permission to market power from Grand Coulee Dam.<sup>101</sup>

Raver turned to BPA's Market Development Section, where a small staff was engaged in a systematic planning effort to bring electrometallurgical and electrochemical industry to the region. The first task of the Market Development Section was to oversee the BPA's participation in an intensive economic-industrial survey of the Pacific Northwest. Co-sponsored by the Pacific Northwest Regional Planning Commission and the Northwest Regional Council, the surveys helped identify potential industrial sites, locations of existing facilities, availability of raw materials and community resources, power costs; and social and economic trends; virtually all the "information that any industrial prospect would want." Market Development staff analyzed and compiled the data and made it available to potential industrial customers. Gus Norwood suggests that

---

<sup>101</sup> BPA, *Annual Report*, 1941: 49, 52.

"for several years BPA was, in effect, a regional chamber of commerce bringing war-oriented defense loads to the Pacific Northwest."<sup>102</sup> The efforts of the Market Development Section met with modest initial success. ALCOA's 1939 decision to build a plant on the Columbia River was followed in 1940 by the establishment of Pacific Carbide and Alloys Company and the Pennsylvania Salt Manufacturing Company in Portland.<sup>103</sup>

Meanwhile, the war in Europe had reached crisis proportions. Hitler invaded Holland on May 10, and within five weeks had taken Belgium and France as well. On May 16, President Roosevelt urged Congress to approve appropriations "to recruit an additional half-million men for the army, to purchase guns and equipment, to build modern tanks, and to construct naval ships." In addition, he called for the production of 50,000 aircraft per year, a staggering number that was "ten times the current [production] capacity."<sup>104</sup> Congress responded in June with a \$5 billion defense appropriation bill that triggered a flurry of defense contracts in the Pacific Northwest and contributed substantially to BPA's transmission system construction budget for 1940-1941.<sup>105</sup>

---

<sup>102</sup> BPA, *Annual Report*, June 1941, p.,54; Norwood, 125; "Bonneville to Survey Northwest Industry," *Electrical West* 83 (December 1939): 56.

<sup>103</sup> BPA, *Annual Report*, 1941, 55.

<sup>104</sup> Goodwin, p.44.

<sup>105</sup> Norwood, 144; BPA, *Annual Report*, 1941, 59-60.

Raver knew that in order for BPA to meet the immense power loads that would be required by the expanding national defense program, it was critical to integrate Grand Coulee power into the transmission system. Roosevelt agreed, and on August 26, 1940 signed an executive order permitting the BPA to market power generated at Grand Coulee Dam.<sup>106</sup> Just three weeks previous to the signing, the BPA had energized "the biggest electric transmission line in the Pacific Northwest," the 235-mile circuit between Bonneville and Grand Coulee dams.<sup>107</sup>

Although construction of transmission lines and substations continued through 1940 and 1941 along routes previously planned, the pace was greatly accelerated. By June 1941, the BPA had energized 1,176.8 miles of line and twenty substations. Through 1941, increasing defense spending, rising production quotas, and a major influx of new industry into the Pacific Northwest saw the BPA scrambling to make "exhaustive reappraisals of future power needs in response to the constantly changing war developments." As Raver explained, "These planning activities were vitally necessary as a basis for determining the direction in which the Government's Northwest grid should be expanded to serve both normal and defense load growth."<sup>108</sup> However, after Japan

---

<sup>106</sup> Tollefson, 146; Norwood 117.

<sup>107</sup> "Bonneville and Grand Coulee Transmission Line Complete," *Electrical West*, 85 (September 1940): 74.

<sup>108</sup> BPA, *Annual Report*, 1941, 57.

attacked Pearl Harbor, "since the war program required the use of critical materials for the production of war goods, the Administrator's program was limited after December 7 to only those extensions of its system which contribute directly to the prosecution of war."<sup>109</sup> This directive did not prevent the completion of the master grid. By the time the U.S. declared war on December 8, 1941, much of the system was already in place along the routes finalized in 1938. The main components that were not yet in place, such as the Covington to Grand Coulee line, were indisputably critical to the war effort. Indeed, it served to permit the construction of several new lines and substations as well as additions and modifications to existing ones specifically to serve defense loads, allowing the grid to expand despite severe material and manpower shortages.

Between 1940 and 1943, BPA signed defense contracts for power sales with nine private industrial companies, six government-owned Defense Plant Corporation facilities, and eleven military establishments. As contracts were signed, BPA engineers made additions and extensions to the main grid in order to reach the new plants.<sup>110</sup> Most the new facilities were engaged in electroprocessing of raw materials and chemicals, using large blocks of electric power to produce aluminum and other chemical compounds. The availability of cheap public power was critical to the productivity of these plants, and

---

<sup>109</sup> BPA, *Annual Report*, 1942, 36.

<sup>110</sup> BPA, *Annual Report*, 1941, 1942, 1943.

made it possible for them to operate profitably "in spite of the region's distance from the nation's heavy production and market centers."<sup>111</sup>

The Defense Plant Corporation built six defense plants throughout Oregon and Washington: an aluminum reduction plant near Mead at Spokane; an aluminum rolling mill near Trentwood at Spokane; a magnesium reduction plant near Hillyard at Spokane; an aluminum reduction plant at Troutdale; an aluminum-oxide manufacturing plant at Salem; an aluminum reduction plant at Tacoma, and a ferrosilicon plant at Wenatchee. A major substation previously planned at Spokane served the Mead and Hillyard plants, while BPA designed a new one for the Trentwood facility. The plant at Troutdale received its own substation, as did the ones in Tacoma and Salem. Sources are unclear which substation served the Wenatchee plant, however, its proximity to the Midway substation suggests that connection. Military installations using BPA power included army air bases, coast guard stations and navy yards. The Puget Sound Naval Shipyard received its own substation at Bremerton. Private industries were also supplied by BPA power, either through municipal interconnections, as were the Boeing facilities in Seattle, or directly, as were the three Portland shipyards built by Henry J. Kaiser.<sup>112</sup> By 1942, "industrial loads, all of them for war production, accounted directly for ninety-two

---

<sup>111</sup> BPA, *Annual Report*, 1941, 50.

<sup>112</sup> Tollefson, 161-169, 214-222; BPA, *Annual Report*, 1943, 5; the substation for the Salem plant was known as "Alumina" sub. The war ended before the Salem plant was operational. (Tollefson, 222.)

percent of current [BPA] contracts."<sup>113</sup>

Although the directive to curtail construction of all portions of the BPA system not directly related to the war effort did not prevent the completion of the master grid, it did have a chilling effect on the construction of finger lines designed to meet the distribution systems of public utility districts and rural electric cooperatives in Oregon and Washington. Just as the original charter of the BPA encouraged the development of industrial markets, it contained even stronger language directing the agency to help establish and provide priority power to public and peoples' utility districts and rural electric cooperatives. However, only a handful of these public agencies were actually up and ready to receive power before the war began.

Public, or People's Utility Districts (PUDs) first emerged in the Pacific Northwest in the early 1930s; rural cooperatives in 1914. They were established by voters on a county-wide (as in Washington) or multi-county-wide (as in Oregon) basis, acquiring distribution systems by building their own or purchasing the existing systems of private utilities within district boundaries. In the private-utility-dominated Pacific Northwest, initial growth of the public agencies was slow. In 1936, Roosevelt created the Rural Electrification Act (REA), which established a federal lending agency to provide loans for PUDs and rural electric cooperatives nationwide to build generation and distribution

---

<sup>113</sup> BPA, *Annual Report*, 1942, 29.

facilities or acquire existing systems. The REA triggered a dramatic increase in the number of PUDs and rural electric cooperatives all across the country. The promise of cheap Columbia River power made the public agencies especially appealing in rural Oregon and Washington and many were formed in anticipation of purchasing power from BPA. However, Roosevelt's declaration of war on December 8, 1941 found many of these agencies only in the planning stages of their distribution systems. Although BPA continued throughout the war years to negotiate contracts with PUDs and rural electric cooperatives, it was only able to transmit power to those that had existing facilities. Cooperatives and PUDs that held REA loan money had to wait to build their systems until after the war was over. Meanwhile, BPA continued to interconnect with large and small municipalities, private utility companies, and any public district or rural cooperative it could service without building new facilities.<sup>114</sup>

#### The Northwest Power Pool

Interconnection of the BPA federal grid with existing municipal, public and private systems was executed as quickly as lines could be constructed and energized. Among the municipal systems integrated into the BPA grid were those of Seattle,

---

<sup>114</sup> Tollefson, 105-106; BPA, *Annual Report*, 1941, 66-67, 1942, 28; Norwood, 141.

Tacoma, Centralia, Eugene, and McMinnville; private systems included Portland General Electric, Washington Water Power and Pacific Power and Light. Raver was a strong proponent of regional interconnection of all power facilities, public or private. To that end, the BPA began in 1940 to conduct extensive studies on regionwide power pooling in anticipation of defense needs. Most of the Pacific Northwest's privately owned power systems had been interconnected during the 1920s. By mid-1942, most of those systems were interconnected with the BPA grid, and consequently, with all the public and municipal systems it represented. By the time the War Production Board made mandatory such regional interconnections between utilities throughout the country, the Northwest Power Pool was essentially in place.

The Northwest Power Pool was made up of eleven major power systems located in the states of Oregon, Washington, Idaho, Montana and Utah. The pool was fed by 130 privately owned and 20 publicly owned plants throughout the systems of the BPA, Portland General Electric, Pacific Power and Light, Northwestern Electric, Puget Sound Power and Light, Tacoma City Light, Seattle City Light, Washington Water Power, Idaho Power, Montana Power, and Utah Power and Light. Drawing on precedent set at the Conowingo superpower plant in 1926, the Northwest Power Pool was operated as a single enormous system. It was administered by an operating committee comprised of one representative from each of the eleven members in the pool. Combining approximately 4.5 million horsepower in electrical generating capacity, the Northwest Power Pool served to "forestall the development of area-wide power shortages within the

region and to make available at all times maximum power for war production."<sup>115</sup>

The Northwest Power Pool officially commenced on August 1, 1942. By that time, the Covington to Grand Coulee line was energized, tying Puget Sound to Grand Coulee and Bonneville dams and completing the primary loop of the master grid. That year, BPA staff grew to a wartime high of 4,700 people.<sup>116</sup>

BPA struggled to complete the master grid despite mounting labor and material shortages. In early 1943, additional unanticipated defense requirements promised more changes to the nearly finished construction program. BPA's chief engineer Sol Schultz received a visit from a representative of the Dupont Company, who had been hired by the government to run a defense plant planned in Washington State. Historian Gene Tollefson quoted Schultz as he recounted the 1943 meeting:

He came in, he said he wanted a block of power, could we provide it? And I said, that depends how soon, where, and how much. Well, he was very evasive about where. Finally, he said it will be in Central Washington and I figured it was near Midway station. Then he told me how much power was needed. It was a lot. He wouldn't divulge much more than that, he said, it's for defense purposes. I told him that with facilities already in operation at nearby Midway we could meet the date.<sup>117</sup>

---

<sup>115</sup> Walter C. Heston, "Kilowatt-Hours Pooled for War," *Electrical West* 92 (March 1944): 51-63; BPA, *Annual Report*, 1943, 14; Tollefson, 228-231; Norwood, 126.

<sup>116</sup> Norwood, 126; "Transmission Line One-Line Diagrams Cross Index," BPA, 9; BPA, *Annual Report*, 1945, 38.

<sup>117</sup> Sol Schultz quoted in Tollefson, 234.

BPA built a 230-kv loop to service the new plant near the tiny Washington town of Hanford. In doing so, "Bonneville-Grand Coulee power made a major contribution to development of the atomic bomb." The defense plant produced the plutonium that powered the world's first nuclear bombs. According to Raver, "the location of the Hanford Engineer Works in the Pacific Northwest was determined primarily by the availability of large quantities of hydro-electric power and pure, cold water from the Columbia River."<sup>118</sup>

### Conclusion

By 1943 the master grid was virtually complete. Although the country was still in full war production, President Roosevelt ordered all federal agencies to submit plans for the post-war period that spring. That year, BPA experienced a "sharp swing [from construction] toward the operating, research and marketing phases of the Administration's activities" in an effort to convert to a peace-time economy. By June 1943, BPA had constructed 2,443 circuit miles of transmission lines and fifty-one substations. Between June 1943 and June 1945 BPA built only 293 circuit miles of lines and four substations. During this time, construction focused on enlarging and modifying existing substations as

---

<sup>118</sup> BPA, *Annual Report*, 1945, 18.

needed for defense loads (Figure 2).<sup>119</sup>

When World War II ended in September 1945, the BPA master grid consisted of 2,736.8 circuit miles of transmission lines and fifty-five substations. The master grid had supplied war plants with almost 20 billion kilowatthours of electricity, and another 7.5 billion to private systems. This electricity made it possible for Pacific Northwest electrometallurgical plants to produce one-third of the light metals used in the war effort. At a cost of approximately \$75 million, BPA had built the second largest power system in the country in six years; only the TVA was bigger, with 6,000 circuit miles of high-voltage transmission lines.<sup>120</sup>

The influence of the war effort in the evolution of the BPA transmission system between 1939 and 1945 cannot be understated. While the depression and later, war shortages, crippled the construction programs of private utilities, the BPA's federal grid flourished under New Deal, then defense appropriations. Although Portland, Yakima and Spokane remained private-power strongholds, eighty-two percent of the 230-kv lines in the region belonged to the BPA by June 1945. According to the BPA's 1945 annual report, "the publicly owned systems of the Bonneville Power Administration, Seattle, Tacoma and other public agencies had 100 percent of the 230-kv lines with

---

<sup>119</sup> BPA, *Annual Report*, 1943, 1944, 1945.

<sup>120</sup> Springer, 46-47; Tennessee Valley Authority, typescript information booklet, (Knoxville: Tennessee Valley Authority, 1946).



FIGURE 2. Map of the Master Grid, 1944. (BPA, Annual Report, 1944.)

approximately 60 percent of energy production." This "preponderance of publicly owned, high-voltage transmission lines in the Northwest" was a far cry from the region's private utility monopolies of the 1920s and 1930s.<sup>121</sup> In addition, the Second World War prompted the establishment of the Northwest Power Pool, which formally marked the beginning of the Pacific Northwest's modern electrical transmission landscape: an integration of public and private distribution systems anchored by federal dams and the master transmission grid of the BPA.

The engineering and technological lessons learned during the construction and operation of the master grid set the foundation for a BPA transmission network that eventually grew to encompass nine states with over 15,000 circuit miles of transmission line; from marketing the power from one dam to marketing the power from thirty. Before World War II was even over, it was obvious to Congress that the BPA's transmission network was a success. In October 1945, Congress directed the BPA to market power from several newly authorized federal dams: Hungry Horse Dam on Montana's Flathead River; McNary Dam on the Columbia River; the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams on the Snake River; and the Lookout Point, Quartz Creek, and Detroit projects on Oregon's Willamette River. Because the master grid components were designed with the anticipation of future growth, the influx of power

---

<sup>121</sup> BPA, *Annual Report*, 14-15.

created by these new dams was easily integrated into the BPA system. In addition, the master grid's closed loop design provided a high rate of reliability, "giv[ing] a customer a two-way feed as compared with a single feed from a radial line."<sup>122</sup> This meant that the BPA system could be expanded, maintained, or repaired without interrupting electrical service.

The master grid represents the intent of the Bonneville Project Act to "encourage the widest possible use" of electric energy generated by Pacific Northwest hydroelectric plants. The master grid finger lines, secondary loops on the network, stand as tangible reminders of the transformation, of what was once primarily a rural region, made possible by the REA and by the BPA's unique "postage-stamp" rate which made Columbia River power affordable no matter how far it was transmitted. Finally, the BPA master grid embodies a public power ideology shared by BPA's first administrator J. D. Ross and Franklin D. Roosevelt. Roosevelt's conviction that the federal government would "never . . . part with its sovereignty or with its control of its power resources, while I am President of the United States," established the policy setting within which the master grid developed, and which changed forever the social and physical landscape of the Pacific Northwest.<sup>123</sup>

---

<sup>122</sup> Norwood, 174.

<sup>123</sup> Rosenman, as quoted in Tollefson, 110.

## CHAPTER II

### IDENTIFICATION

#### Purpose and Methodology

The purpose of this chapter is to identify resources associated with the Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945, as outlined in the Historical Overview. In this phase, property types are defined, and resource information is compiled and presented.

Several methods were used to identify property types. Research undertaken in preparation of the historical overview revealed specific property types, and general and specific locational data; and a search for previous inventories and surveys in Washington and Oregon revealed a National Register nomination prepared for several master grid properties. Together with BPA Annual and Engineering Reports and additional BPA documents and files, these sources provided the basis for a limited field study of property types in Oregon and Washington.<sup>124</sup>

---

<sup>124</sup> Although the BPA has an updated list of all the substations on their system, these lists do not include dates. Identification of the 55 original substations was made from a combination of maps dating from 1944 and 1946, figures from annual reports, and current locational data. Substations shown in current

The National Register nomination, prepared in 1987, nominated fourteen BPA substations and six transmission lines as part of a discontinuous district. The document presented detailed descriptions of fourteen substations on the master grid built between 1939 and 1945 by the BPA. It also gave a brief description of several properties that were not included in the nomination. Using this existing information as a starting point, six substations were chosen for site visits. Substations at Eugene, Oregon; Troutdale, Oregon; and Ellensburg, Washington were chosen because they represented the three methods of construction used by the BPA during the period of significance. The Salem, Oregon substation was selected for the reason that it was the only one on the system that illustrated a peculiar variation of two property subtypes: the structural combination of a control house and an untanking tower. The Vancouver, Washington substation named for J. D. Ross was picked because it was designed as the dispatching center for the entire master grid. It remains the largest substation on the grid. Finally, the substation at Astoria, Oregon was chosen as it typified a substation that was originally built by the

---

data to be located on the identical sites of substations shown in historic data are presumed to be the same substation, even though they may have different names; sources consulted for this section include: Bonneville Power Administration, "Building Data: Control Houses," 2 July 1990, BPA, Portland; Bonneville Power Administration, "BPA Definitions," 1975, BPA, Portland; Bonneville Power Administration, "Location of Substations, Radio Stations, Hydromets," 1989, BPA, Portland; Bonneville Power Administration, "Transmission Line One-Line Diagrams-Cross Index," 15 April 1991, BPA, Portland; Craig Holstine, "National Register of Historic Places Inventory Nomination Form: Bonneville Power Administration Master Grid," 1987, Oregon State Historic Preservation Office, Salem; Michael Hall, "Irrigation Development in Oregon's Upper Deschutes River Basin, 1871-1957: A Historic Context Statement," 31 August 1994, Deschutes County Community Development Department, Bend, Oregon.

BPA but has since been transferred out of BPA's ownership. In addition to the reasons stated, time and financial constraints were factors in the sites chosen for field verification. Site visits included tours of the building and grounds, interviews with BPA substation operators, and photographic recordation of features.

Two major property types were found to be associated with the transmission of hydroelectricity by the BPA between 1939 and 1945: electrical substations and transmission lines. Tables 1 and 2 at the end of this chapter quantify the identified property types, while Figures 4 through 36 at the end of this chapter show the identified property types.

#### Property Type: Electrical Substation

There are approximately fifty-five substations associated with the transmission of hydroelectricity by the Bonneville Power Administration between 1939 and 1945. The electrical substation is made up of several components; correspondingly, four sub-types were identified within the property type. A BPA substation may contain one or all of the following structures:

#### Subtype: Control House

Control houses were the operations hub of an electrical substation. Character-

defining features of the control houses were identified through field survey, construction drawings, and BPA documents that discussed certain design features that were standardized throughout the grid. In general, control houses built by the BPA can be identified by their simple, unit-based plans and stripped-classical architectural style. This style is manifested through symmetrical facades; flat roofs; plain wall surfaces; and fenestration that includes generous, vertical, multi-light, steel-sash windows and metal-frame doors. In addition to establishing a unified architectural style for the buildings, the BPA made efforts to achieve "natural, dignified, and pleasing structures" by surrounding their substation control houses with landscaped grounds. The level of effort varied with the importance of the substation on the grid. Originally, landscaping features ranged from water fountains and decorative outdoor lighting to simple lawns or gravel yards. Contemporary landscaping immediately surrounding the control house could include lawns, crushed gravel yards, sidewalks, large trees and bushes, and flower gardens. While there is little elaboration found at the control house grounds these days, all landscaping is tidy and well manicured.

#### Range of Variation

According to available information, control houses were built at twenty-three substations by the Bonneville Power Administration between 1939 and 1945. While the control houses clearly reflect a unified design concept, there was variation in materials

used, building plans, building size, decorative detailing, and construction methods. Approximately seventy percent of the buildings are built of board-formed, reinforced concrete. The remaining thirty percent are built of wood-frame construction, with the exception of two that have steel frames and brick walls. Plans are typically rectangular, with modest projecting wings whose locations were dependant on the site. Most of the control houses have one story over full basements containing additional rooms, but some were built over crawl or tunnel spaces just large enough to permit maintenance personnel to access underground equipment. The size of the control houses was determined by the type and quantity of equipment needed at their locations. Some control houses exhibit overhead garage doors, although most have only personnel doors. One control house out of the twenty-three is structurally combined with an untanking tower. All the others stand alone. Whether concrete, brick or wood, decoration on the buildings was minimal. However, there were some features used consistently throughout the system, albeit randomly enough to allow each building a distinct personality. Cast stone capped parapet walls, and concrete formed dentils, corbels and beads around window and door frames. Both concrete and galvanized steel were used for canopies over secondary entrances. Exterior stair railings were of wrought iron or pipe. Glass block was utilized a great deal in transoms and sidelights. Many of the concrete control houses and at least one of the wood-frame ones are painted a beige tone. Sources consulted during the course of this study made no mention of the original paint color, if any, on these buildings. Today, some variation of paint colors among substations can be found.

### Description/Concrete

According to available information, there were sixteen board-formed, reinforced concrete control houses on the BPA grid. This type of construction was used on the earliest control houses and continued to be the most common type through 1945. Concrete had some distinct advantages. It was fireproof and readily available. Many of the sites of the control houses sites were remote, and the cost of trucking in materials would have been costly. Concrete could be mixed on-site. Poured concrete construction is completely sealed, providing excellent protection for the equipment inside. In addition, with the prospect of war looming over the early planning years, it is likely that the BPA made a conscious decision not to invest in a construction program based on steel.

The Eugene substation control house is representative of a medium-size, reinforced concrete control house on the master grid, displaying all of the character-defining features listed above. The building is set back about ninety feet from the east side of Highway 99W across a wide expanse of lawn. The grass wraps around its northwest end, while a paved parking lot extends off the south corner. Directly behind (northeast) the control house, a chain-link fence encloses a large switchyard.

The control house is a one-story, reinforced concrete structure with a concrete foundation and flat roof. Measuring 57'-0" wide and 40'-4" deep, its rectangular plan contains approximately 1, 869 square feet. The walls are sheathed in stucco, and in some places, covered with fiberglass cloth. At the roofline, tiered parapet walls are capped with

metal coping. The built-up, concrete-slab roof is pierced at the southeast end by a gabled, 6' x 4' skylight with wired glass. A canted watertable circumnavigates the building 2'-10" from grade. The entire structure is painted a beige tone.

The primary facade of the control house faces southwest. A shrubbery-lined concrete walk leads to the front entrance, which is located at the southeast end of the facade. Short wing walls flank a shallow flight of concrete steps that ascend to a concrete stoop. A central opening, 11' tall x 7' wide, dominates an entry bay, which projects 7'-4" forward from the main volume of the building. Slightly recessed within the opening is a bronze-finished, aluminum frame. The frame, divided into six sections, contains a glazed aluminum door, also with a bronze finish; two plate-glass sidelights; and a three-light, plate-glass transom. Fluorescent bulbs light the entry from within very slender metal casements located on each side of the doorframe, in the narrow wall plane between the frame and the main facade. There are three casements on each side, filled with fluted glass and set vertically in a continuous metal frame. Above and adjacent to the entrance are metal letters reading, "Columbia River Power, Eugene Substation," and "Bonneville Power Administration." In contrast to the rest of the building, the capped parapet walls of the projecting entry bay are double-tiered. In addition, the entry bay is distinguished by a canted belt course that runs just above the watertable.

Directly southeast of the entry bay, the southwest facade extends just two feet. On the other side of the bay, the facade stretches 34'-6" to the northwest end. Three, vertical, ten-foot-tall window bays dominate this portion of the primary facade, rising from the

water table to the top of the wall. Each bay is filled with three, four-light, steel sashes. The top one opens for ventilation in an awning style; the bottom one in a hopper style. The middle sash is fixed. A concrete spandrel panel surmounts each window. The window bays are slightly recessed, relieving the main wall plane in a rhythmic sequence. The symmetrical fenestration of the northwest facade displays a pair of window bays identical in style to those on the front. Also evident from this end is the northwest side of the projecting entry bay, which has a very narrow, seven-foot tall, multi-light casement window recessed into the wall. On the other side of the northwest facade, a portion of the building's back porch is visible. A chain-link and barbed-wire fence extends northwest off the north corner of the building, separating public space from the switchyard.

The rear facade faces northeast. Located in the switchyard, this side of the building is accessed from a concrete walk that cuts through the graveled yard. This facade is divided into two sections along the same line that separates the projecting entry bay from the main volume of the building at the front facade. Three window bays in a pattern identical to the front dominate the main volume. The remainder of this side consists of a wing projecting 5'-9" out into the switchyard. At the juncture of the main volume and the rear wing is a small porch sheltered by a square, concrete canopy with rounded corners. A short wing wall extends toward the northwest, containing four steps and supporting an original, curved, Moderne-style steel handrail. The porch's concrete stoop provides access to two glazed metal doors; one that faces northeast and another facing northwest. Next to the porch, on the wall of the rear wing, an access ladder rises the height of the building.

The facades of the rear wing and the projecting entry bay comprise the southeast end of the building. At the east corner of the wing, the chain-link and wire fence extends to the southeast. The wing displays symmetrical fenestration, with a pair of window bays in the typical style. Directly adjacent, the entry bay holds a single window bay, also in the typical style.

Inside the control house, clay-tile walls divide the building into four principal rooms. Throughout the building, ceilings and walls are finished with painted plaster over metal lath; floors are asphalt tile with rubber bases. Most of the windows are covered with a steel mesh for added security. Electric-heat radiators and ducts throughout the building are covered with plated steel grilles.

Visitors enter the control house through the main entrance. Suspended overhead in the small lobby is the only original light fixture in the building: a streamlined bowl with a bronze finish. Through a door to the left, is a hallway containing a small bathroom to the left, and a closet to the right. Inside the closet is a trap door for a ceiling storage space and access to a crawl space under the building. Through the hallway is the control room, which is contained in the main volume of the building.

The control room is the command center for the substation. An eight-foot-tall, steel switchboard unit runs down the center of the room. The unit is comprised of two instrument and control panels placed back-to-back; a small aisle between them permits access to the backs of both panels. From these control panels the main power circuits in the switchyard are opened, closed, metered and relayed via cables that travel between the

switchyard and the control house. These underground cables enter the building through a conduit run in the foundation wall and travel through a trough in the crawl space, reaching the control panels through removable metal plates in the floor under the unit. The control panels represent an array of functions that take place at the substation, and are covered with meters, gauges, instruments and handles. On the face of one of the panels is a single-line diagram of the substation's main bus and feeder transmission lines.<sup>125</sup> Known as a "mimic bus," this diagram provides operators with a physical representation of the circuitry being controlled. Once manually operated twenty-four hours a day, this substation is now automated; its operations are under supervisory control of the Dittmer Control Center at the J. D. Ross Substation in Vancouver, Washington. Nevertheless, the control panels remain fully functional, monitoring switching operations and allowing manual switching on a routine and maintenance basis. In addition to the control panel unit, the control room contains several tables, an operator's desk, office equipment, and vertical and flat file cabinets. The room is lit by modern fluorescent fixtures suspended from the plaster ceiling. Venetian blinds provide window coverings.

From the control room there is access to the back porch through a door at the east corner of the room. In addition, a door at the southeast end leads into a communications

---

<sup>125</sup> A "bus" at a substation is a rigid conductor that interconnects equipment of the same voltage.

equipment room. Filled with electronic racks laden with transmitter and receiver apparatus for carrier and land telephone, radio and microwave equipment, this room is lit by a gabled skylight with wired glass. On the other side of the communication room's northeast wall is a battery room. This space is entered from the second door off the back porch. The battery room holds three, narrow, built-in platforms; run along each side of the room, one runs down the middle. The platform surfaces are covered with sand and support rows of battery cases. In addition, the battery room has an original, built-in lead-sheathed sink and counter. These batteries provide direct-current power to equipment in the switchyard and the control room.

#### Description/Steel and Brick

There were two control houses on the master grid that were built with steel frames by the Bonneville Power Administration between 1939 and 1945. In distinct contrast to the control houses on the rest of the grid, those at Troutdale and Tacoma had steel frames and red-brick walls. Both were built in 1942-43 to service war-time aluminum plants owned by the Defense Plant Corporation. They have identical measurements. The reasons for the dramatic change in materials in just two of the control houses can be explained by another feature the two buildings share: they are both built on weak soil. The Tacoma substation stands on silty alluvium, or sediment, from Puget Sound. The Troutdale substation was built on silty, Columbia River sediment. Steel and brick construction was

lighter and more flexible than the poured concrete used at most of the other BPA substations. BPA engineers chose a construction method that would absorb the settlement associated with poor sub-soil conditions without the structural cracking that would occur with a concrete structure.

The Troutdale substation control house is representative of the two steel-and-brick control houses on the master grid, displaying all of the character-defining features listed above. The building is located just east of Sundial Road between the Columbia River and Oregon State Highway 84. It faces west across an access road toward an enormous switchyard that wraps around the south facade. A manicured lawn surrounds the north end and east side of the control house, while the west side is bordered by mature bushes. The Reynolds Aluminum Plant abuts the switchyard to the south.

The Troutdale control house has a rectangular plan consisting of a one-story main volume with a wing at each end. Both wings are set back slightly from the main volume at the front (west) and rear (east) facades, and are seven feet shorter than the main volume. Measuring 81'-3" wide and nearly forty-three feet deep, the building contains almost 3,500 square feet. Atop a concrete foundation and crawl space, the control house has a frame of steel, and walls of red brick laid in a common bond. On the main volume as well as the wings, the roof is essentially flat and the short parapet wall that surrounds it supports a metal fascia. The upper two feet of the concrete foundation wall circumnavigates the building, its beveled cap serving as a watertable.

The front and rear facades of the control house are very similar to each other. On

both, the main volume is divided into three bays by full-height brick pilasters. The pilasters indicate the location of the building frame's steel columns. The north and middle bays each hold a 10-foot-tall, 5-foot-wide, steel-sash window. The window's fifteen lights are vertically arranged in three columns of five lights each. In contrast to small lights in the outer columns, the middle column exhibits much larger panes of glass. All sashes are fixed except for two in the middle column. The south bay holds a glazed, metal door surmounted by a small metal canopy. At the front facade, this door is preceded by a concrete stoop with four steps and a metal handrail, and opens into the switchyard. There are no stairs at the rear entrance. The control house wings hold one window each at the front and rear facades. In contrast to the dominating windows of the main volume, the steel-sash wing windows are just five feet tall, each with three lights divided by horizontal muntins. On the front facade of the north wing, there is a glazed, metal door identical to the one on the main volume. With the same metal canopy, concrete stoop, steps and handrail, this door serves as the public entrance to the control house. Access to the south half of the control house is prevented by a chain-link sliding gate that extends west from the middle bay of the front facade.

The north facade of the control house comprises the north wing, and displays three symmetrically placed windows: two are steel-sash windows in the three-light style previously described, one is a smaller, two light example, also with steel sash. Between two of the windows is a prominent metal downspout providing drainage to a roof-line scupper in the wing's parapet wall. Above the wing is visible seven feet of the main

volume. Prominent downspouts near each corner break the wall plane, draining scuppers in the parapet wall. A chain-link fence extends to the east off the northeast corner of the building.

The south facade is comprised of the south wing, which is located in the switchyard. The south wing has two, steel-sash windows in the three-light style, and a glazed, metal door located near the southeast corner. This entrance, which is surmounted by a large security light, opens onto a concrete stoop with steps and a metal handrail. Between the door and a window is a prominent downspout providing drainage to a roof-line scupper at the wing's parapet wall. Above the wing, on the wall of the main volume, there are two scupper downspouts near each corner.

Inside the Troutdale control house, brick walls separate the wings from the main volume. The main volume holds one large room, while clay-tile partition walls divide each wing into individual rooms. Walls are furred with wood and covered with metal lath and plaster, except for those in the south wing where the brick is exposed and painted. Ceilings are suspended and plastered, with the exception of the south wing where the steel truss remains exposed. Currently the exposed ceiling is covered with reflective foil. Floors throughout the building are of asphalt tile.

Visitors enter the control house through the door in the north wing at the front facade. From a small lobby, a doorway to the right opens into a control room. Four, eight-foot-tall, steel switchboard units run parallel to each wall. Each unit is comprised of two instrument and control panels placed back-to-back; a small aisle between them

permits access to the backs of each panel. From these control panels, the main power circuits in the switchyard are opened, closed, metered and relayed via cables that travel between the switchyard and the control house. These underground cables enter the building through a conduit run in the foundation wall and travel through troughs in the crawl space, reaching the control panels through removable metal plates in the floor under the units. The control panels represent an array of functions that take place at the substation, and are covered with meters, gauges, instruments and handles. On the face of one of the panels is a single-line diagram of the substation's main bus and feeder transmission lines. Known as a "mimic bus," this diagram provides operators with a physical representation of the circuitry being controlled. Although this substation is still manned, many of its operations are under supervisory control by the Dittmer Control Center at the J. D. Ross Substation in Vancouver, Washington. Nevertheless, the control panels remain fully functional, monitoring switching operations and allowing manual switching on a routine and maintenance basis. In addition to the control panel units, the control room contains several tables, an operator's desk, office equipment, and vertical and flat file cabinets. The room is lit by modern fluorescent fixtures suspended from the ceiling. Modern blinds provide window coverings.

The south wall of the control room has doorways at each end that provide access into the south wing. Originally housing the "relay lab" and a separate office, this space is now one room, holding several work stations and modern office equipment. A glazed, steel partition wall spans the width of the wing at the east end, separating the office space

from an additional work space, and traffic flow near the wing's south-wall entrance.

The north wing is divided into three primary spaces, each accessed by doors in the north wall of the control room. A communication room at the east end contains vertical electronic racks laden with transmitter and receiver apparatus for carrier and land telephone, radio and microwave equipment. Next door, to the west, is a battery room. Along the east and west walls of this room are built-in battery platforms, covered with sand and holding rows of battery cells. These batteries provide direct-current power to equipment in the switchyard and the control room. The rooms at the west end of the wing includes the small lobby, a kitchen, a bathroom, a dark room and a storage room. A hatch in the storage room floor, and one located just across the wall in the control room, provides access to a five-foot-high crawl space underneath the building.

#### Description/Wood Frame

According to available information, there were five wood-frame control houses built by the BPA between 1939 and 1945. These tiny, inexpensive buildings represented small substations serving local loads along the master grid. The control houses at the smaller substations were usually one-room buildings of wood frame construction, plywood walls and metal roofs.

The Ellensburg Substation control house is representative of the five wood-frame control houses on the master grid. These small control houses do not share the character-

defining features found on the concrete and brick substations. The control house at the Ellensburg Substation control house is completely enclosed inside a switchyard located just west of Ellensburg, Washington. The switchyard is circumnavigated by a chain-link, barbed-wire fence, and is entered at several points through chain-link gates. The control house faces north, surrounded by a groundcover of crushed rock. A concrete walkway leads to the front door, and parallels the east and south walls of the building.

The Ellensburg control house has a wood-stud frame over a concrete foundation and crawl space. When constructed in 1941, it measured just fourteen feet wide by twelve feet deep. In the early 1950s, the building received a seamless, 10' x 10' addition to its west end, raising its volume to a total of 288 square feet. The control house has a hipped roof covered with standing-seam metal, and plywood walls sheathed with vertical T1-11 plywood siding with wood cornerboards. The building's original siding was waterproof plywood with horizontal battens spaced a foot and a half apart. At the center of the roof, a short shaft supports a capped and louvered ventilator. Closed eaves support metal gutters, which are drained by downspouts at the north, east, and south facades. Just beneath the eaves, a wide metal frieze surrounds the building. The entire structure is painted beige.

The primary (north) facade of the control house represents the original section and the later addition. The original section holds a centrally placed front door. Two windows abut the door, one on each side, in contiguous batten frames. A simple wood casing, affixed to the siding, follows the outline of the fenestration from the wide metal frieze above to the bottom of the door. Both windows and the door are wood with fixed-sash,

three-light glazing and horizontal muntins. The door is obscured by an aluminum screen door. To the west, the addition is set back two feet from the original section. It displays a wood, fixed-sash, six-light window, also surrounded by a simple, wood casing affixed to the siding. At the juncture of the two sections is a downspout and a small switchbox and metal conduit attached to the wall.

The west end of the control house is an unbroken wall plane. The south (rear) facade is also unbroken. The twenty-four-foot expanse has been fitted with metal hooks for storing large equipment. A ladder hangs horizontally against the wall, a large conduit is suspended just below. On the ground, just off the rear facade, is a square access-hatch cover and a large black box known as a spill response unit. The east facade of the control house is broken only by a small window high in the wall that contains a prominent air-conditioner unit. The unit is screened on three sides. The window opening is surrounded by a wood casing affixed to the siding. A downspout runs near the northeast corner.

Inside the one-room control house, walls are of painted plywood with widely spaced vertical battens. Insulation tiles sheath the ceiling, which is pierced in the middle by a grated vent. The concrete floor is covered with industrial carpeting. A vertical, steel switchboard unit, eight feet tall and eighteen feet long, rises to the ceiling, filling most of the room. The unit is comprised of instrument and control panels from which the main power circuits in the switchyard are opened, closed, metered and relayed via cables that travel between the switchyard and the control house. These underground cables enter the building through a conduit run in the foundation wall and travel through troughs in the

crawl space, reaching the control panels through removable metal plates in the floor under the unit. The control panels represent an array of functions that take place at the substation, and are covered with meters, gauges, instruments and handles. Along the west wall is a three-level metal rack holding rows of battery cases. These batteries provide direct-current power to equipment in the switchyard and the control room. In addition, there is a desk on the north wall, and a full-height cabinet built-in to the east wall. The room is lit by overhead, fluorescent fixtures.

### Distribution Patterns

Several factors determined the distribution patterns of the BPA control houses. Firstly, they were always located at a substation. Secondly, the locations of the substations were dictated primarily by the technological requirements set forth by the transmission of electricity in an alternating-current system. The stepping up and down of voltages had to occur at different points on the transmission line; points that were determined by engineers based on the length, direction, and voltage level of the line. Consequently, the substations followed the rights-of-way of the transmission lines. For these reasons, the control houses built between 1939 and 1945 can be found along the routes represented by maps of the master grid drawn between 1939 and 1945 (Figure 3). However, only about forty-two percent of the substations built during that time had control houses. They typically occurred at the substations that served larger loads:

populated areas and/or industrial plants. For this reason, control houses are most likely to be found at the substations located near cities and near the sites of the wartime industrial plants along the master grid.

According to available information, the BPA built twenty-four control houses between 1939 and 1945. It is possible, however, that control houses were built at four substations that were built by the BPA during the period of significance but have since passed out of BPA ownership. Sites such as these are not represented in any detail in current BPA locational data, and time constraints did not permit field verification of these substations (Table 1). Although the BPA system has expanded greatly since 1945, most of the transmission rights-of-way represented by the master grid maps of 1939 through 1945 are still in use, consequently, so are the substations located on the lines. Because they were built to serve such a specific function, and because that function is still required of them, most are estimated to all be in use today, with the exception of South Bank Substation. Comprised of a control house and switchyard, the substation was demolished when the Army Corps of Engineers built a new lock system at Bonneville Dam in 1987. In general, however, property loss over time has been minimal because of the continuity of function. For the same reasons, the condition of the BPA control houses can be generally characterized as good to excellent. They are well maintained because they are still in use.

### Subtype: Untanking Tower

Untanking towers were used to house maintenance and repair activities at the substation. Multi-ton traveling cranes on overhead beams facilitated the "untanking" of power transformers and other giant, oil-immersed equipment. The enormous size of the equipment being serviced necessitated the extreme height typical of this property type. Character-defining features of the untanking towers were identified primarily through field survey and historic photographs. In general, untanking towers built by the BPA can be identified by their unit-based plans, extreme vertical proportions, and stripped-classical architectural style. This style is manifested through symmetrical facades; flat roofs; plain wall surfaces; and fenestration that includes enormous, symmetrical banks of multi-light, steel-sash windows and giant, overhead steel doors. Like the control houses, the untanking towers were surrounded by landscaped grounds on at least the primary facade. One or more sides of the tower was enclosed within the switchyard. Landscaping features could include lawns, sidewalks, large trees and foundation plantings.

#### Range of Variation

According to available information, untanking towers were built at six substations by the Bonneville Power Administration between 1939 and 1945. All of the six are constructed of reinforced, board-formed concrete. Some variation in building plans have

been identified, and in the height of the towers, which range from fifty to seventy feet high. Only one of the towers is structurally combined with a control house (Salem), all the others are free-standing buildings. Decoration was used on a few of the towers: some have porthole windows in the entry bay, some have concrete corbelling and lintel detailing around the doors and windows.

### Description

Although it is the only tower in the system that contains a control house, the Salem Substation untanking tower is a good representative of this property type. The building's unit-based arrangement is very similar to the majority of the other towers; instead of housing control house rooms, the other towers would house shop, tool, oil and storage rooms. In addition, the Salem untanking tower displays all of the character-defining features listed above. The Salem Substation is sited on a hill overlooking State Highway 22 and the Willamette River just west of Salem, Oregon. Access to the site is provided by a road from the highway located west of the building. The access road, which continues north on the hilly site, branches off to abut the west side of the building. A wooded hillside rises directly behind (north) the tower. The building anchors the southwest corner of a large switchyard that covers the hillside.

The Salem untanking tower is a reinforced-concrete structure over a basement and a concrete foundation. The building has a cross plan, with the tower serving as the central

volume. Measuring thirty-three feet wide by eighty-four feet deep, the untanking tower rises to a height of forty-three feet. Two one-story wings flank the tower at its south end, each measuring thirty-three feet wide, forty-six feet deep, and 16'-6" tall. A shorter, one-story entry bay projects from the south end of the tower. All components of the building have flat roofs with parapet walls topped with metal caps and fascia. The walls are sheathed with stucco and painted beige. All windows have multiple lights, and ventilated, steel sash.

The primary facade of the Salem untanking tower faces south. It consists of all four components: the tower, wings and entry bay. At this facade, the wings project several feet south from the tower; the central entry bay projects several feet south from the wings. Short wing walls enclose a concrete terrace that precedes the entrance to the building, which is located in the entry bay. Three, symmetrically placed, ten-foot-tall, five-feet-wide bays dominate the entry's facade. The center one is filled with a modern metal door surmounted by an original, multi-light transom. The other two are filled with steel-sash windows, also with multi-light transoms. The windows and door are deeply recessed; concrete corbels run the length of the bays, filling the space between the wall plane and the window (or door) frame. Lintel soffits hold lighting fixtures set flush with the concrete. Above, the lintel edges are beveled, divided into sections that are alternately recessed, creating the illusion of dentils. Above the entry bay, three columns of narrow, twenty-foot-tall windows with horizontal muntins dominate the south facade of the untanking tower. These windows are also recessed, with corbelling running the length of

the bays. To the east and west of the entry bay, the two wings each exhibit three, ten-foot-tall windows. The bays are recessed, with the same corbelling found at the entry.

Spandrel panels surmount each window, also recessed from the wall plane.

The east and west facades of the untanking tower are virtually identical. At these sides, each one-story wing has four, ten-foot bays containing recessed windows. The tower section exhibits symmetrical fenestration characterized by tall openings at the floor level and shorter openings at the upper level. Four, seven-foot wide, thirty-foot-high pilasters divide this facade into three bays. The long central bay is dominated by a twenty-foot-tall overhead door located at the crux of the wing and tower. On the west facade, this door is made of solid steel; on the east it is a steel grid, glazed with multi-light, steel-sash windows. Above the door, the central bay is pierced by a row of five 6'x 4' windows. Next to the door are two, small square windows. The north bay is filled with an eight-foot-wide window that rises to the same height as the door, surmounted by a recessed concrete spandrel. Above the spandrel is a second window, nearly six feet tall. The south bay is filled with the same upper-level window and spandrel panel; the lower window is smaller, as it sits above the roof of the one-story wing. All the second-level windows are aligned with the tops of the pilasters, leaving the upper fourteen feet of wall, on all sides of the tower, unbroken.

The north end of the tower is dominated by three, narrow, thirty-foot columns of multi-light, steel-sash windows; the upper six feet of each window is separated from the lower sections by a recessed spandrel. The one-story wings at this facade each exhibit

three window bays filled with ten-foot-tall windows.

Inside the building, the one-story wings hold the facilities typically found in a control house; components which, at a more typical substation, would be housed in a separate building. Interior finishes in the wings include asphalt tile floors; structural tile walls sheathed with painted plaster over metal lath; and painted plaster ceilings. The control room, located in the east wing, exhibits glazed-tile window sills and a horizontal beadcourse that circumnavigates the room, halfway up the wall.

Visitors enter the building through the entry bay at the front facade. The north wall of the lobby holds a glass-block window, and a door that leads into the untanking tower. A glazed door and sidelight in the east wall of the lobby leads to the control room. An eight-foot-tall switchboard unit dominates the room, running from one end of the room to the other, parallel to the east wall. Two smaller ones run parallel to the north wall. The large unit is comprised of two instrument panels placed back-to-back; a small aisle between them permits access to the backs of both panels. From the control panels on all three units the main power circuits in the switchyard are opened, closed, metered and relayed via cables that travel between the switchyard and the control house. These underground control cables enter the building through conduit runs in the foundation wall of a basement cable room. The cable room is located directly beneath the control room. Cables then travel up through vertical, steel, terminal cabinets where they enter the control room switchboard units from the bottom, through metal plates in the cable-room ceiling. Much of the buswork in the cable-room cabinets still dates to the 1940s. The

control panels in the control room represent an array of functions that take place at the substation, and are covered with meters, gauges, instruments and handles. The large unit's control panels display a single-line diagram of the substation's main bus and feeder transmission lines. Known as a "mimic bus," this diagram provides operators with a physical representation of the circuitry being controlled. Once manually operated twenty-four hours a day, this substation is now automated; its operations are under supervisory control of the Dittmer Control Center at the J. D. Ross Substation in Vancouver, Washington. Nevertheless, the control panels remain fully functional, monitoring switching operations and allowing manual switching on a routine and maintenance basis. In addition to the control panel units, the control room contains several tables, an operator's desk, office equipment, and vertical and flat file cabinets. The room is lit by modern fluorescent fixtures set flush with the surface of the ceiling. Venetian blinds provide window coverings. There is a glass-block window in the west wall. A door in the west wall leads into the untanking tower.

Access to the west wing facilities is provided from inside the untanking tower. Maintenance and equipment storage room, bathrooms, and a communications room are found in the west wing. The communications room contains vertical racks laden with transmitter and receiver apparatus for carrier and land telephones, radio, and microwave equipment. Original hanging light fixtures light the room.

The untanking tower is open from the painted concrete floor to the ceiling forty-three feet above. Banks of twenty- to thirty-foot-tall windows light the "cathedral-like"

space. Rails embedded in the floor run under the east-wall door, out into the switchyard. On these rails, transfer cars move giant transformers from the switchyard into the tower for maintenance. Two overhead travelling cranes, one fifteen-ton; the other sixty-ton, are suspended on steel beams overhead. The cranes enable crews to extract the core and coils from the transformer tank during maintenance procedures. Near the south end of the tower, the outline of a concrete pad remains on the floor. The pad used to hold a large piece of equipment known as the synchronous condenser. Essentially a giant electric motor, the condenser used to regulate circuit voltage at the substation. The machine was a key component of most substations along the master grid until they became obsolete with the introduction of other, more compact regulation equipment. Open stairwells parallel the north and south walls of the tower, descending to the basement.

The basement contains a battery room, the cable room, and a smaller communications room.. The battery room holds three built-in platforms; two run along each side of the room, one runs down the middle. The platform surfaces are covered with sand and support rows of battery cases. These batteries provide direct-current power to equipment in the switchyard and control room.

### Distribution Patterns

Several factors determined the distribution patterns of the BPA untanking towers. Firstly, the towers are always located at a substation. The locations of the substations

were dictated primarily by the technological requirements set forth by the transmission of electricity in an alternating-current system. The stepping up and down of voltages had to occur at different points on the transmission line; points that were determined by engineers based on the length, direction, and voltage level of the line. Consequently, the substations followed the rights-of-way of the transmission lines. For these reasons, the untanking towers built between 1939 and 1945 can be found along the routes represented by maps of the master grid drawn between 1939 and 1945 (Figure 3). However, less than fifteen percent of the substations built during that time had untanking towers. It is not known what specific factors were considered when determining where to place the towers, however, locational patterns indicate that the towers were built at the largest substations on the grid, and perhaps were distributed to provide regional coverage, for example, one in Oregon's Willamette Valley, one in central Washington, one in the Puget Sound area, etc. . . . It is known that transformers across the system that needed repair and overall maintenance were, and still are, shipped to substations with untanking towers for servicing.

According to available information, the BPA built six untanking towers between 1939 and 1945.<sup>126</sup> It is possible, however, that untanking towers exist at two substations

---

<sup>126</sup> There is an untanking tower at the Troutdale substation, but available information suggests that it was built by the Defense Plant Corporation for use by Alcoa, which ran the aluminum plant adjacent to the substation. The untanking tower at Troutdale, which also housed a synchronous condenser, displays none of the character-defining features identified above, and lacks the proportions and architectural consistency of towers built by BPA. In addition, site plan drawings dating from 1941 show the building

that were built by the BPA during the period of significance but have since passed out of BPA ownership. Sites such as these are not represented in any detail in current BPA locational data, and time constraints did not permit field verification of these substations (Table 1). Oil-immersed equipment is being gradually replaced by that which does not require oil insulation, therefore the untanking towers are not as busy as they used to be. However, they remain fully equipped and operational to function as they were originally intended and remain a vital component of their respective substations. There has been no property loss over time because the towers have been in continual use for over fifty years. For the same reasons, the condition of the BPA untanking towers can be generally characterized as good to excellent. They are well maintained because they are still in use.

#### Subtype: Oil House

Pumps housed in small, semi-subterranean substation oil houses pumped oil out to oil-immersed equipment in the switchyard, such as power transformers and power circuit breakers, through a complex system of underground pipes. This process flushed dirty oil from the equipment, refreshing it with clean oil. Character-defining features of the oil houses were identified through field survey and historic photographs. In general,

---

marked as "Alcoa Condenser Building."

oil houses built by the BPA can be identified by their semi-subterranean setting, plain wall surfaces, flat roofs, and glass-block or steel-sash fenestration. Oil houses are always enclosed within the switchyard fence, surrounded by a crushed rock yard and sidewalks. Typically the oil that is drawn by the oil-house pumps is stored in vertical tanks on a concrete pad close to the oil house.

#### Range of Variation

Construction methods and materials used to construct oil houses mirrored those used on the control houses at the substations. Substations with a concrete control house had a concrete oil house. Substations at Tacoma and Troutdale, which exhibit the only brick control houses on the system, both have brick oil houses. Variations were also identified in the size of the oil houses, although most contained only one, semi-subterranean room. The biggest variations were identified in an oil house at the J. D. Ross Substation in Vancouver. This structure has an above-ground first floor and a full basement, with louvered windows that look out into a huge pit where horizontal oil tanks lay side by side.

#### Description/Concrete and Brick

Oil houses on the master grid, whether concrete or brick, follow the same general

design; most encompassing all of the character-defining features listed above. Anchored by a reinforced concrete foundation, the nearly square building stands less than four feet above grade. The roof are flat and glass block and opaque glass fill windows that typically occur on three sides of the building. Wing walls contain the door, which stands approximately five feet below grade, at the bottom of a steep flight of concrete steps.

Inside the single room, the concrete foundation walls, floor, and ceiling are unfinished. In the brick houses, the walls are painted and the ceiling is finished. Industrial light fixtures, typical of the 1940s, hang from the ceiling. Pumping equipment was removed from all the oil houses on the system in the early 1990s, leaving behind pumping gauges, valve nests, pipes and gears that date from the 1940s.

### Distribution Patterns

According to available information, oil houses were built at eight substations by the Bonneville Power Administration between 1939 and 1945. It is possible, however, that oil houses exist at two substations that were built by the BPA during the period of significance but have since passed out of BPA ownership. Sites such as these are not represented in any detail in current BPA locational data, and time constraints did not permit field verification of these substations (Table 1). Like the control houses and the un tanking towers, the distribution patterns of oil houses depended on the locations of the substations of which they were an integral component. Locations of the substations were

dictated primarily by the technological requirements set forth by the transmission of electricity in an alternating-current system. The stepping up and down of voltages had to occur at different points on the transmission line; points that were determined by engineers based on the length, direction, and voltage level of the line. Consequently, the substations followed the rights-of-way of the transmission lines. For these reasons, the control houses built between 1939 and 1945 can be found along the routes represented by maps of the master grid drawn between 1939 and 1945 (Figure 3). However, less than fifteen percent of the substations built by the BPA during that time had oil houses. It is not known with certainty why some substations had oil houses and some did not, as every substation had equipment that needed periodic oil changes. It is reasonable to assume that if the cost was justified, such as at substations with large switchyards and lots of equipment, an oil house would be built on the grounds. In at least one case, at the Chehalis Substation, oil pumps were installed in the basement of an untanking tower. In all the other cases, portable oil pump units must have been utilized to bring oil to the substation and flush out equipment as needed. Based on these suppositions, oil houses could likely be found at the substations serving the largest loads.

Environmental regulations, an increasing use of portable pumping units, and gas or air for insulation have eliminated the need for pumping equipment originally housed in the oil houses. Consequently, most of the original pumping equipment has been removed from them. However, there is no indication that the oil houses are being removed from the substations. They currently stand empty or are utilized for storage. The overall

condition of the oil houses can be generally characterized as fair to good.

#### Subtype: Switchyard

The switchyard is an installation of equipment designed to control power flow and transform voltages for distribution. The switchyard contains the fundamental electrical components that comprise an electrical substation. Character-defining features of the switchyards were identified through field survey, interviews, engineering literature reviews and construction drawings. These features consist of transformers and power circuit breakers, steel lattice-work support structures, giant dead-end transmission towers, smaller feeder transmission towers, wrought-iron and aluminum buswork, and outdoor lighting fixtures. Switchyards are enclosed by a chain-link, barbed-wire fence. Ground cover is crushed rock crisscrossed by concrete sidewalks.

An installation of equipment similar to a switchyard is also found along the master grid. Known as switching stations, these installations are unmanned and contain only that equipment necessary for the control of power flow. Voltage is not transformed at switching stations. The BPA did not typically make the distinction between substations and switching stations in their early documents, therefore, the number of switchyards identified along the master grid presumably includes switching stations.

### Range of Variation

All equipment inside the switchyards are industry standard. Equipment located in each switchyard varies according to the substation's size and function within the grid. Some switchyards contain just a few components, while the larger ones display more variety. During the period of significance, only forty percent of the switchyards contained major buildings. Since then, buildings have been added to many of them, ranging from control houses to storage sheds.

### Description

High-voltage transmission lines on the master grid dead-end at steel towers located in the switchyard. From the towers, circuits are carried down to wrought iron or aluminum connecting busses mounted on tubular steel pedestals that may reach a height of twenty-eight feet. The connecting busses extend horizontally, carrying circuits to disconnecting switches mounted on steel supports, then to power circuit breakers, and finally through other disconnecting switches before reaching the main busses. Main busses are mounted approximately sixteen feet above the ground. From the main busses, circuits reach power transformers where circuit voltages are stepped down. Feeder lines from the main bus then carry the circuits to transmission lines running out of the substation to local customer distribution lines.

The size of the substation and its function on the grid determined the number, size and type of equipment a switchyard would hold. The following is a list of some of the major components found in a typical master-grid switchyard. These are virtually the same features that the switchyards held between 1939 and 1945 with the exception of the capacitors and reactors. Capacitors and reactors regulate and correct voltage on the system. Between 1939 and 1945, this function was served by a giant electric motor known as a synchronous condenser. This massive motor sat horizontally on a concrete pad and saddles in the switchyard. If economic considerations warranted, the machines would be placed indoors. It is known that condensers were located indoors at Salem, Troutdale and Tacoma. Most, however, were located outdoors. Condensers were removed in the 1970s, as the static capacitors and reactors were easier to house and maintain than the giant mechanical condenser. There is only one condenser left on the master grid, at Tacoma. It is enclosed in a small, one-story brick building next to the control house.

**Buswork** - Busses are rigid conductors that carry circuits between equipment in a substation. There is a separate bus for each voltage level entering a substation ( i.e. 13.2kv, 115kv, 230kv). Comprised of hollow, pipe-like conductors, buswork at the earliest switchyards was wrought iron which could be bent and welded on site which greatly facilitated erection. As aluminum became plentiful during the war it replaced the wrought iron. Buswork is supported at various heights by pedestals depending on whether they are connecting or main busses.

**Steel Framework** - Utilized to support electrical apparatus including light fixtures,

these lattice-style structures were standardized throughout the BPA system, resulting in lower costs and rapid erection. Steel lattice framework was arranged in the switchyard in such a way to permit the addition of lines and transformers with minimum of shut-down expense.

**Power Transformer** - Transformers step current down to voltages suitable for local distribution. Each AC current is 3-phase, therefore transformers usually occur in banks of three, single-phase units. The core and windings of the transformer are contained within a case or tank, and are immersed in oil which serves as an insulating medium. The tanks are fluted for better cooling of the oil, a system sometimes augmented with fans. Busses meet the transformers through antennae-like, insulated extensions projecting off the top of the transformer tanks.

**Power Circuit Breaker** - These giant breakers are designed to open, or break, a circuit in the event of an overload or short-circuit on the system. Power circuit breakers used oil, then later, compressed air and compressed gas to quench the arc that forms when a circuit under load is opened. Power circuit breakers take the form of tanks: large vertical ones for the older oil-filled type; smaller horizontal ones for the modern gas-filled type. Busses connect to the circuit breakers through antennae-like projections much like those on the transformers.

**Dead-End Tower** - Typically the tallest structures in a switchyard, these towers mark the end of the line for high-voltage lines entering a substation.

**Feeder Tower** - Smaller than the dead-end towers, these structures support the

transmission lines that radiate out to local customer distribution lines.

**Capacitor** - Designed to increase voltage at the end of a transmission line, capacitors are stored in small, square metal tanks mounted one after another on tall, open, steel racks in the switchyard.

**Reactor** - This device is essentially an auto transformer, serving to limit the system voltage. Reactors take a cylindrical form and occur in banks of three, supported on a steel structure.

**Disconnect Switch** - These are manually or motor operated devices that open circuits not under load in order to isolate specific equipment. Typically suspended high above ground on steel support frames, disconnect switches can be identified by their accompanying sets of vertically suspended insulators.

**Lighting Fixtures** - Outdoor lighting fixtures used in the switchyards were also industry standardized. The most common outdoor type found on the system was a fixture consisting of an egg-shaped globe cupped by a glazed steel-frame bowl. The fixtures were found either mounted to the switchyard's lattice framework or fitted to the tops of tall, slender posts which were regularly spaced along the switchyard sidewalks.

### Distribution Patterns

Every substation had a switchyard. Although a substation is made up of many integral components, the switchyard is, in effect, the substation. The yard contains the

equipment that performs the voltage and circuit switching the makes long-distance transmission possible. The locations of the switchyards were dictated primarily by the technological requirements set forth by the transmission of electricity in an alternating-current system. The stepping up and down of voltages had to occur at different points on the transmission line; points that were determined by engineers based on the length, direction, and voltage level of the line. Consequently, the switchyards followed the rights-of-way of the transmission lines. For these reasons, the switchyards installed between 1939 and 1945 can be found along the routes represented by maps of the master grid drawn between 1939 and 1945 (Figures 1-3).

According to available information, the BPA built at least fifty-five substations between 1939 and 1945. Although the BPA systems has expanded greatly over time, most of the transmission rights-of-way represented by the master grid maps of 1939 and 1945 are still in use today, and consequently, so are the substations located along those lines. Because they were built to serve such a specific function, and because that function is still required of them, most are estimated to all be in use today, with the exception of South Bank Substation. Comprised of a control house and switchyard, the substation was demolished when the Army Corps of Engineers built a new lock system at Bonneville Dam in 1987. At least six of the fifty-five or more substations built between 1939 and 1945 have passed out of BPA ownership, but are still in use (Table 1). Although overall property loss over time has been minimal because of the continuity of function, there are five properties that appear on historic maps but are not represented on contemporary

maps. Whether these switchyards have truly been de-installed is unknown. In addition, individual components of switchyards have been lost over time because of failure, age, and improving technology. The BPA switchyards are impeccably maintained because they are an integral part of a functioning transmission system.

#### Property Type: Transmission Line

Transmission lines were the first structures built by the BPA. Most of the lines on the master grid operated at 230kv or 115kv and carried aluminum or steel-reinforced aluminum conductor cables. Character-defining features of the transmission towers on these lines were identified through field survey, construction drawings, and engineering literature. Most of the transmission towers on the master grid are made of steel, although there were some lines built with wood structures. Most of the steel towers are suspension towers, defined by the BPA as "towers designed to support conductors strung along a virtually straight line with only small turning or descending or ascending angles."<sup>127</sup> Steel transmission towers are characterized by their truss framework. From this basic structure, components are added depending on function, topography, and electrical considerations. Steel tower components include: the tower body, which is the basic trunk of the tower,

---

<sup>127</sup> BPA Definitions, T-5

designed in standard heights; the crossarm or bridge, which is the horizontal component near the top of the tower to which insulator strings are attached; leg extensions, which comprise the lowest part of the tower and are designed in various lengths to permit towers of differing heights and stability on uneven ground; and ground-wire brackets, the vertical brackets attached to the crossarm that support an overhead ground wire for lightning protection.

Wood transmission towers are characterized by their simple H-frame, which is also comprised of distinct components. Made of Douglas Fir, these components include the pole, which is the basic vertical trunk of the structure; the crossarm, which is the horizontal member that supports insulator strings; various plates and braces, their uses determined by specific function and location on the line; and guy-wires, steel wires used to anchor or support a structure.

### Range of Variation

There are five primary steel transmission tower designs used on the master grid: Single-circuit suspension, double-circuit suspension, dead-end, crossing structures, and lattice pole. Within each design the towers are typed alphabetically (A-F); each type representing different weights, heights, strengths, and functions, although most of these differences are subtle enough to the untrained eye that they are nearly impossible to identify in the field.

There are two primary wood transmission structure designs used on the master grid: the H-frame and single pole. Within the H-frame design, structures are typed alphabetically (A-F, TE); each type representing a specific function on the line. Types are physically distinguished from each other by various cross-braces, plates and bracket arrangements, and placement of the insulator strings on the frame. The second design is the single pole structure anchored with guy wires. Variations of this design include guy numbers and locations on the pole, and ground wire installations. Variations range with function and location of the pole on the line.

#### Description/Steel

Single-circuit Suspension - This design is identified by its "hourglass" shape with a central "throat" or open space under the crossarm component; and a body height of between fifty and seventy feet. Insulator strings hang from each tip of the horizontal crossarm and from the crossarm's middle, in the tower throat. Leg extensions are either set square in the direction of the line, or rotated, like a diamond in the direction of the line. Ground-wire brackets sit like horns on top of the crossarms.

Double-circuit Suspension - Ranging from sixty to sixty-five feet in height, this design is identified by its tall, tapered body and three crossarms, vertically stacked, near the top of the tower. Insulator strings hang from the tips of the crossarms, one circuit (three conductors) on each side of the tower.

Single- or double-circuit Dead-end - These towers are used for turning large angles on a line, or terminating a line at a substation. On a line they take the form of either the single or double circuit tower, with variations that make it heavier and stronger. These variations result in a tower that looks shorter and stockier than its suspension-type cousins. In a substation, dead-end towers take the form of giant pylons, tapered to a point at the top. Standing several feet apart, the towers are connected to each other by horizontal lattice crossarms to which strings of insulators are attached. These structures are found typically straddling banks of power transformers in the switchyard.

Single-circuit Crossing Structures - There are only four of these towers on the master grid. Designed to cross the Columbia River at Bonneville Dam, they are the tallest towers on the master grid, ranging from ninety-five feet to over 300 feet. Their cross-braced truss frames take the form of a slightly tapered pylon with a short crossarm at the very top of the tower. Horn-like brackets support ground wires above the crossarms. The towers retain their original orange and white paint scheme.

Single-circuit Lattice Pole - This design, used at angle points on a line, consists of three steel lattice poles supporting a lattice crossarm. Insulator strings hang from three points on the crossarm. This type of structure requires guy wires for support.

#### Description/Wood

Single-circuit H-frame - This design consists of two poles supporting a wood

crossarm. There are many variations of the H-frame, which is modified by adding various braces, plates and crossarms to the basic frame. This type of structure requires guy wires for support.

Single pole - This design consists of a single pole. Insulator strings hang from a simple wood crossarm at the top of the pole. This type of structure requires guy wires for support.

### Distribution Patterns

The master grid transmission lines were designed to connect the major population centers with Bonneville and Grand Coulee dams in a giant loop. Secondary loops and segments radiated out to connect with smaller communities and rural lines. Once those general routes were determined, specific rights-of-way were chosen with preference given to the most direct route over the smoothest terrain. In addition, BPA historian Gene Tollefson indicates in his 1987 history of the agency that some lines were located along rights-of-way that were highly visible to promote the government-funded project during the Depression.<sup>128</sup>

Most lines on the master grid were supported by a combination of steel tower

---

<sup>128</sup> Tollefson, 156.

designs, although it is known that the Spokane-Grand Coulee lines No. 1 and 2, the Walla Walla-Lewiston line, and the Vancouver-Eugene line were originally built with wood H-frame structures.

Approximately ninety-one transmission lines comprise the master grid (Table 2). The total number of transmission towers on those lines was not available among current locational data. That number remains undetermined because of time and geographical constraints. Today it is estimated that most of the steel structures on the original master grid transmission lines are original. However, some lines have been relocated over time or include towers that have been replaced in-kind with identical design types. Wood structures are much less likely to be original. Although treated to retard deterioration, they required more maintenance than steel towers and were replaced more often. If locational and electrical requirements allowed, they were more likely to be replaced with steel towers than with new wood structures. All original conductor cable on the master grid is assumed to have been replaced.

Condition of the transmission lines is estimated to be excellent. Although the BPA system has expanded greatly over time, most of the transmission line rights-of-way represented by the master grid maps of 1938-1945 are still in use. Transmission line and tower deterioration and loss has been minimal because of this continuity of function. They are well maintained because they are still in use.



TABLE 1. Substations Identified

Name	Date	County	State	Status	Control House	Untanking Tower	Oil House
Ainsworth	c. 1940-1944	Walla Walla	WA	unclear			
Albany	1940	Linn	OR				
Alcoa	1940	Clark	WA		X		
Allyn <sup>a</sup>	1942	Mason	WA				
Astoria <sup>b</sup>	1941	Clatsop	OR		X		
Bayview <sup>c</sup>	c. 1940-1944	Kootenai	ID				
Bell, G. H.	1942	Spokane	WA		X	X	X
Boyer <sup>d</sup>	1943	Yamhill	OR		?		
Bremerton <sup>e</sup>	1942	Kitsap	WA		X		
Cathlamet	c. 1940-1944	Wahkiakum	WA				
Chehalis	1940	Lewis	WA	NRE	X	X	
Colfax	c. 1940-1944	Whitman	WA		X		
Columbia	1942-1944	Chelan	WA	NRE	X		X
Condit <sup>f</sup>	1940	Skamania	WA				
Cosmopolis	1940	Grays Harbor	WA		X		
Covington	1941	King	WA	NRE	X	X	
Cowlitz	1945	Cowlitz	WA				
Creston	1942	Lincoln	WA				
Ellensburg	1941	Kittitas	WA		X		
Eugene	1940	Lane	OR	NRE	X		
Forest Grove	1940	Washington	OR				
Grand Coulee <sup>g</sup>	1940	Grant	WA		?		

TABLE 1 (Continued)

Name	Date	County	State	Status	Control House	Untanking Tower	Oil House
Longview	1941	Cowlitz	WA				
McMinnville	1940	Yamhill	OR				
Midway	1941	Benton	WA	NRE	X	X	
Monmouth	1940	Polk	OR				
Mossy Rock	1941	Lewis	WA				
Moxee	c. 1940-1944	Yakima	WA				
North Bonneville	1939-1940	Skamania	WA	NRE	X		X
Oregon City	1940-41	Clackamas	WA		X		
Pasco <sup>h</sup>	1941	Walla Walla	WA		?		
Pendleton	1941	Umatilla	OR		X		
Pendleton Airport	1941	Umatilla	OR	unclear			
Pomeroy	1943	Columbia	WA				
Raymond	1940	Pacific	WA	NRE	X		
Ross, J. D.	1939-43	Clark	WA	NRE	X	X	X
Salem	1940	Marion	OR	NRE	X	X	X
Salem Alumina	1944	Marion	OR				
South Bank	1940	Multnomah	OR	NRE	X		
South Renton <sup>i</sup>	1941	King	WA	demolished			
St. Johns	1940	Multnomah	OR	NRE	X		X
Svenson <sup>j</sup>	c. 1940-1944	Wahkiakum	WA				
Tacoma	1941	Pierce	WA	NRE	X		X

TABLE I (Continued)

Name	Date	County	State	Status	Control House	Untanking Tower	Oil House
The Dalles	1941	Wasco	OR				
Tide Flats <sup>k</sup>	1940	Pacific	W/A				
Tillamook	1943	Tillamook	OR				
Trentwood	1942	Spokane	W/A				
Troutdale	1942	Multnomah	OR	NRE	X		X
Valley Way	1945	Spokane	W/A				
Walla Walla	1941	Walla Walla	W/A	NRE	X		
Walla Walla	c. 1940-1944	Walla Walla	W/A	unclear			
Army Air Base Wells <sup>l</sup>	1940	Benton	OR				
Wenatchee	c. 1940-1944	Douglas	W/A	unclear			
Westport	c. 1940-1944	Clatsop	OR	unclear			
Willamina <sup>m</sup>	1943	Polk	OR		?		

<sup>a</sup> Known currently as Belfair Substation.

<sup>b</sup> Now owned by Pacific Power and Light.

<sup>c</sup> Known currently as Athol Substation.

<sup>d</sup> Now owned by Pacific Power and Light. Based on predictions made about subtype distribution patterns, it is possible that this substation

TABLE 2. Transmission Lines Identified  
 TABLE I (Continued)

could include a control house. Because the property is no longer owned by the BPA, detailed locational data on the substation is not available.

<sup>e</sup> Now owned by the U.S. Navy.

<sup>f</sup> Known currently as Carson Substation.

<sup>g</sup> Now owned by Grant County P.U.D. Based on predictions made about subtype distribution patterns, it is possible that this substation could include a control house, untanking tower and oil house. Because the property is no longer owned by the BPA, detailed locational data on the substation is not available.

<sup>h</sup> Now owned by Pacific Power and Light Based on predictions made about subtype distribution patterns, it is possible that this substation could include a control house, untanking tower and oil house. Because the property is no longer owned by the BPA, detailed locational data on the substation is not available.

<sup>i</sup> Known currently as the Maple Valley Substation.

<sup>j</sup> Known currently as Gray's River Substation

<sup>k</sup> Known currently as Naselle Substation.

<sup>l</sup> Known currently as the Adair Substation.

<sup>m</sup> Known currently as Portland General Electric's Grand Ronde Substation. Based on predictions made about subtype distribution patterns, it is possible that this substation could include a control house. Because the property is no longer owned by the BPA, detailed locational data on the substation is not available.

TABLE 2. Transmission Lines Identified

Constructed As	Date	Operated As	NR
Albany Bureau of Mines	1944	Albany-Bureau of Mines	
Albany - Wells	1940	Salem-Albany No. 2	
Bonneville-Coulee Line	1940	Underwood Tap to Bonneville-Sifton No. 1 & Bonneville-Alcoa No. 2	
North Bonneville-Midway No.1	1941	Midway-Potholes No. 1 Midway-Grand Coulee No. 3	
Bonneville-Coulee Line No. 2	1942	North Bonneville-Midway No.1	DE
Bonneville-The Dalles Line	1941	Bonneville-Hood River No. 1 Hood River-The Dalles No. 1	
Bonneville-Vancouver No. 1 Loop to Troutdale	1942	North Bonneville-Troutdale No.1	
Bonneville-Vancouver No. 1 Loop to Troutdale	1942	North Bonneville-Troutdale No.2	
Bonneville-Vancouver No. 1 and 2	1939	North Bonneville-Ross No. 1	DE
Bonneville-Vancouver No. 1 and 2	1939	North Bonneville-Ross No. 2	DE

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Bonneville-Vancouver No. 5 and 6	1943	Bonneville-Sifton No. 1 and Sifton-Ross No. 1	
Bonneville-Vancouver No. 5 and 6	1943	Bonneville-Alcoa No. 1 and 2	
Bradford Island Crossing	1939	Bonneville-North Bonneville No.1	DE
Bradford Island Crossing No. 2	1939	Bonneville-North Bonneville No. 2	DE
Bradford Island Crossing No.3	1940	Bonneville-Sifton No. 1	DE
Bradford Island Crossing No.4	1943	Bonneville-Alcoa No. 1 & 2	DE
Chehalis-Centralia Line	1940	Chehalis-Centralia No. 1	
Chehalis-Covington Line	1941	Chehalis-Covington No. 1 Olympia-White River No. 1 Covington-White River No. 2	
Chehalis-Longview Line	1941	Lexington-Delameter (Cowlitz Co. PUD) No. 1	
Chehalis-Longview Line	1941	Lexington-Longview No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Chehalis-Mossyrock Line	1941	Mossyrock Tap to Silver Creek-Morton No. 1	
Chehalis-Mossyrock (Str. 21/2-15/10)	1941	Silver Creek-Leonard Road No. 1	
Chehalis-Raymond Line	1940	Chehalis-Raymond No. 1	
Columbia-Moxee No. 1 Covington-Coulee No. 2 Columbia-Ellensburg	1944	Columbia-Moxee No. 1	
Covington-Grand Coulee Line	1942	Columbia-Grand Coulee No. 1	
Covington-Grand Coulee No. 2	1942	Columbia-Moxee No. 1	DE
Covington-Seattle Line	1942	Covington-(SCL) Creston No. 1	
Grand Coulee-Davenport	1942	Almira Tap to Creston-Davenport	
Grand Coulee-Davenport	1942	Creston-Davenport No. 1	
Grand Coulee-Spokane No. 1	1942	Grand Coulee-Bell No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Grand Coulee-Spokane No. 2	1942	Grand Coulee-Bell No. 2	
Grand Coulee-Spokane Nos. 3 & 4	1943	Grand Coulee-Bell No. 3	DE
Grand Coulee-Spokane Nos. 3 & 4	1943	Grand Coulee-West Side (WWP) #1 West Side (WWP)-Bell No. 1	DE
Hanford-Pasco	1941	Midway-Benton No. 1	
Hanford-Pasco	1941	Benton-Franklin No. 1	
Hanford-Pasco	1941	Franklin-Walla Walla No. 1	
Kelso-Chehalis Line	1940	Lexington-Longview No. 1	
Kelso-Chehalis Line	1940	Longview-Chehalis Nos. 1 & 3	
Longview-Astoria	1941	Longview-Allston No. 3	
Longview-Rainier No. 2	1942	Longview-Astoria No. 1	
Midway-Benton Line	1941	Benton-Taunton No. 1 (WWP)	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
(Hanford-Benton Section) (Midway-Hanford Section)		Midway-Benton No. 2	
Midway-Columbia Line	1945	Midway-Vantage No. 1 Vantage-Columbia No. 1	
Midway-Ellensburg (Midway-Yakima Section)	1941	Columbia-Moxee No. 1 Midway-Moxee No. 1	
Midway-Walla Walla Line (Midway-Hanford Section) (Hanford-Pasco Section)	1941	Midway-Benton No. 1	
Midway-Walla Walla Line (Hanford-Pasco Section)	1941	Benton-Franklin No. 1	
Midway-Walla Walla Line (Pasco-Walla Walla Section)	1941	Franklin-Walla Walla No. 1	
North Bonneville-Troutdale Line	1940	North Bonneville-Troutdale No.1	
North Bonneville-Troutdale Nos. 1 and 2	1939	North Bonneville-Ross No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
North Bonneville-Troutdale Nos. 1 and 1	1942	North Bonneville-Troutdale No.2	
North Bonneville-Vancouver Nos. 1 and 1	1940	North Bonneville-Troutdale No.2	
Poltatch-Bremerton Line (Allyn-Bremerton Section)	1942	Kitsap-Bremerton No. 1 and Shelton-Kitsap No. 2 (Allyn-Kitsap Section)	
Rainier-Longview Line	1943	St. Helens Tap to Longview-Astoria No. 1	
Rainier-Longview Line	1943	Longview-Astoria No. 1	
Raymond-Cosmopolis Line	1940	Raymond-Cosmopolis No. 1 (Purchased)	
Raymond-Raymond Tideflats	1940	Raymond-Raymond Tideflats No. 1	
Ross-St. Johns Line Nos. 1 and 2	1940	Ross-St. Johns No. 1	
Salem-Alumina Plant Line	1944	Chemawa-Salem Alumina No. 1	
Salem-Tillamook (Williamina-Grand Ronde)	1943	Salem-Boyer No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Salem-Tillamook (Boyer-Tillamook)	1943	Boyer-Tillamook No. 1	
Service to Electro Metallurgical Line No. 2	1942	St. Johns-Gilmore Steel No. 2	
Service to Vancouver Shipyard	1942	Ross-Vancouver Shipyard No. 1	
Shelton-Allyn Line	1942	Shelton-Kitsap No. 2	
Shelton-Allyn-Kitsap No. 2 and Kitsap-Bremerton Mile 3 Relocation	1942	Shelton-Kitsap No. 2	
Spokane-Trentwood Lines 1 and 2	1942	Bell-Trentwood No. 1	
Spokane-Trentwood Lines 1 and 2	1943	Bell-Trentwood No. 2	
St. Johns-Astoria Line	1941	St. Johns-St. Helens No. 1 St. Helens Tap to Longview-Astoria No. 1	
St. Johns-Astoria Line	1941	Longview-Astoria No. 1	
Trentwood-Valley Way	1945	Trentwood-Valley Way No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Vancouver-Alcoa No. 2	1941	Bonneville-Alcoa No. 2	
Vancouver-Alcoa No. 2	1941	Bonneville-Alcoa Nos. 1 & 2	
Vancouver-Alcoa No. 2	1941	Sifton-Ross No. 1	
Vancouver-Alcoa Line	1940	Ross-Carborundum No. 1	
	1940	Ross-Alcoa No. 2	
	1940	Ross-Alcoa No. 2	
	1941	Ross-Vancouver Shipyard No.1	
Vancouver-Eugene No. 1	1940	Ross-Clark County PUD NO.1	
Vancouver-Eugene Line	1939	Ross-St. Johns No. 1	
Vancouver-Eugene Line	1939	Ross-Rivergate No. 1	
Vancouver-Eugene	1939	Ross-St. Johns NO. 1	
Vancouver-Eugene	1939	Ross-Rivergate No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Vancouver-Eugene Line	1940	St. Johns Tap to Keeler-Oregon City No. 2 Keeler-Oregon City No. 2	
Vancouver-Eugene Line	1940	Oregon City -Chemawawa No. 1 (de-energized)	
Vancouver-Eugene Line	1940	Chemawawa-Salem No. 1	
Vancouver-Eugene Line	1940	Salem-Albany NO. 1	
Vancouver-Eugene No. 1	1940	Ross-Clark County PUD No.2	
Vancouver-Eugene Line #2	1941	St. Johns-Keeler No. 1 Oregon City Sub	
Vancouver-Eugene Line No. 2 (Reblt 230 kV)	1945	Oregon City -Chemawawa No. 2	
Vancouver-Eugene Line No. 2 (Oregon City-Salem Section) (Reblt 230 kV)	1945	Chemawawa-Salem No. 2	
Vancouver-Eugene Line	1940	Albany-Eugene No. 1	
Vancouver-Kelso Line	1940	Ross-Lexington No. 1	

TABLE 2 (Continued)

Constructed As	Date	Operated As	NR
Walla Walla-Lewiston Line	1941	Walla Walla-North Lewiston No. 1	
Walla Walla-Lewiston Tap to Pomeroy SS	1943	Pomeroy Tap to Walla Walla-North Lewiston No. 1	
Walla Walla-Pendleton Line	1941	Walla Walla-Milton No. 1 State Line Tap to Walla Walla-Milton No. 1 Pendleton Tap to State Line Tap	

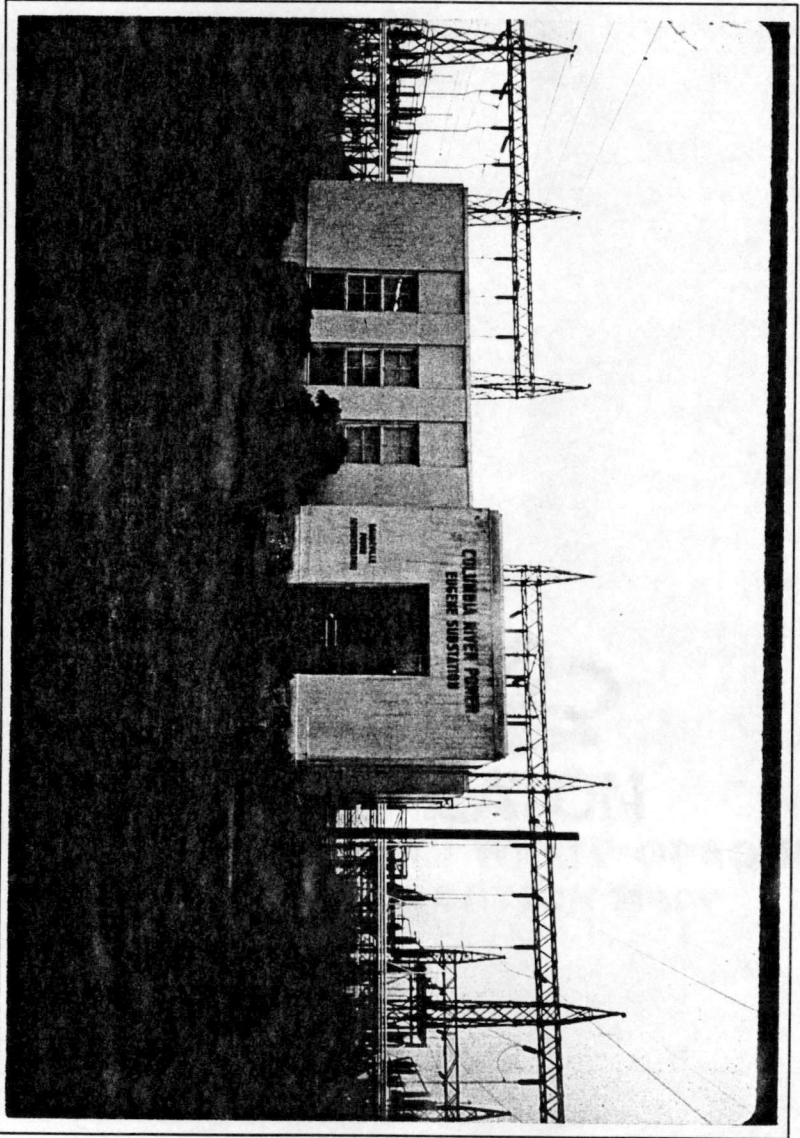


FIGURE 4. Control House, Eugene Substation, Eugene, Oregon.

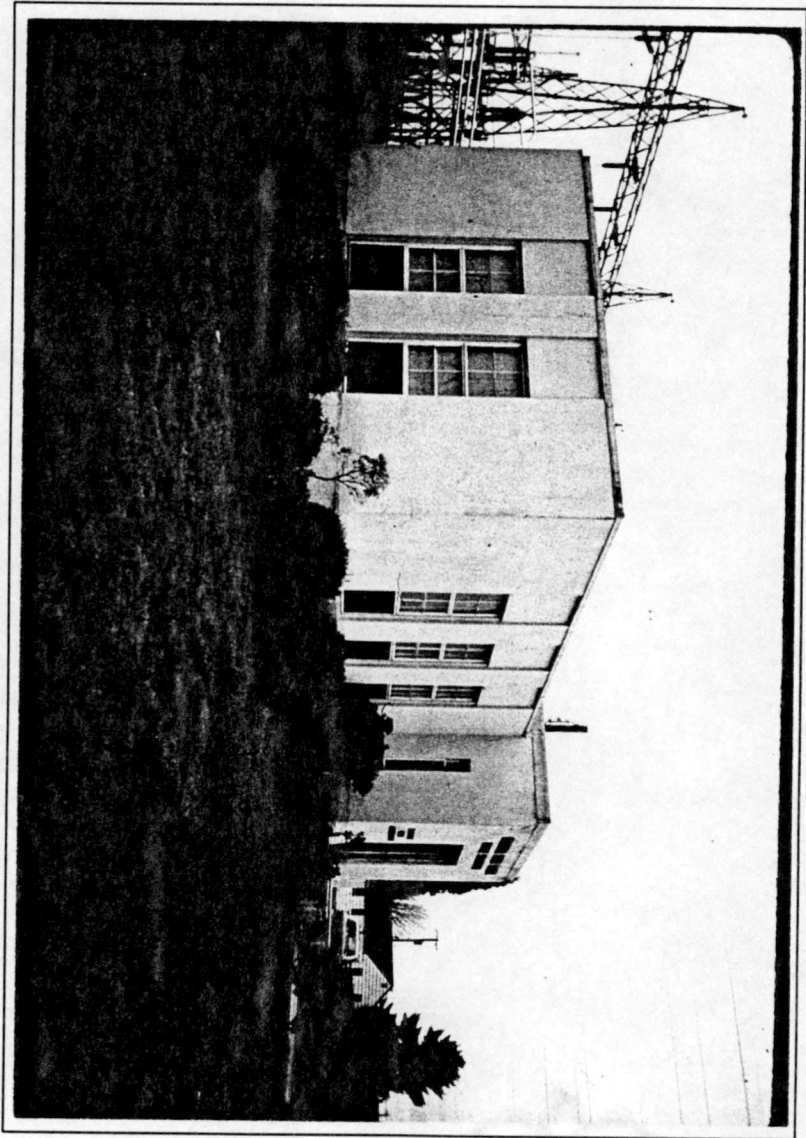


FIGURE 5. Control House, Eugene Substation, Eugene, Oregon.

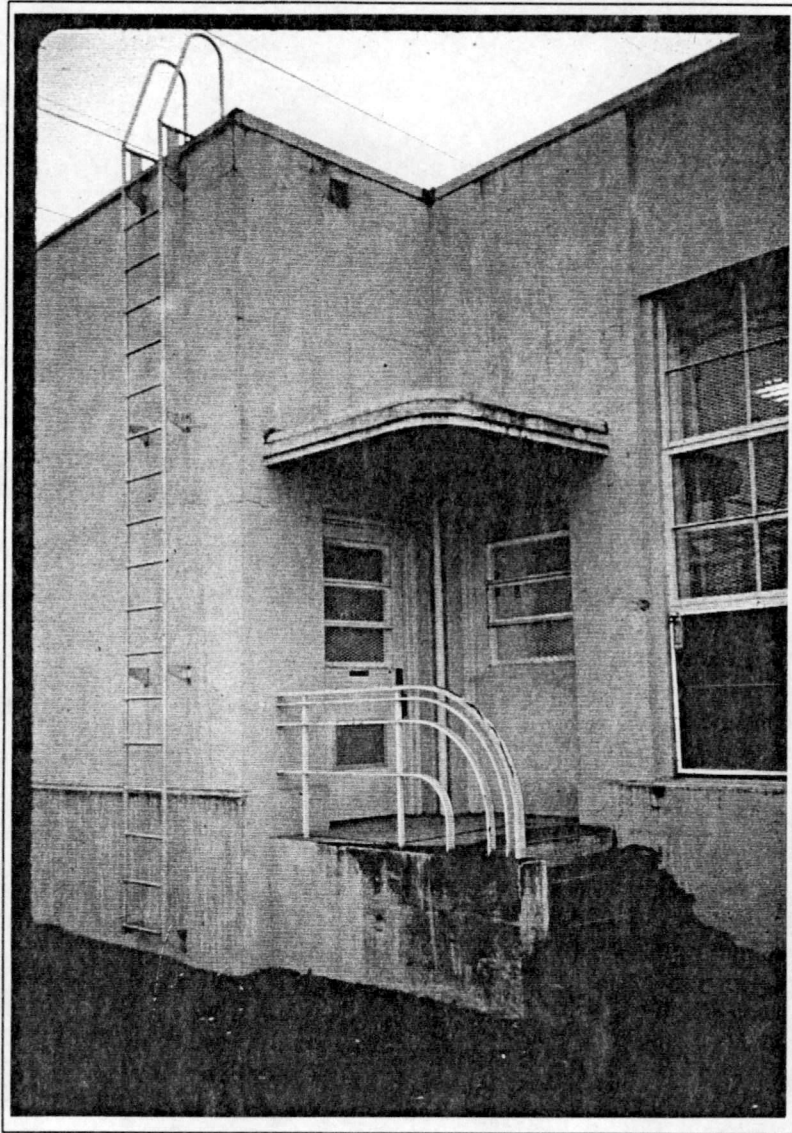


FIGURE 6. Control House, Eugene Substation, Eugene, Oregon.

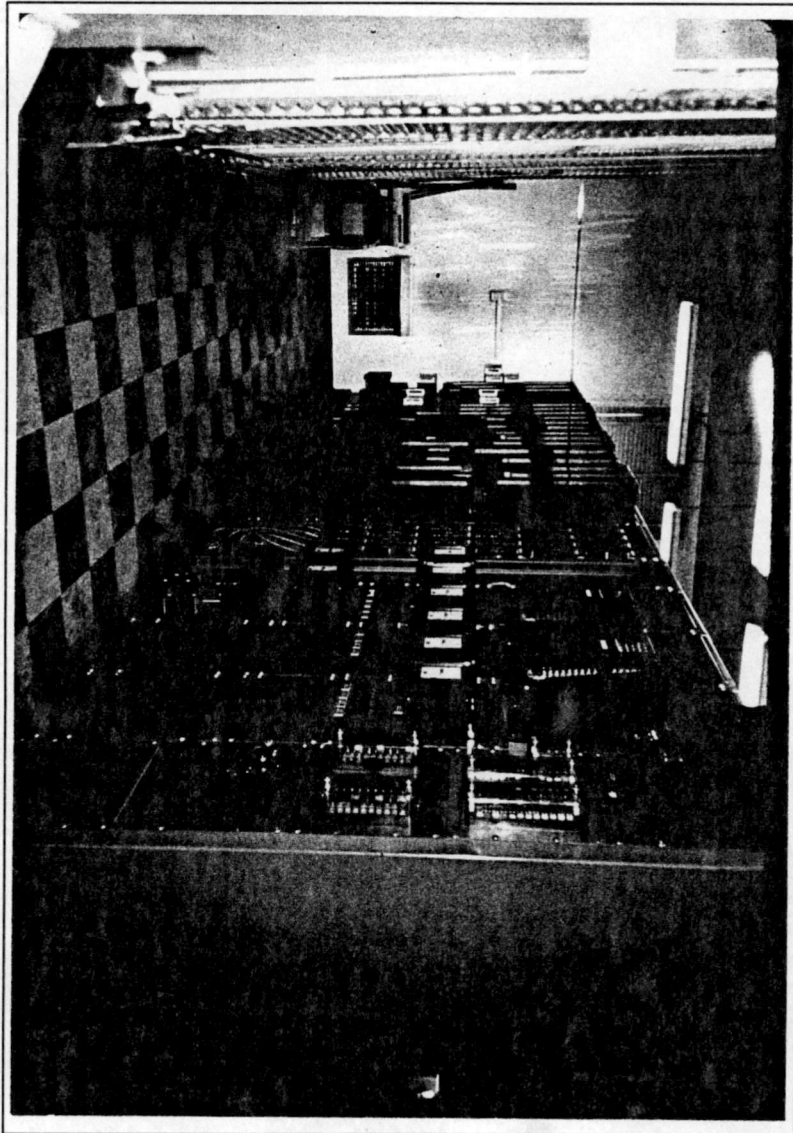


FIGURE 7. Control Room, Eugene Substation, Eugene, Oregon.

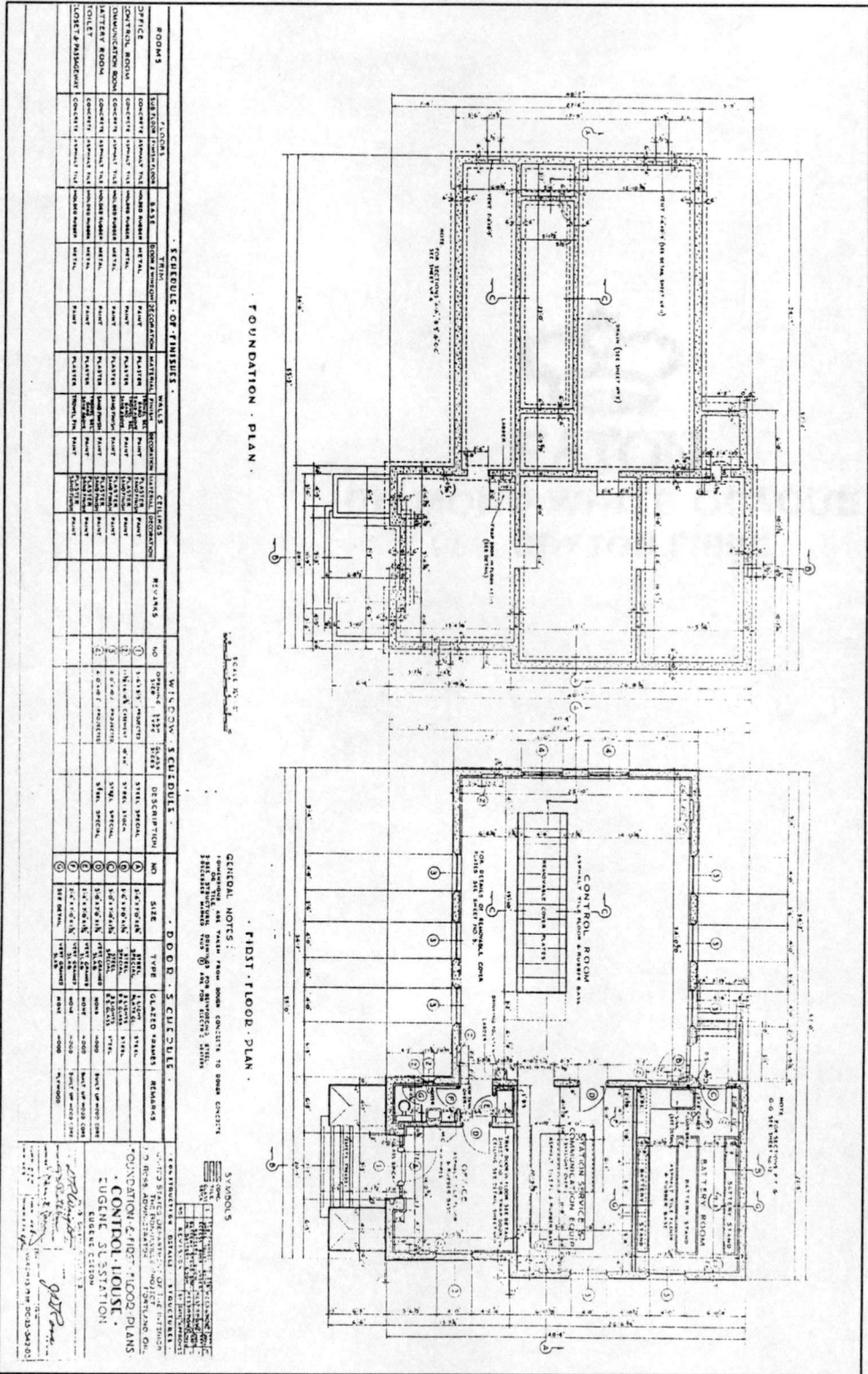


FIGURE 8. Control House Plan, Eugene Substation, Eugene, Oregon. (Drawing courtesy of the BPA.)

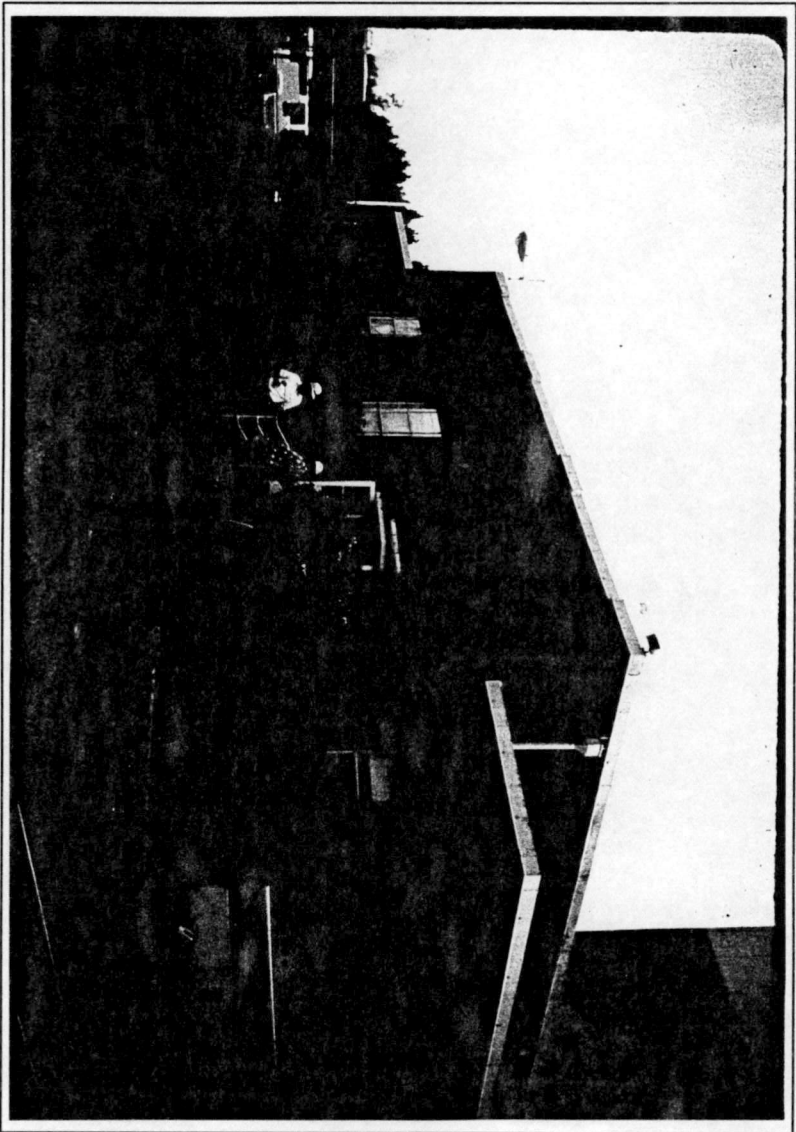


FIGURE 9. Control House, Troutdale Substation, Troutdale, Oregon.

EATON  
DIAMOND WHITE OPAQUE  
NON-COTTON FIBRE

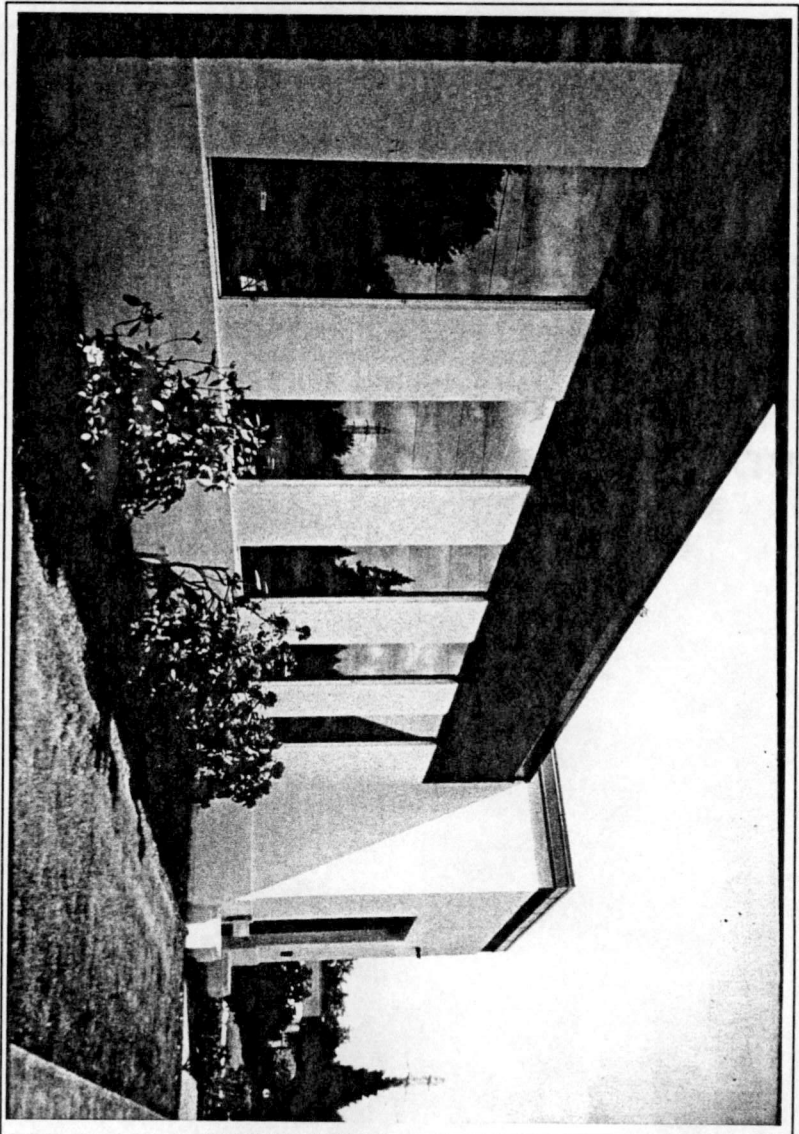


FIGURE 10. Control House, J. D. Ross Substation, Vancouver, Washington.

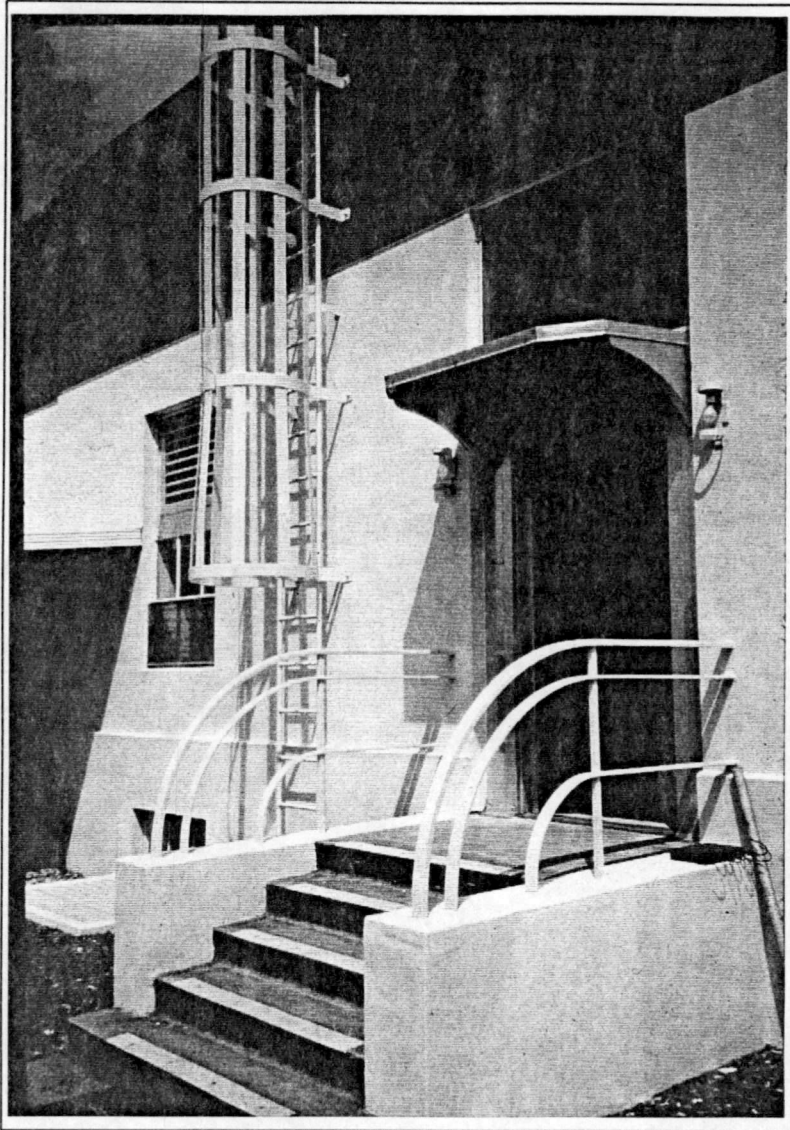


FIGURE 11. Control House, J. D. Ross Substation, Vancouver, Washington.

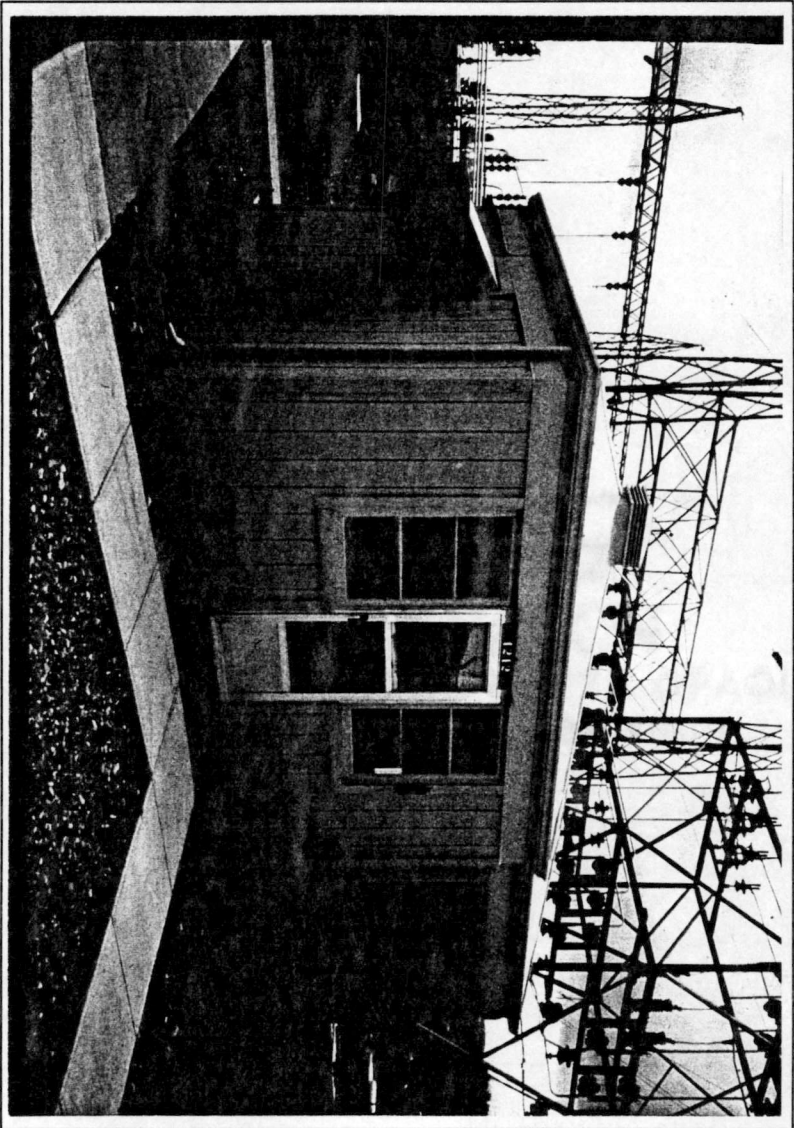


FIGURE 12. Control House, Ellensburg Substation, Ellensburg, Washington.

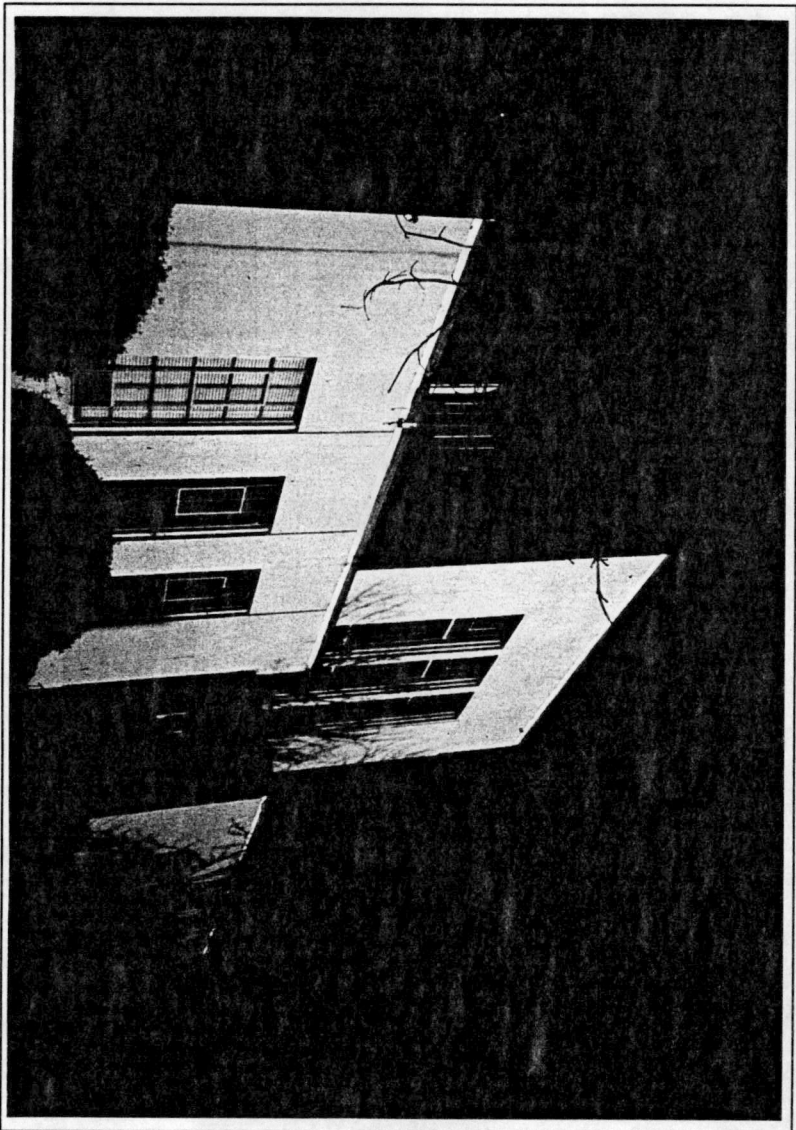


FIGURE 13. Control House/Untanking Tower, Salem Substation, Salem, Oregon.

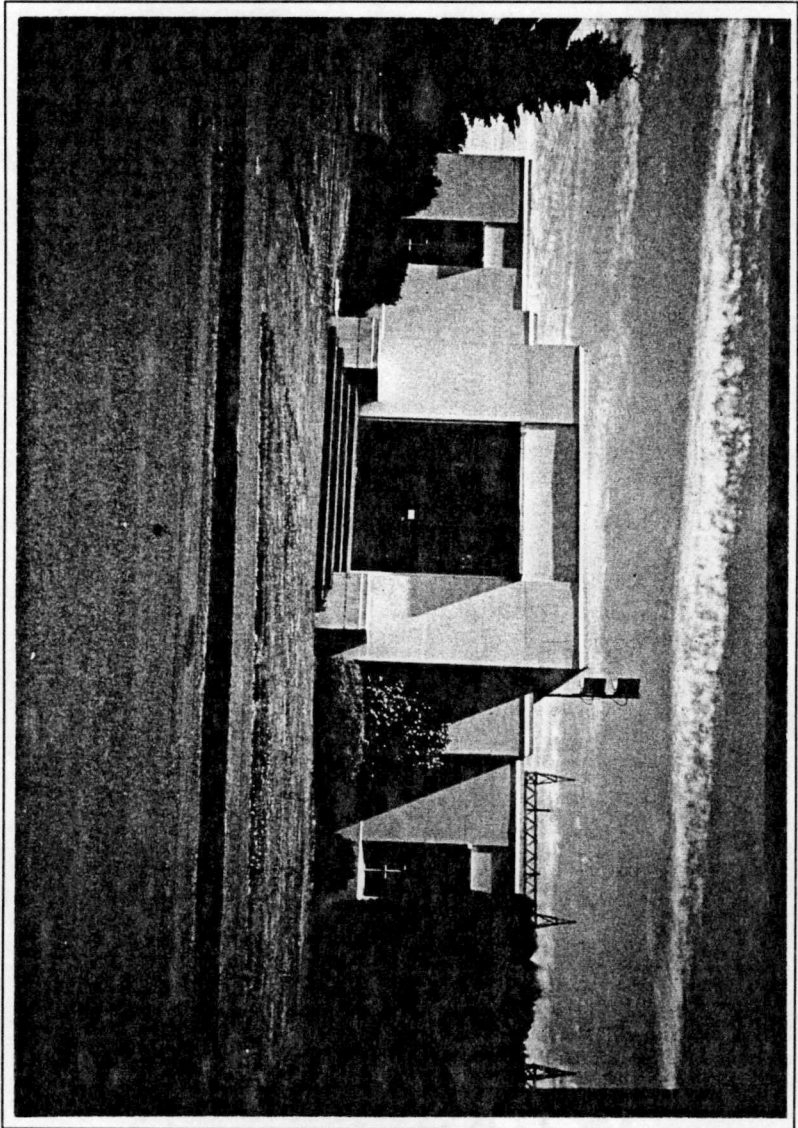


FIGURE 14. Control House, Astoria Substation, Astoria, Oregon.

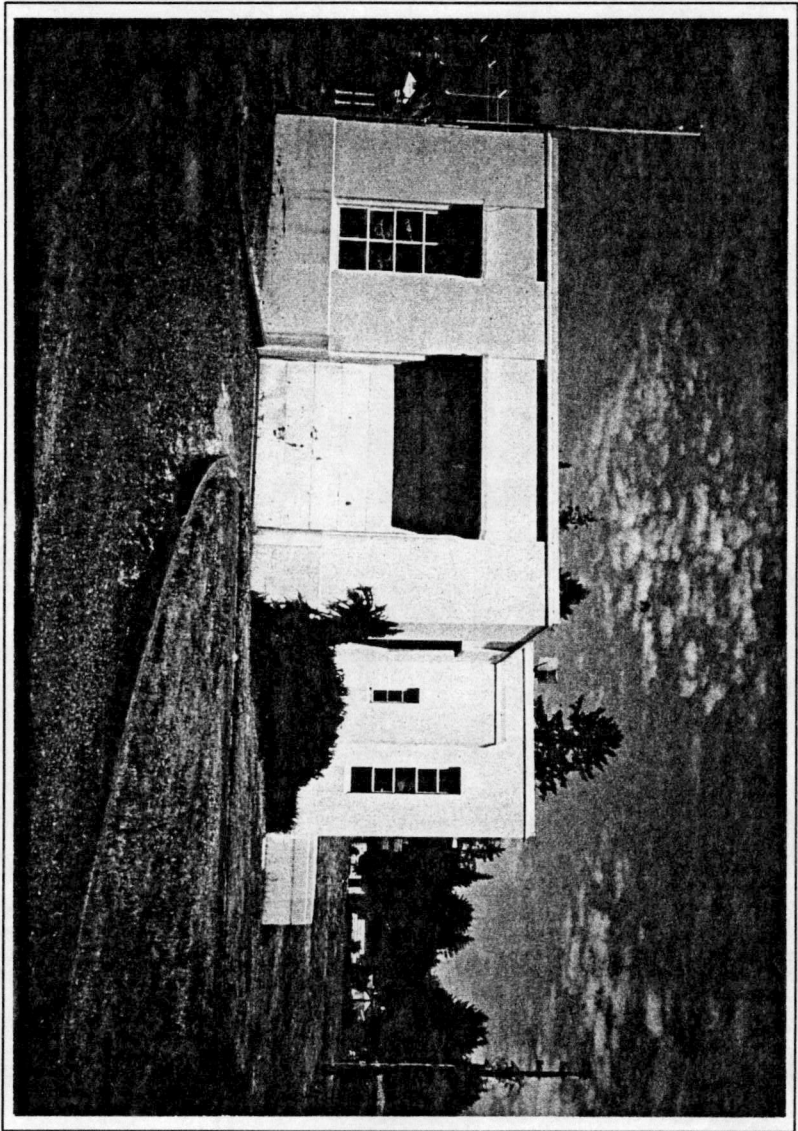


FIGURE 15. Control House, Astoria Substation, Astoria, Oregon.

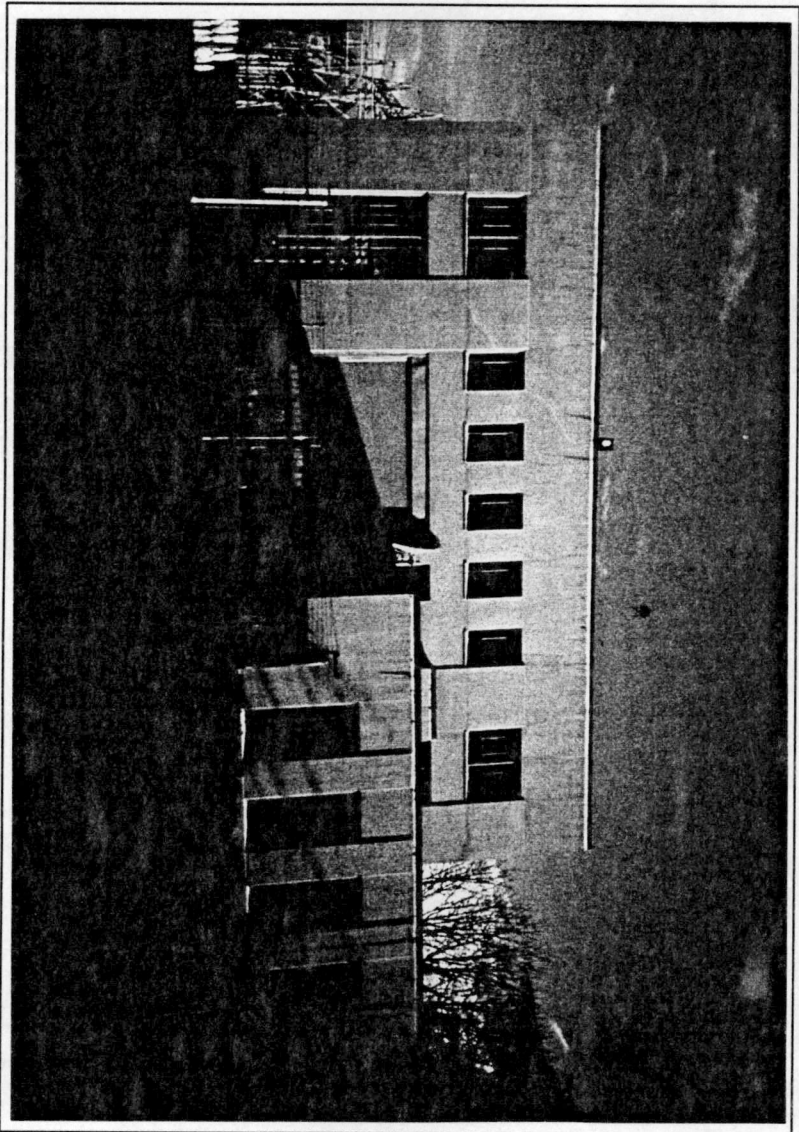


FIGURE 16. Untanking Tower, Salem Substation, Salem, Oregon.

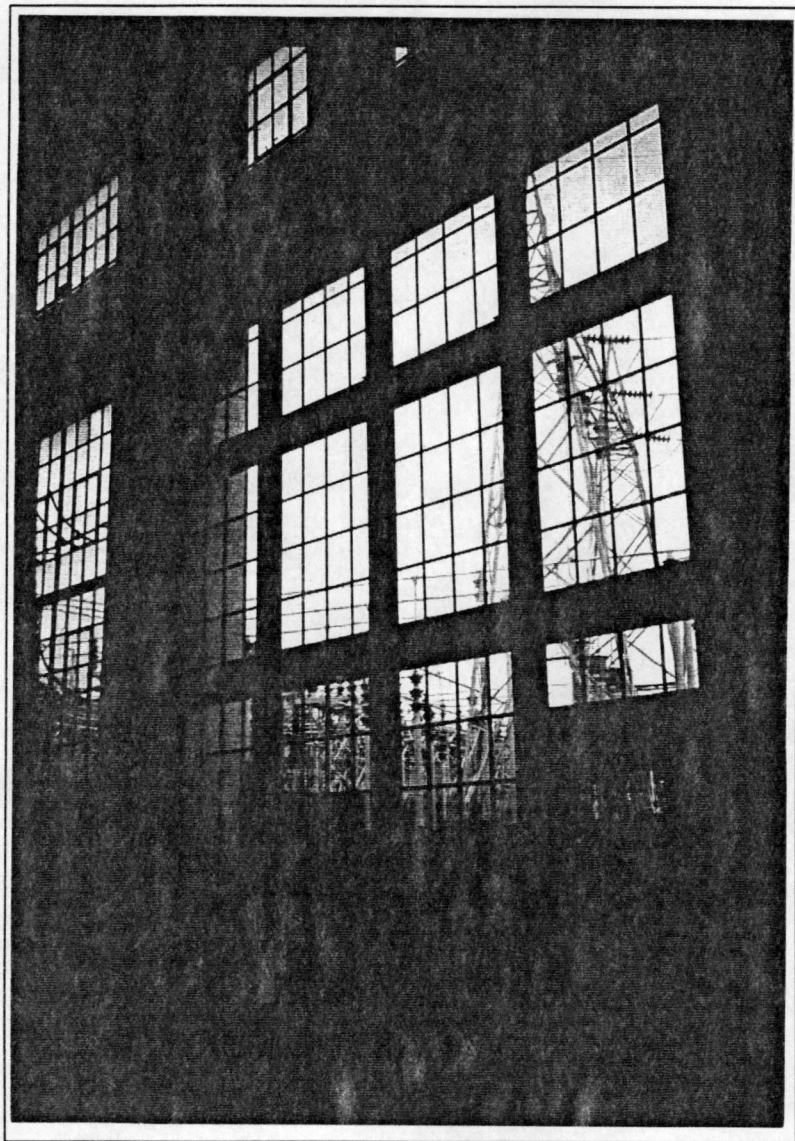


FIGURE 17. Interior of Untanking Tower, Salem Substation, Salem, Oregon.

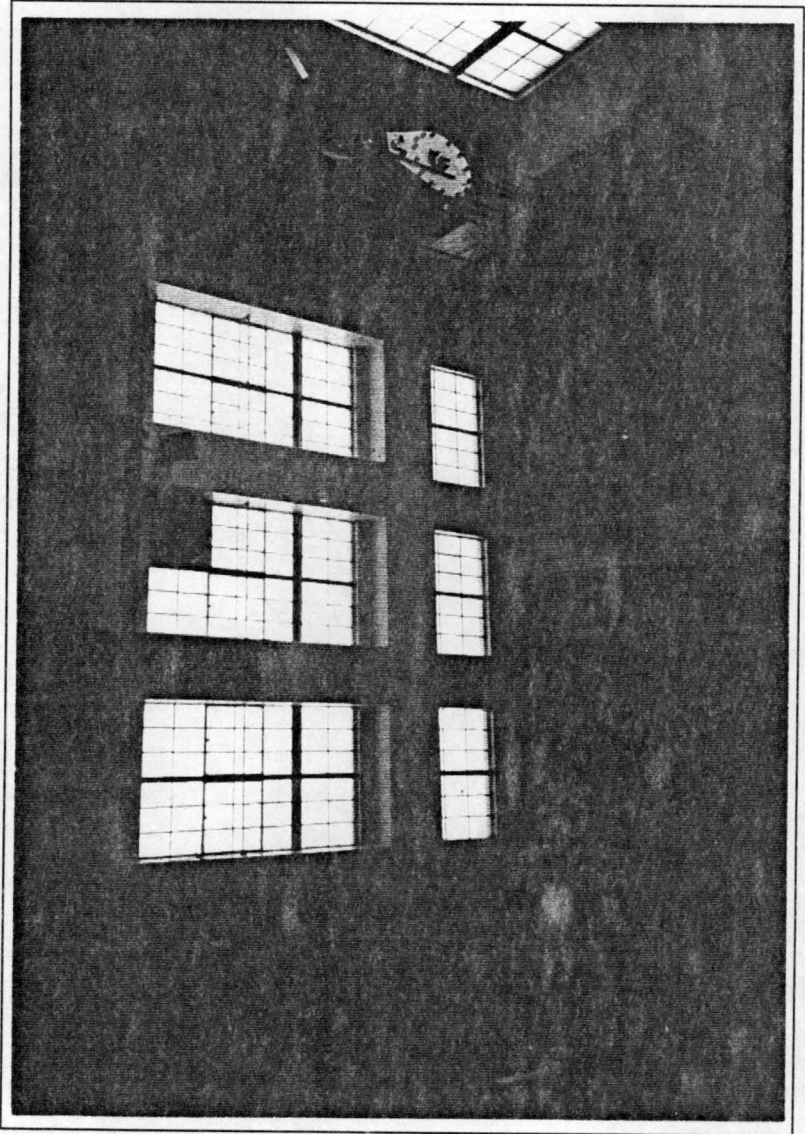


FIGURE 18. Interior of Untanking Tower, Salem Substation, Salem, Oregon.

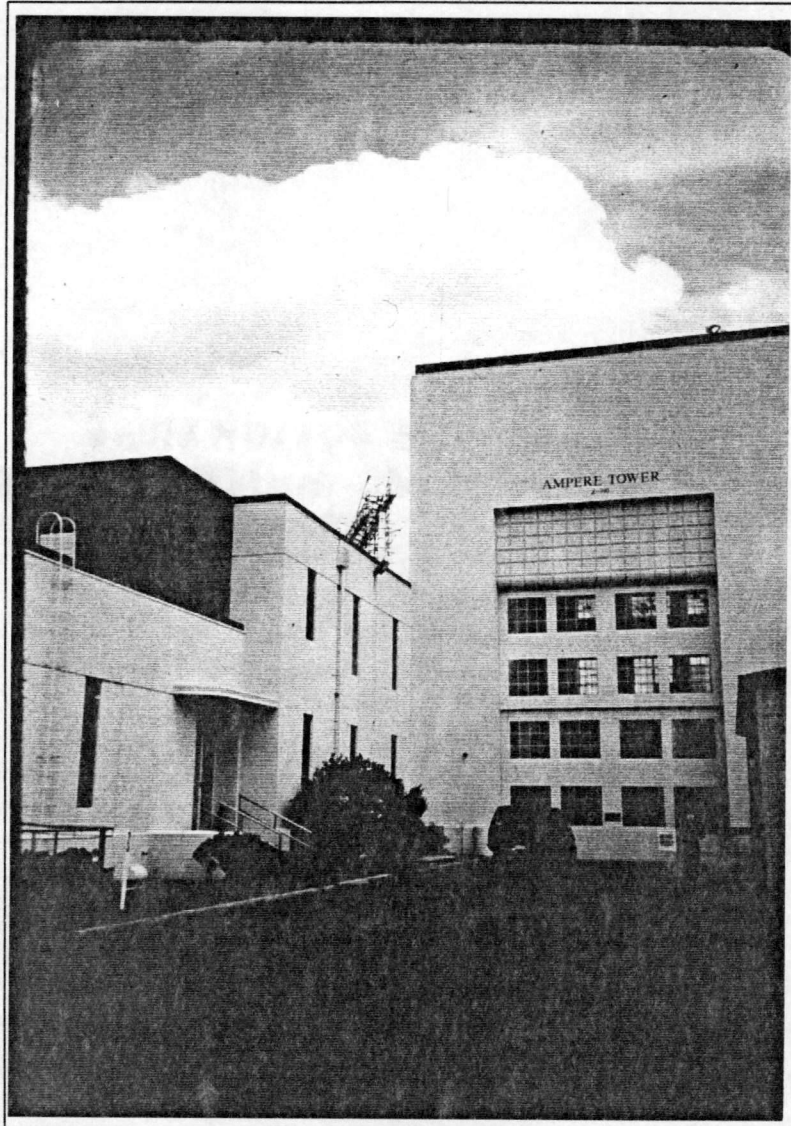


FIGURE 19. Untanking Tower, J. D. Ross Substation,  
Vancouver, Washington.

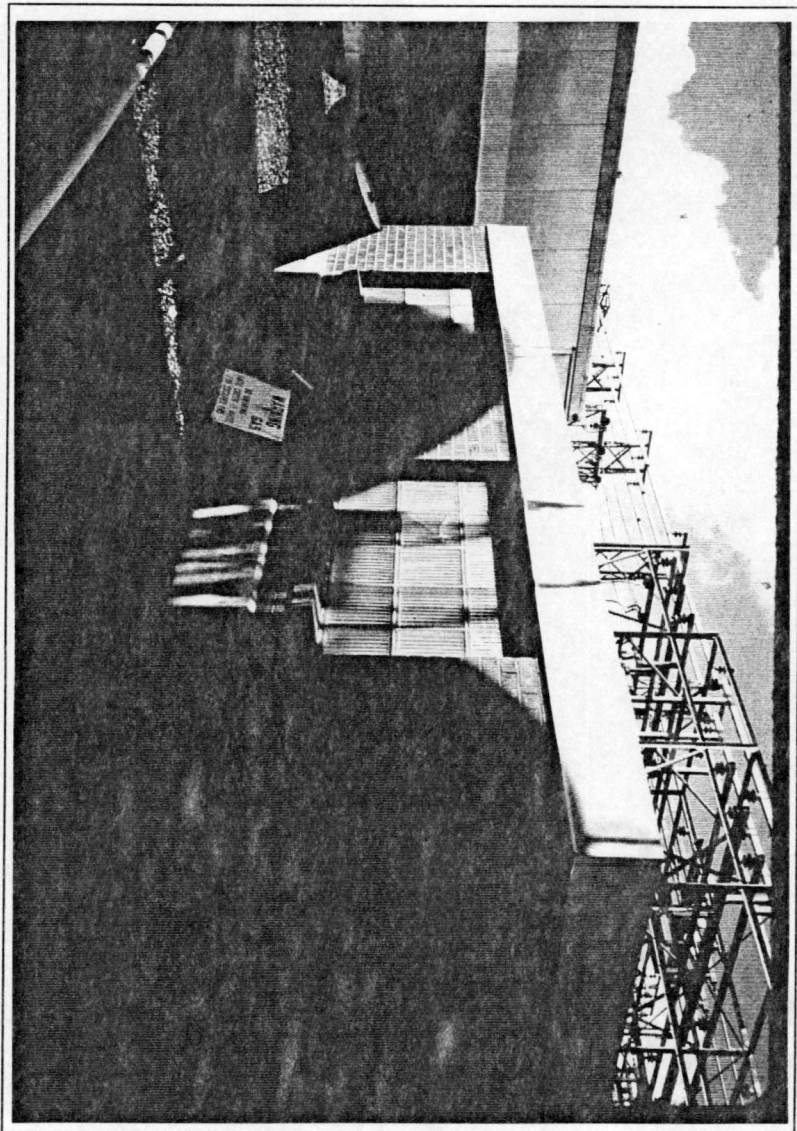


FIGURE 20. Oil House, Troutdale Substation, Troutdale, Oregon.

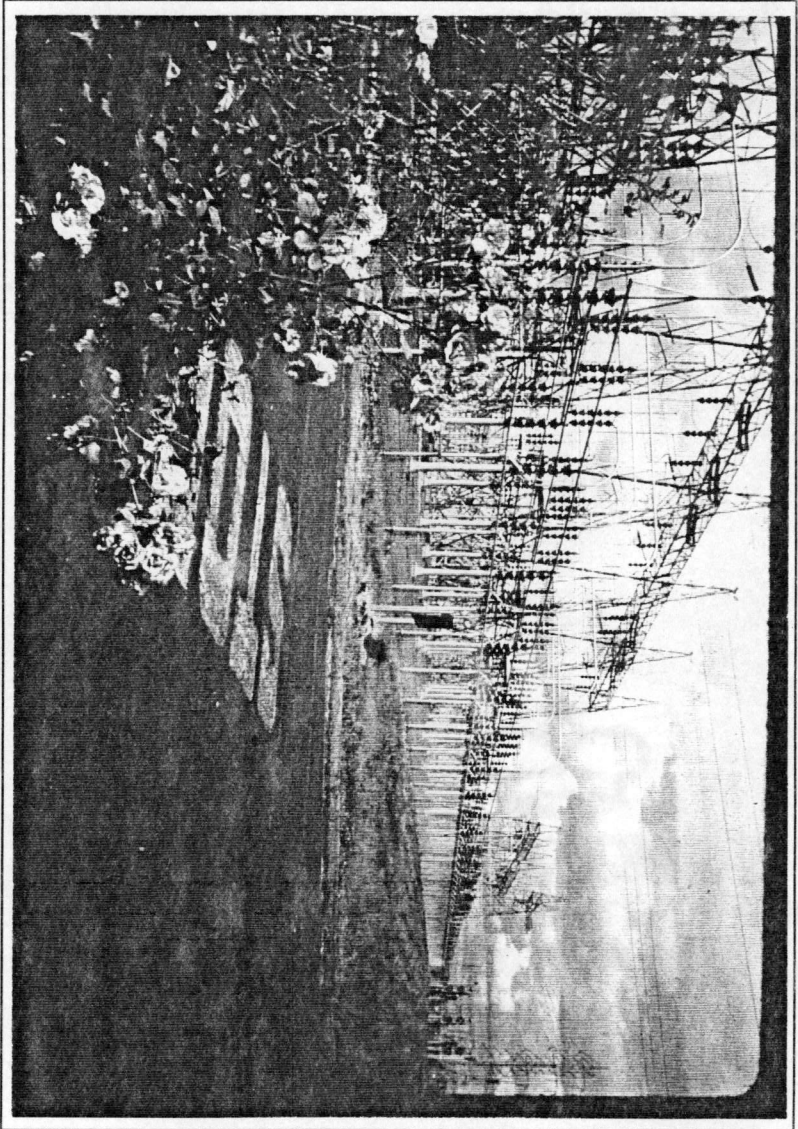


FIGURE 21. Switchyard, Troutdale Substation, Troutdale, Oregon.

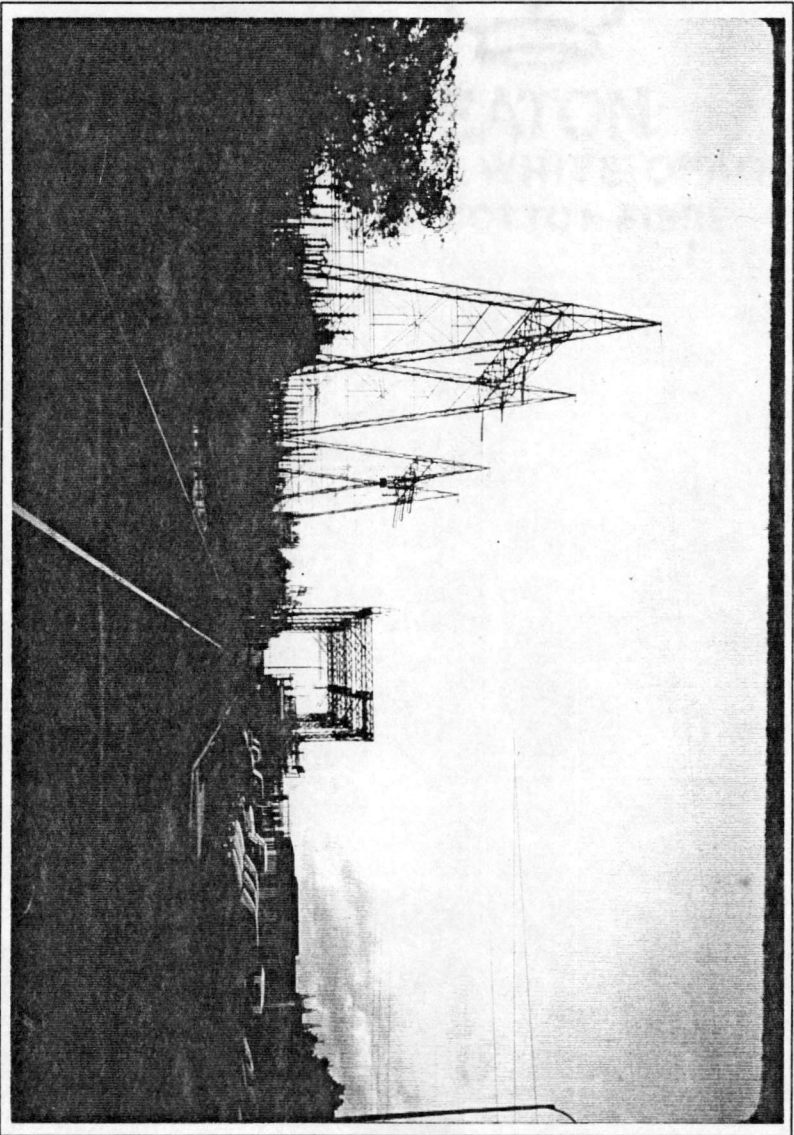


FIGURE 22. Switchyard, J. D. Ross Substation, Vancouver, Washington.

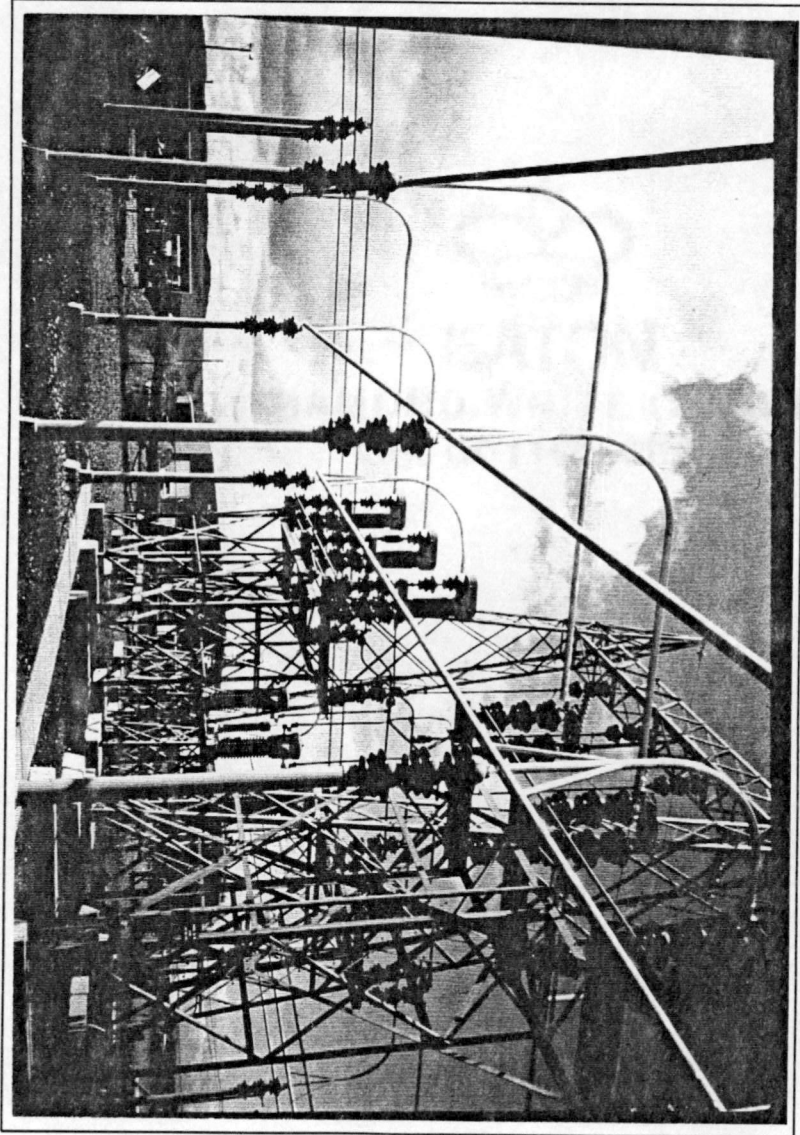


FIGURE 23. Buswork, Ellensburg Substation, Ellensburg, Washington.

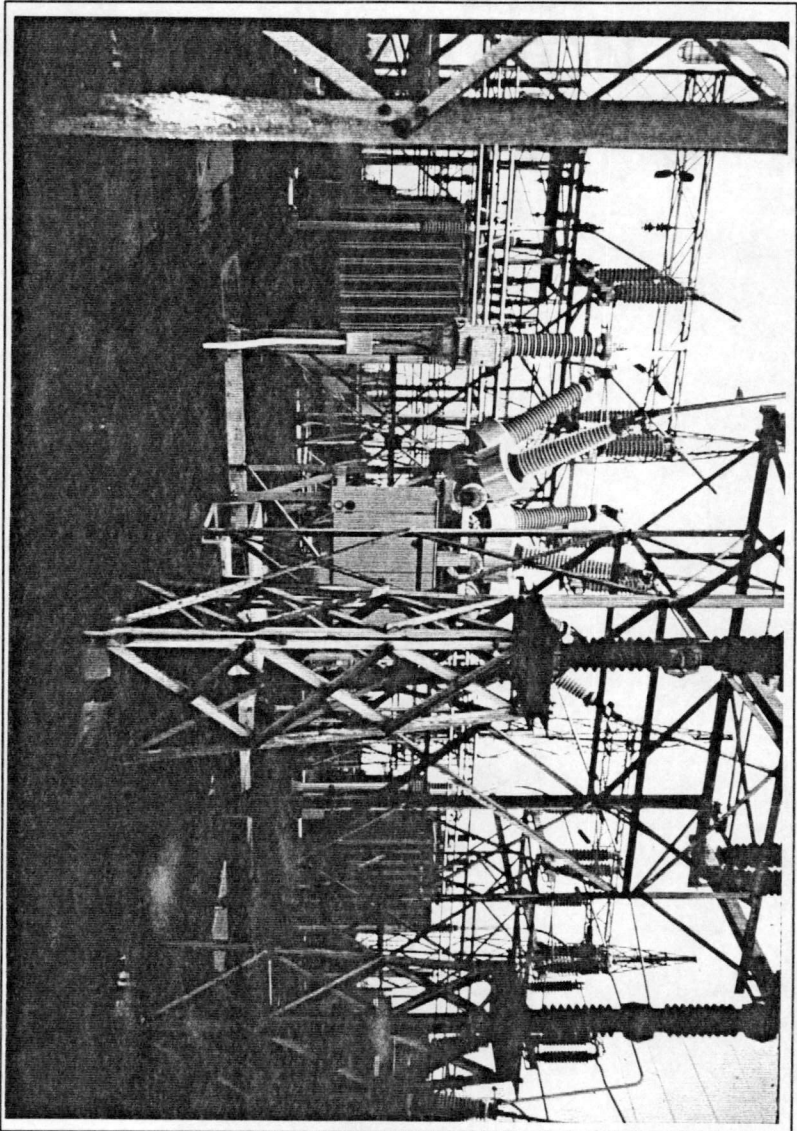


FIGURE 24. Gas Circuit Breaker and Transformers, Eugene Substation, Eugene, Oregon.

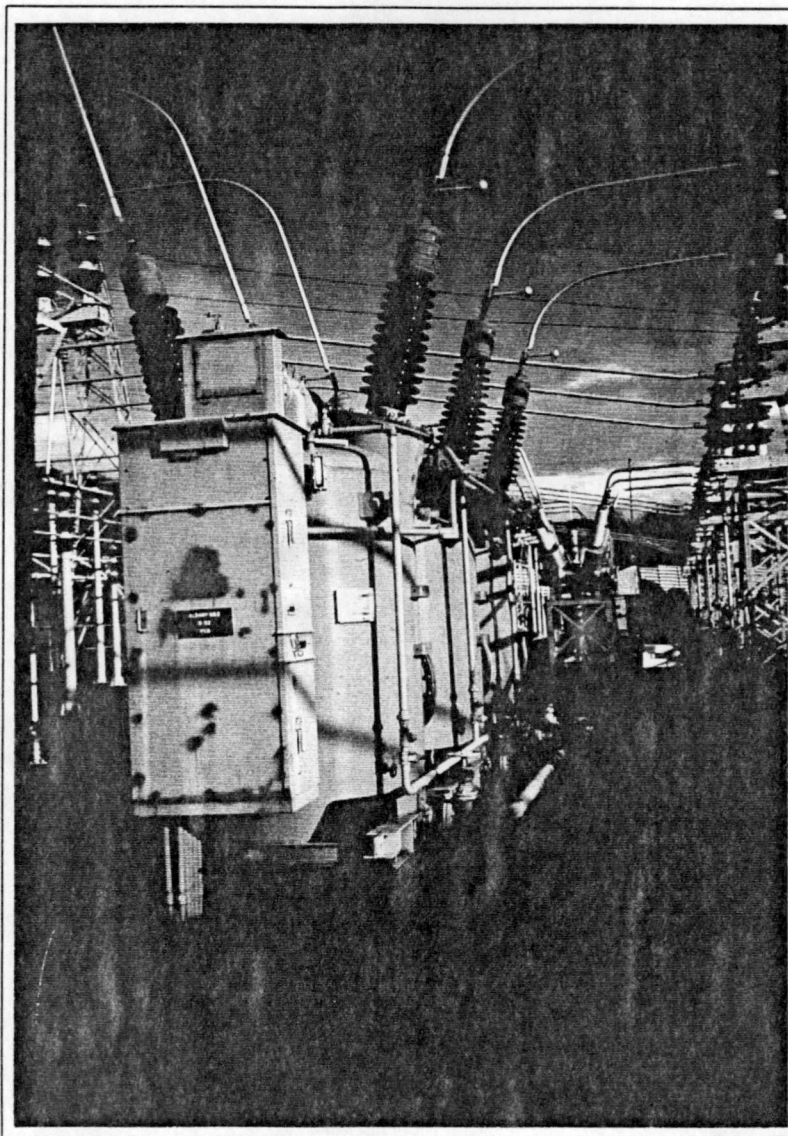


FIGURE 25. Oil Circuit Breakers, Salem Substation, Salem, Oregon.

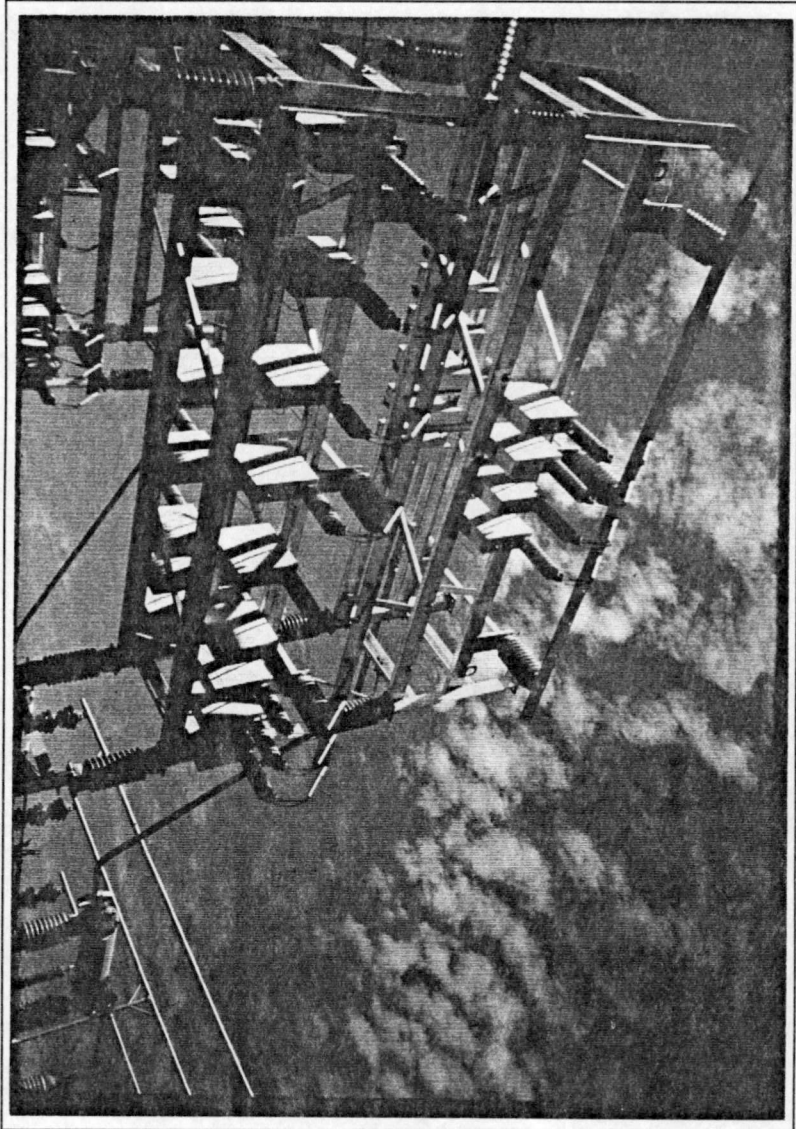


FIGURE 26. Capacitor Banks, Astoria Substation, Astoria, Oregon.

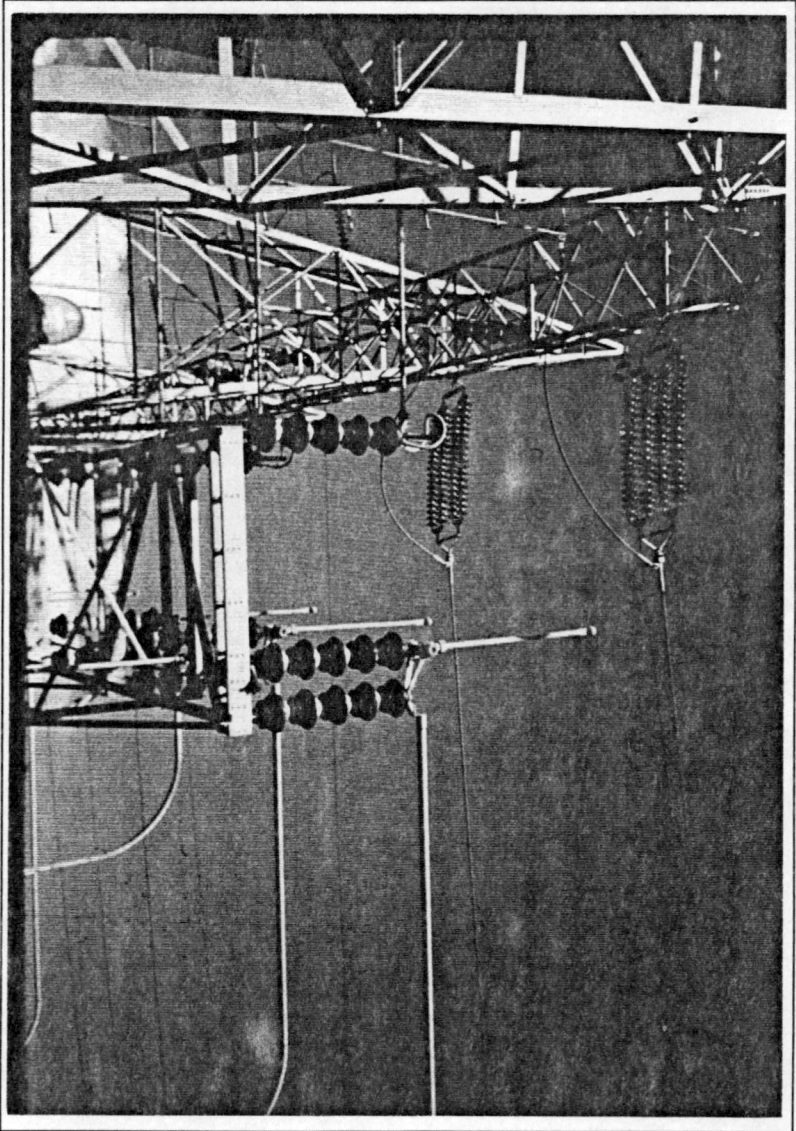


FIGURE 27. Disconnecting Switch, Troutdale Substation, Troutdale, Oregon.

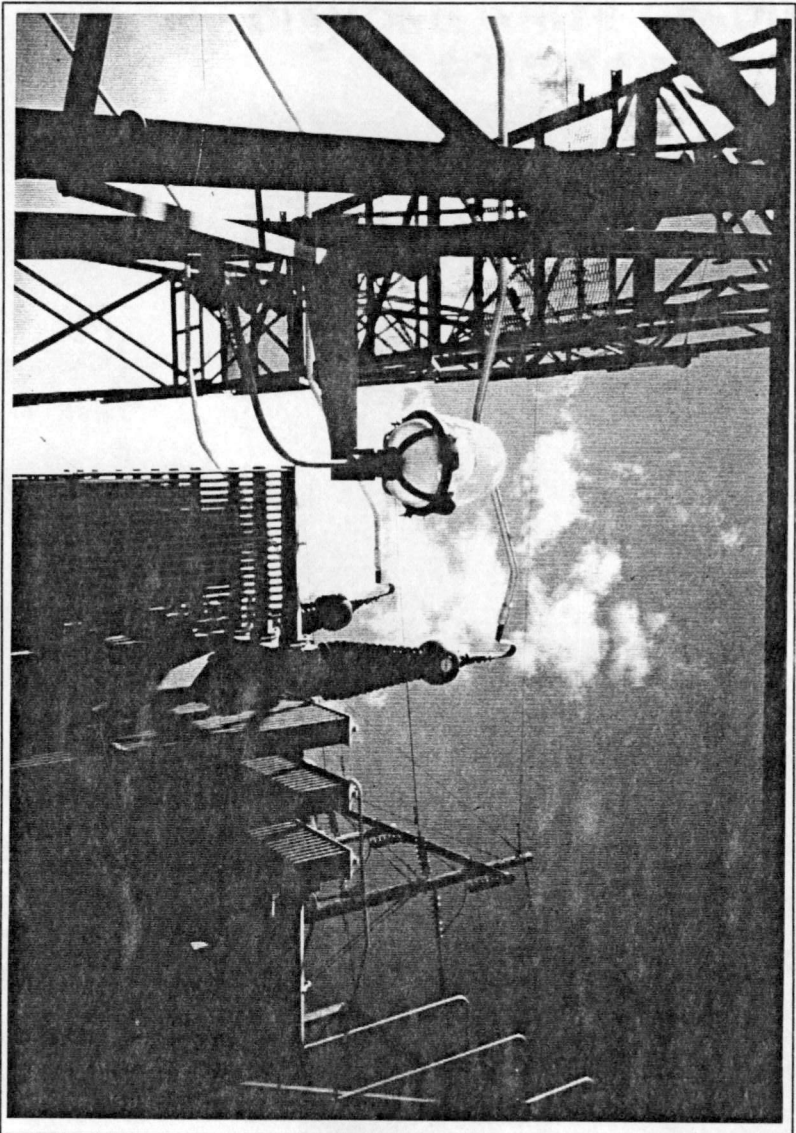


FIGURE 28. Switchyard Lighting Fixture, Ellensburg Substation, Ellensburg, Washington.

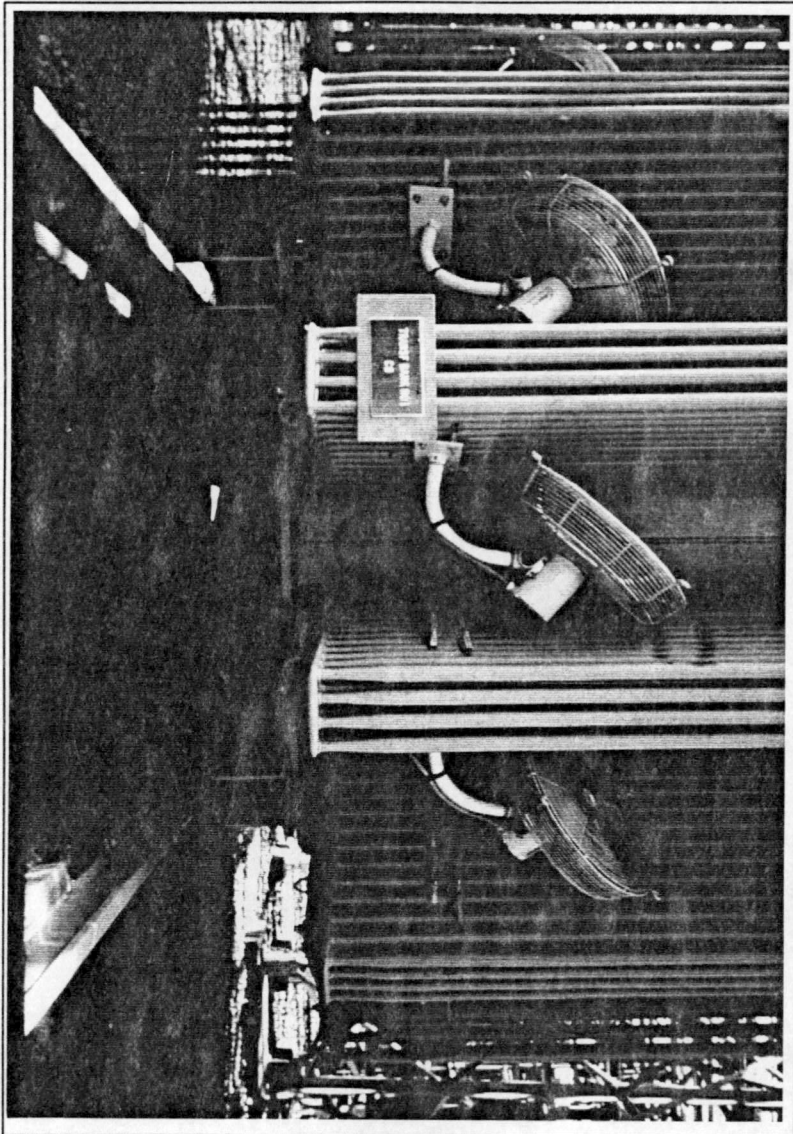


FIGURE 29. Transformer Fans, Troutdale Substation, Troutdale, Oregon.

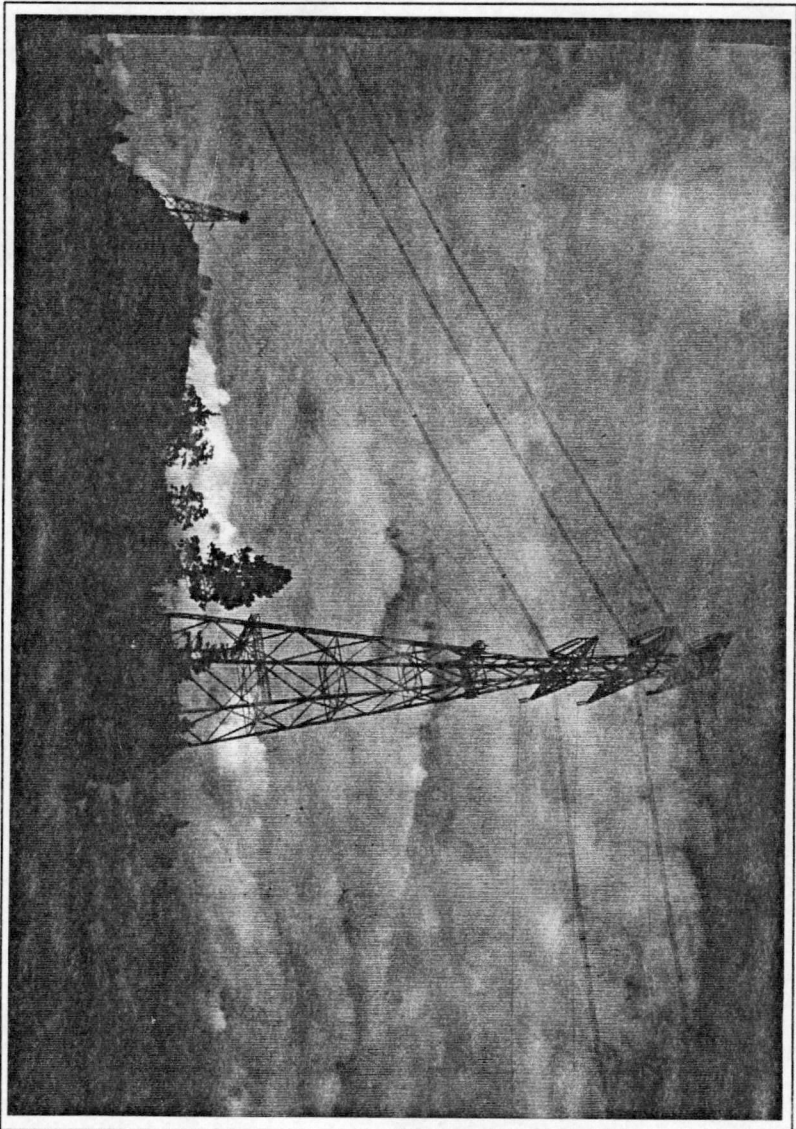


FIGURE 30. Double-Circuit Suspension Tower, Bradford Island, Bonneville Dam.

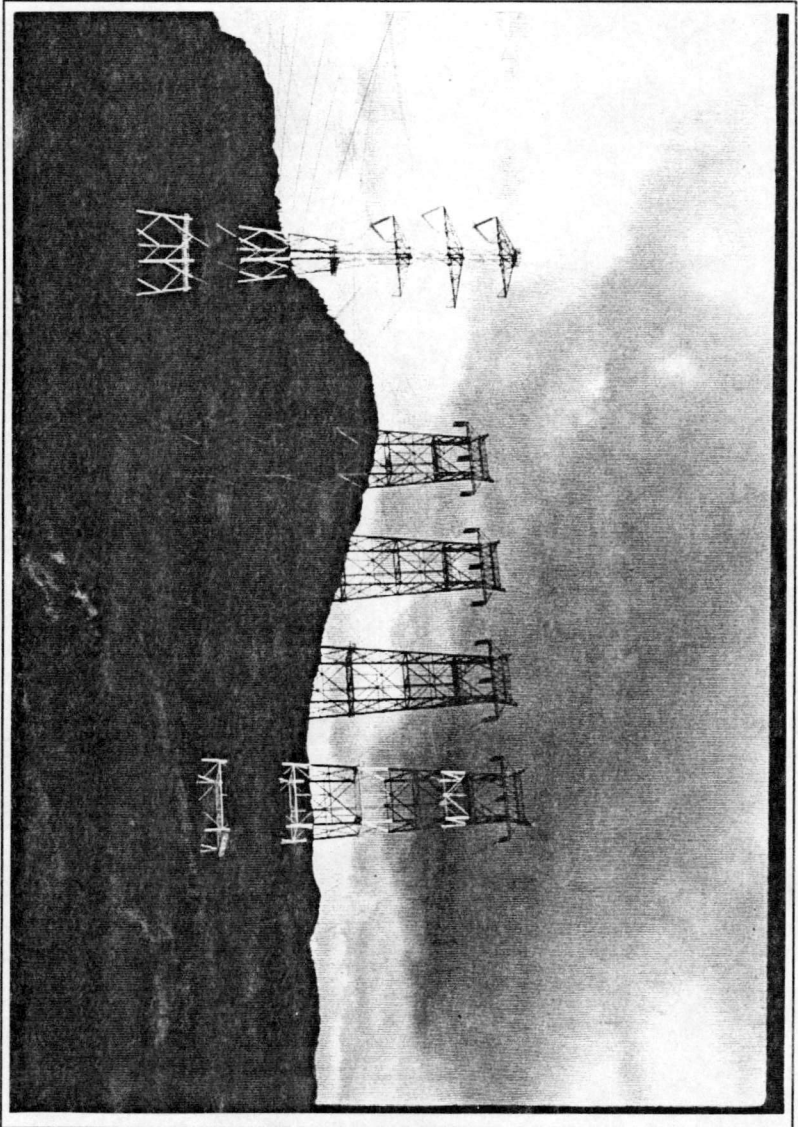


FIGURE 31. Single-Circuit Crossing Towers, Bradford Island, Bonneville Dam.

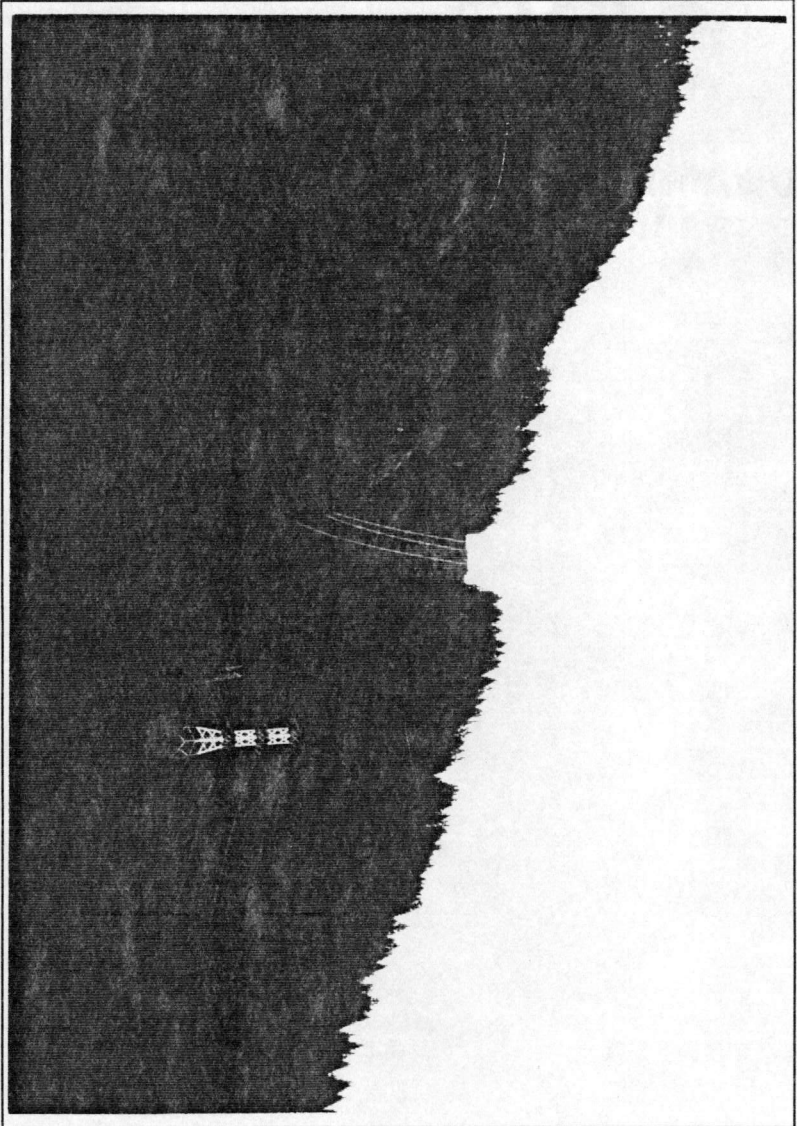
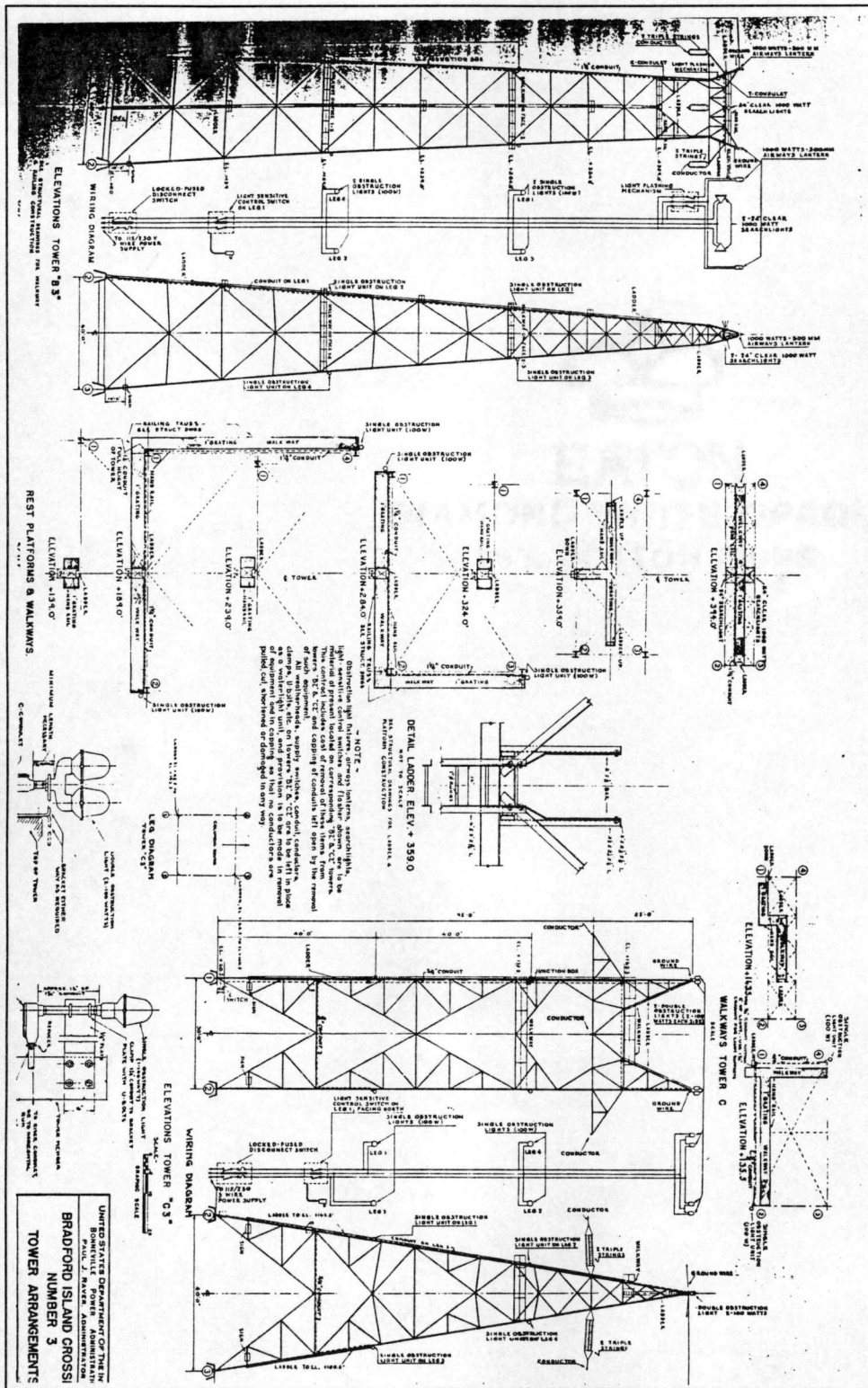


FIGURE 32. Transmission Line Corridor, Oregon Side, Bonneville Dam.



FIGURE 34. Single-Circuit Crossing Tower. (Drawing courtesy of the BPA.)



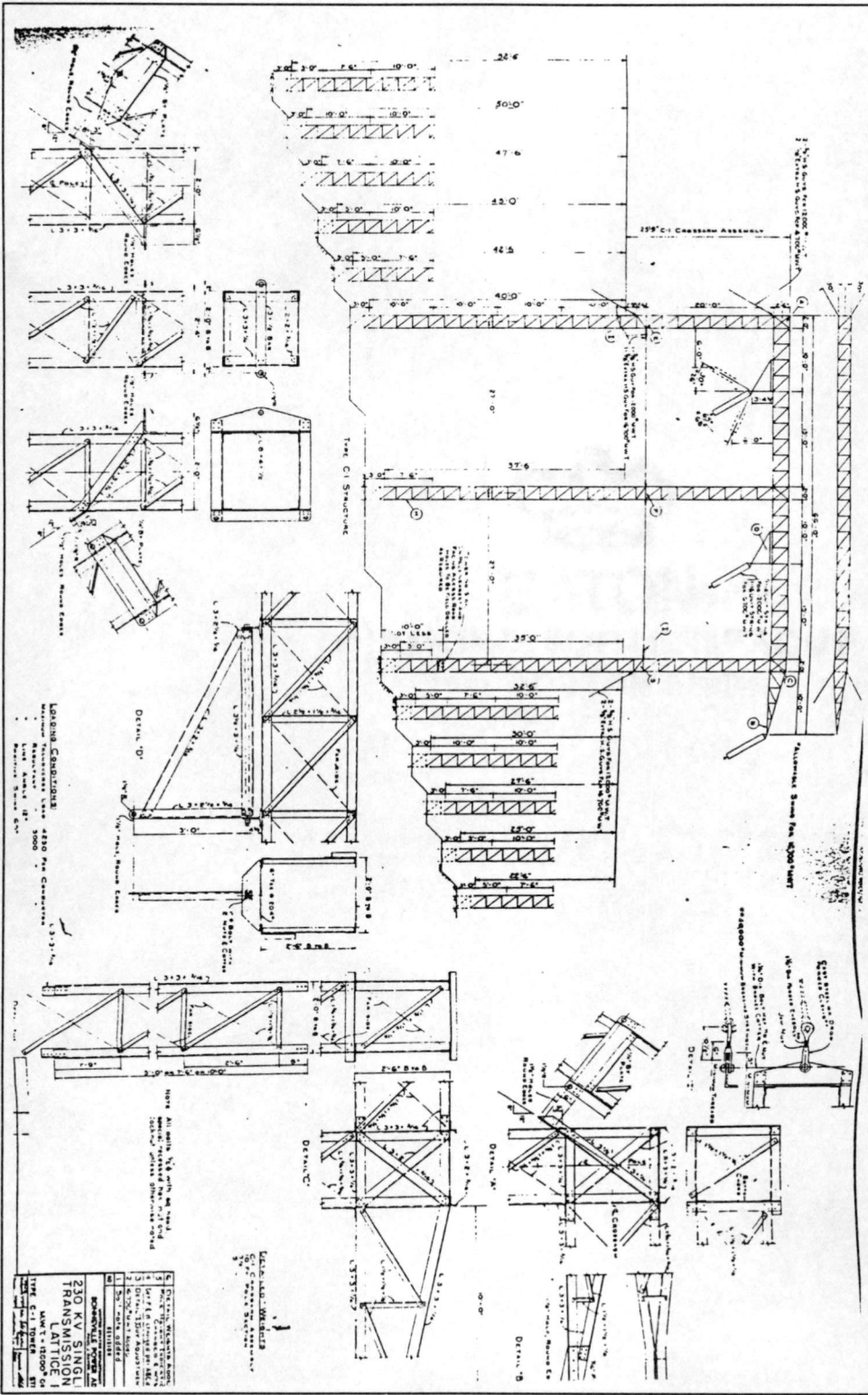
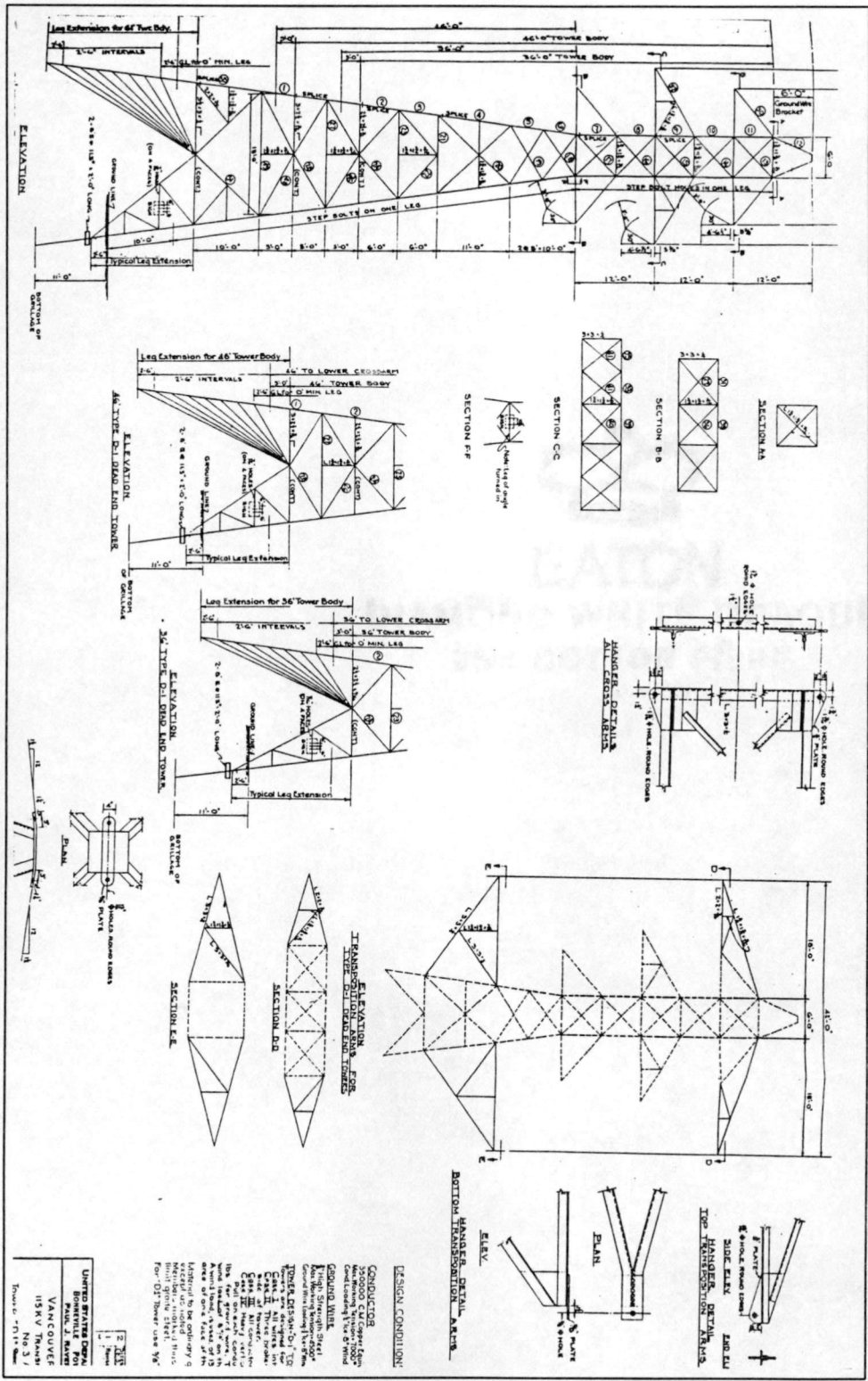


FIGURE 35. Single-Circuit Lattice Pole Tower. (Drawing courtesy of the BPA.)

FIGURE 36. Double-Circuit Suspension Tower. (Drawing courtesy of the BPA.)



## CHAPTER III

## EVALUATION

The purpose of this chapter is to set parameters for the evaluation of the properties identified in the Identification chapter. The property types will be evaluated according to criteria set forth by the National Register of Historic Places. Properties are eligible if they:

- A. Are associated with events that have made a significant contribution to the broad patterns of our history; or
- B. Are associated with the lives of persons significant in our past; or
- C. Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
- D. Have yielded, or may be likely to yield, information important in prehistory or history.<sup>129</sup>

---

<sup>129</sup> National Register Bulletin, #16B, "How to Complete the National Register Multiple Property Documentation Form," 1.

In addition to meeting one of the above criteria, a property must possess integrity to be considered significant. The definition of integrity, as it is applied to National Register criteria, is the "authenticity of a property's historic identity, evidenced by the survival of physical characteristics that existed during the property's prehistoric or historic period." Historic integrity is characterized by seven qualities: location, design, setting, materials, workmanship, feeling and association. All seven qualities do not need to be present for a resource to have integrity, depending on which qualities are most important to a particular property.

In 1987, a National Register nomination form was prepared for fourteen BPA substations and six transmission lines under Criteria A and C in the areas of Engineering, Energy Management and Utilization, and Politics and Government. The nomination was approved by both the Oregon and Washington State Historic Preservation Offices but was held in suspension at the agency's request. Although the properties nominated were found to be eligible, there are currently no BPA substations or transmission lines listed on the National Register.

Property Type: Electrical Substation

#### Statement of Significance

Electrical substations located along the original "master grid" transmission

network built by the Bonneville Power Administration between 1939 and 1945 are significant on national, regional, and statewide levels within the context, "Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945." The substations are a functionally integral component of a system that was second only to the Tennessee Valley Authority in representing President Franklin D. Roosevelt's vision of a federal power system in the United States during the New Deal years preceding World War II. During the war, power from the BPA system was used to operate regional aluminum plants that provided one-third of the country's total aluminum output. In addition, the BPA system brought power to private and naval shipyards, military air bases, and to Hanford, the nuclear power plant that created the plutonium for the bomb that ended the war. Regionally and statewide, the BPA system is significant for electrifying rural areas of Oregon and Washington, for diversifying the regional economy, and for bringing about an industrial transformation of the Pacific Northwest.

### Registration Requirements

There are three methods for nominating the BPA's electrical substations: individually; as part of a multiple property submission; or as part of a discontinuous district. Whereas an individual nomination addresses just one property, a multiple property submission nominates groups of related significant properties. In both cases, all individual properties must meet the National Register criteria. In a discontinuous district

nomination, multiple properties are evaluated as one unified entity which can possess integrity even if some of its properties do not individually meet the National Register criteria.

Registration requirements for nominating a substation individually or nominating several substations as part of a multiple property submission are essentially the same, as both evaluate the property as an individual entity. Under Criterion A, a substation must retain integrity of location, feeling, and association. The ideal substation is one that is most representative of all of BPA's activities between 1939 and 1945; it is an unaltered substation that includes all four property subtypes within its boundaries. The best example of this kind of substation is found at Salem, Oregon; another good example is found at Chehalis, Washington. An unaltered substation that includes just a control house and a switchyard is representative of typical BPA activity between 1939 and 1945, and is therefore considered eligible. The best example of this type of substation is found at Eugene, Oregon, and St. Johns, Oregon. A substation that consists only of a switchyard would not be considered eligible. Typically serving local loads as opposed to high-population areas, this kind of substation is difficult to interpret. It is hard for them to convey qualities of integrity, particularly if they do not retain any original equipment. It is also difficult to present a best example of this type of substation because control houses were added, after the period of significance, to many of the ones that were originally built without control houses. Also ineligible is a substation that no longer retains its ability to represent the BPA's activities between 1939 and 1945; it is a substation that has been

moved, or altered badly enough that it no longer conveys feeling or association. An example of this type of substation is the Glenn H. Bell Substation near Spokane, Washington. Alterations and additions to the entire site have transformed the character of this substation so that it no longer retains integrity of feeling and association.<sup>130</sup>

Substations evaluated under Criterion C must retain integrity of design, materials, feeling, and association. They will include at least a control house. An ideal substation is one that is most representative of the BPA design principles presented in Chapter I: Historical Overview; it is an unaltered substation in which any or all buildings on site exhibit all the character-defining features identified in Chapter II: Identification for that subtype. The best example of this type of substation is found at St. John's, Oregon and Salem, Oregon. Also eligible is a substation where perhaps not all the buildings on site retain the character-defining features identified in Chapter II: Identification for that subtype. The best example of this type of substation can be found at Midway, Washington, where the untanking tower remains unaltered but the control house has been modified. A substation that is not eligible is one whose buildings no longer represent the BPA design principles presented in Chapter I: Historical Overview; it is one whose building or buildings have been so altered that they no longer retain any or the character-

---

<sup>130</sup> BPA, "BPA Substations Dating 1939-1945 (Reviewed 1987-1987) for Inclusion in the Master Grid Discontiguous District Nomination to the National Register of Historic Places," typescript list in the files of the BPA, Portland, Oregon.

defining features presented in Chapter II: Identification, nor do they exhibit integrity of design, materials, feeling and association. An example of this kind of substation can be found at Oregon City, Oregon. The control house at this substation is "unrecognizable" from its original plan, and none of the character-defining features are present.<sup>131</sup>

Those properties eligible for architectural significance should be considered even if alterations to materials exist as long as the significant design is prominent and intact. Because the substations have been in continuous use since they were constructed, replacement of electrical equipment has been necessary to maintain quality of service and to accommodate new technology. Although many substations still retain some original equipment, the loss of original electrical equipment does not necessarily diminish integrity.

Registration requirements for nominating a substation as part of a discontinuous district focus on the master grid as a whole. To be eligible for the National Register under Criteria A and C, the district must be able to convey the historical, functional, and spatial relationships between property types. For the master grid district to retain integrity as a unified entity, the majority of its components must themselves possess integrity. However, the integrity threshold for a contributing resource within a district is necessarily lower than that of an individually nominated property. That is, the integrity of

---

<sup>131</sup> Ibid.

properties within a district is based primarily on the relationships among the district properties and their shared historical associations rather than on individual distinction.

It is recommended that the electrical substations built by the BPA be evaluated within the parameters of a discontinuous district. This is the only way to preserve the interrelationships between the master grid components. The master grid was designed to function as a system and should be evaluated as a system. As such, every substation in the BPA system that was built between 1939 and 1945 is eligible for the National Register under Criterion A in the areas of industry, social history, and politics/government; and under Criterion C in the area of architecture. Within the district, substations can then be designated as a contributing or non-contributing resource based on their level of historic integrity. Because the relationships among the master grid properties has remained substantially unchanged since the period of significance, and because all the properties share historical and functional associations, it is expected that most of the fifty-five substations and ninety-one transmission lines on the master grid would be considered contributing resources in a discontinuous district nomination. Exceptions would include those properties whose integrity has been badly compromised by extensive alterations or modifications.

Property Type: Transmission Line

Statement of Significance

Transmission lines of the original master grid network built by the Bonneville Power Administration between 1939 and 1945 are significant on national, regional, and statewide levels within the context, "Transmission of Hydroelectricity by the Bonneville Power Administration, 1939-1945." The transmission lines comprise the backbone of a system that was second only to the Tennessee Valley Authority in representing President Franklin D. Roosevelt's vision of a federal power system in the United States during the New Deal years preceding World War II. During the war, power from the BPA system was used to operate regional aluminum plants that provided one-third of the country's total aluminum output. In addition, the BPA system brought power to private and naval shipyards, military air bases, and to Hanford, the nuclear power plant that created the plutonium for the bomb that ended the war. Regionally and statewide, the BPA system is significant for electrifying rural areas of Oregon and Washington, for diversifying the regional economy, and for bringing about an industrial transformation of the Pacific Northwest.

## Registration Requirements

There are three methods for nominating the BPA's transmission lines: individually; as part of a multiple property submission; or as part of a discontinuous district. Whereas an individual nomination addresses just one property, a multiple property submission nominates groups of related significant properties. In both cases, all individual properties must meet the National Register criteria. In a discontinuous district nomination, multiple properties are evaluated as one unified entity which can possess integrity even if some of its properties do not individually meet the National Register criteria.

Registration requirements for nominating a transmission line individually or nominating several transmission lines as part of a multiple property submission are essentially the same, as both evaluate the property as an individual entity. Under Criterion A, a transmission line must retain integrity of location, setting, design, materials, workmanship, feeling, and association. Because the transmission lines have been in continuous use since they were constructed, replacement of towers, cable and other equipment has been necessary to maintain quality of service and to accommodate new technology. Although the presence of every original component is not essential to integrity, a transmission line being nominated as an individual property must have most of its original equipment intact. An ideal transmission line is one that is most representative of the original master grid configuration designed during the period of

significance; it is a transmission line which includes a majority of original towers or poles, and follows an original right-of-way. A good example of this kind of transmission line is the double-circuit Bonneville-Vancouver line that runs from Bonneville Dam to Vancouver, Washington along the north shore of the Columbia River. A transmission line that follows the original right-of-way but includes a different type of tower or support than was originally used on the line would not be eligible. An example of this kind of transmission line is the Vancouver-Eugene line which runs from Vancouver, Washington south along Interstate-5 to Eugene, Oregon. Now supported by steel towers, this line originally had wood poles.<sup>132</sup> A transmission line that has been relocated along a later right-of-way, even if towers from the period of significance were utilized along the new route, would not be eligible. An example of this kind of transmission line is the western half of the Covington-Grand Coulee line, which has been converted to a higher voltage and completely relocated from its original right-of-way.<sup>133</sup>

Registration requirements for nominating a transmission line as part of a discontinuous district focus on the master grid as a whole. To be eligible for the National Register under Criteria A and C, the district must be able to convey the historical, functional, and spatial relationships between property types. For the master grid district

---

<sup>132</sup> Holstine, sec. 7, p.8.

<sup>133</sup> Ibid.

to retain integrity as a unified entity, the majority of its components must themselves possess integrity. However, the integrity threshold of a contributing resource within a district is necessarily lower than that of an individually nominated property. That is, the integrity of properties within a district is based primarily on the relationships among the district properties and their shared historical associations rather than on individual distinction. For a transmission line in a district, this means that the existence of original towers, cable, and electrical equipment is not essential to integrity. Within a district, a transmission line's ability to convey integrity depends more on the corridor within which it travels than its historic fabric. The corridors, or rights-of-way, were indeed the first representations of the master grid. So long as the corridors exist in their original configurations, one will always be able to interpret the design of the master grid. In other words, one could interpret a corridor without transmission towers, but one would never find a transmission tower without a corridor. Obviously, the more historic fabric that exists, such as a succession of transmission towers, the easier it will be to interpret the line, and the higher its level of integrity will be.

It is recommended that the transmission lines built by the BPA be evaluated within the parameters of a discontinuous district. This is the only way to preserve the interrelationships between the master grid components. The master grid was designed to function as a system and should be evaluated as a system. As such, every transmission line in the BPA system that was built between 1939 and 1945 is eligible for the National Register under Criterion A in the areas of industry, social history, and

politics/government; and under Criterion C in the area of architecture. Within the district, transmission lines can then be designated as a contributing or non-contributing resource based on their level of historic integrity. Because the relationships among the master grid properties has remained substantially unchanged since the period of significance, and because all the properties share historical and functional associations, it is expected that most of the fifty-five substations and ninety-one transmission lines on the master grid would be considered contributing resources in a discontinuous district nomination. Exceptions would include those properties whose integrity has been badly compromised by extensive alterations or modifications.

## CHAPTER IV

### TREATMENT

The primary focus of the Treatment chapter is to determine research and survey needs defined during the Historic Overview, Identification, and Evaluation phases of this study. In addition, treatment strategies and mitigation measures are presented for the property types identified in Chapter II: Identification.

#### Survey Needs

In 1986, Bonneville Power Administration initiated a survey and inventory of its historic resources to comply with a 1983 Memorandum of Agreement between the agency and the Advisory Council on Historic Preservation. Under contract with a Cheney, Washington consulting firm, Archaeological and Historical Services, a discontinuous district nomination to the National Register of Historic Places was prepared in 1987 for fourteen substations and six transmission lines under Criterion A and C. Reasons for not including the remaining forty-one substations along the master grid were not detailed in the document. The nomination was approved by the Oregon and Washington State Historic Preservation Offices (SHPO) but was held in suspension at the

request of the BPA. To this date, the properties identified in the nomination are not listed on the National Register. As a result of the nomination, however, the resources are included in a general SHPO data base in each state. The nomination, entitled "Bonneville Power Administration Master Grid Discontiguous Historic District," is located at the Oregon and Washington SHPOs.

Subsequent to the completion of the National Register nomination, the BPA initiated a Programmatic Agreement with the State Historic Preservation Offices in Washington and Oregon for the contributing properties in the nominated historic district. In the Programmatic Agreement, the BPA agrees to "on a continuing basis, consult with the Oregon and Washington SHPOs to conduct studies of BPA's facilities to ensure that appropriate historic properties have been identified and eligibility for inclusion in the National Register determined." To date, no additional surveys of BPA facilities have been conducted since the 1987 inventory.

Because more than ten years have passed since the last survey of BPA facilities, it is recommended that future survey needs focus on BPA properties that were not included in the previous survey because they were not old enough. Specifically, properties constructed after 1946 that are now over fifty years old, and properties that are newer than fifty years old but that might be eligible under exceptional merit. It is also recommended that the Oregon and Washington SHPOs nominate the master grid properties to the National Register. It is most preferable to nominate the master grid as a discontiguous district. The second most preferable option would be to nominate the

properties as part of a multiple property submission. In some cases, it might be appropriate to nominate master grid properties individually. This approach might better accommodate local community planning strategies.

### Research Needs

There is a distinct lack of information available regarding the architectural design of electrical substation control houses. Although it was not within the scope of this study to investigate the evolution and precedents of control house design, it is a topic worthy of additional research and would contribute greatly to our understanding of the BPA facilities. It would be useful to know how private and federal ownership influenced the design of the buildings, and what kind of design evolutions took place when large electrical equipment moved from interior spaces to outside switching yards.

Another related topic that was not investigated was the level of WPA involvement in the construction of the master grid. Literature reviewed for the historical overview made brief mention of the BPA utilizing WPA labor to clear rights-of-way and build maintenance roads. It would be valuable to know if WPA crews took part in the construction of the actual facilities on the master grid.

The most compelling research need, however, is the one for additional oral histories. Interviews with BPA engineers and architects involved in the design, and crews who actually helped build the master grid are primary sources for information that may

not be available anywhere else.

### Treatment Strategies and Mitigation Measures

In some ways, the BPA properties are better protected because they are government owned. Section 106 of the National Historic Preservation Act (NHPA) mandates that federal agencies "take into account" any undertaking that will effect the historic property, including sale, transfer of ownership, demolition, alterations and modifications. On the other hand, because these buildings and structures are still in use, they are more vulnerable to some of these effects than privately owned buildings. In fact, the biggest threat to the properties are routine maintenance and retrofitting procedures. Secondly, historic preservation has not always been a priority for federal agencies and is too often seen as primarily a compliance problem. This attitude can prompt an agency to seek compliance waivers from their stewardship responsibilities, or to meet bare minimum mitigation measures, with no attention to quality. And finally, because the buildings are federally owned, they are vulnerable to shifting political values, budget cuts, and agency restructuring.<sup>134</sup>

The BPA has procedures in place to comply with Sections 106 and 110 of the

---

<sup>134</sup> *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (Washington, D.C.: Advisory Council on Historic Preservation, 1991).

NHPA. The BPA initiated their first Memorandum of Agreement in 1983 in response to concern that the agency's energy conservation programs would effect historic properties. In 1984, the BPA's environmental manual addressed in detail procedures for compliance with the NHPA. Later, the BPA initiated a historic properties survey, a nomination to the National Register, and a Programmatic Agreement. In the early 1990s the BPA took steps to integrate the Section 106 process into systems operations so effects to historic properties could be identified early in the planning stages of maintenance projects or modification programs. They also prepared specific maintenance guidelines for the treatment of the fourteen master grid properties determined eligible for the National Register by the 1987 nomination form.

However, more can be done by the agency to further protect their historic resources. Mitigation measures could include:

1. Locating and archiving copies of construction drawings for substations and transmission towers. It appears that original construction drawings of substations are located in flat files at individual substation control houses. An inventory should verify this. Copies should be made of these drawings and stored at the control houses for use by the operators. The originals should be consolidated and archived at a central site. If inventory results suggest that some drawings are missing, documentation drawings should be prepared of the quality equal to those mandated by the Historic American Engineering Record of the National Park Service.

2. Locating and archiving historic photographs and movie footage of facilities.

The BPA has an extensive collection of historic photographs; however, only a small percentage of them are catalogued. Management of this photo collection should be improved. The addition of a computerized data base for cataloguing purposes to improve access to the collection should be a priority.

3. Promoting a better understanding of the facilities by the public. The BPA has a tradition of concern about its public image; it was an issue when considering the landscaping and architectural designs of its substation buildings, as well as with the placement of some of the earliest transmission lines. The public drives past substations every day; transmission lines following highway rights-of-way are such a common sight that they are barely noticed. Yet most people in the community have little understanding of the technological and historical implications of these structures. To learn about the BPA, one has to travel to Bonneville Dam, a structure that was not built or owned by the agency but shares with the BPA a strong association. Developing public information centers or sponsoring open houses at facilities that are in constant use is difficult, but not impossible. The BPA could consider opening some of their larger, manned substations like the J. D. Ross Substation for tours once a year, or develop public information kiosks or signboards at some of the other properties.

4. Encourage a fuller understanding of Section 106 within the engineering and facilities management sectors of the agency. Documents reviewed suggest that BPA is aware of the problems associated with integrating the review process into early stages of planning and engineering, and that some measures have been taken to broaden awareness

of the NHPA within the agency. These measures need to be expanded to include inter-agency seminars on a yearly basis and more frequent coverage of the BPA's role as stewards of our collective cultural heritage in the agency's monthly bulletin. There are still many people within the agency who have trouble seeing the historical and architectural value of substations and transmission towers, and will therefore be less likely to be willing participants in important mitigation measures involving these property types.

## SUMMARY

When this study began, it was intended as a means to understand a charming little concrete building out on Highway 99W in Eugene, Oregon. It was clear that the building had something to do with the transmission of electricity, as it was nestled among giant electrical transmission towers. It was also clear that it had something to do with "Columbia River Power," that it belonged to the "Bonneville Power Administration," and that it was a "substation," because that is what the letters spelled on the front of the building. The questions posed at the beginning of the study included, what was the function of a substation? How long has it been here? Who designed the building?

Is this the only substation owned by the Bonneville Power Administration? What was the connection between this building and Columbia River power? What was the connection between this building and Bonneville Dam?

A quick call to the Bonneville Power Administration (BPA) and a tour of the building answered some of those initial questions. The primary function of a substation such as the one at Eugene was to step down voltages from incoming, high-voltage transmission lines so electricity could be distributed throughout the city at lower voltages more appropriate for domestic and commercial circuits. The substation had been there since 1939 and the building, which was known as a control house, was designed by a team of BPA draftsmen and constructed in 1940. Originally, the electricity coursing

through the lines at the Eugene substation had been generated by the Corps of Engineers' Bonneville Dam on the Columbia River. The electricity traveled to Eugene through a series of high-voltage transmission lines built and maintained by the BPA. This study enlarged considerably when it became clear that this charming concrete building in Eugene was now part of a 15,000-circuit-mile system of transmission lines, including hundreds of substations. An initial literature review helped put the Eugene substation into a narrower context, that of the BPA's original network of transmission lines designed in 1935 and constructed between 1939 and 1945. Known as the "master grid," it was essentially a closed loop connecting Oregon's Bonneville Dam and Washington's Grand Coulee Dam with the highly populated areas of Portland and Seattle. Other major lines reached south to Eugene, Oregon and east to Spokane, Washington. The master grid included fifty-five substations and nearly 3,000 circuit miles of transmission lines.

Sources consulted during the research process illuminated the extraordinary significance of the master grid system. Originally funded by New Deal appropriations, the grid quickly became a means for supplying cheap power to Pacific Northwest aluminum plants built by the government as the United States prepared to enter World War II. For a region that was heavily dependant on a timber and agricultural economy, and where only thirty percent of its farms were electrified by 1937, the influx of heavy industry brought dramatic changes. Not only did it substantially increase the quality of rural life, it literally transformed the regional economic base. Pacific Northwest plants, powered by electricity brought to market over the master grid, supplied one-third of the

aluminum used by the national defense program during World War II. In addition, the master grid supplied the plant at Hanford, Washington that produced the plutonium for the first atomic bomb.

It has been established then, that the Eugene substation did not exist in a vacuum. It was part of a system represented by varying property types. The Identification chapter of the study sought to find common threads and patterns for the property types along the master grid. Two major property types were identified: the electrical substation and the transmission line. Substations are comprised of several components, therefore, four subtypes were defined within that property type: control houses, untanking towers, oil houses, and switchyards. The Eugene control house turned out to be one of sixteen concrete control houses on the master grid. Another five control houses were built of wood-frame construction, while two more were built with brick over steel frames. The master grid included six concrete untanking towers, eight oil houses (two of brick, six of concrete), and fifty-five switchyards, or, installations of outdoor electrical equipment present at every substation. Transmission lines on the master grid were originally supported by five primary designs of steel towers and two primary designs of wood structures. Descriptions within the Identification chapter detail the physical characteristics of all these property types and subtypes.

The Evaluation chapter presented three frameworks within which master grid properties could be evaluated. The master grid could be nominated as a discontinuous district, as part of a multiple property submission, or individually. For the multiple

property and individual options, integrity thresholds were presented using specific examples from master grid properties. The substations were found to be eligible under Criteria A and C, and the transmission lines under Criterion A. Since the master grid was clearly designed, built, and operated as a system, it was ultimately recommended that the master grid properties be evaluated as a discontinuous district in order to preserve the interrelationships between the property types. Consequently, all the electrical substations and all the transmission lines built by the BPA between 1939 and 1945 were found to be eligible for the National Register under Criteria A and C. Properties within the district will be determined contributing or non-contributing based on their level of integrity.

Finally, questions were posed regarding the physical preservation of these types of resources. How threatened are the buildings at each of the master grid substations? What are the chances the master grid transmission-line corridors could be moved, making it impossible to interpret the original configuration of the grid? As is the case with many industrial or engineering resources, most of the properties on the master grid are still in use for the specific functions for which they were built. This continuity of use is a contributing factor in their preservation; as long as the properties can function as needed, they will remain. However, continuity of use, and the routine maintenance and repair inherent in that use, is also the one factor that poses the greatest threat to the integrity of the master grid properties, particularly the substations. The integrity of the transmission lines is less threatened, as the original master grid routes are integrally woven into the transmission networks of other private and public systems in the region; an arrangement

that started as the Northwest Power Pool in 1942. The routes will remain because they work.

Because the master grid properties are owned by a federal agency, they are subject to Section 106 review. In addition, the BPA has in place an in-house preservation management plan to integrate the preservation of their historic resources into the early stages of project planning. They also have a small cultural resources staff. However, owner agencies will continue to pose the biggest threat to their own resources until they start seeing historic preservation as a planning priority instead of a compliance issue. The utilitarian nature of electrical substations and transmission lines makes it hard for some people to see them as historic resources that should be considered in the planning process much as one would consider a 100-year-old Victorian-era mansion. Recommendations were made in the Treatment chapter for mitigation measures and preservation strategies.

The importance of looking at the master grid properties as a system as opposed to individually cannot be underestimated. Within the system, the properties along the grid are highly interpretable. Transmission lines represent physical connections between the substations and Bonneville and Grand Coulee Dams; and between substations themselves. Clearly identifiable routes, and the location of the substations along them, tell a story about heavy industry, wartime plants, rural electrification, and a region rising out of the depths of the Depression. They tell a story about public power that started on the Colorado River with Hoover Dam, made its way to the Tennessee Valley, then west to the Columbia. They represent the determination of Franklin D. Roosevelt to

"encourage the wider use of that servant of the American people - electric power."<sup>135</sup>The essence of the master grid lies in the threads of common purpose, integral functions, and thoughtful design that join its properties together. It is the hope of this author that this study will provide a means for understanding these properties as components in the larger picture of a unique regional history.

---

<sup>135</sup> Rosenman, quoted in Norwood, 26.

## BIBLIOGRAPHY

Published Sources

*Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (Washington, D.C.: Advisory Council on Historic Preservation, 1991).

Bonneville Power Administration. *Annual Report of the Bonneville Power Administration, 1938-1946.*

Craig, Lois A. *The Federal Presence.* Cambridge: The MIT Press, 1984.

Creager, William P. and Joel D. Justin. *Hydroelectric Handbook.* New York: John Wiley and Sons, Inc., 1950.

Dierdorff, John. *How Edison's Lamp Helped Light the West.* Portland: Pacific Power and Light Company, 1971.

Goodwin, Doris Kearns. *No Ordinary Time.* New York: Simon and Schuster, 1994.

Hay, Duncan. *Hydroelectric Development in the United States, 1880-1940.* Washington, D.C.: Edison Electric Institute, 1991.

Hobday, Victor C. *Sparks at the Grassroots.* Knoxville: The University of Tennessee Press, 1969.

Holbrook, Stewart H. *The Columbia.* New York: Rinehart, 1956.

Hughes, Thomas P. *Networks of Power*. Baltimore: The Johns Hopkins University Press, 1983.

Hunt, Inez and Wanetta W. Draper. *Lightning in His Hand: The Life Story of Nikola Tesla*. Hawthorne, CA: Omni Publications, 1964.

Kleinsorge, Paul L. *The Boulder Canyon Project*. Stanford: Stanford University Press, 1941.

Lowitt, Richard. *The New Deal and the West*. Bloomington: Indiana University Press, 1984.

Martin, Roscoe C., ed. *TVA: The First Twenty Years*. Knoxville: The University of Tennessee Press, 1956.

Norwood, Gus. *Columbia River Power for the People: A History of Policies of the Bonneville Power Administration*. Portland: Bonneville Power Administration, 1980.

O'Neill, John J. *Prodigal Genius: The Life of Nikola Tesla*. New York: Ives Washburn, Inc., 1944.

Pitzer, Paul C. *Grand Coulee: Harnessing a Dream*. Pullman: Washington State University Press, 1994.

Reisner, Marc. *Cadillac Desert*. New York: Penguin Books USA Inc., 1993.

Steinberg, William B. And Walter B. Ford. *Electricity and Electronics: Basic*. Chicago: American Technical Society, 1961.

Tennessee Valley Authority. *Annual Report of the Tennessee Valley Authority*. Washington, D.C.: USGPO, 1936.

Tennessee Valley Authority. *Tennessee Valley Authority, 1933-1937*. Washington, D.C.: USGPO, 1937.

Tollefson, Gene. *BPA and the Struggle for Power at Cost*. Portland: Bonneville Power Administration, 1987.

Willingham, William F. *Water Power in the Wilderness: The History of Bonneville Lock and Dam*. Portland: U.S. Army Corps of Engineers, Portland District, 1987.

#### Unpublished Sources

Beckham, Stephen Dow and Donald C. Jackson. "National Register of Historic Places Inventory Nomination Form: Bonneville Dam Historic District." Oregon State Historic Preservation Office, Salem, Oregon, n.d.

Bonneville Power Administration. "Building Data: Control Houses." Bonneville Power Administration, Portland, Oregon, July 1990.

Bonneville Power Administration. "BPA Definitions." Bonneville Power Administration, Portland, Oregon, 1975.

Bonneville Power Administration. "Location of Substations, Radio Stations, Hydromets." Bonneville Power Administration, Portland, Oregon, 1989.

Glaser, Leah S. "Historic American Engineering Record, Eastern Mining Area Transmission Line (The 115kV System), HAER No. AZ-6-B, Gila County, Arizona." Salt River Project, Phoenix, Arizona, June 1996.

Hall, Michael. "Irrigation Development in Oregon's Upper Deschutes River Basin, 1871-1957: A Historic Context Statement." Deschutes County Community Development Department, Bend, Oregon, August 1994.

Holstine, Craig. "Historic American Engineering Record, Bonneville Power Administration South Bank Substation, HAER No. OR-4, Multnomah County, Oregon." Bonneville Power Administration, Portland, Oregon, September 1987.

\_\_\_\_\_. "National Register of Historic Places Inventory Nomination Form: Bonneville Power Administration Master Grid." Oregon State Historic Preservation Office, Salem, Oregon, 1987.

Schaffer, Dr. Daniel. "National Register of Historic Places Inventory Nomination Form: Norris Dam." Tennessee State Historic Preservation Office, Knoxville, Tennessee, 1981.

#### Periodicals

"ALCOAs New Northwest Plant to Use Bonneville Energy." *Electrical West* 84 (January 1940): 64.

"Bonneville Activities: New Administrator Named." *Electrical West* 83 (September 1939): 64.

"Bonneville Administration Active on Many Fronts." *Electrical West* 83 (August 1939): 64.

"Bonneville and Grand Coulee Transmission Line Complete." *Electrical West* 85 (September 1940): 74.

"Bonneville Begins to Build New Alcoa Power Substation." *Electrical West* 84 (June 1940): 182.

"Bonneville Bids Awarded To Contractors." *Electrical West* 83 (December 1939): 56.

"Bonneville Contracts Awarded." *Electrical West* 81 (November 1938): 58.

- "Bonneville Lines and Substations Disclosed." *Electrical West* 81 (December 1938): 53.
- "Bonneville to Survey Northwest Industry." *Electrical West* 83 (December 1939): 56.
- "Bonneville-Vancouver Line Work About Ready." *Electrical West* 81 (August 1938): 60.
- "Cascade Locks First Customer of Bonneville Project." *Electrical West* 83 (August 1939): 64.
- "Engineer Urges Development." *Electrical West* 83 (September 1939): 64.
- Heston, Walter C. "Kilowatt-Hours Pooled for War." *Electrical West* 92 (March 1944): 51.
- "KW. Year Rates Set For Bonneville; Linework Begun." *Electrical West* 81 (July 1938): 44.
- "Master Power Plan for Northwest Announced." *Electrical West* 82 (February 1939): 62.
- "Plans for Bonneville Lines, Stations Revised." *Electrical West* 82 (January 1939): 52.
- "Portland G-E Signs First Major Contract for Bonneville Power." *Electrical West* 84 (January 1940): 64.
- "Promote Industry with Bonneville Power, Says FPC." *Electrical West* 81 (November 1938): 58.
- Worth, Donald G. "J. D. Ross Substation Is Northwest's Largest." *Electrical West* 89 (August 1942): 41.
- "1940 Bonneville Appropriation Totals \$13,400,000." *Electrical West* 83 (July 1939): 54.

Newspapers

"Bonneville Lines Over Roads Okeh." *Salem Statesman*. 26 August 1939.

"Bonneville Line Speedup Talked." *Oregon Journal*, 20 October 1939.

"Cities Eye Deals for Dam Power." *The Oregonian*, 27 October 1939.

"Dam Line Buys Halt." *The Oregonian*, 28 October 1939.

"Pepco Builds New Lines, Substations." *Oregon Journal*, 1 October 1939.

"P.G.E. Awaits Dam Power." *The Oregonian*, 6, October 1939.

"Puget Sound Power Lines To Start Soon." *Portland, Oregon Sunday Welcome*, 30 August 1939.

"Transmission and Generator Program Progresses." *The Oregonian*, 14 September 1939.

"Wallace Comments on REA." *REA News*, 29 August 1939.

"2,000 Working on Bonneville Power Lines." *Seattle Post-Intelligencer*, 24 October 1939

"\$400,000 Due Landowners." *Tacoma News-Tribune*, 29 August 1939.

Archival Collections

Bonneville Power Administration Library. Bonneville Power Administration, Portland, Oregon.

Bonneville Power Administration Photograph Collection. Bonneville Power Administration, Portland, Oregon.

Oregon State Historic Preservation Office Property Files. Salem, Oregon.