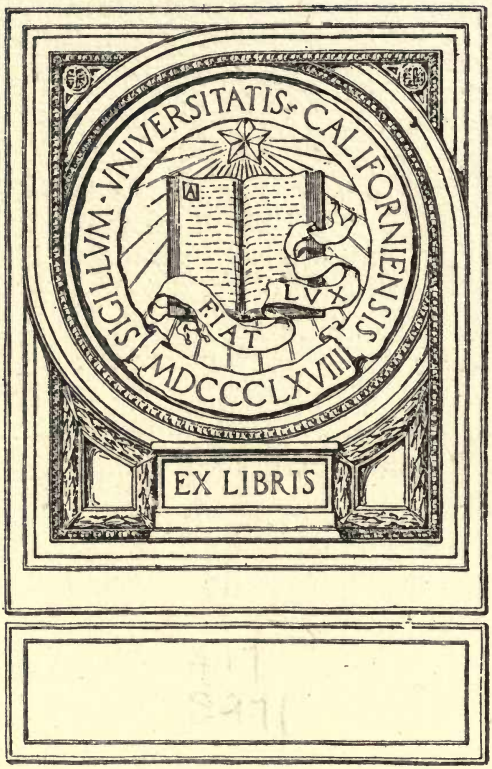
Conservation of Water By Storage

By

George Fillmore Swain, LL.D.

Yale University Press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CHESTER S. LYMAN LECTURES

CONSERVATION OF WATER BY STORAGE

"Read not to contradict and confute, nor to believe and take for granted, nor to find talk and discourse, but to weigh and consider."

—*Bacon.*

Snoqualmie Falls, Washington
About 269 Feet High
(Stone and Webster Eng. Corp.)

CONSERVATION OF WATER BY STORAGE

By

GEORGE FILLMORE SWAIN, LL.D.

Gordon McKay Professor of Civil Engineering
in Harvard University
Past President, American Society of Civil Engineers

ADDRESSES DELIVERED IN THE CHESTER S. LYMAN LECTURE SERIES, 1914, BEFORE THE SENIOR CLASS OF THE SHEFFIELD SCIENTIFIC SCHOOL YALE UNIVERSITY

NEW HAVEN: YALE UNIVERSITY PRESS
LONDON: HUMPHREY MILFORD
OXFORD UNIVERSITY PRESS
MDCCCCXV

First printed March, 1915, 1000 copies

THE CHESTER S. LYMAN LECTURESHIP FUND

The Chester S. Lyman Lectureship Fund was established in 1910 through a gift to the Board of Trustees of the Sheffield Scientific School by Chester W. Lyman, Yale College, 1882, in memory of his father, the late Professor Chester S. Lyman, for many years Professor of Physics and Astronomy in the Sheffield Scientific School. The income of this fund, according to the terms of the gift, is used for maintaining a course of lectures in the Sheffield Scientific School on the subject of Water Storage Conservation. The present volume constitutes the third of the series of memorial lectures.

PREFACE

The present course of lectures is the third given in the Chester S. Lyman series. In planning this course the endeavor has been made to avoid duplicating, more than seemed necessary, the material given in the previous courses in the series.

The first chapter is devoted to the general subject of Conservation. In this chapter the situation which now confronts the people of this country is outlined, and the nature of the problem described. The facts stated are, of course, largely, if not entirely, to be found in the voluminous report of the National Conservation Commission, published by the Federal Government in 1909, in three volumes. This is the great mine of information on this topic.

The next four chapters, constituting an amplification of the second lecture, are devoted to the relation of the conservation of water to the conservation of the other resources, and to a somewhat lengthy discussion of the water-power question and of the controversy which has been waged, in Congress and out, with reference to questions of Federal control of water powers. These chapters deal largely, but necessarily, with legal technicalities, and it is necessary to study these in order to understand the general problem. As chairman of the Water-Power Committee of the Fourth Conservation Congress, held at Washington in 1913, the writer had occasion to investigate this question in some detail. Since this Congress he has pursued the subject further, and this further study has resulted in some modification of the conclusions to which a less thorough investigation had led him. In this part of the subject, he must acknowledge his great indebtedness to Mr. Rome G. Brown of Minneapolis, whose knowledge of the water-power situation, both legally and practically, is probably as thorough as that of any man

in this country. The writer has carefully studied all of the papers of Mr. Brown on this subject, and has also examined most of the Congressional and other Government publications bearing upon the question, particularly those giving the views of the so-called conservationists. It is believed that, independent of the conclusions arrived at, with which some will not agree, this chapter contains a more thorough discussion and summary of the entire question than is to be found in any other single publication.

The sixth chapter deals with the technical aspects of water-power development, and in this chapter there is necessarily some repetition of material contained in former volumes of the series.

Storage of water is not necessarily in open reservoirs. Storage in the ground is almost equally important, and perhaps more so. The seventh chapter, therefore, deals with the much mooted question of the relation of forests to stream flow. In this chapter the endeavor has been not so much to give a minute technical discussion of the question as to treat of the general principles involved and the general methods of investigation which are appropriate in this case, regarding which the writer believes there is much misapprehension even among scientific men and engineers.

The last chapter deals with floods and their prevention.

In the preparation of this course, the writer has made use of certain papers previously written by him, although published as reports of committees, as for instance, the report of the Water-Power Committee made to the Fourth Conservation Congress, and the report of the Conservation Committee of the American Unitarian Association, of both of which committees the writer was chairman. It has not been deemed necessary to include in quotation marks any extracts from these reports which were written by the present writer.

It is hoped that these lectures will constitute a contribution to the general subject which may be of some interest and value, not only to engineering students but to members of the profession, and especially to those interested in the legal aspects of the water-power discussion.

For the illustrations in this book the writer is indebted, among others, to the United States Reclamation Service, the United States Bureau of Forestry, the New York Board of Water Supply, the Ambursen Hydraulic Construction Company, the Pennsylvania Railroad Company, and especially to Messrs. Stone & Webster of Boston, who have furnished him with a large number of excellent photographs, illustrating the numerous works constructed and controlled by them in various parts of the country from Maine to Oregon and Florida.

Messrs. Stone & Webster have also supplied the writer with much technical information regarding their various plants.

To all these parties who have assisted the author by information or by illustrations, his sincere thanks are hereby expressed.

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CHAPTER I

CONSERVATION IN GENERAL

The Chester S. Lyman lectureship fund provides for a course of lectures each year on the subject of the Conservation of Water by Storage. Already two courses have been given, and the present course is the third. The subject designated, however, is a somewhat limited one; it treats of the conservation of a single natural resource, and in a single way. It deals only with the storage of water. It would naturally include a consideration of the reasons why storage is desirable, the methods of attaining it, and the results produced. It would include the construction of dams, the reasons why they are built, and the good they accomplish.

Now, although these courses are given each year to different classes, it does not seem desirable that they should be mere repetitions of the same things by different lecturers. Being published in book form, each course of lectures is available for succeeding classes. The two courses preceding this have covered the subject in a most excellent and comprehensive way, and I could not improve upon them if I should attempt to do so.

Moreover, the subject of the construction of dams is a purely technical engineering subject, upon which large treatises have been written, and which I assume is covered with all the detail that is desirable in the purely technical courses of study in this University. I assume that the present course is not desired to be of a strictly technical character, discussing mathematical formulæ and questions of mechanics, suited to an audience of trained engineers, but a course of a broader and more popular character, suited to the comprehension of a mixed audience rather than to hydraulic specialists.

I shall, therefore, attempt to treat the subject in a very broad manner, not confining myself to the storage of water, but discussing other questions, some engineering and some economic, relating to the uses of water, its dangers, and its control; and not even confining myself to the conservation of water, for that is only one phase of a larger and more important topic, that of conservation in general; for the conservation of water cannot be thoroughly understood except in its relation to the more general and larger question.

What, then, is conservation anyway, and why do we hear so much about it just now? Like many other terms in common use, it is much used, and also much abused. It has been the means of accomplishing much good, and also of doing a good deal of harm. Conservation means "preservation from loss, decay, injury." It does not, however, as applied to natural resources, properly mean withdrawal from use; it is simply a wise use, with the avoidance of waste. We find ourselves on this little planet surrounded by forces and products of nature, upon the utilization of which not only our happiness, but our very existence depends. We daily require for our use the products of forest, mine and quarry, the flowing water, the beasts of the field, and the birds of the air. When population is scanty, the natural resources available are far in excess of the needs of man, and are either wasted, doing no good, or else are preserved for future generations. Rivers flow to the sea unharnessed by man, forests grow up and decay, the beasts of the field destroy each other or else accumulate in such large numbers as to be themselves a pressure upon the resources which sustain them, while mineral deposits lie in slumber beneath the surface of the earth until the needs of man shall call them into use. But as population increases, these resources are brought more and more into requisition, until finally they may be insufficient for the needs of the population dependent upon them.

At first, when the resources are in excess of the needs, their use is naturally accompanied with much waste. Forests are ruthlessly destroyed by the woodsman's axe, to make place for the wheat fields and habitations of growing communities. Where there

is an excess, there is no need for saving. Future generations are not thought of, for it seems impossible that there could ever be less than enough for all. But at some time it is suddenly realized that the resources given us by the Creator have been and are being squandered, warning voices are raised, and the pinch of necessity forces a pause, and a serious study of the situation.

Through such a period have we, the people of these United States, been passing. Our forefathers came to this country some three hundred years ago. They had been brought up in the various countries of Europe, and their experience and that of their ancestors had taught them the virtues of puritanism—economy, industry, simplicity, frugality, humility, and reverence. They found a land of boundless opportunity, of marvelous richness, practically untouched by the hand of man; and this land they and their descendants, and the others who have joined them, have been developing during the past three centuries. At first, they suffered many discouragements and hardships in combating the adverse forces of nature, but, as the years went by and the earth yielded her richness into their hands, the comforts available began to multiply, and with their multiplication the ancient virtues have been gradually less and less observed, and, in some classes, seem now to have largely disappeared. Wealth increased rapidly; and science, progressing with rapid strides, made available to men's hands all the boundless riches of the new land. It was no longer necessary to practice frugality, for there was more than enough for all. The homogeneity of the population, and the establishment of a form of government which does not recognize the inequalities between men, while they have fostered a certain degree of individual self-confidence, have decreased the sense of humility. The statement in the Declaration of Independence that "all men are created equal"—meaning, of course, that all men are equal before the law—has gradually become misunderstood and perverted until it is now widely considered to mean that all men are intrinsically equal and deserving of equal respect and the same opportunities. At present, the young grow up in an atmosphere which leads them to feel that

they are in every respect the equal of anybody else, and respect for age and wisdom is rare. Advice is, therefore, seldom sought or thoughtfully received. The rich have become numerous—not those who have been rich for decades, like the aristocrats of Rome—but the newly rich, whose riches have come as if by magic through the development of the country.

Ferrero, writing of the condition of Rome in the second century B. C., uses the words: "The destruction of Carthage and Corinth had already worked serious havoc in Roman life, spreading luxury and ostentation among the upper classes, a distaste for work among the lower, and wastefulness and intemperance in all ranks of society." In the case of America, it has not been the conquest of other countries which has brought wealth, prosperity, and material progress, but the conquest of the land, the marvelous development of the riches of the virgin continent. The result, however, is precisely the same as that described by the historian of Rome. *Waste and extravagance have become common; frugality has, in large measure, given place to improvidence.*

There is no doubt that the time has come when a halt should be called, and when the serious condition which confronts us should be realized. While the resources of our country have not by any means been exhausted, they have been consumed at an alarming rate. Our forests are already half gone, and we are taking from them each year approximately three times what they produce. Our supplies of coal, iron, gas, oil, fertilizers, and other material resources, are being consumed at a rate which, in the case of some of them at least, apparently indicates a definite end in sight. Our waters, instead of being utilized, are allowed to go to waste and to cause destruction where they should be of service. Our soil, instead of being conserved, is wasted by erosion and by unwise methods of cultivation. If all this consumption of our resources were legitimate, if there were no waste, we might be justified in going on without pause, leaving future generations to take care of themselves. The fact is, however, that much of our consumption of these resources is wasted—absolutely thrown away.

The seriousness of the situation has long been recognized by thinking men. As far back as 1884, Mr. D. J. Whittemore, in his address as president of the American Society of Civil Engineers, used the following words:

"Our older members have observed with deep concern the rapid denudation of our forest lands, and the demands of increasing population bring questions of grave moment to the minds of every thoughtful engineer. Returning to the home of my boyhood with the recollections of only one-third of a century, I find now bare rocks and crags that in my youth were covered with a luxuriant growth of those green forest trees whence my native State derived its distinctive name. Visiting the great pine regions of the Northwest, we find the railway pushing its iron arms into the depths of the forest, seeking the lumber demanded in the settlement of those great treeless tracts of our continent west of the Mississippi and Missouri Rivers. Like conditions are found all over our continent wherever our work leads us. Though many may imagine that the supply of timber cannot be exhausted in the near future, we know the fact that stumpage has nearly doubled in value in the last decade; and I am assured by authority deemed reliable, that the aggregate amount of standing pine in the States of Wisconsin, Michigan and Minnesota does not much exceed 80 billion feet, while the present annual cut in these three States is 8 billion feet—the average cut per acre being about 5,000 feet.

"Many of our railway companies in the West now find in the transportation of lumber their principal item of traffic. On some of the streams of Wisconsin the conversion of logs into lumber is so rapid and of such volume that navigation is impeded by bars of sawdust. It is estimated that the tonnage from one acre of pine land equals the tonnage of agricultural products subject to transportation that is likely to be raised on the same area in from ten to thirty years. In view of these facts, is it not pertinent to ask how the rapid diminution of this now cheap and chief resource of the engineer and architect for constructive purposes is to be compensated in the future? It is not in the power of man to arrest the demand, and I assume that it would not be policy to do so if the power were granted. It is within our province of duty, however, to suggest processes by which decay may be arrested in degree."

The American Institute of Mining Engineers founded in 1871 has from the very beginning emphasized the importance of preventing waste in mining. At the first meeting of the Institute, in 1871, the late Richard P. Rothwell emphasized this point, and the same thing was urged by J. W. Harden in 1873, and by Eckley B. Coxe in 1893.

As the years went by, the problem attracted more and more attention, particularly on account of the continual exhaustion of our forests and the consequent increasing cost of lumber, and also on account of increasing devastation by floods, and the evident need of controlling them. In 1903, President Roosevelt, in an address before the Society of American Foresters, said:

"Your attention must be directed to the preservation of the forests not as an end in itself, but as a means of preserving the prosperity of the nation. . . . . In the arid regions of the west, agriculture depends first of all upon the available water supply. In such a region forest protection alone can maintain the stream flow necessary for irrigation and can prevent the great and destructive flow so ruinous to communities further down the same stream. . . . . The relation between forests and the whole mineral industry is an extremely intimate one. The very existence of lumbering . . . . depends upon the success of our work as a nation in putting practical forestry into effective operation. As it is with mining and lumbering, so it is in only a less degree with transportation, manufactures and commerce in general."

Later, in response to a demand from the people of the interior sections of the country, the President appointed the Inland Waterways Commission. In his letter creating this commission he said:

"It is becoming clear that our streams should be considered and conserved as great natural resources. . . . . The time has come for merging local projects and uses of the inland waters in a comprehensive plan designed for the benefit of the entire country. . . . . It is not possible to properly frame so large a plan without taking account of the orderly development of other natural resources. Therefore, I ask that the Inland Waterways Commission shall consider the relations of the streams to the use of all the

great permanent natural resources and their conservation for the making and maintenance of prosperous homes."

During the inspection trip along the lower Mississippi, made in May, 1907, by the Inland Waterways Commission, the general policy of conservation was discussed, and it was decided, subject to the approval of the President, to hold a conference in Washington during the ensuing winter. This suggestion developed into the plan of inviting the governors of all the states to take part in such a conference, and this conference was held at the White House in May, 1908. Subsequent to this conference, the membership of the Inland Waterways Commission was enlarged, and other coördinate commissions or branches were appointed by the President, relating to the subjects of lands, minerals, and forests; these three, together with the Inland Waterways Commission, constituting the National Conservation Commission. This commission held a lengthy meeting in Washington in December, 1908, and adopted reports upon each of the four topics.

Later, another conference of governors was held, and still later a meeting of representatives of this country in connection with others from Canada, Mexico, and other countries of this continent, in the interest of a comprehensive movement not confined to the United States alone. Beginning in 1910, a National Conservation Congress was organized, to hold annual meetings, and the fourth of these congresses was held last in November, 1913.

It will be observed, therefore, that the serious agitation of this subject has been confined to the last ten years. All great movements, however, develop slowly, and notwithstanding the seriousness of the problem which now confronts us, probably the majority of our people are far from appreciating its vital importance.

The Situation

The natural resources which we have been wasting so recklessly and which it is so necessary to conserve, are generally considered to be four in number, namely, the forests, the waters, the lands,

and the minerals. That we are wasting these resources most recklessly has been very apparent to far-sighted observers.

Professor Shaler long ago made the statement: "Of all the sinful wasters of man's inheritance on earth—and all are in this regard sinners,—the very worst are the people of America."

Professor I. C. White, State Geologist of West Virginia, in his address at the conference of governors, said:

"What will it profit this nation to have won the wealth of industrial supremacy, if in our thirst for gold and sudden riches we permit corporate greed, as well as individual avarice and selfishness to waste and devastate the very sources of our prosperity? For just as sure as the sun shines, and the sum of two and two is four, unless this insane riot of destruction and waste of our fuel resources which has characterized the past century shall be speedily ended, our industrial power and supremacy will, after a meteor-like existence, revert before the close of the present century to those nations that conserve and prize at their proper value their priceless treasures of carbon."

The seriousness of this waste will, perhaps, be apparent when it is remembered that many of these resources "have required untold ages for their accumulation; that no human being has contributed toward this accumulation or has increased the intrinsic value of these resources; and that hence their present owners, whether acquiring them through discovery or purchase, have no right to waste or destroy that which is necessary to the wealth of the nation, which they did not create and which they cannot replace." A man may have a right to waste, or to use in any way which he pleases, property which he has himself accumulated; but he certainly has no right to waste the resources which God has given us, and which belong as much to our successors as to ourselves. Economy is to be commended, provided it is governed by a consideration of the present as well as the future. Natural resources were given us for our use, and the use of our successors, but where the real interests of the present and the future conflict, present interests are paramount, and the future must be left to solve its own problems; but waste, if preventable, has no justification.

Let us consider some figures which will illustrate what this waste amounts to:

With reference to our forests, the people of the United States use annually 40 cubic feet of wood per acre, while the natural growth produces 12 cubic feet per acre. We are, therefore, using over three times what we produce. And if asked whether we need to use this large quantity, we may answer by bringing forward the fact that while the consumption of wood in this country amounts to 260 cubic feet per capita, Germany uses only 37, France 25, and Great Britain 14 cubic feet per capita. Moreover, forest fires consume each year immense quantities of merchantable and young timber. Since 1870, forest fires have each year destroyed an average of fifty lives and fifty million acres of woodland.

In our use of timber there is great and unnecessary waste due to uneconomical and careless methods of logging and manufacturing, and to the lack of coöperation between the different industries. Only 320 feet of timber are used for each 1,000 standing in the forest and cut for use. Tanning establishments utilize the bark from thousands of trees and leave the naked trunks to die and rot or to be destroyed by fire, while in other localities the lumber is used and the bark wasted. Uneconomical methods of boxing trees, in obtaining turpentine, result in the destruction of many valuable trees each year. Wherever we look we see evidences of waste and extravagance, much of which is preventable. As a result of all this the price of lumber has steadily risen, and yellow pine now costs over 60 per cent more at the mill than it did in 1900.

If we turn to our mineral resources, the waste is perhaps even more alarming:

"The seriousness of this loss is more clearly appreciated when it is remembered that our production and consumption are increasing much more rapidly than the population of the country; that the mineral supplies for future use are limited in quantity and cannot be reproduced. No new supplies are being created to take the place of those withdrawn from the earth and either used or wasted. When once these supplies are exhausted, the exhaustion is complete and permanent."

Natural gas, the best of fuels, has been allowed to waste without restraint in many parts of the country. The amount known to be going to waste at one time has been sufficient to light all the cities of the United States having a population of over 100,000. In one field alone in Louisiana, there was enough going to waste a few years ago to light ten cities as large as Washington. Within twenty-five years, at the present rate of use and waste, all the known supplies of natural gas will be exhausted. Only one state, namely, Indiana, had, up to a very few years ago, passed effective laws directed against the waste of natural gas.

With reference to oil, at the present rate of increase, the available supply will be exhausted before the year 1950. Much of this valuable resource is wasted in various ways, particularly by improper use as fuel when less valuable fuels would suffice.

If we turn to our coal supply, we find that by uneconomical methods of mining and by the extraction of only the high-grade material and allowing the mines to cave in, a large percentage is still wasted, although there has been an improvement of about 50 per cent within recent years. Nevertheless, the easily accessible and available coal in this country will, according to the best estimates, be exhausted by the middle of the next century. It is a remarkable fact that in any period of ten years the production of coal, and therefore its consumption, equals the total production up to the beginning of that period. Whether this enormous rate of increase will continue is, of course, a matter of speculation, and must be considered at least doubtful.

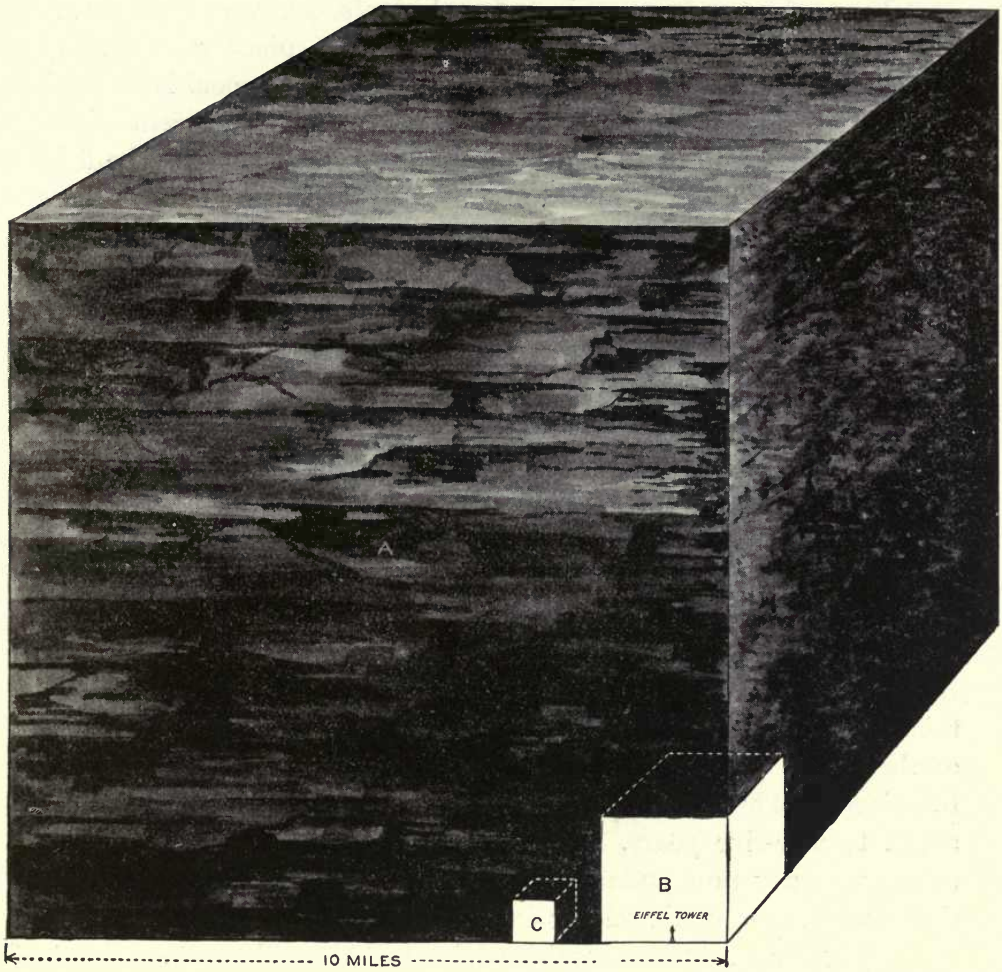

FIG. 1. DIAGRAM ILLUSTRATING OUR COAL RESOURCES, THE AMOUNT THAT HAS BEEN USED, AND THE AMOUNT STILL REMAINING UNUSED IN THE UNITED STATES

A represents the total coal supply of the United States
B " " amount used to the end of 1912
C " " " consumed in a single year

This diagram was prepared by Edward W. Parker, chief of the Division of Mineral Resources of the U. S. Geological Survey.

(From *National Geographic Magazine*, February, 1914)

You, of course, as engineering students, are very well aware of the fact that in the ordinary steam-power plant considerably less than 10 per cent of the theoretical energy of the coal is utilized, while in lighting plants, it is stated that less than 1 per cent of the energy of the coal is utilized in the form of light. Here is the field of the engineer and the inventor. The modern gas engine utilizes a much larger percentage of the theoretical energy available, and with increasing use of this form of power, a reduction in the loss of fuel will ensue; and if some means can be devised to utilize a still larger percentage of the energy of the fuel, the period of exhaustion of our fuel supplies will be pushed still further into the future.

Nevertheless, these resources must inevitably come to an end. This significant fact, if thoroughly realized, should impress upon us our duty towards those who are to follow us upon this earth.

Turning to our iron ores, at the present rate of increase of consumption, it is estimated that the known supplies of high-grade iron ores will be practically exhausted by the middle of the present century.

Another of our important minerals is phosphate rock. Of this we have large deposits in the Southern states, and in some parts of the West, which are extremely valuable in the manufacture of fertilizers. These, it is estimated, will be entirely exhausted in about twenty-five years, and representatives of foreign countries are apparently now endeavoring to gain control of them, so that the product may be largely or exclusively sent abroad.

The total waste of our mineral products is said to approximate $1,000,000 per day, or more than one-sixth the value of the total production. In addition to this waste of material is the waste of life. During the year 1909 in coal mining operations alone more than three thousand men were killed and more than seven thousand injured.

I need hardly refer before this audience to the great and unnecessary waste by fire. The cost of fires in this country, including the property destroyed, insurance, and the cost of additional water supplies, amounting in 1907 to over $450,000,000,

or to nearly 50 per cent of the value of new buildings erected. This amounted to over five dollars per capita, and constituted a tax exceeding the total value of the gold, silver, copper, and petroleum produced in the United States in that year. Property loss alone, not including insurance, water supplies, etc., was estimated at $2.51 per capita, while in the six largest European cities the corresponding loss was 38 cents per capita. Surely something is wrong when we, who consider ourselves the most enlightened people in the world, allow an annual destruction by fire to constitute a tax about seven times as great as the corresponding tax in European cities. The following table, prepared by a Committee of the National Board of Fire Underwriters, shows to what extent our fire loss has increased since 1875:

Year	Aggregate Property Loss	Population
1875	$78,102,285	
1876	64,630,000	
1877	68,265,800	
1878	64,315,900	
1879	77,703,700	
1880	74,643,400	50,155,783
1881	81,280,900	
1882	84,505,024	
1883	100,149,228	
1884	110,008,611	
1885	102,818,796	
1886	104,924,750	
1887	120,283,055	
1888	110,885,665	
1889	123,046,823	
1890	108,993,792	62,947,714
1891	143,764,967	
1892	151,516,098	
1893	167,544,370	
1894	140,006,484	
1895	142,110,233	
1896	118,737,420	
1897	116,354,575	
1898	130,593,905	
1899	153,597,830	
1900	160,929,805	76,085,794
1901	165,817,810	
1902	161,078,040	
1903	145,302,155	
1904	229,198,050	
1905	165,221,650	
1906	518,611,800	
1907	215,084,709	
1908	217,885,850	
1909	188,705,150	
1910	214,003,300	92,174,515

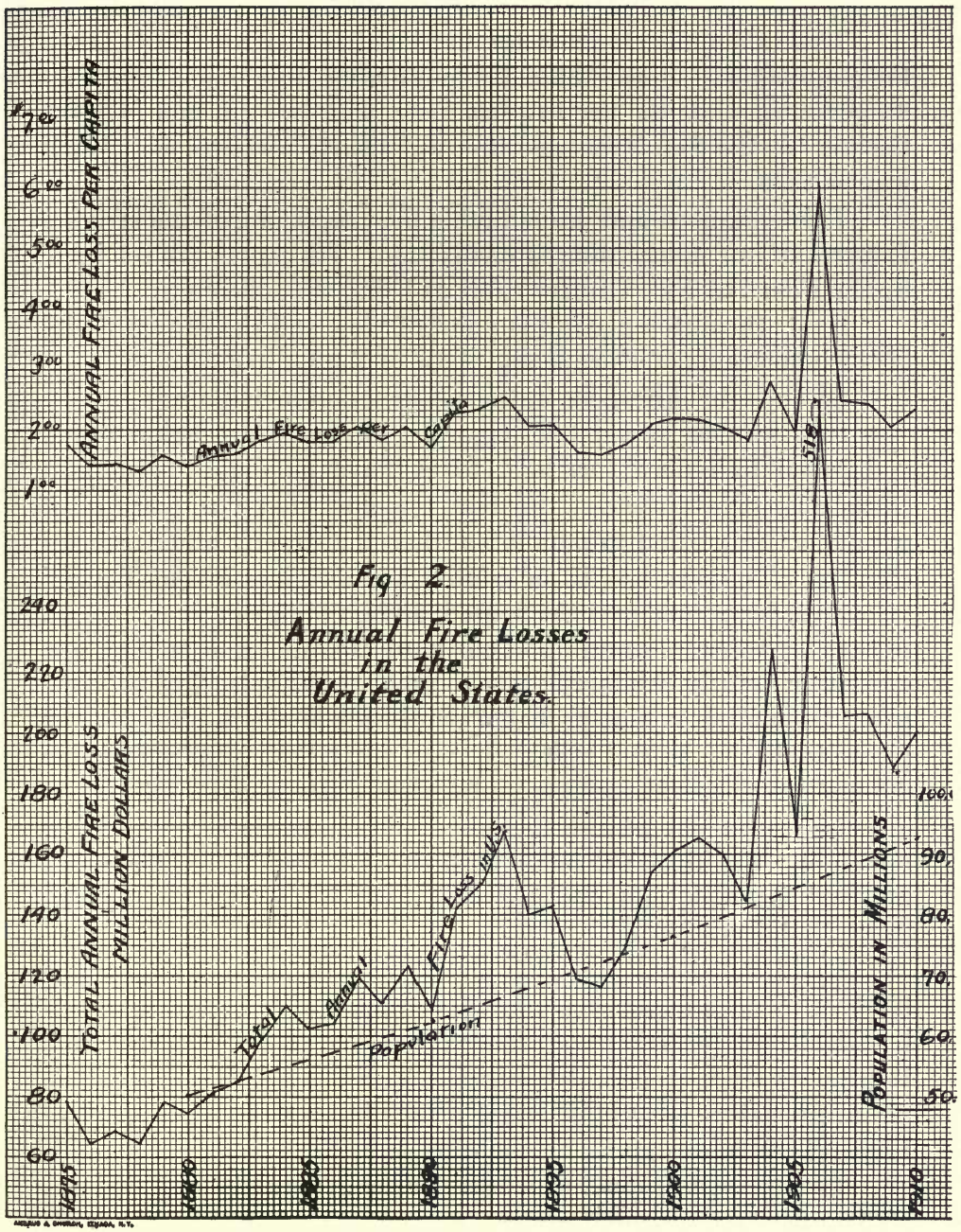

Fig 2.

Annual Fire Losses in the United States.

This table indicates that the fire loss has increased faster than the population. Since 1880, the population has increased about 84 per cent, while the fire loss has more than trebled, and in 1906, the year of the San Francisco fire, was nearly seven times what it was in 1875.

This enormous and discreditable fire loss is one of the striking features of our much vaunted civilization. Its causes are set forth by the Board of Fire Underwriters as being the following:

First: the difference in the point of view and the responsibility of the inhabitants of Europe and those of the United States;

Second: the difference in the construction of buildings.

It should be added that vigorous measures are being urged and taken to reduce this loss, which have no doubt been most efficacious. Nevertheless, the fact remains, that our fire loss is greater in proportion to population than that in any other civilized country. This fire loss is, of course, a direct loss of our natural resources, for people must be housed, and buildings must be rebuilt, so that the wasteful drain upon our natural supplies of timber, ore, and other natural products, is by so much increased. The sad fact about this matter is that probably two-thirds of the fire loss is from preventable causes, and that each year nearly two hundred million dollars' worth of property is unnecessarily destroyed. Insurance, of course, does not restore this loss, but simply shifts it upon our remaining wealth. Preventable fire waste has been termed a national disgrace, and yet our country is far in the lead in this discreditable condition.

I will not dwell upon the situation with reference to public lands or to lands in general, but will confine myself to the statement that, while the fertility of our lands is not decreasing, we are failing to grow as large crops as we ought to grow, largely because we do not appreciate some fundamental principles, such as the benefit of rotating crops, ploughing on contours so as to prevent wash, etc.

The average product of wheat per acre from 1897 to 1906 was 13.8 bushels in the United States, 28 in Germany, 32.2 in the United Kingdom; and somewhat corresponding figures in other crops.

There is also great waste and damage due to animals and insects. The Hessian fly in one year did a damage of $24,000,000; the San Jose scale of $10,000,000. In Texas, there is one colony of prairie dogs which is said to cover 25,000 square miles and to contain a population of 400,000,000 dogs. Two hundred and seventy dogs eat as much grass as one steer, so that this district, if the dogs were exterminated, would support one million and a half head of cattle.

With reference to the waters, which will be the subject of the remaining lectures of this course, these constitute a resource more permanent and inexhaustible than the others. Whatever men may do, rain will continue to fall upon the surface of the earth, but it is not the less important to conserve these waters, and to take such precautions as will allow of their utilization to the fullest extent. The statements which have been made with reference to the exhaustion of our fuel supplies clearly indicate that in the years to come water power will become more and more important as a national asset. Indeed, as the fuel supplies approach exhaustion, it is probable that our streams will be utilized for power to the greatest practicable extent. In this utilization it is of great importance that extremes of flow should be reduced as much as possible, so that the waste of water in floods may be made a minimum. With reference to the damage annually done by floods, so far as statistics are at hand, they indicate that this damage has been increasing in recent years, having risen from $45,000,000 in 1900 to $118,000,000 in 1907. Even a small effect of forests or reservoirs in regulating flow might easily reduce the flood damage sufficiently to pay in a few years for the expenditure involved. The Merrimac River, for instance, when at the highest flood, discharges about seventy times as much water per second as it does when at its lowest stage, and about ten times as much as when at its average flow during the year. No water-power plant attempts to use the maximum flow, and few attempt to use an amount of power greater than is afforded by the flow of the stream during the lowest six months. Supplementary steam power is provided for use

during periods when the stream will not afford water enough to generate all the power that can be generated by the water wheels. Even at the present time, with a comparatively low price for coal, any increase in the regularity of the flow of a stream used in this way for power would be a considerable gain. Much more will be this gain as our fuel supplies approach exhaustion. This may not concern us, but it will probably seriously concern our descendants.

From the above statement of the problem, it is clear that conservation means wise use and the avoidance of waste. It is largely a technical and engineering question, and it would seem that nothing more than a mere statement of the situation would be necessary to enlist every intelligent and public-spirited person in the movement. But it was so evidently a matter that would enlist large numbers of people in its support, that upon the original object became engrafted all sorts of economic and governmental propositions, so that the name conservation has come to be considered by some to include almost every imaginable good. This enlargement of the original idea is justified by its adherents by the statement that the problem is not only to prevent waste, and to secure wise and economical use, but that this use must be such as to be in all respects for the best interests of the people.

In the beginning of the movement, the definition of conservation given by Dr. C. W. Hayes, Chief Geologist of the United States Geological Survey, in an address at the University of Chicago, as "Utilization with a maximum of efficiency and a minimum of waste" was received with approval, and has been often quoted since. Today it is disclaimed by many who claim to be conservationists, because it says nothing as to the rights of the public.

A discussion of conservation today, therefore, is likely to involve questions of state rights vs. national control, the regulation of corporations, the rates charged by public utility corporations, and many other similar matters.

Now probably every one would agree, in theory, that our natural resources should be utilized in such a way as to be for the

best interests of all. But when we come down to details, there will necessarily be disputes between conservationists as to questions of public policy, which may retard the actual prevention of waste and the remedying of pressing evils. This enlarged view of conservation is somewhat like a movement for "social justice." We all believe, no doubt, in social justice. The phrase is attractive. But when we try to find out just what each man conceives to be social justice, we at once meet with radical differences of opinion, and we find men advocating social justice whose views as to what constitutes social justice, or how it is to be attained, are as far apart as the heaven is from the earth. Any movement founded on the idea of promoting social justice must, therefore, necessarily disintegrate; it has no coherence; its members can agree on no definite practical policies.

Perhaps the same may be said as to the conservation movement in its enlarged aspect. When it comes to involve all sorts of social, economic, and governmental policies, there will be disagreements within the ranks, and the power of the conservation idea, as a movement animating large numbers of men with a common object, will be lost, or at least seriously diminished. For this reason, many able and influential men, engineers, lawyers, legislators, and others, while they believe in avoiding preventable waste, are not willing to ally themselves with the so-called conservation movement, or to lend their aid to it.[1]

Nevertheless, in order to understand clearly the conservation of water, and the present questions which are being discussed in connection with it, it will be necessary for us to consider not alone

[1] Dr. Hayes in the address already referred to, said:

"The reform that is needed throughout the country as a whole must gain its motive power not from sporadic instances where true business methods prevail, or from the well-intentioned enthusiasm of the few, but from the well-informed intelligence of the many. The campaign for conservation must be one of education.

"There appears to be an unfortunate confusion in the minds of certain advocates of conservation. They have apparently confused conservation of natural resources with destruction of the trusts, and the mixture has resulted in pure demagoguery. . . . . Anyone who has studied conditions attending the development of mineral deposits must have been impressed by the fact that those deposits held by large companies are being developed

the technical aspect of the subject, but also some of the administrative, legal, and governmental problems which it involves.

One conclusion will probably be agreed to as a result of the preceding statement of the case, namely, that the problem of conservation is a twofold one. It is, in the first place, a technical problem, concerned with the methods of preventing waste. This part of the problem is largely engineering in character, dealing with methods of forestry, means of controlling and utilizing waters and preventing floods, methods of mining, of consuming fuel, and numberless strictly engineering questions. But this portion of the subject is, also, to some extent, legal and administrative in character, involving a consideration of the legislative and administrative measures necessary to put into operation and enforce the use of the technical methods which the engineer may find most suitable.

But the conservation problem is in the second place a question of the attitude of the public, or rather, of the individual man regarding the subject. It is largely a social problem. If we are to secure conservation, we must alter the public state of mind, we must make people thrifty and economical instead of extravagant and wasteful. It is an attribute of mind that we have to deal with,

and utilized with a view to prevention of waste, in accordance with the principles of conservation, to a much greater extent than are the deposits held by small companies or by individuals."

President Taft, in addressing the Third Conservation Congress in 1912, used the following language:

"I am bound to say that the time has come for a halt in general rhapsodies over conservation, making the word mean every known good in the world; for after the public attention has been roused, such appeals are of doubtful utility and do not direct the public to the specific course that the people should take, or have their legislators take, in order to promote the cause of conservation. The rousing of emotions on a subject like this, which has only dim outlines in the minds of the people affected, after a while ceases to be useful, and the whole movement will, if promoted on these lines, die for want of practical direction and of demonstration to the people that practical reforms are intended. . . . . I beg of you, therefore, in your deliberations and in your informal discussions, when men come forward to suggest evils that the promotion of conservation is to remedy that you invite them to point out the specific evils and the specific remedies; that you invite them to come down to details in order that their discussions may flow into channels that shall be useful rather than into periods that shall be eloquent and entertaining without shedding real light on the subject. The people should be shown exactly what is needed in order that they may make their representatives in Congress and the State Legislatures do their intelligent bidding."

and the fact that makes the problem so difficult to solve is that our present attitude as a people—the result of several centuries of plenty and of resources far in excess of our needs—is not the proper one. If the attitude of mind of the public toward this problem could be made the correct one, if the individual could be made thrifty, frugal, careful, thoughtful of the future, the problem of conservation, with the assistance of our engineers, lawyers, and administrators, would be solved.

All the preaching in the world, all the lectures, books, or magazine articles, will do little good until the problem is brought home, in all its seriousness, to the consciousness of the individual. The problem will be met not alone by newspaper articles, meetings of societies, or the reading of papers or publishing of books on conservation, but only as the individual man may be made to realize the situation and realize it keenly, and as he may be made conscious of the necessity for doing something, and of what he individually can do.

The real problem of conservation, then, appears to be to bring the situation, the necessity for action, and the remedies which may be adopted, to the consciousness of the individual. This, of course, is promoted, to a certain extent, by publicity, by holding meetings, by the writing of books and papers; but we all know how little such things affect the individual, unless something more powerful is brought in to reinforce them. Books and papers may be read and then put away or thrown into the waste basket, and the extravagance goes on as before. As Mark Twain said about the weather, "We all complain about the weather, but nothing is done."

"Wisdom," said Bulwer, "is an acquisition purchased in proportion to the disappointments which our own frailties have entailed upon us. For no one is taught by the sufferings of another. We must ourselves have felt the burning in order to shun the fire."

Shall we then, have to experience the pinch of actual want before we learn to provide for the future? Shall we see our natural resources squandered, our forests destroyed, our fuel supplies depleted, before we become conscious of our duties to generations

yet unborn? Or may we give evidence of the greater wisdom which is shown by the capacity to learn from the experience of others, so that by a study of history and by a serious consideration of our present conditions and tendencies we may avert disasters which are threatening, and which, unless guarded against, will inevitably come upon us?

CHAPTER II

THE CONSERVATION OF WATER, AND ITS RELATION TO THE CONSERVATION OF OTHER RESOURCES

The Water-Power Question

From the facts presented in the previous lecture, it is clear that there are three kinds of natural resources, in the conservation of which we are concerned.

1. Those resources which are not renewable, and in which utilization, even though without any waste, necessarily destroys the store available for future generations. Such are coal, oil, gas, phosphates, and other mineral deposits. Every particle of these resources which is utilized diminishes by so much what is left for our successors.

2. Those resources which are self-renewing, though at a comparatively slow rate, requiring considerable time for a complete renewal. In this class are included the forests, which may be entirely cut down, but which will ordinarily reproduce themselves in time. In the case of these resources, as in the case of those in the first class, any utilization diminishes the store available for our immediate successors, although distant future generations may be able to replace the loss of those resources which fall in the second class.

When a forest is cut down, it may renew itself in time with little loss. This may be the case if the land is level. On steep slopes, however, the destruction of the forest may leave the soil so unprotected that it is eroded by the rains, and if thin, may be entirely washed away. The world offers numerous instances of

countries, once densely wooded, but now almost entirely treeless. Such are Greece, parts of Spain and China, and many other regions. If proper methods of forestry are employed, however, timber may be cut like any other crop, and the forest maintained perpetually while yielding an annual return.

3. Water power falls in a different class from either of the above, and seems to occupy a place by itself, having several peculiar characteristics. In the first place, while resources of the first two kinds, if not utilized, are in general stored and *preserved* for the use of future generations, water power, if not utilized, is *constantly wasting with no good results to anybody*. Nevertheless, the water flows day by day and year by year, and, speaking generally, the power is perpetual. It is like a free gift offered by the Creator to man, which flows by him in a continuous stream and may be had for the taking.

Water power, however, presents a second peculiar characteristic in that its conservation is a double conservation. The utilization of water power for a purpose for which steam power, or some other form requiring the use of fuel, would be employed, is not only the utilization of a freely given resource which would otherwise be wasted, but it involves the saving of a corresponding amount of one of the non-renewable or slowly renewable resources. The use of water power to furnish motive power for street or steam railways, or for lighting, saves an equivalent amount of coal. The conservation of water power, therefore, is a double conservation, and it would seem, therefore, inasmuch as it involves the conservation of a non-renewable resource of a strictly limited supply, that its conservation is of greater importance than that of any other of our material resources.

But there is a third peculiarity of water power, which renders its conservation a triple conservation. This power arises from the water flowing in a stream, but this stream affords other uses, as for irrigation, water supply, and navigation. For the proper conservation of the water in a stream, all these four uses must be considered. Its development for one purpose must, so far as

possible, be consistent with its development for the others. All should be developed so as to be productive of the greatest total good. The four uses above referred to are inseparably connected; particularly so are the two uses of a river for water power and for purposes of navigation, in cases where both of these uses are economically practicable.

The development of water power requires that the water shall be conducted to a power house, and there experience a concentrated fall, passing through the wheels and causing them to revolve. The development of water power upon a river, therefore, requires, in general, the construction of a dam, to control the flow and afford storage, a canal leading from one end of the dam to the power house, and a tailrace leading from below the wheels to the main stream at a greater or less distance below the dam. There are thus two typical forms of water-power development: (1) a comparatively low dam at or near the head of the falls or rapids, with a comparatively long canal leading to a power house located near the foot of the falls, and with a short tailrace; or else a power house near the dam, or at some intermediate point, with a correspondingly longer tailrace; (2) a comparatively high dam near the foot of the fall, with the power house located at one end of the dam, and a short tailrace. These are typical forms of development on large or moderate-sized streams. Modifications occur, varying largely with reference to the storage desired. Thus, there may be a high dam at the head of a fall, simply to form a storage reservoir. Again, particularly on small streams, there may be a long pipe line or flume, perhaps miles in length, leading from the dam to the power house. On navigable rivers, however, the forms of development are generally of the typical forms.

Now the point to be observed is that the development of water power *aids in rendering the stream navigable.*

We are all aware of the fact that rivers, except the very largest, have the navigation obstructed at intervals by falls, rapids, or shoals. Shoals may be dredged, or training dikes may be constructed which will cause the current to scour them out, and deposit

the material in less objectionable locations. Falls and rapids, however, can only be surmounted by the construction of a dam, with a lock or locks in connection with it, generally at one end, by which vessels are lifted or lowered between the two water levels above and below the dam; or with a canal leading from one end of the dam to navigable water below the rapids, having a lock or locks at some suitable point, with a lift sufficient to overcome the elevation between the two navigable water levels.

The construction of a navigation dam, therefore, affords an opportunity for the development of water power, using the surplus water above the needs of navigation; and conversely, the development of a water-power dam, if properly located, aids in improving navigation, for all that is necessary to render the river navigable is to build a lock or locks with suitable approaches. The development of water power, therefore, not only conserves one of the non-renewable resources, but also conserves or develops navigation.

These differences between water power and the other natural resources lead necessarily to the conclusion that the fundamental principle to be kept in mind in the conservation of water power is one diametrically opposite to that which should be kept in mind in the consideration of the others. In conserving the non-renewable or slowly renewable resources, restriction, economy, frugality, even parsimony, should be the governing principle. Waste should be eliminated to the utmost degree possible, and use should be curtailed so far as this can reasonably be done. We all agree, I presume, that conservation means use, but such use should be with a minimum of waste, with a maximum efficiency, and with due regard to the future. The avoidance of waste and the maintenance of efficiency are not the only requirements. Use for purposes of luxury or ostentation or for any unnecessary purpose which will injure coming generations, is to be deprecated. Our attitude toward future generations, however, is not to be considered as debarring us from making a wise and economical use of our resources, for each generation must solve its own problems, and new resources are continually being discovered.

To repeat, therefore, in conserving the non-renewable and slowly renewable resources, the avoidance of waste, the maximum economy, and a frugal and economical use, should be the guiding principles.

In the case of water power, however, a point of view almost the opposite of this—within proper limits—would seem to be the true one. Here, instead of restriction, the greatest possible use should be encouraged. That use should not be wasteful; nor is it consistent with sound principles of public and individual economy, to have it used for extravagent purposes. But *any use* is better than *no use at all,* because every use conserves a non-renewable resource and is also, or may also be made, an aid to navigation. In the one case, therefore, our guiding principle is restriction; in the other case, it is the encouragement of the greatest possible development.

These principles should distinctly affect our attitude toward water-power enterprises. There is no form of individual enterprise more worthy of encouragement, or which in the interest of true conservation should be made more tempting to the investment of capital, than the development of water powers. Our laws and regulations governing the development of water power should be made so that a liberal rate of return may reasonably be anticipated. If any one disagrees with this proposition, he must disagree with it, not as a conservationist, but from some other point of view.

There seems to be an impression among some people that, since water runs down hill, water power can be developed at very little cost and with very little risk. Such an impression is, in most cases, very far from the truth. There is, of course, a great difference in local topographical conditions. Sometimes a water power may be developed at slight expense, but in many cases, if not in most cases, and especially in the case of the largest water powers, a very large investment of capital is necessary for their utilization—a much greater investment per horse power, in general, than is required for a steam plant. Moreover, the risks attending this investment are serious. Floods may destroy the works during

construction, unforeseen contingencies of various other kinds may largely increase the cost, the flow of the stream is, to a considerable extent, a matter, not of fact, but of conjecture, and may not prove to be what was anticipated, and this flow may be injuriously affected by the operations of man or the agencies of nature acting above the power site. The history of water-power enterprise is not by any means a history of unbroken successful effort. It is strewn with wrecks, and there is no industrial field in which a sound engineering preliminary judgment, as well as careful construction and economical financing, would seem to be more necessary.

As stated in the last chapter, conservation in itself, and as originally interpreted, would seem to be a movement in which all intelligent and public-spirited men might properly join; but the significance of the term has in some cases been extended to cover so many economic questions, so many government policies, some of which are open to grave doubt, and upon which serious differences of opinion may exist between the best informed authorities, that unless these questions are excluded, the conservation movement will appear to many to be one with which they cannot coöperate. Especially with reference to water power, that resource the conservation of which not only conserves itself, but conserves another, and also may be made a means of improving navigation, and whose conservation is, therefore, of the utmost importance, is it necessary that above all things *use* should be encouraged.

It may here be remarked, that the improvement of the navigation of a river is not strictly speaking the conservation of a resource, however desirable from an economic point of view. The improvement of a river for navigation would seem to be no more conservation than the building of a railroad across the dry land. Either one is a simple transportation project requiring the expenditure of money. In the one case, the river is there and it offers an opportunity, if the shoals are removed and the falls overcome, for the development—or we may say, the construction of a line of river navigation. In the other case, the dry land is there and it offers an opportunity, by the expenditure of money, for the

construction of a line of railroad. The presence of the dry land in the one case, which is the only suitable medium for a railroad, or for land transportation, is exactly analogous to the presence of the river in the other case, which is the only suitable medium for water transportation. The main distinction is that in the case of a railroad a track must be laid to carry the vehicles, while in the case of a river no track is needed. We must, therefore, not confuse the development of navigation with the conservation of water power. Where a river falls in passing over a rapid, the same amount of energy is exerted as if the water passed through turbine wheels and operated a railroad. In the one case the energy is wasted, while in the other it is utilized. The utilization of the water power is the conservation of a resource that would otherwise be wasted. The development of navigation is not conservation in just the same sense.

In view, therefore, of the great importance of encouraging in every legitimate and proper way and to the greatest legitimate and proper extent the development of water power, it remains to consider the methods of its use, and their relations to public and private interests.

The assertion has been made without qualification that "any use is better than no use at all," because the writer is first and foremost a conservationist in the original sense, and strongly impressed with the necessity of avoiding waste. To his mind, there is no evil which can arise in the future from unrestricted private or corporate control which cannot be legally remedied if it should prove dangerous to the community, or which is as serious as the loss of the multiple conservation which the development of water power affords. There are many, however, who emphatically dissent from this statement, and who think that no development at all is much better than a development without due regard to the rights of the public—that is to say, to what they conceive to be the rights of the public. They conceive that there is great danger to be feared from a monopoly of water power, and that its unrestrained and unsupervised development may result, in the distant future, when

our supplies of coal and other fuel will be exhausted and falling water will become the sole source of power, in placing us all at the mercy of those who control this source. The reasons for this belief will be discussed later, but they may be simply stated here. They are three, viz.: (1) If the use of water power is by a public-service corporation, that corporation will always be subject to public control; (2) that if the use is by a private individual, any serious danger which might arise from that use would still be within the reach of law; (3) that if the development of water power in the future is accompanied, in cases where such a restriction is legally possible, by a definite provision authorizing such taking by the public at any time after a reasonable period, with full compensation, all danger to the public will surely be provided against.

Be this as it may, the principal questions which have arisen regarding the development of water powers have reference to the kind and degree of control which should be exercised by the Federal and state governments. Let us therefore outline the situation, in order that we may clearly understand the present status of the water-power discussion. This outline will involve the statement of some legal principles.

Riparian Rights

The discussion hinges upon the rights which a riparian owner—that is, the owner of the banks of a stream—has in the water, and the control which the state or the nation possesses over it. Now it is a well-established principle that the riparian owner has no ownership in the *water,* but only possesses the right to use it in a reasonable way, and to use it subject to any prior rights of the state. The American law is stated by Kent in his Commentaries as follows:

"Every proprietor of lands on the banks of a river has naturally an equal right to the use of the water which flows in the stream adjacent to his lands, as it was wont to run (currere solebat), without diminution *or alteration.* No proprietor has a right to use the water, to the prejudice of other proprietors, above or below him, unless he has a prior right to divert it, or a title to some exclusive enjoyment. He has no property in

the water itself, but a simple usufruct while it passes along. *Aqua currit et debet currere ut currere solebat* is the language of the law. . . . . The owner must so use and apply the water as to work no material injury or annoyance to his neighbor below him, who has an equal right to the subsequent use of the same water; nor can he, by dams or any obstruction, cause the water injuriously to overflow the grounds and springs of his neighbor above him. Streams of water are intended for the use and comfort of man; and it would be unreasonable and contrary to the universal sense of mankind to debar every riparian proprietor from the application of the water to domestic, agricultural and manufacturing purposes, provided the use of it be made under the limitations which have been mentioned; and there will, no doubt, inevitably be, in the exercise of a perfect right to the use of the water, some evaporation, and decrease of it, and some variation in the weight and velocity of the current. But *de minimis non curat lex*, and a right of action by the proprietor below would not necessarily follow from such consequences, but would depend upon the nature and extent of the complaint or injury, and the manner of using the water. All that the law requires of the party, by or over whose land a stream passes, is that he should use the water in a reasonable manner, and so as not to destroy, or render useless, or materially diminish, or affect the application of the water by the proprietors above or below on the stream. . . . . The just and equitable principle is given in the Roman law: *Sic enim debere quem meliorem agrum suum facere ne vicini deteriorem faciat.*"

The right of a legislature, however, to authorize a diversion of the water of a stream, for some public use (as, for instance, for purposes of water supply), as against the natural rights of riparian owners, has in a few states been upheld.

The riparian owner, therefore, does not own the water, but simply has the right to use it. With regard to ownership of the bed of the stream, under the common law of England, a distinction was made between ownership on tidal and on non-tidal waters. In the case of the latter, the riparian owner owned the bed to the center of the stream, and an exclusive right to use the water flowing over that bed, while in the case of tidal waters, he owned the land only to high-water mark, with such right to use the bed as would enable him to make a proper use of the water.

In this country ownership of the bed is determined by the laws of the respective states. There is a private ownership of the bed in the states of Connecticut, Delaware, Georgia, Illinois, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey, New York, Ohio, South Carolina, and Wisconsin, and public ownership in the other states.

Further, rivers are divided into navigable and non-navigable streams. Under the common law, only those streams are navigable in which, and as far as, the tide ebbs and flows. As to the former, the riparian owner has no proprietary interest in the bed or the waters, but he has a right of usufruct subject only to the limited paramount rights of the public. The owner in such cases is the sovereign state which owns the bed, holding the same in its sovereign capacity as a sort of trustee for the public, and which in the same capacity controls the use of the waters and has therein a paramount right and interest principally for the purpose of navigation, but also for some other public uses. But the common law classification into navigable and non-navigable streams, has to some degree been modified in this country and replaced by a division into "public" and "private" waters. The question of navigability is one of fact, and a navigable or public stream includes not only those which are in fact or theory navigable, but also those adapted for floating logs, for boating, or for any public use; and it has sometimes been asserted that this class includes all streams which are directly tributary to the navigable waters of the United States, since the control and regulation of remote sources may be necessary for the preservation of navigation on the lower reaches. The classification is, therefore, becoming confused, and it is claimed by some that every stream, however small, is to be classed as a navigable, or, at least, as a public water.

The National Waterways Commission, in its final report (1912), asserts: "There can be no doubt . . . . that the authority of Congress reaches to the remotest sources in the mountains of every navigable stream. It could hardly be said that any stream, no matter how small, which contributed its waters to a navigable

water-course did not, at least to some extent, affect its navigable capacity." This latter is the ultra-Federal-control view, which is not only doubtful, but is inconsistent with the respective rights of the individual and of the public as established by the courts in riparian-law states. Such view is absurd, for the same process of reasoning upon which it is based would lead to the preposterous result that the Federal Government could assert control of all the watersheds of the country and of their use—that is, to every acre of land and to the use of every acre of land in the United States—and all this on the pretext of exercising the limited power of the Congress "to regulate commerce" between the states.

The law of riparian rights, by which every riparian owner has a right only to the reasonable use of the water as it flows past his land, and must transmit it practically unaltered in quantity, and undefiled in quality, to similar owners below him on the stream, is not in force in certain western states where the requirements of irrigation have made necessary the abstraction of large quantities of water from the streams, only a fraction of which returns to them, and perhaps only returns at some distance below, depending upon the flow of the underground water. In these states the "law of prior appropriation" prevails, and any riparian owner has a right only to the water which flows after the quantities previously appropriated by owners farther up the stream have been abstracted from its flow. "Priority of occupation or appropriation gives rights superior to those of the riparian owner in the beneficial use of the water and beds of streams." A riparian owner who desires to use a certain quantity of water must file with the proper state tribunal a claim for that amount and must make provision for using it; if his claim is allowed, as it generally will be if there is water enough to satisfy it after all prior claims are satisfied, he is entitled to that quantity, as against any subsequent claims filed by riparian owners either below or above him.[1]

Still another law prevails in California, Kansas, Montana,

[1] The law of prior appropriation, known as the "Colorado doctrine," is in force in Arizona, Colorado, Idaho, New Mexico, Nevada, Utah, and Wyoming.

Nebraska, Oklahoma, Oregon, South Dakota, Texas, and Washington. In these states the law of riparian rights holds, modified only by appropriation rights vested before the lands in question passed to private ownership.

But whatever quantity of water a riparian owner may be entitled to use, and whether the title to the bed is held by him or by the state, it has been determined by the courts without question, for all streams: "That, subject to the public uses, if it be a public stream, and without such restriction, if it be a private stream, the riparian owner has a natural, proprietary right, by reason of his ownership of riparian land, to the reasonable use of the waters as they flow past his land; and for this purpose, subject to protective regulations made by the holder of the paramount title, that is, the State, the individual riparian owner may go upon the bed of the stream and construct and maintain such structures as may be necessary or desirable in order to give to him the full use and benefit of the waters naturally flowing past his land."[2] The power of the state is simply "a holding in trust, as a sovereign, for the specific purpose of protecting a public use, to wit, navigation and certain allied uses," as for instance, fishing, bathing, cutting ice, or water supply; and the right of the individual state is subject only to the paramount power of control of the Federal Government. Thus the Supreme Court of Minnesota has held:

"In the recently decided case of Morrill v. St. Anthony Falls Water Power Co., ante, (p. 222), we had occasion to consider the question of the rights of riparian proprietors upon the Mississippi River. The general rule arrived at was that a riparian owner may use the waters of a navigable stream adjoining his land, for any purpose, for his own advantage, so long as he does not impede navigation, and in the absence of any counterclaim by the State or the United States. As the riparian owner has this right to the use of the water, he has a right to enjoy it and make it available; otherwise, his right would be a worthless abstraction. He may, therefore, subject to the limitations of the general rule before stated, use the bed of the stream, if necessary or convenient to the enjoyment of his right to the use of the

[2] Rome G. Brown. Points and Lines on Lakes and Streams, p. 6.

water. He may erect dams there, and such other structures as will promote and facilitate the enjoyment of this right. For these purposes the riparian proprietor may properly be said to have, if not an interest, certainly a right, in the bed of the stream itself." (State v. Minneapolis Mill Co., 26 Minn. 229, 231.)

In 1909 the Supreme Court of Minnesota, referring to a dam built and maintained by a riparian owner on the Snake River, after holding that that river was a navigable stream, said, with reference to the riparian owner's rights to build and maintain a dam:

"So far as the State was concerned, the owner of the bank was at liberty to construct and maintain the dam so long as it did not constitute an interference with the navigable rights of the public in the stream, and the State had no authority to authorize the construction of a dam across the river without providing for compensation to all parties who might be damaged thereby. It is the well-settled law of this country that the legislature cannot authorize the flooding of lands without compensation to the owner, and the right to flood land by extending a dam across such streams may be acquired by adverse possession for the statutory period. A riparian owner has the right, without license, to construct a dam which does not obstruct or interfere with the navigation of the stream. This is a right which is appurtenant to the ownership of the bank." (Simons v. Munch, 107 Minn., 370, 372.)

Apparently, then, in Minnesota:

"The riparian owner has a right to build and to maintain his water-power dam, without any franchise or license from the State; because his right to do so is 'appurtenant to the ownership of the bank.' He has this absolute right with the only limitation that his structure shall not interfere with navigation. That right belongs to him entirely by reason of the fact of his riparian ownership. He is not obligated to get a license from the State even though the obligation to obtain a license is imposed by statute. More than that, as shown by the case next to last above, the State itself has not such an interest in the bed or waters of a stream that it can build a dam, or authorize the construction of a power dam in the river adjacent to the land of a riparian owner, or by any such structure flood or injure

the land of a riparian owner, 'without providing for compensation to all parties who might be injured thereby.' "[3]

As a general rule, then, riparian ownership carries with it the right to a reasonable use of the water in the stream for the development of power. The water, if diverted from the stream, must be returned to it above the land of the owner next below. The user can use only the natural flow. He must not only build the works so as to further the development of navigation, but he cannot use the water in any way which will interfere with the needs of navigation, nor can he hold back the flow at one time and allow a greatly increased flow at another, if such a procedure would injure other riparian owners below.[4] Nor can he set the water back upon the

[3] Rome G. Brown. Limitations of Federal Control of Water Powers, p. 24.

[4] On small streams, and sometimes on large ones, it is common for a water-power plant, especially in dry seasons, to draw down the water in the pond above its dam, during running hours; so that when the wheels are stopped at night no water at all passes the dam until the pond fills up. If the stream is very low and the pond large enough, the pond may not fill up until work is resumed in the morning. Obviously, it would not be desirable to draw so much from the pond that it would not fill during the night, for in such case the plant would be using each day more than the daily flow of the stream, and the pond would be gradually depleted, and the head available—and therefore the power—would be reduced. To draw down the pond so that no water would waste at night—that is, so that it would just fill up by morning—would utilize the entire daily flow during working hours, and would be the most economical use of the water, provided it did not involve too great a reduction of head. Such a procedure, however, might be a serious injury to mills farther down the stream, which, on starting in the morning, would have no water except what they might draw from their own ponds, until the flow from the plant above should reach them. Such a condition might not be a proper use of the stream, and might lead to disputes and law suits. On the other hand, such a use might be most advantageous to the mills below, if they were not too far below; for it would enable them, like the mills above, to use the entire daily flow during working hours,—in other words, to take advantage of the large pond of the mill above as if it were their own.

As between owners of different developments on the same stream, the methods of operation allowable are determined by the legal rule of reasonable use, under which one owner must exercise his rights with reasonable regard for the others and must cause as little damage as is reasonably consistent with his proper and reasonable use of the stream. Whether in any particular case he does so is a question of fact, dependent upon all the circumstances. He cannot by wasteful or out-of-date methods cause injury which otherwise would be avoided. The best statement of the application of this rule of reasonable use is made by the Minnesota court. (Red River Roller Mills v. Wright, 30 Minn., 253):

In determining what is a reasonable use, regard must be had to the subject-matter of the use; the occasion and manner of its application; the object, extent, necessity, and duration of the use; the nature and size of the stream; the kind of business to which it

owner above, unless he purchase the right to do so (so-called flowage rights). In short, having no ownership in the water but only the right to use the natural flow, he must do nothing which will interfere with the interests of navigation, or with the rights of other riparian owners, above or below. Opposite riparian owners have each a right to use half the flow, independent of the comparative quantity which flows upon either side of the so-called thread of the stream. The right of the riparian owner to the use of the water is, therefore, a "private, vested property right, subject only to whatever paramount right the Federal Government or the State Governments, or both, may have in the waters and beds of such streams." It is important, therefore, to understand just what those paramount rights are.

Powers of Government Over Navigable Streams

The question of government control arises in two rather distinct cases:

(a) When water powers are developed at dams constructed by the Federal Government for purposes of navigation or are sought to be used or developed by private riparian owners on navigable streams; (b) When water powers are sought to be developed on public lands, under a grant from the Government.

(*a*) *Water Power on Navigable Streams*

If the Government builds dams to render a river navigable, the surplus water power is a by-product of the navigation works. If it allows others to build dams for water-power purposes, the improvement of navigation is a by-product of the power development.

is subservient; the importance and necessity of the use claimed by one party, and the extent of the injury to the other party; the state of improvement of the country in regard to mills and machinery, and the use of water as a propelling power; the general and established usages of the country in similar cases; and all the other and ever-varying circumstances of each particular case, bearing upon the question of the fitness and propriety of the use of the water under consideration.

Under our form of government, certain specified powers have, by the express terms of the Constitution, been delegated to the Federal Government, and Article 10 provides that

"The powers not delegated to the United States by the Constitution, nor prohibited by it to the states, are reserved to the states, respectively, or to the people."

In view of this, there seems no reason to doubt the correctness of the following principles, as stated by Mr. Brown, which have been established by decisions of the Supreme Court of the United States:

"1. That the authority for Federal control of fresh navigable streams and waters in the United States, which at the same time defines and limits such control, arises solely from that power which has been expressly reserved to the United States by the Federal Constitution—the power to regulate commerce between the several States and foreign nations.

"2. That this power of control was expressly reserved to the Federal Government by the States originally adopting the Federal Constitution, and by all States since admitted under that Constitution; and, subject to this specific power so reserved in the Federal Government, there has passed over to these States, upon their entry into the Union, all powers and interest, whether of ownership or of control, now or formerly belonging to the Federal Government, in the beds and waters of such navigable streams, and the Federal Government has since retained, and still retains, either as against any claim by a State or by an individual riparian, or both, only the specific paramount right of control for the specific and limited purpose of commerce—that is, of navigation. Moreover, this Federal power of control is purely a sovereign power of control for a specified public use, and does not include, and cannot be extended to, any element of a proprietary right or interest.

"3. That, subject to this purely sovereign right of control of navigation, all right, title, and interest, sovereign and proprietary, belongs to the States or to individual riparian owners, or both; and it is not within the Federal authority or power, either judicial or legislative, to fix or determine, as between a State and an individual owner, the limitations between State and individual ownership or control of water powers. The rights and obligations, as between a State and an individual owner, are

fixed by the law of property as established by the decisions of the State supreme court in the State in question. This law of property, as so fixed in any State, is, as to streams in that State, binding upon the Federal Government and its Supreme Court."[5]

From all the foregoing it therefore appears:

"1. The only power of control belonging to the Federal Government is under the commerce clause of the Constitution, to regulate navigable streams as highways—that is, for the purpose of navigation—and this power excludes every proprietary element, and is purely a limited sovereign power of control for a specified purpose.

"2. All other rights, sovereign or proprietary, have passed to the States or to individual owners. But the State has no proprietary interest in the bed or the waters. Its interest is a holding as a sovereign, in trust, for a specified purpose, primarily for navigation.

"3. All proprietary elements of title or of rights of user of the bed and waters belong to the riparian owner as a part of the riparian estate; they are vested property rights, and subject only to the exercise of the limited power of sovereign control, reserved to the State and the Federal Government for a specific purpose—that is, to use and regulate the use of the river for navigation. These private rights of the riparian owner include the right to all the beneficial use of the natural water powers in the stream opposite his riparian land, including the right to develop and operate and to enjoy the revenues from such power.

"4. It matters not that by one State law the riparian fee has been limited to high-water mark, or has been by another State law extended to the center of the stream. The paramount right of the sovereign being limited to a specific use and purpose, and all of the rights and beneficial use belonging to the riparian, the vested property rights of the riparian are the same in all cases.

"5. Nor are the riparian rights any different in the case of a stream which happens to be a boundary stream, whether such boundary is international or State."[6]

With regard to the control of navigation and the control of the public domain, the power of Congress is paramount in each

[5] Rome G. Brown. Limitations of Federal Control of Water Powers, p. 10.
[6] Rome G. Brown. Limitations of Federal Control of Water Powers, pp. 35-36.

case. Justice Brewer, in the case of The United States v. Rio Grande Co., 174 U. S., 690, 703, declares:

"Although this power of changing the common-law rule as to streams within its dominion undoubtedly belongs to each State, yet two limitations must be recognized; First, that in the absence of specific authority from Congress a State cannot by its legislation destroy the right of the United States as the owner of lands bordering on a stream to the continued flow of its waters, so far at least as may be necessary for the beneficial uses of the Government property. Second, that it is limited by the superior power of the General Government to secure the uninterrupted navigability of all navigable streams within the limits of the United States. In other words, the jurisdiction of the General Government over interstate commerce and its natural highways vests in that Government the right to take all needed measures to preserve the navigability of the navigable watercourses of the country even against any State action."

CHAPTER III

WATER POWER AT GOVERNMENT DAMS ON NAVIGABLE STREAMS

In the case of water powers on navigable streams, the dam may be constructed by the Federal Government or by private parties. If constructed by the Government, the case is comparatively simple, and there is little discussion or difference of opinion regarding it. In such cases the Government generally purchases or condemns the riparian lands or rights necessary for flowage, abutments, locks, and other works, and thus becomes the owner of the water power. It has no power to construct a dam primarily for water power, except for its own use. But when it becomes the owner of water power incidentally created by a navigation improvement, it may sell or lease the surplus power above the requirements of navigation upon any terms it sees fit to make. The right to do this does not rest upon the fact that the water power is incidental to a navigation improvement, nor upon the government control of the river for navigation, but simply upon its ownership of the water power, as owner of the riparian rights. The nature and extent of its powers will depend upon the nature and extent of its riparian ownership. It may clearly condemn or acquire by purchase such riparian rights as are reasonably necessary for the construction and operation of the dam; whether it can do more is a disputed point of law.

Having constructed the dam, if water power is developed in excess of the requirements of the Government, the question arises as to the rights of the Government in this surplus power. To quote Mr. Rome G. Brown: "The mere fact that the surplus water power is developed by the navigation dam does not change the proprietary

right to such water power from the riparian to the sovereign. The water power is not *created* by the dam. It was created by nature when the quantity of flow and the head and fall were made a natural incident to the riparian estate. . . . . Its incidental development through a construction by one who is not its owner does not change its ownership any more than would the fetching to market by one man of goods owned by another. . . . . The reasonable necessity for navigation purposes marks the limit of the rights which the Government has or can acquire against the will of the riparian, or as purely paramount rights. . . . . Without acquirement by the Government with compensation, the surplus water power at navigation dams belongs to the riparian; meaning by surplus water power all water power and all use of the water, not reasonably necessary to the operation of the dam as a navigation facility."[1]

Farnham, in "Water and Water Rights," Vol. 1, p. 137, says:

"When it is said that the right of the public is paramount, nothing more is meant than that the riparian owner can do nothing to close the highway. He cannot divert the water from the stream, nor consume it so as to defeat the possibility of navigation; nor can he place insuperable obstructions in the stream. Conversely, the right of public navigation is not such as to destroy the rights of the riparian owner. The right cannot be exercised to the unnecessary or wanton destruction of private rights, or so as to deprive riparian proprietors of the use of the stream for legitimate purposes which will not unreasonably interfere with the right of navigation. The navigation right is the right of passage merely, and so long as that right is preserved without unreasonable impairment the riparian owner may bridge the stream, or use water therefrom or even throw a dam across it if he makes provision for the right of passage. The rights may be said to be reciprocal, each modifying the other, each to be used so as not to interfere unreasonably with the other right."

If, however, the riparian owner uses the surplus power by making use of the dam instead of by a development entirely independent of it, it is obviously fair and proper, regardless of his technical legal rights, whatever they may be, that he should pay the

[1] Rome G. Brown. The Conservation of Water Powers.

Government fully for such advantages as he receives by reason of his use of the Government dam.

The sub-committee of the Senate Committee on the Judiciary reported in 1912[2] as follows regarding this phase of the question:

"If, for the purpose of improving the navigability of a stream carrying interstate commerce, the Federal Government constructs and maintains a dam, with locks and gates, on its riparian lands or on lands in which it has acquired an easement for such construction and maintenance, the Government has the undoubted right to establish and maintain, in connection with such dam, an electric power plant for the purpose of furnishing motive power to operate such locks and gates. And the Federal Government has the right to sell, lease, or rent, for compensation, any surplus power that may arise from and be an incident to such an improvement of navigation. (Kaukauna Water Power Co. v. Green Bay & Mississippi Canal Co., 142 U. S., 254.)

"This case relates to the construction of a dam for purposes of navigation and the use of the surplus water incident thereto. In 1846 Congress made a grant of land to the State of Wisconsin for the improvement of the navigation of the Fox and Wisconsin Rivers. The State assumed the grant and the work. In the act of assumption it was provided among other things:

" 'Whenever a water power shall be created by reason of any dam erected or other improvements made on any of said rivers, such water power shall belong to the State, subject to the future action of the legislature.'

"The court, in passing upon the effect of this reservation to the State, declares:

" 'But if, in the erection of a public dam for a recognized purpose, there is necessarily produced a surplus of water, which may properly be used for manufacturing purposes, there is no sound reason why the State may not retain to itself the power of controlling or disposing of such water as an incident of its right to make such improvement. Indeed, it might become very necessary to retain the disposition of it in its own hands, in order to preserve at all times a sufficient supply for the purposes of navigation. If the riparian owners were allowed to tap the pond at different places and draw off the water for their own use, serious consequences might arise, not only in connection with the public demand for the purposes of

[2] Power of the Federal Government over navigable and non-navigable streams, 62d Congress, 2d Session (1912), pp. 11-12.

navigation, but between the riparian owners themselves as to the proper proportion each was entitled to draw—controversies which could only be avoided by the State reserving to itself the immediate supervision of the entire supply. As there is no need of the surplus running to waste, there was nothing objectionable in permitting the State to let out the use of it to private parties, and thus reimburse itself for the expenses of the improvement.'

"The court, after further comments and the citation of three Ohio cases, adds:

" 'The true distinction seems to be between cases where the dam is erected for the express or apparent purpose of obtaining a water power to lease to private individuals, or where in building a dam for a public improvement a wholly unnecessary excess of water is created, and cases where the surplus is a mere incident to the public improvement and a reasonable provision for securing an adequate supply of water at all times for such improvement.'

"In general, it may be said that whenever the Federal Government is engaged in improving the navigability of a stream on which there is interstate commerce, if by reason and in consequence of such improvement, and as an incident thereto, surplus power is created, the Federal Government has the right to lease or sell such power on such terms and for such compensation as it may deem just.

"Congress, as in the case of Wisconsin, Ohio, and other States, can delegate the work of improving portions of navigable rivers to States, municipalities, private corporations, and individuals, and if in connection with such improvement and as an incident thereto surplus power is created, Congress may authorize those to whom the right of improvement is delegated to lease and secure compensation for such surplus power. In such cases those to whom the power of making the improvement is delegated are the agents for and stand in place of the Federal Government. *But unless such work of improvement is primarily made for the purpose of improving the navigation on streams or other waters carrying interstate commerce, the Federal Government could not confer the power to obtain compensation for the use of the water.*"

Congress has in a number of instances provided for the use of surplus water power at dams on navigable streams. In some of the cases the improvement has been made by the United States, in

other cases by private parties. Senate Document 57, 62d Congress, 1st Session, contains a list of such cases, and is appended hereto, with one case added, which has been granted since the document was printed, as given in Exhibit B of the report of sub-committee of the Senate Judiciary Committee.

Nevertheless, while, in the interests of conservation, it is eminently desirable to encourage to the utmost the development of such surplus power at government dams, the total amount yet utilized is small, and such use is not very attractive. General Mackenzie, Chief of Engineers, U. S. A., in an opinion submitted January 16, 1905, to the Secretary of War, used the following language regarding this matter:

"To legislation authorizing the Secretary of War to lease water power created by works constructed by the Government I see no special objection, but I know of no demand for it in the public interest.

"The right of Congress to regulate, control, and dispose of such water power is believed to be unquestionable, inasmuch as the power constitutes a valuable property created at the public expense, and when utilized by private persons or corporations should be paid for. Whether a general policy of this kind should be adopted, however, is a question that should be very carefully considered. Locks and dams are built and operated for the purpose of facilitating navigation and commerce, and nothing should be permitted that would tend to impair their usefulness or interfere with their operation for this purpose. Partnerships or quasi partnerships between the Government and private persons or corporations have not been generally favored in the past, as experience has shown that they are apt to be attended by many annoying complications. I do not believe that sufficient revenue would be derived from renting water power to compensate for the trouble and inconvenience that might ensue from the adoption of such a policy. Congress has heretofore authorized the renting of land and water power at the locks and dams on the Muskingum River and Green and Barren Rivers; but it is understood that this was done for the reason that at the time these works came into the possession of the United States, there were in existence a number of leases granted by the former owners which constituted an easement on the property, some of which leases had many years to run. In cases where a new privilege is asked it has been customary to invite public competi-

tion, setting a minimum price; but no active competition has been developed. There is also one company which used land and water power at Lock No. 4 on the Kentucky River, under a lease granted by the State of Kentucky, which expires in 1977. During the past fiscal year there were in existence 27 different leases and the total gross revenue received by the Government was only $4,500, and in a number of instances in the past the Government has been compelled to resort to suits against lessees to collect the rental. While many applications would be made for permission to use Government water power if no charge was made therefor, it is believed that few leases would be made, and then only at favored localities, if adequate compensation were exacted. In the river and harbor act of June 13, 1902, Congress authorized the leasing of water power at the locks and dams on the Cumberland River. Before the enactment of this law a number of persons appeared to be desirous of using water power in this river, but although the law has been in existence more than two years not a single lease has been applied for or granted."

While it seems equitable and fair that private parties should pay for power which they are permitted to use at Government dams, it is clear from the foregoing that the Federal Government must, in order to control the interests of navigation, retain control of all surplus power and regulate its use, and that under these conditions there is little demand by private parties for the right to use such power. Furthermore, that the legal right of the Federal Government to the water power incidentally created at navigation dams built by it is open to some question, will become evident by consideration of the following views of the courts, and the expressions of eminent lawyers:

The Supreme Court has held that:

"Each individual State of the Union has control of the waters of navigable streams and lakes within its borders, the right and interest of the United States in such waters being only that their navigability be preserved for interstate commerce. The title is in each State and the use of the water is a matter of State regulation. (Pollard v. Hagan, 3 How., 212; Shively v. Bowlby, 152 U. S., 1.)" See also St. Anthony Falls Water Power Co. v. Water Commis., 168 U. S., 358.

Senator Borah, in a speech, June 10, 1910, on "Conservation of Natural Resources," said:

"The water and the streams of the States belong to and are subject to the control of the States and are not subject to the control of the National Government except in so far as it is necessary to control them in the regulation of commerce. . . . .

"The National Government cannot, under the guise of regulating commerce, effect objects and purposes not authorized by the Constitution of the United States. Justice Marshall said:

" 'Should Congress, under the pretext of executing its powers, pass laws for the accomplishment of objects not intrusted to the Government, it would become the painful duty of this tribunal, should a case requiring such a decision come before it, to say that such an act was not the law of the land.' "

The Secretary of War (Mr. Stimson), in his report dated December 2, 1912, takes the opposite view, and says (p. 29):

"That the Federal Government has the right to construct dams for the improvement of navigation and a proprietary interest in the water power developed by the structures so built is settled beyond question. (Green Bay Canal Co. v. Patten Paper Co., 172 U. S., 58; 173 U. S., 190; 29 Op. Atty. Gen., 173, 185.) It seems equally clear that what the Government may do of itself it may do by an agent, and may, therefore, utilize and adopt for the purposes of navigation a dam allowed to be built by private capital upon fair and proper terms between the two interests as to the value of the water power thus created. Applications are being constantly made by private parties for permission to build dams in such rivers for the purpose of developing water power. These applications usually take the form of bills granting the consent of the National Government to the construction of such a dam, the construction being made subject to the terms of the General Dam Act (act of June 23, 1910, 36 Stat., 593). An examination of this act has convinced me that it is insufficient to adequately protect the interests of the Federal Government in the situation which I have just described, and that it does not permit the Federal Government, as a condition of its permit, to require that a part of the value of the water power thus created shall, under proper circumstances, be applied to the further general improvement of navigation in the stream."

Regarding these remarks of the Secretary, however, Senator Culberson says:

"To sustain the right of the Federal Government to dispose of surplus power and water incidentally created in the course of improving the navigability of a stream, reliance is placed upon two decisions of the Supreme Court; i.e., in the cases of Kaukauna Water Power Co. v. Green Bay & Mississippi Canal Co. (142 U. S., 254), and Green Bay, etc., Co. v. Patten Co. (172 U. S., 58).

"The case first cited is not in point. The right of the Federal Government to sell or dispose of incidentally created surplus water power was not involved. . . . .

"The other case, that of Green Bay, etc., Canal Co. v. Patten Paper Co. (172 U. S., 58), is another suit against the same company as above. In this suit the right of the United States to control and dispose of the surplus waters created by the improvement of navigation heretofore described was brought directly into question. As said by Mr. Justice Shiras for the court (pp. 68-69):

" 'Whether the water power incidentally created by the erection and maintenance of the dam and canal for the purpose of navigation in Fox River is subject to control and appropriation by the United States, owning and operating those public works, or by the State of Wisconsin within whose limits Fox River lies, is the decisive question in this case.

" 'Upon the undisputed facts contained in the record we think it clear that the canal company is possessed of whatever rights to the use of this incidental water power that could be validly granted by the United States.' "

And Senator O'Gorman, on the same subject, said:

"The right of the Government to sell or lease its own property does not justify this attempted appropriation of the property of a State. Section 3, article 4, of the Constitution is a grant of power to the United States of control over its own property, but what belongs to the State cannot be the property of the Federal Government.

"The United States is not authorized by any of the enumerated powers to engage in the business of manufacturing, transmitting, or selling electrical power, whether at cost or for a profit, and the commerce clause was never designed to permit the Federal Government to secure a revenue or profit as an incident to the promotion of the facilities of navigation.

"Federal expenditures must be reimbursed exclusively through taxation. The function of taxation is to secure sufficient money to perform the delegated governmental functions. This power was limited by section 8, article 1, as follows:

" 'The Congress shall have the power to lay and collect taxes, duties, imposts, and excises, to pay the debts and provide for the common defense and general welfare of the United States; but all duties, imposts and excises shall be uniform throughout the United States.'

"The Constitution merely permits regulation in the interest of navigation and commerce by the Federal Government. Regulation does not mean appropriation or confiscation of the rights of a State in its natural resources.

"The contention in favor of the right of the Federal Government to lease the excess water power is without authority or reason to sustain it. Kaukauna Co. v. Green Bay (142 U. S., 254) and Green Bay Co. v. Patten (172 U. S., 58) are not in point and do not support the proposition. The commerce clause was not involved in either case. In the former case the controversy arose between a State and a riparian owner, and in the latter case the right of the Federal Government grew out of a grant and was not based upon the commerce clause.

"The claim is made that the Government's improvement creates the excess power, but the fact is that the water that produces the power concededly belongs to the State, and the only effect of the improvement by the Government is to enlarge the potentiality of the State's water at the point of improvement.

"The Government has no more right to claim ownership of the increase of the water than the State or a riparian owner would have to require the Government to make compensation for impairment of the stream at other points resulting from the improvement. Where depreciation is necessarily caused by the improvement for navigation, the State must bear the loss; where appreciation results from the improvement the State is entitled to the gain. In either case the property affected belongs to the State. As we have seen, the title of the State includes the water as well as the bed of the rivers. The right of the State under its title to appropriate the water, subject only to the power of the Government under the commerce clause, is recognized by the cases cited, and the State's title necessarily excludes dominion over its waters by the Government except for the single purpose above indicated. The Government may improve navigation; it cannot confiscate the property of the State."

Regarding the assertion of Senator Burton in his committee report on the Connecticut River bill, that "The Federal Government may impose a charge for the use of surplus water not needed for navigation," and substantially the same assertion made by the Secretary of War (Mr. Stimson), who claimed that the Federal Government has a "proprietary interest in the water power" developed by all structures built in the aid of navigation and by structures built with government consent by a private enterprise for water-power purposes across navigable streams, Mr. Rome G. Brown makes the following remarks:[3]

"The Secretary of War and Senator Burton refer to this question as 'settled' by the decision in Green Bay & M. Canal Co. v. Patten Paper Co., 172 U. S., 58; 43 L. ed., 364; 19 Sup. Ct. Rep., 97; 173 U. S., 190; 43 L. ed., 663; 19 Sup. Ct. Rep., 316. An examination of this case shows clearly that it does not support any such contention. It is true that it was held in that case that the water power created by the dam in question was incidental to the navigation improvement and was subject to the control and appropriation by the United States; but such power of control in the United States was not based either upon the fact that it was a navigation dam, or upon the fact that the water power in question was created incidentally to a navigation improvement. The conclusion in that decision was based expressly upon the fact that, by reason of certain conveyances from the private owners of the water power in question to the United States and confirmed by state legislation, both the private right and the right of the state had passed to the United States as proprietor.

"It has never been settled by any Federal decision that the Government could appropriate to itself, or for its benefit, revenues from water power, by virtue of a right arising solely from its constitutional power to regulate navigation, nor in any other case except where it had acquired the proprietary rights of either the individual riparian owner or of the state, or of both."

From the preceding discussion, the following conclusions regarding the case of water power at Government dams seem justified:

[3] Rome G. Brown. "Who Owns the Water Powers?", in Case and Comment, Vol. 19, No. 10, March, 1913.

1. The Federal Government has, of course, the right to condemn riparian lands and to develop water power *for its own use* in connection therewith, as, for instance, to supply power to an arsenal or other government works. Aside from such use, when the Government constructs a dam for the purpose of improving navigation, its powers are strictly limited by what is necessary in the interests of commerce. It cannot take any more property or any rights not necessary for this purpose.

2. Having constructed a navigation dam, the Government has the right to control the flow over the dam, or from the pond created, to any extent that may be necessary in the interests of navigation. Congress may declare at any time that navigation requires the use of the entire flow of the stream, and may prohibit the use of any power from the dam except for Government purposes.

3. If there is surplus power not necessary for navigation purposes, such surplus power belongs to the riparian owner unless his right to such power has been purchased and paid for by the Government. If the Government acquires by purchase, or otherwise, all the riparian estate to which all the water power is appurtenant, then the Government owns and controls all the water power, including the surplus not needed for navigation. If, in order to use his surplus, the riparian owner has to use land or structures belonging to the Government, it is proper that he should pay a suitable charge for such privilege.

4. There seems to be little demand from private parties for surplus power from Government dams, owing to the uncertainty of tenure, and the recognized right of the Government to limit or prohibit the use of power at any time when such use is inconsistent with the needs of navigation.

CHAPTER IV

WATER POWER AT PRIVATE DAMS ON NAVIGABLE STREAMS

The principal controversy with regard to water power has arisen in cases where the Government has been asked to give authority to private parties to construct dams primarily for water-power purposes. In some of these cases the construction of the dam with locks would, by overcoming the obstruction due to a fall or rapid, extend the navigable portion of the stream; in other cases the construction of the dam would have no immediate effect in affording navigation, because portions of the stream below had not at the time been improved. For instance, the construction of a dam and lock at Windsor Locks, across the Connecticut River, which was proposed by private parties in 1913, would have afforded continuous navigation from Hartford, the present head of navigation, to Holyoke. On the other hand, the construction of a dam across the Coosa River, Alabama, which was sought by private parties in 1912, would not have immediately rendered navigation possible, because the site in question was but one of a series of sites at which dams were contemplated for a comprehensive plan of navigation improvement, and until the dams below were completed, continuous navigation would not be possible.

In regard to this matter, there are two radically differing opinions. Those who claim to be the only true conservationists, using the term in its modern extended sense, claim vehemently that no such permission to develop a water power should be given to private parties unless it is accompanied by various provisions, including the payment to the Government of an annual rental or

fee. They emphatically condemn what they term the giving away by the Government of its resources, which they maintain should be preserved for the use of all the people.

On the other hand, there are many who claim to be just as good conservationists as those in the first class, who maintain that the Government has no legal right to make any charge for power at dams built and maintained by private parties, or to impose any burdens beyond what is implied in the right to regulate commerce, that is, to preserve the interests of navigation.

The majority of the Congress has, up to this time, been opposed to the levying of tolls or charges for power by the Federal Government; while the executive departments of the Government, during the past two administrations, have generally been in favor of such charges. While the present administration has not formulated its policy in detailed terms, it has announced its purpose to secure the removal of the obstacles to water-power development which are now presented by existing dam acts. Representative leaders of the administration policies have announced their unqualified opposition to the levying of any charge in the nature of a toll as a condition of development by private capital.

In following this controversy, it will be instructive to consider the attitude of the Federal Government as embodied in Acts of the Congress.

Prior to 1899 the Congress had apparently recognized the principle that the riparian owner had the right to the full beneficial use of the water, subject only to the provision that such use did not interfere with the paramount right of the Government to regulate navigation. No owner could build a dam which interfered with navigation, but if it did not so interfere, he could use the power without restriction or regulation or the payment of any fee. If at any time the Government desired to have a lock in the dam, it could build it at its own expense, and if at any time all the water of the stream should be required for the preservation of navigation, the entire flow could be so used, leaving none to the riparian owner for power. If at any time subsequent to the construction of the

dam, the Government desired to make any improvement for navigation which interfered with the rights of the user, whether exercised or not, the Government could make such improvement without paying any compensation for rights diminished, impaired, or taken; though compensation would have to be paid for any injury to his tangible property, as for instance, for any of his riparian land taken for a canal or for locks.

General Dam Acts

Acts prior to 1899 had prohibited the building of dams (or other structures, including bridges) in navigable rivers "in such manner as shall obstruct or hinder navigation, commerce, or anchorage of said waters," and also the construction of dams in places where they might interfere with actual navigation "until the location and plan of such bridge or other works had been submitted to and approved by the Secretary of War." In 1899 an Act was passed which provided:

"That it shall not be lawful to construct or commence the construction of any bridge, dam, dike, or causeway over or in any port, roadstead, haven, harbor, canal, navigable river, or other navigable water of the United States, until the consent of Congress to the building of such structures shall have been obtained, and until the plans for the same shall have been submitted to and approved by the Chief of Engineers and by the Secretary of War. Provided, that such structures may be built under authority of the legislature of a state across rivers and other waterways, the navigable portions of which lie wholly within the limits of a single state, provided the location and plans thereof are submitted to and approved by the Chief of Engineers and by the Secretary of War, before construction is commenced." (6 Fed. Stat. 805.)

Since the passage of this Act, it has been customary, in developing water powers on streams covered by the Act, to obtain in each case a Special Act of the Congress authorizing the construction of a dam according to plans to be approved by the Chief of Engineers, U. S. A., and by the Secretary of War. The Act generally requires that any changes which may be rendered neces-

sary if the structure is found to obstruct navigation in the future, shall be carried out by the owners at their own expense.

In 1906 further restrictions were added, and the so-called General Dam Act of that year provided not only that no dam across a navigable stream should be built until the plans and specifications should be approved by the Secretary of War, and the Chief of Engineers, but also

"Provided, That in approving said plans and location such conditions and stipulations may be imposed as the Chief of Engineers and the Secretary of War may deem necessary to protect the present and future interests of the United States, which *may* include the condition that such persons shall construct, maintain, and operate, without expense to the United States, in connection with said dam and appurtenant works, a lock or locks, booms, sluices, or any other structures which the Secretary of War and the Chief of Engineers at any time may deem necessary in the interest of navigation, in accordance with such plans as they may approve, and also that whenever Congress shall authorize the construction of a lock, or other structures for navigation purposes in connection with such dam, the person owning such dam shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States a free use of water power for building and operating such constructions. . . . . The persons owning or operating any such dam shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe."

Section 2 allowed the United States at its own expense to construct and maintain locks or any other structures required for navigation, and to control the dam and pool for navigation.

The Act was subject to revocation for breach of conditions, and the owners of the dam were required to comply with all lawful orders of the Government, on pain of punishment by fine and the removal of the dam at the expense of the owners. It was also provided that any dam authorized by the Congress without a time limit for commencement and completion of the work, should be begun within one year and completed within three years from the passage of the authorizing act. Section 7 contained the following

provision: "That the right to alter, amend, or repeal this Act, is hereby expressly reserved as to any and all dams which may be constructed in accordance with the provisions of this Act, and the United States shall incur no liability for the alteration, amendment, or repeal thereof to the owner or owners or any other persons interested in any dam which shall have been constructed in accordance with its provisions."

In 1910 the Act of 1906 was amended and still further restrictions added, which provided in Section 1:

"That in acting upon said plans as aforesaid the Chief of Engineers and the Secretary of War shall consider the bearing of said structure upon a comprehensive plan for the improvement of the waterway over which it is to be constructed with a view to the promotion of its navigable quality and for the full development of water power; and, as a part of the conditions and stipulations imposed by them, *shall* provide for improving and developing navigation, and fix such charge or charges for the privilege granted as may be sufficient to restore conditions with respect to navigability as existing at the time such privilege be granted or reimburse the United States for doing the same, and for such additional or further expense as may be incurred by the United States with reference to such project, including the cost of any investigations necessary for approval of plans and of such supervision of construction as may be necessary in the interests of the United States: Provided further, That the Chief of Engineers and the Secretary of War are hereby authorized and *directed* to fix and collect just and proper charge or charges for the privilege granted to all dams authorized and constructed under the provisions of this Act which shall receive any direct benefit from the construction, operation, and maintenance by the United States of storage reservoirs at the headquarters of any navigable streams, or from the acquisition, holding, and maintenance of any forested watershed, or lands located by the United States at the head-waters of any navigable stream, wherever such shall be, for the development, improvement, or preservation of navigation in such streams in which such dams may be constructed."

In Section 41:

"The Congress may revoke any rights conferred in pursuance of this Act whenever it is necessary for public use, and, in the event of any such

revocation by the Congress, the United States shall pay the owners of any dam and appurtenant works built under authority of this Act, as full compensation, the reasonable value thereof, exclusive of the value of the authority or franchise granted, such reasonable value to be determined by mutual agreement between the Secretary of War and the said owners, and in case they cannot agree, then by proceedings instituted in the United States circuit court for the condemnation of such properties: And provided also, That the authority granted under or in pursuance of the provisions of this Act shall terminate at the end of a period not to exceed fifty years from the date of the original approval of the project under this Act, unless sooner revoked as herein provided or the Congress shall otherwise direct: Provided, however, That this limitation shall not apply to any corporation or individual heretofore authorized by the United States, or by any State, to construct a dam in or across a navigable water-way, upon which dam expenditures of money have heretofore been made in reliance upon such grant or grants."

There can, of course, be no question of the wisdom of requiring all plans and specifications to be approved before a dam is constructed, as provided conditionally before 1899 and definitely in the Acts of 1906 and 1910.

The same may be said of the provision authorizing the Government to make a charge for the actual cost of investigations and supervision. There is also no doubt of the power of the Government to revoke the rights granted whenever this should be necessary in the interests of navigation. There had never been any question that the Federal Government could at any time order the removal of any structure, such as a bridge, or dam, which interfered with navigation, or with what the Congress should properly consider the interests of navigation. The law in this respect had been clearly laid down by the United States Supreme Court in Union Bridge Co. v. United States, 204 U. S., 388-401, as follows:

"Do the principles announced in the above case require us to hold, in the present case, that the making of the alterations of its bridge specified in the order of the Secretary of War will be a taking of the property of the bridge company for public use? We think not. Unless there be a taking, within the meaning of the Constitution, no obligation arises upon

the United States to make compensation for the cost to be incurred in making such alterations. The damage that will accrue to the bridge company, as the result of compliance with the Secretary's order, must, in such case, be deemed incidental to the exercise by the Government of its power to regulate commerce among the States, which includes, as we have seen, the power to secure free navigation upon the waterways of the United States against unreasonable obstructions. There are no circumstances connected with the original construction of the bridge, or with its maintenance since, which so tie the hands of the Government that it cannot exert its full power to protect the freedom of navigation against obstructions. Although the bridge, when erected under the authority of a Pennsylvania charter, may have been a lawful structure, and although it may not have been an unreasonable obstruction to commerce and navigation as then carried on, it must be taken, under the cases cited, and upon principle, not only that the company when exerting the power conferred upon it by the State, did so with knowledge of the paramount authority of the Congress to regulate commerce among the States, but that it erected the bridge subject to the possibility that the Congress might, at some future time, when the public interest demanded, exert its power by appropriate legislation to protect navigation against unreasonable obstructions. Even if the bridge, in its original form, was an unreasonable obstruction to navigation, the mere failure of the United States, at the time, to intervene by its officers or by legislation and prevent its erection, could not create an obligation on the part of the Government to make compensation to the company if, at a subsequent time, and for public reasons, the Congress should forbid the maintenance of bridges that had become unreasonable obstructions to navigation. It is for the Congress to determine when it will exert its power to regulate interstate commerce. Its mere silence or inaction when individuals or corporations, under the authority of a State, place unreasonable obstructions in the waterways of the United States, cannot have the effect to cast upon the Government an obligation not to exert its constitutional power to regulate interstate commerce except subject to the condition that compensation be made or secured to the individuals or corporation who may be incidentally affected by the exercise of such power. The principle for which the bridge company contends would seriously impair the exercise of the beneficent power of the Government to secure the free and unobstructed navigation of the water-ways of the United

States. We cannot give our assent to that principle. In conformity with the adjudged cases, and in order that the constitutional power of the Congress may have full operation, we must adjudge that the Congress has power to protect navigation on all waterways of the United States *against unreasonable obstructions*, even those created under the sanction of a State, and that an order to so alter a bridge over a water-way of the United States that it will cease to be an *unreasonable obstruction* to navigation will not amount to a taking of private property for public use for which compensation need be made."

This danger that the needs of navigation might at some time require all the water in the stream, and that the right of the riparian owner to the water power of the stream was liable at any time to be thus diminished or destroyed, was, of course, one that had always to be considered in developing water powers on navigable streams; and the effect of the Acts of 1906 and 1910 was to impress this fact in advance upon the mind of the riparian owner.

The Act of 1910 was, however, more fair to the riparian owner than that of 1906, so far as concerned a revocation of the rights granted, in that it provided for compensation to the owner; though it did not provide for compensation or renewal at the end of the 50-year term. It was therefore necessary for any company subject to this act to amortize the entire cost during the 50-year period.

There are, however, grave doubts regarding the right of the Government to compel riparian owners to give land to the Government free of cost for the improvement of navigation, or to construct locks, or to maintain lights at their own expense. It is absurd that locks or gates in water-power dams should be constructed for navigation purposes long in advance of the time when they might be needed, if ever. When that time should arrive, those who had developed the water power, by the mere construction of the dam, would have saved to the Government a large sum of money. Why should they be required to give more? Why should a tribute be exacted from them? The right of the riparian owner must, of course, in all cases *yield* to the interests of navigation, but why should it be made to *contribute* toward them?

It will be noted that neither of these Acts *compelled* the riparian owner to construct locks, or to contribute land, though it authorized the Secretary of War and the Chief of Engineers to impose these requirements; the right of the Government to itself construct them, at its own expense, was expressly reserved. Notwithstanding the evident fact that the construction of a water-power dam, if properly located, is an assistance to navigation, which can be utilized by the Government when the river is made navigable, the riparian owner, according to these Acts, may, therefore, be compelled, at his own expense, to construct locks and to furnish power to operate them. If the water-power dam had not been built, the entire expense of building it, with locks, canals, and appurtenances, would have had to be borne by the Government. But by these statutes, the fact that the riparian owner has exercised his legal rights, and by doing so benefits navigation, and saves money to the Government, may be made the basis for imposing upon him additional burdens.

It is, of course, possible that a certain portion of a river might be navigable for small craft, or available for logging or other purposes which would come under the commerce clause of the Constitution, and that the construction of a dam without locks might destroy or interfere with this use. In such a case it would clearly be proper for the riparian owner building a dam to be obliged, whenever required by the Federal Government, to make good, at his own expense, whatever facilities for navigation had been interfered with by the construction of the dam, such as the provision of sluice-ways, or even the construction of a lock and the conveying of the necessary land to the Government, but only to the extent of restoring whatever navigation facilities had been interfered with, and not to the extent of improving them.

Further, if improvements are made by the Government in the watershed above the dam, by which the flow is increased or made more regular, the Acts provide that the owner of the dam *shall* be charged for the benefit. He has not asked for the improvement; it is made solely for the benefit to navigation, for that is the

sole power of the Government; its benefits are given without charge to those who benefit from the navigation facilities, for the Federal policy regarding navigation is stated as follows by the Act of February 27, 1911: "No tolls or operating charges whatever shall be levied upon or collected from any vessel, dredge, or other water craft for passing through any lock, canal, canalized river, or other work for the use or benefit of navigation now belonging to the United States or that may be hereafter acquired or constructed."

The riparian owner may not desire any improvement in the flow; he may have developed his plant to the full extent that circumstances warrant, and may have already power to waste, even in dry seasons. Why, then, should he be obliged to pay for an improvement that he does not ask for, does not desire, which does him no good, and which is for the benefit of those who navigate the river, who are not charged one cent for it? If, however, any actual benefit does accrue to the user of the power due to Government improvements above him, there are reasons for saying that he should not object to paying for it, even if such payment cannot legally be exacted.

And these burdens are laid upon the riparian owner notwithstanding that he must always be subject to any diminution of his rights due to the necessary requirements of navigation, that his permit has a time limit, without provision for renewal or compensation, and is revocable at any time, in the latter case, however, with compensation, as provided by the Act of 1910.

Indeed, according to Section 7 of these Acts, it seems that any riparian owner developing water power under these Acts must place himself entirely at the mercy of the Federal Government, and rely upon the fairness of the Congress and of the cabinet officer charged with administering the Act. The policy embodied in these Acts is not encouraging conservation of water power, but is distinctly the reverse. The construction of the dam is a large contribution by the riparian owner—often a contribution of millions of dollars—to the interests of navigation; but he is likely to be required to contribute still more by being obliged to build locks, to

give land, and to contribute power with no compensation. On the other hand, he is *required* to pay for any benefit which he may receive, without having asked for it, by an improvement of the regimen of the stream made by the Government in the interest of navigation. It would be difficult indeed to find an instance of a more unwise proposition, looked at from the point of view of pure conservation.

Demand of the Self-styled Conservationists for a Government Charge for Power

But even the burdens imposed under the Acts of 1906 and 1910 are not sufficient for the self-styled conservationists. They urge that a further charge be exacted from any private parties who are allowed to build water-power dams across navigable streams, merely for the use of the water power, and entirely aside from the interests of navigation. Under the Act of 1910, it was proposed to apply the revenue, thus obtained, to further development of the navigation of the same stream. Although that Act provided that the Secretary of War *might* impose such conditions and stipulations as he "might deem necessary to protect the present and future interests of the United States," it was not considered that these words, or the other provisions of the Act, would allow the imposition of a specific charge for the power developed. Accordingly it has for several years been urged upon the Congress that all Acts of the Congress permitting the construction of a dam in accordance with the Act of 1910 should contain a further specific authorization of such charge, and the right to regulate the power thus developed.

The Committee on Interstate and Foreign Commerce, however,[1] considered that the General Dam Act fully protected and recognized the interests of the Government. The report of the committee further states:

"Your committee has observed the vast number of projects demanding the aid of the Government to perfect navigation, and the hundreds of millions

[1] 62d Congress, 2d Session, Report No. 1050.

of money required for that purpose, as well as the improbability, if not inability, of the Government's undertaking such vast expense within any reasonable period of time. Therefore we conceived the idea that in the shoaly rivers of the country, which could not be navigated without the expense of locks and dams, yet in which shoals owned by private citizens offer tempting opportunities for the development of water power and the conservation of our resources, the Government might avoid the great expense of building dams and locks, hasten the navigability of the rivers, and at the same time permit the development of water power by private capital by granting the consent of the Congress that private capital and enterprise might erect dams in such streams, under the direction and with the approval of the War Department, imposing such conditions and requirements as would prevent such development of water power from interfering in any respect with any movement the Government might afterwards wish to make to improve the navigability of the stream, but on the contrary would advance the interests of navigation and help the Government by eliminating the expense of the dams. . . . .

"Your committee submits to the judgment of a candid world as well as to the statesmen and lawyers in the House and out, if the Act as amended [in 1910] does not present and adopt a fixed policy with reference to the water powers in our navigable rivers. A commission, known as the National Waterways Commission, composed of able statesmen of every shade of opinion, objection, and notion on that subject, has thoroughly considered the questions in all their aspects and details, and in conclusion advise that for the present we proceed as we have been proceeding. The Secretary of War, however, taking up some old suggestions that were insisted upon before the amendment of 1910, has demanded that each of these bills be amended so as to incorporate certain restrictions which the General Dam Act already permits the Secretary of War to impose in each case as conditions of approval if he sees proper. We cannot concur in those suggestions, because one wise purpose of the General Dam Act was to avoid prolixity and multiplicity of detail in each separate bill, and the terms of that bill conferred upon the Secretary of War plenary power to impose those conditions. We have to consider it unwise to adopt his suggestion and thereby forego that much benefit of the General Dam Act, and we have disregarded his suggestion as to the eight projects in this bill."

It seems, therefore, that the Act of 1910 is not free from

ambiguity, and it may be interpreted, as it was by the former Secretary of War, Mr. Stimson, to confer upon him only authority to "exact compensation sufficient to maintain the physical condition of the dam and locks, and, if necessary, to compel the dam to be torn down or modified should it in future be deemed an obstruction in the river." For this last object, however, no compensation by the Federal Government would be required, since according to the Union Bridge decision, the Government could require the dam to be torn down or modified at the expense of the owners at any time when it might become an unreasonable obstruction to navigation.

We therefore find the so-called conservationists insisting on the imposition of a charge for power, together with other burdens upon riparian owners who desire to utilize their natural riparian rights and incidentally to confer a benefit upon the Government without expense to it. President Roosevelt in 1908 and 1909 vetoed bills providing for dams across the Rainy River in Minnesota, and across the James River in Missouri, because there was no compensation exacted, and because the Act of 1906 did not terminate the permit at some fixed time. He maintained that the policy pursued in making the grants desired was "giving away the property of the people in the flowing waters," and granting valuable privileges in perpetuity. The Rainy River bill was finally passed over the President's veto, but no effort was made to pass the James River bill over the veto. The Act of 1910, as we have seen, met one of his objections by definitely limiting further grants to not exceeding fifty years unless sooner revoked, as it could be at any time by action of the Congress; but in 1912 President Taft vetoed the bill authorizing private parties to build a dam across the Coosa River in Alabama in accordance with the provisions of the Act of 1910. In his veto message he said:

"If the Federal Government chose to build this dam itself in aid of navigation, its right to the water power incidentally created by the dam would be beyond question. When, instead of building the dam itself, it builds it by an agent, as proposed by this bill, I believe it to be equally clear that the dam and all its incidents, including the water power created, is

within the regulative power of the Federal Government in respect to navigation.

"It is said that the grantee, the Alabama Power Co., proposes to spend over a million dollars in the construction of a dam, as well as to furnish toward the project its riparian rights and to stand the expense and cost of the damages by flowage. It is manifestly entitled to be credited for all these expenditures, and is manifestly entitled to a fair, full, and reasonable profit for its investment and work. But after all these items are fully allowed for it is equally manifest that in the course of time the return from the privilege thus granted in the shape of valuable water power created may far exceed a reasonable return for these items.

"No provision is made in the bill whereby the Secretary of War may, in granting the permit, exact such compensation as in the course of time may prove to be necessary to equalize this account. I think this is a fatal defect in the bill, and that it is just as improvident to grant this permit without such a reservation as it would be to throw away any other asset of the Government. To make such a reservation is not depriving the States of anything that belongs to them. On the contrary, in the report of the Secretary of War it is recommended that all compensation for similar privileges should be applied strictly to the improvement of navigation in the respective streams—a strictly Federal function. The Federal Government by availing itself of this right may in time greatly reduce the swollen expenditures for river improvements which now fall wholly upon the general taxpayer. I deem it highly important that the nation should adopt a consistent and harmonious policy of treatment of these water-power projects which will preserve for this purpose their value to the Government whose right it is to grant the permit. The necessity for the adoption of such a policy has recently been pointed out, with my approval, by the Secretary of War, and I see no reason why this bill should be exempted from the safeguards which have been recommended by him in the cases of other bills now pending before Congress."

The President evidently believed, with President Roosevelt and other conservationists of that class, that the Federal Government had the right, and that it was wise public policy, to exact a substantial charge for power, in addition to the other burdens imposed by the Act of 1910.

We have seen that eminent lawyers maintain that the Federal

Government has no legal right to make a charge for surplus power, in itself, and independent of its riparian ownership or of use of Government property by individuals, even at navigation dams constructed by the Government. Still greater is the doubt as to the legality of any charge levied by the Government on private individuals for power developed at dams which, at their own expense, they construct on navigable streams. The situation seems clearly to be this:

The power of the Government over navigable streams is strictly limited to what is required in the interests of navigation. When, therefore, a riparian owner applies to the Federal Government for permission to construct a dam across a navigable stream and to use the power developed, it is essential that the Government should make such study of the proposal as to make clear whether the proposed project would or would not be injurious to, or incompatible with, the present or future interests of navigation. For such examination and study the Government may properly charge a fee. If the proposed works are found to be injurious to navigation, they should not be allowed at all; if they are not, they should be allowed, for they promote industry and conservation, and no charge in the form of a toll, tribute, or rental should be made for the power. Much more is this the case if the proposed works, as will nearly always be possible, are constructed so as to be—not simply not injurious to navigation—but directly and largely contributory to it. The water power legally belongs to the riparian owner, and is in no sense "an asset of the Government," whose only power is to regulate commerce. No doubt the Government has—if not the legal—the physical right to exact compensation for the water power, because, since no dam can be, or should be, constructed without its consent, it may withhold such consent until any and all conditions that it may see fit to impose—reasonable or unreasonable, legal or illegal—are complied with. Such power, however, should not necessarily be exerted unless it is believed that might makes right. All this seems so clear, not only legally but in equity, as to need no further discussion. Nevertheless, around this simple

question the conservation discussion has waged hot and heavy for years, and it is necessary here to give the arguments advanced on each side.

The rather unstable character of opinions on this subject is shown by comparing the preliminary and final reports of the United States National Waterways Commission, of which Senator Burton was chairman. In the preliminary report, presented in 1910, the Commission said:

"When water power is developed in navigable streams . . . . several plans have been proposed for the collection of tolls upon the water power developed by dams whenever their construction is permitted by the Congress. The right of the Federal Government to collect such tolls must rest on one of three theories:

"1. That the Federal Government has some proprietary right in the waters of navigable streams, so that the collection of tolls can be based upon actual ownership of or right in the waters.

"2. That as the right to grant or withhold consent for the construction of a dam in navigable waters rests in the Congress, it is allowable to make a charge for the consent or privilege and authorize the collection of tolls.

"3. That the Federal Government in its jurisdiction of interstate commerce has control of navigable streams and has a certain degree of responsibility for their improvement. Under this theory it is maintained that the tolls upon the water power developed can be collected and paid into a fund for the improvement of navigable streams, including not only the one on which the toll is charged, but all others capable of improvement for navigation.

"The Commission is of the opinion that the Federal Government has no proprietary right or interest in navigable waters which would authorize the collection of tolls. The right, if it exists at all, rests upon either the second or third theory stated."

The Commission goes on to state that the second theory does not commend itself to the Commission, and that

"It is to be doubted whether, even in case a bill should be passed or other action taken by the Congress for granting this permission, with a provision for charging tolls, such tolls could be collected."

The Commission further states regarding the third theory that if the toll is a tax it should be imposed upon all classes of water power, in navigable or non-navigable streams.

The Commission also calls attention to the fact that to require the imposition of tolls for dams hereafter constructed would cause a discrimination between water powers developed in the future and those already enjoyed, which are subject to no such charge. The Committee points out that there is

"An undoubted right to impose charges sufficient to pay the expenses of the examination and supervision and to secure the Government against cost by reason of obstacles to navigation created by the erection of dams; but this rests upon an entirely different principle from the proposal to charge tolls."

The Commission, therefore, recommended simply that in each grant for the development of power, the requirement be made that the grantee must, whenever necessary to subserve the interests of navigation, construct a lock and furnish power for operating it. "These requirements," they stated, "rather than the imposition of tolls appeal to the Commission because they are free from legal objections and are in entire accordance with the objects for which the Federal Government has jurisdiction over navigable streams."

In the case of water power developed from dams constructed by the Government, the Commission favored an adequate charge.

Notwithstanding these statements in its preliminary report, the Commission, only two years later, in its final report of 1912, urged complete Federal control, under the power to regulate commerce over all streams, navigable and non-navigable. They say (pp. 49, 61):

"It would seem, therefore, to be a settled principle of law that where the power to grant or withhold a permit exists, *then substantially any conditions not in themselves unlawful may be imposed as a condition of the grant.* If such be the case when the permit of Congress is necessary for the construction of a dam for power purposes, there can be no doubt of its power to impose charges or the right to regulate the rates to be charged by the operating company as a condition of such grant." . . . .

"*Charges and regulation.* That a grant for water-power development constitutes a special privilege, for which the Government is entitled to proper compensation, is a principle which should be clearly established. The actual value of such privilege will, of course, vary greatly under different conditions. Every grant of the Government should, however, be dependent on the payment of such reasonable charges as may be determined by the circumstances and equities involved in each case. The Commission does not suggest or advise that this right or power of the Congress should be invoked as a means of raising revenue for general purposes, but only to reimburse the Government for the cost of surveys, inspection, and similar expenses, and for the purpose of controlling the use of streams in the interest of the public."

It is to be noted that the Commission does not say that the right of the Government to receive compensation "*is* clearly established" but that it "*should be* clearly established." Surely, also, there is a radical difference between charging a fee for actual expense incurred in surveys and supervision, and "controlling the use of streams in the interest of the public" when there is grave legal doubt whether the latter is constitutional. These two things should be sharply distinguished, not coupled together as in the Commission's report.

On the other hand, and in contrast with these last views, a large number of people who believe in conservation in the sense of economical use and the prevention of waste, and including many of the most eminent lawyers of the country, believe that the rights of the Federal Government in navigable streams extend solely to the preservation of the interests of navigation, and that the Congress has no legal right to exact compensation for water power except when the Government builds and therefore owns the dam, and that even in the latter case a charge for power in itself is illegal. They believe that the Government has no water power to sell, and can, therefore, make no charge to riparian owners for its use. It is true that the Government, in its function of controlling navigation, has a legal and moral right to insist that no dams be built across navigable waters without its consent and the approval of the plans, and consequently it may refuse to approve any act which does not

provide for compensation and contain any other stipulation which it may desire to include in the permit. This, however, as already suggested, is simply the exercise of might, not of authority or right, as the bandit extorts tribute as the price of life. The power may be there, but the legality or morality of the exercise of that power may be questionable. The fact that the riparian right to use power is a resource does not justify claiming compensation for it. It is private property, which by law goes with the riparian land, and if the Federal Government has no power except over navigation, it has no more right to claim compensation for the use of water power than for the use of the riparian land for agriculture. The riparian owner has the right to every cent that he can make out of his power, and he must yield to the Federal Government only to the extent that is demanded by the reasonable necessities of navigation. As expressed by one writer:

"To levy a toll, either in advance of the navigation improvement or afterwards, to be paid out of the revenues of the water power, is to appropriate, without compensation and without consideration, to the benefit of the Government that which belongs to the riparian owner. It is a confiscation, to the extent that such tribute is demanded and enforced. The riparian owner is not benefited by the improvement of navigation any more than any other individual of the general public. On the contrary, he is the one especially damaged, to the extent that he has to yield the maintenance of his water-power plant and dams to the necessities of navigation improvements. He is always subject to such damage."[2]

Senator Nelson, chairman of the Senate Committee on Commerce, in a report April 30, 1908, discussing the James River bill, and the attitude of President Roosevelt, said:

"From the foregoing it will appear that there are three different parties who are interested in the waters of a navigable stream:

"1. The United States.

"2. The State in which the stream is located.

"3. The riparian owner.

[2] Rome G. Brown. Limitations of Federal Control of Water Powers, p. 46.

"The interest of the United States is derived from and rests upon that paragraph of the Constitution which gives the Congress the power to regulate interstate commerce, and this power only extends to the extent of conserving the navigability of the stream. Beyond that the Federal Government has no interest or property in the stream.

"The interest of the State in the stream is derived from its sovereignty and it holds its property in the stream in trust for all public uses but in subrogation to the rights of the Federal Government as to navigation and of the riparian owner. The right to the use of the waters of a stream for any lawful purpose outside of the right of navigation belongs wholly to the State and the riparian owner. . . . .

"From the foregoing statement and citation of authorities it is evident that the only use of the waters of a stream in which the United States has any property is its use for purposes of navigation. In the use of the stream for any other purpose the Federal Government has no property, and hence has nothing to sell or to exact compensation for.

"The plan proposed by the President would deprive the States and the riparian owners of their rights in the use of the water of a navigable stream now vested in them by law, and would concentrate the entire disposal and control in the Federal Government, a power which neither the States nor the riparian owners can, with justice or safety, for a moment concede. But assuming for the sake of the argument that the Federal Government can lay a tribute in such cases as is proposed by the President, it cannot be under the interstate-commerce clause of the Constitution, but must be under section 8 of Article I, which reads as follows:

" 'Sec. 8. The Congress shall have power to lay and collect taxes, duties, imposts, and excises, to pay the debts and provide for the common defense and general welfare of the United States; but all duties, imposts, and excises shall be uniform throughout the United States.'

"Such tribute must be either a direct tax or in the nature of an impost or excise tax. If a direct tax, it cannot be levied directly by the Federal Government, but must be apportioned among the States, leaving each State to make the collection; and if an impost or excise tax, then it must be levied by the rule of uniformity upon every dam and water power in the United States not constructed directly or indirectly by the Federal Government. In other words, there must be a general excise law on the subject. The power of the Federal Government over the navigable streams of the country

is no greater in the so-called Western or public-land States than in the New England States. If a tribute can be levied on a dam and water power in Minnesota or Colorado, it can be levied on a dam and water power in Maine or Massachusetts, for the power of the Federal Government over navigable streams is the same in the one case as in the other. . . . .

"An act authorizing the construction of a dam is, so far as the United States is concerned, a mere revocable license or privilege, and if a tax can be imposed on such a privilege it must be general and uniform throughout the United States. It must apply to all dams and water powers on navigable streams throughout the entire country.

"Nearly all navigable streams in their upper and more remote courses are not, as a matter of fact, navigable, and in such reaches of the river dams can be erected and water powers created under State authority and State license, and so long as such dams and water powers do not materially injure or diminish the navigability of the stream in its navigable portions the Federal Government has no ground for interference. It has been customary, however, in many of such cases to apply to Congress for a Federal license, and the granting of it, while not necessary, serves a twofold purpose: First, that it authorizes the Federal Government, through the War Department, to control and direct the construction of the dam, and, second, that it recognizes the fact, which might otherwise require proof, that the dam will not affect the navigability of the stream in its navigable portions. (Kansas v. Colorado, 206 U. S., 46; United States v. Rio Grande Co., 174 U. S., 690.)

"And in such cases it is of as much advantage to the United States as to the grantee of the license to have congressional action and recognition, but in such cases the Federal Government has nothing to sell and therefore has no moral or legal ground to demand compensation in any form."

Indeed, President Taft, when Secretary of War, on the application of a riparian owner on the Des Plaines River for the approval of plans for the construction of a water-power dam, had refused the application as being unnecessary, for the reason that the river was not a navigable stream, and therefore did not come within the Federal authority. He said:

"The truth is that the Des Plaines River, not being a navigable stream, no permit was necessary to put any obstruction into it which the War Department could prevent. But even if it had been a navigable stream,

and even if the application had been made, and properly made to this department, to say whether this would interfere with navigation, if the department concluded it would not interfere with the navigation, then it is not within the power of the department to withhold its expressing such an opinion and granting such a permit, so far as the United States is concerned, for the purpose of aiding the State in controlling the water power. If the State has any control over the water power, which it may exercise in conflict with the claimed rights of the riparian owner, then it must exercise it itself, through its own legislation and through its own executive officers. All the United States does, assuming it to be a navigable stream, is merely to protect the navigation of the stream. With reference to the water power, it has no function except in respect to water power which it itself creates by its own investment in property that it itself owns, and then, of course, it may say how that water power shall be used.

"But with respect to the water power on a navigable stream, which may be exercised without interference with the use of the river for navigation purposes, that is controlled by the laws of the State. It is controlled by the riparian ownership and by the common law as it governs those rights; therefore I do not see, with reference to this matter, that this department has any function to perform or which it can perform."

It is difficult to reconcile this opinion with that expressed by Mr. Taft, when President, in his veto of the Coosa River bill.[3]

The sub-committee of the Senate Judiciary Committee, answering the question

"Has it [the National Government] any authority in granting permits to develop water power on a navigable stream to impose and enforce conditions relative to stated payments to the Government, regulation of charges to consumers, and determination of the right to make use of such developed power?"

reported categorically as follows:

"Responding to the second interrogatory, we are of the opinion, divorcing the question from riparian rights, that the Federal Government, in authorizing the construction and maintenance of a dam on a navigable stream by States, municipalities, or private parties, for the chief and primary purpose of improving the navigation of the stream, has the same right to

[3] Supra, pp. 64-65.

prescribe the terms and compensation for the use of the surplus power, created as an incident to the main improvement, as the Government would have in case it had itself built the dam or made the improvement, and that the Government having delegated the power of building such a dam to private parties might well confer upon them as compensation for the work thus undertaken the right to do what the Government itself could do in case it had itself constructed the work. In this connection, and as a further response to the interrogatory, it must be noted that the mere grant by the Federal Government of authority to construct a dam in a navigable river, not for purposes of navigation, but really for the creation of a water power, is merely a license or permit, the effect of which is that if the dam is constructed and operated conformable to plans approved by the Government, it will not be deemed an obstruction or impediment to navigation. And in such case the Government would be authorized to charge a nominal license fee for inspecting and passing upon the plans and for watching over the work to see that it conforms to the plans and is properly maintained; but the regulative power of the Government would not extend to the use of the water for other purposes than navigation and interstate commerce. In such a case it seems to us that the Federal Government has no water power to sell or charge compensation for, for it is only authorized by the Constitution to regulate interstate and foreign commerce, which in this case means navigation."

This latest act in the water-power drama was the case of the Connecticut River bill, allowing private parties the right to construct a dam at Windsor Locks, Connecticut. This bill provided for compensation to the Government, and was otherwise in general accordance with the Act of 1910, requiring the grantee to construct at its own expense a lock and appurtenances, and to convey the same to the United States free of cost, together with the title to such land as might be necessary for approaches, and to furnish power for operating and lighting. The compensation to be paid to the Government was not to "be such as to deprive the said corporation of a reasonable return on the fair value of such dam and appurtenant works and property, allowing for the cost of construction, maintenance and renewal, and for depreciation charges." In one respect, however, the Connecticut River bill was distinctly more

favorable to water-power development than the General Dam Act. It will be remembered that the latter Act provided for a fixed tenure of not over fifty years, subject to revocation at any time for violation of terms or for public use, with compensation, and without provisions for renewal or for compensation at the end of the term. The Connecticut River bill provided that at the expiration of fifty years, the grant might be renewed, or transferred to other parties; and in case it was not so renewed, the United States was required to pay to the original grantee "the reasonable value of the improvements and appurtenant works constructed under the authority of this Act and of the property belonging to said corporation necessary for the development hereby authorized, exclusive of the value of the authority hereby granted. Said improvements and appurtenant works and property shall include the lands and riparian rights acquired for the purposes of such development, the dam and other structures, and also the equipment useful and convenient for the generation of hydro-electric power or hydro-mechanical power, and the transmission system from generation plant to initial points of distribution, but shall not include any other property whatsoever. Such reasonable value shall be determined by mutual agreement between the Secretary of War and the owners, and, in case they cannot agree, then by proceedings instituted in the United States District Court for the condemnation of such properties. The basis for determining the value shall be the cost of replacing the structures necessary for the development and transmission of hydro-electric power by other structures capable of developing and transmitting the same amount of marketable power with equal efficiency, allowance being made for deterioration, if any, of the existing structures in estimating such efficiency, together with the fair value of other properties herein defined, to which not more than ten per centum may be added to compensate for the expenditure of initial cost and experimentation charges and other proper expenditures in the cost of the plant which may not be represented in the replacement valuation herein provided."

The minority of the Senate Committee on Commerce, in reporting in 1913 on this bill, recommended striking out the provisions for compensation to the Government, citing in support of their position the views above quoted, and giving categorically their reasons as follows:

"(1) If the Federal Government has no right, and it has none, to control the use of the water power in the Connecticut River, then Congress cannot legally legislate on the subject of such control.

"(2) Because if the bill is not amended as suggested a valuable natural resource of the State of Connecticut is confiscated.

"(3) Because the State of Connecticut owns the water and the bed of the Connecticut River and the Federal Government having no 'Proprietary interest in the water power' of said river 'has no moral or legal ground to demand compensation in any form' for the use of the water power in said river.

"(4) Because the Federal Government has no right to withhold its permit for the building of the dam proposed by the Connecticut River Co. in said Connecticut River, for the building of this proposed dam and lock will not interfere with navigation but improve it, and on this point we quote President Taft, when he, as Secretary of War, in rendering his decision on the Des Plaines River case, says, in part, as follows:

" 'But even if it had been a navigable stream, and even if the application had been made and properly made to this department to say whether this would interfere with navigation, if the department concluded it would not interfere with navigation then it is not within the power of the department to withhold its expressing such an opinion and granting such a permit, so far as the United States is concerned, for the purpose of aiding the State in controlling the water power.'

"A majority of the committee in their report say:

" 'It appears to be a settled question that the Federal Government may impose a charge for the use of the surplus water not needed for navigation.'

"We, the minority, deny that this question has been settled, and we challenge the majority to point to a single law on the statute books, or to a report of a single committee in the Congress, or to a single decision of the Supreme Court which tends to establish their contention. On the con-

trary, the principle has been denied from the beginning of the Government, and that denial has been upheld by the Supreme Court deciding the question more than sixty years ago and repeated at least thirty times since.

"The principle invoked is a new departure and is exceedingly dangerous. It is an attempt, under the guise of regulating commerce, to invade the settled rights of the States for commercial purposes.

"It is a principle which, if established, will confiscate the natural resources and the property of the States and of their citizen riparian owners without a legal right or a moral right to do so. The minority of your committee are convinced that the adoption of the principle recommended by a majority of your committee will bring on conflicts between the States and the Federal Government. It would create a divided responsibility, causing two sovereign powers to attempt to regulate and control the same property at the same time, and would grant to the Secretary of War discretionary powers never contemplated under the commerce clause of the Constitution."

This Act was defeated in the Senate by the votes of those who were willing to give the company the privilege desired, without compensation to the Government, but who were unwilling to establish the precedent or recognize the principle that the Government should receive compensation even though the company was willing to agree to pay. For this they have been hysterically criticized by the pseudo-conservationists. Properly regarded, however, they deserve only approbation for having taken a high moral stand, which they knew would subject them to captious criticism. Their action was of the same kind as that which would lead an honorable man to correct, in a bill, an error which was in his favor; they refused to sanction the acceptance by the Government of compensation which they believed it had the *power* but no legal or moral *right* to accept.

The Chandler-Dunbar Decision

It is frequently remarked that the recent decision of the Supreme Court of the United States in the Chandler-Dunbar case has settled this entire matter in favor of the views of the ultra-conservationists, or, as they are called by their opponents, the

confiscationists. Reading the opinion carefully, however, the writer must confess himself unable to see how it modifies the situation in any degree, or decides the mooted question. This was a case in which private riparian owners on the Sault Ste. Marie River, the outlet of Lake Superior into Lake Huron, had been allowed by the Federal Government, under permits revocable at any time, to construct wing dams into the river and to utilize the water power. The falls in this river have been overcome by the construction of one canal on the Canadian side and two on the American side, with appropriate locks. There is an immense commerce through these canals, and in the lakes above and below, and thus commerce has increased by leaps and bounds. The total freight tonnage in short tons has been as follows:

Year	Total tonnage in short tons	Net registered tonnage
1875	833,465	1,259,534
1880	1,321,906	1,734,890
1885	3,256,628	3,035,937
1890	9,041,213	8,454,435
1895	15,062,580	16,806,781
1900	25,643,073	22,315,834
1905	44,270,680	36,617,699
1906	51,751,080	41,098,324
1907	58,217,214	44,087,974
1908	41,390,557	31,091,730
1909	57,895,149	46,751,717
1910	62,363,218	49,856,123
1911	53,477,216	41,653,488
1912	72,472,676	56,736,807
1913	79,718,344	57,989,715[4]

By an Act passed March 3, 1909, the Congress declared that the ownership by the United States of all lands and property of every kind and description between the then existing ship canal and the international boundary line in the center of the stream was "necessary for the purposes of navigation of said waters and the

[4] The total gross tonnage through the Suez Canal was, in 1907, 20,553,241.

waters connected therewith." The Secretary of War was directed to take by condemnation or otherwise all such property, and all permits for the development of power thereon were revoked; and the President was requested to open negotiations with the Government of Great Britain for the purpose of effectually providing for the maintenance of ample water levels, for the purposes of navigation, in the Great Lakes and waters connected therewith, by constructing regulating works. Among the properties so condemned was that of the Chandler-Dunbar Co. for the development of water power under revocable license.

The lower court awarded damages to the Company for the taking of the water power. Both the Company and the United States appealed to the Supreme Court, the former claiming that the award was too low, the latter that no damages should have been allowed for the water power. The decision sustained the contention of the United States. The Court said:

"If, on the judgment of the Congress, the use of the bottom of the river is proper for the purpose of placing therein structures in aid of navigation, it is not thereby taking private property for a public use, for the owner's title was in its very nature subject to that use in the interest of public navigation. If its judgment be that structures placed in the river and upon such submerged land are an obstruction or hindrance to the proper use of the river for purposes of navigation, it may require their removal and forbid the use of the bed of the river by the owner in any way which in its judgment is injurious to the dominant right of navigation. So, also, it may permit the construction and maintenance of tunnels under or bridges over the river, and may require the removal of every such structure placed there with or without its license, the element of contract out of the way, which it shall require to be removed or altered as an obstruction to navigation. . . . .

"The conclusion to be drawn is, that the question of whether the proper regulation of navigation of this river at the place in question required that no construction of any kind should be placed or continued in the river by riparian owners, and whether the whole flow of the stream should be conserved for the use and safety of navigation are questions legislative in character; and when Congress determined, as it did by the

Act of March 3, 1909, that the whole river between the American bank and the international line, as well as all of the upland north of the present ship canal, throughout its entire length, was 'necessary for the purposes of navigation of said waters, and the waters connected therewith,' that determination was conclusive. . . . .

"That riparian owners upon public navigable rivers have in addition to the rights common to the public certain rights to the use and enjoyment of the stream, which are incident to such ownership of the bank, must be conceded. These additional rights are not dependent upon title to the soil over which the river flows, but are incident to the ownership upon the bank. Among these rights of use and enjoyment is the right, as against other riparian owners, to have the stream come to them substantially in its natural state, both in quantity and quality. They have also the right of access to deep water, and when not forbidden by public law may construct for this purpose wharves, docks, and piers in the shallow water of the shore. But every such structure in the water of a navigable river is subordinate to the right of navigation, and subject to the obligation to suffer the consequences of the improvement of navigation, and must be removed if Congress in the assertion of its power over navigation shall determine that their continuance is detrimental to the public interest in the navigation of the river. . . . .

"We need not consider whether the entire flow of the river is necessary for the purposes of navigation, or whether there is a surplus which is to be paid for, if the Chandler-Dunbar Co. is to be excluded from the commercial use of that surplus. The answer is found in the fact that Congress has determined that the stream from the upland taken to the international boundary is necessary for the purposes of navigation. That determination operates to exclude from the river forever the structures necessary for the commercial use of the water power. That it does not deprive the Chandler-Dunbar Co. of private property rights follows from the considerations before stated."

These principles are precisely those laid down in the Union Bridge case, quoted above.

The court proceeds to show that the Congress did not act arbitrarily in determining that for the purposes of navigation the whole flow of the stream should be devoted exclusively to that end, by showing the relation which the stream held to the navigation in

the lakes above and below, thus clearly indicating that in exercising its paramount power to regulate navigation, the Congress cannot act arbitrarily, but that its acts must be reasonable and having due regard to the facts and necessities of the situation and the rights of other parties.

I may add, in support of the above view of the Chandler-Dunbar decision, that Mr. Rome G. Brown says regarding it:

"It has been claimed by certain extremists that the recent Chandler-Dunbar decision is 'epoch-making,' that it turns over to Federal control all the rights heretofore claimed to belong to the respective States and to private riparian owners in the beds and waters of navigable streams, and that in the case of even a private hydro-electric navigation development it authorizes a charge and toll out of the revenues of the investor for the benefit of the Federal Government. On the contrary, this decision confirms the law of control as theretofore established. It confirms the recognized paramount right of the Federal Government to regulate navigable streams in the interests of navigation. It confirms the right of the Congress to pass and to enforce the Act of 1909, asserting the necessity of entire control in the interests of navigation of the straits of the Sault Ste. Marie in order adequately to protect the navigation between the two great inland seas through which the yearly tonnage exceeds by far that of the Suez Canal. That decision was neither an assertion nor authority for an assertion upon the part of the Federal Government of the unlimited Federal control for all purposes of the highway streams of the United States."

The Niagara Falls Situation

For the sake of completeness, the situation with relation to the power at Niagara Falls may be described, as stated by Mr. Brown, in his paper on "The Conservation of Water Powers," in the Harvard Law Review of May, 1913, published also as Senate Document No. 14, 63d Congress, 1st Session.

"In one instance even treaty provisions are disregarded. The United States and Great Britain, in 1910, ratified a treaty between the two nations by which the diversions for power at Niagara Falls were expressly limited to specific quantities for each side of the international boundary. The

amounts of diversion allowed were fixed from the computations of the United States engineers and other experts as being neither a hindrance to navigation nor to the scenic beauty of the Falls. Pending the negotiations for the treaty, and as a tentative arrangement, a statute was passed limiting the amounts of diversion upon this side of the river to amounts less than those afterwards fixed by the treaty, and restricting importation to this side of power from the Canadian side. Since the ratification of the treaty several bills have been presented to carry out its object and terms, but for successive sessions such bills have been opposed by those assuming to act in the interests of conservation, so that the restrictions and limitations existing before the treaty have been continued in force.

"The treaty expressly limited the diversion upon the American side to less than 36 per cent of the total amount of diversion allowed upon both sides, the total amount being fixed below the amount which would affect either navigation or scenic beauty or any public interest. That the diversions could not affect navigation in the slightest degree is apparent and is conceded by all engineers. The only basis for Federal interference is therefore lacking. However, under an imaginary constitutional power in the Congress to protect scenic beauty, the Burton Act of 1906 was passed pending the treaty negotiations. A dozen years before, in accordance with their property rights, arising from riparian holdings and legislative grants from the State of New York, two companies had invested millions of dollars in the construction of plants upon the American side, requiring for their operation at full capacity diversions from the falls of amounts of water not exceeding the amounts afterwards fixed by the treaty for the American side. The conservation of scenic beauty was thus assured by the treaty provisions and at the same time interference with navigation was prevented, for the treaty amounts were based upon careful scientific investigation. It is manifest that, especially after the treaty, the Congress had no constitutional right to limit directly or indirectly, diversions upon either side—at least, not to any amounts below those fixed by the treaty. Diversions beyond the treaty limits were by the treaty discouraged and, in fact, prevented. The treaty contemplated unrestricted rights of importation.

"None of the American investors have ever asked Congress for permission to divert a single cubic foot of water beyond the limits expressly fixed by the treaty, but have confined their requests to have the statutory authority for permits extended to the limits fixed by the treaty. At the

same time, Canadian investors have asked permission to import to this side the electrical energy manufactured from the water power that they develop within the limits fixed by the treaty. Nevertheless, these requests, which are consistent with and promotive of the true policy of conservation, whether it be viewed as a conservation of power or of scenic beauty, have been vigorously opposed by certain self-styled 'defenders' of Niagara, who misrepresent to the public the nature of the requests made by the American investors at Niagara and distort those reasonable requests into demands for unlimited permits for diversion. Those investors are heralded as assailants of the beautiful Niagara. Their modest prayer for an observation of the limited treaty provisions is heralded as a wholesale 'attack' which threatens the very 'life of the falls,' and as an attempt to 'cut the throat of beauty for gold.' It has been demonstrated that whatever unwatering of the crest of the falls has occurred in past years has been due entirely to the natural gradual recession of the apex of the Horseshoe Falls and is not due at all to any water-power diversions. In fact, the extra amount of diversion which is asked and which is allowed by the treaty, upon the American side, over the amounts now allowed by continuing in force the original statute enacted as a modus vivendi pending the negotiations of the treaty, is only 4,400 cubic feet a second, or less than 8 per cent of the total amount fixed by the treaty and less than 2 per cent of the total ordinary flow over the falls, which amount has been demonstrated to be utterly inappreciable so far as it could possibly affect either scenic beauty or any public interest.

"The result has been the prevention of further development of industries on this side of the river, where there is a demand for immediate use of all the electrical energy that could be produced on the American side and of all that could be imported from the Canadian side. At the same time there is a forced and steadily increasing industrial development upon the Canadian side, where the use of the falls for power is limited only by the terms of the treaty. As fast as the electrical energy manufactured from the water power allowed to the Canadian side is taken up there, the amount which can ever be imported to this country is permanently decreased. The extra amount allowed by the treaty for use upon this side over the limit retained by Federal legislation is still unutilized. Thus, in the name of conservation, industrial growth and all other advantages of water-power development and use are promoted by the United States Congress upon the

Canadian side at the same time that they are retarded upon the American side. A more unreasonable and suicidal thwarting of the true policy of conservation could not be devised."

The writer has endeavored, in the previous pages, to outline clearly the situation in regard to the water-power controversy. It will be observed that it is a matter of principle that is involved, as to the legal and moral rights of the Federal Government. It is, therefore, largely a matter of law, and in regard to this the views of a layman may be considered by many to be without value. It has, therefore, been shown that the lawyers are themselves divided on this question, and since lawyers have to deal with technical matters, it may perhaps be true that engineers are equally well qualified to form some judgment of legal matters.

It is said by those who urge that compensation should be paid to the Government, that if the Government, instead of building the dam itself, "builds it by an agent" it is equally clear that "the dam and all its incidents, including the water power created, is within the regulative power of the Federal Government in respect to navigation." But there seems to the layman surely a real difference between employing an agent to build a dam for Government purposes, and permitting a riparian owner to build the dam for his own purposes, at his sole instance, and at his own expense. If the proposed dam would interfere with navigation, then the Government should not permit it in any case; if it does not, then it does not injure the Government or the people in any way, but on the contrary, confers a valuable benefit upon them without expense. Why should this benefit conferred be made the pretext for the exaction of further benefits? Indeed, while much has been said of the value conferred upon riparian owners by allowing them to construct dams in navigable rivers and to utilize the water powers, very little has been said of the benefits which the Government receives from the construction of such dams. In their pretended fear of monopoly or other dangers, the so-called conservationists forget true conservation, which in the case of water means use.

Indeed the conservation movement in the past, particularly as regards water powers, has been too much dominated by the idea

of enforcing the arbitrary powers of the Federal and State governments, and extending regulation and restriction to their utmost limits. This view called forth from a well-known Senator, not long ago, the remark: "That is the trouble with the present craze for restriction and regulation of private investment in these enterprises. You regulate and restrict to the extent that you have nothing to regulate."

To the present writer there seems to be throughout this discussion a confusion in the minds of the so-called conservationists, between the right which comes from might, and legal right or equity. He is convinced that the Federal Government has no legal right to impose any charge for water power at private water power dams on navigable streams, except what may be considered a mere license fee sufficient to reimburse the Government for the expense of the procedure involved. This, as already seen, is the opinion of many eminent lawyers. The contrary opinion, however, has been supported by President Roosevelt, President Taft, Mr. Stimson, ex-Secretary of War, and Mr. Fisher, ex-Secretary of the Interior. Conservationists in the older sense, however, must admit that the views of those who oppose a Government charge are without question best calculated to promote the conservation that consists in the *utilization* of water power. It is inconsistent with this aim to view private water powers as a possible source of revenue for any public use. President Taft in his veto of the Coosa River bill said, referring to the right to exact a charge: "The Federal Government by availing itself of this right may in time greatly reduce the swollen expenditures for river improvements which now fall wholly upon the general tax-payer." Such, however, does not appear to have been the result thus far. The veto of the Coosa River bill prevented the Government, and therefore the general public, from gaining the direct benefit of an expenditure of about $1,500,000 which would have been made by the private company, and which would have directly promoted the navigability of the stream. The same thing is true with reference to the Connecticut River bill, which would have resulted in saving the Government the expenditure of many

millions to render the river navigable to Hartford. The imposition of a charge for power is evidently a direct discouragement to development.

The Coosa bill, and others like it, are sometimes referred to by the so-called conservationists, as vicious; but surely there is nothing vicious in allowing a man his legal rights, or in limiting the power of the Government to those powers specifically delegated to it by the Constitution. Mr. Rome G. Brown, after stating, in regard to water powers on the public lands, that the Federal Government has a perfect legal right to make such rules and exact such compensation for their use as it sees fit, makes the following striking statement:

"But the question is entirely different where it arises between the Government on the one hand, and, on the other, the private owner of riparian land, who, with his predecessors, has long held the riparian land under unqualified grants or patents, by which the entire proprietary fee, with all the appurtenances belonging to that fee, has passed to private ownership. In the modern hue and cry about 'natural resources,' and the conservation thereof, this distinction is too often lost sight of. There is no right of title or right of interest belonging to the public, in every natural resource, arising because of the mere fact that it is a natural resource. The ownership, at least the right and the privilege of beneficial use, of a natural resource, whatever it may be, which is appurtenant to a tract of land, whether it be riparian or otherwise, belongs, where the land is held by private ownership, to the owner. Such ownership or right of use adds value to the land, and always is taken into consideration as an element of its value. It is the difference in such natural resources which makes largely the difference in the values of various tracts. The difference in value by reason of location or contour arises from just such differences of natural resources. Such is the difference between the high land and the low land; the difference between land with a soil of alkali sand, and land with a soil of fertile loam; between land in localities of great precipitation of rainfall, and that in localities of small precipitation; between land in proximity to, and that at a distance from, the natural or artificially made urban centers; or the difference in proximity to natural features, which, either alone or in connection with the land in question, may be used for scenic beauty or for

industrial development. Such, and other natural resources, and the advantage and value of their beneficial use and enjoyment, are an essential part of the land, and as such, belong to the owner of the land.

"Such a natural resource is a water power. In its unutilized state it consists of two factors, both of which are a part of and appurtenant to the riparian land: (1) The natural flow of water over or past the land in question of sufficient quantity and constancy to make its use feasible in connection with the second factor; (2) a natural slope, or head and fall, of the land itself or of the bed of the stream adjacent to the land sufficient in extent so that in connection with the first factor, quantity of water, it may under all the circumstances involve a feasible development for power purposes. These two factors, which go to make up a possible water-power development, are each natural features, natural resources, but they are features peculiar to the land upon or appurtenant to which they exist, and as such, together with their beneficial use, belong to that land and therefore to the owner thereof, whether before or after actual development or utilization by mechanical or artificial means. The advantage, value, and financial benefits of water powers naturally appurtenant to riparian land belong to the riparian owner, as I shall demonstrate. There is no more basis in law or in reason for attempting to deprive him of such privilege or the beneficial use thereof, when once he has acquired his riparian land by an unqualified fee, by imposing restrictions upon him or by appropriating to the Government for the public benefit a part of the proceeds derived from such beneficial use by the riparian owner, on the ground that it arises from a 'natural resource,' than there would be to impose restrictions and to levy in behalf of the general public upon a private owner of agricultural land a tribute graduated according to the amount of rainfall his farm might receive, or based upon the percentage of fertility per acre, and to attempt to justify such a restriction or tribute, in addition to taxes based upon fair assessment values, upon the fact that his advantages result from 'natural resources.' Conservation—the reserving of that which one has—is legal and proper, but the attempted appropriation of any beneficial use or the proceeds or advantage thereof from another which has passed to the latter in private ownership is not conservation; it is confiscation."[5]

Much is made, in conservation literature, of the fact that in some cases, as in the Connecticut River case, the grantees were

[5] Rome G. Brown. Limitations of Federal Control of Water Powers, pp. 7-8.

willing to pay a rental to the Government for the privilege of developing the power. They were willing to, simply because they thought they had to, in order to secure the permit. The Secretary of War himself states that he insisted upon it. The fact that the grantee was willing to accede to the demand does not, therefore, in itself justify that demand.

Mr. Brown expresses himself as follows on this phase of the subject:

"It is hopeless to discuss these questions with those legislators who refuse to recognize any distinction between the constitutional *right* of the Congress, as fixed by a proper regard for the limitations of constitutional authority, and the *power* of the Congress to do this or that thing, measuring such power only by the possible inability of those against whom it is exerted to protect themselves. There is a vast difference between mere physical or brute power and a right based on authority. It is true that under its authority to protect navigation the Congress may prohibit, as it does, the construction of private water-power dams in navigable streams, except with congressional consent. But its right to reserve and exercise such power of consent extends no further than the general right to which it is an incident, that is, the right to protect navigation. To the extent necessary to protect navigation, and to that extent only, is the right and power of consent exercised with authority. It is useless to argue with a legislator who says that, having the right of prohibition except upon consent, the Congress has, therefore, not only the power, but the constitutional right, arbitrarily to give or to withhold the consent, and that having such arbitrary power, it has not only the power but also the right to attach any condition, of whatever nature or for whatever purpose it may choose, to the granting of the consent."[6]

It must not be forgotten that for the conservation of our water powers it is essential that capital shall be attracted to these enterprises, and while, of course, the interests of the public, both present and future, must be fully protected, we are not conservationists if we advocate the imposition of terms which restrict rather than encourage development. We must also remember that under

[6] Rome G. Brown. Conservation of Water Powers, pp. 14-15.

present conditions water-power investments are not especially attractive, and that steam power is a more desirable form of power, since it can be located wherever needed, and the supply regulated according to demand. Water power is more variable, and furthermore, it requires, in general, a very much larger investment per horse power than steam, though its running expenses are less. Because of the large first cost of water-power developments the risk of loss in case of failure of the enterprise is correspondingly large. Capital, therefore, does not need water-power enterprises, and it will not take them up to any considerable degree, unless fully protected.

It is from a point of view of pure conservation that the development of water power is most important. When we consider also that the development of water power not only conserves fuel, but directly serves to promote the navigability of rivers, we should be very careful how we discourage this triple conservation in order to secure other results which we may consider desirable. If we do discourage it we may be antimonopolists, or something else, but we are certainly not conservationists.

The conservation movement, originating in a wise demand for the economical use of our natural (not national) resources, has too much deteriorated into a demand that those resources be retained by the national Government, and not permitted to be developed by private capital except under restrictive burdens. There is no doubt that every burden put upon water-power corporations will hinder developments and consequently conservation. There is great difference between water powers; some may be developed at slight expense, others are very costly, but every additional burden will render some powers incapable of economical development, which otherwise would be capable of it. The subject, therefore, should be considered from the viewpoint of true conservation, or use.

The total power developed by all of our streams in their flow to the sea, on the average through the year, was estimated by the writer in 1885 as over 200,000,000 horse power. Much the greater

portion of this can never be profitably developed, as it lies in the lower portions of the rivers, or in the very small headwaters; or it may be distant from markets, or the water may be more useful for other purposes. For instance, the theoretical power generated by the Mississippi River alone, from Cairo to the Gulf, is not less than 13,000,000 horse power, or over 6 per cent of the above total. Mr. M. O. Leighton, in 1909, on the basis of much more accurate data, in a report to the National Conservation Commission, arrived at the following result: "In any case, therefore, it may be assumed with confidence that, were all practicable storage sites utilized and the water properly applied, there might be established eventually in the country a total power installation of at least 200,000,000 horse power, and probably much more." This estimate, however, appears to the writer much too large.

The Secretary of Commerce and Labor, in a report March 14, 1912, estimated the total stationary power now developed by steam, water, or gas, as probably over 30,000,000 horse power, of which water power constitutes 6,000,000 horse power; and he states that "the water power now economically capable of development probably does not exceed 25,000,000 horse power, including that already developed"; that is, he estimated the power still undeveloped, but economically developable, as about 19,000,000 horse power. In 1912 there was developed and operated under permits in the National Forests 294,575 horse power, and the Forest Service roughly estimated that there remained undeveloped and capable of development 13,624,000 horse power.

The development of electrical transmission has greatly increased the availability of water power. Formerly, a water power could be utilized only on the site of the fall, so that it was only economically available where means of transportation were available, and where labor could be obtained. Steam power, on the other hand, can be developed anywhere, and can, therefore, be located at the most commercially favorable points, and in this respect its superiority to water power is so marked that it is safe to say that under the old conditions but a small fraction of the

water power which could be easily developed was commercially available. A water power in a wilderness was practically worthless. Today, however, water power can be developed anywhere within some three hundred miles of the point where it is required for use, and is available over an area of some 300,000 square miles. Voltages as high as 150,000 have been utilized in such transmissions.

The present annual coal consumption of the United States exceeds 500,000,000 tons, and at the present rate of increase, the anthracite coal deposits will be exhausted before the end of the present century. The known supply of bituminous coal will last much longer, but it, too, has a definite end, and its cost will, of course, increase as the supply diminishes.

The quantity of coal necessary to produce a horse power per hour varies, according to the quality of the coal and the efficiency of the plant, from about 1.75 to 8 or 10 pounds or even more. If we assume the low average of 3 pounds per horse power per hour, and on the average a twelve-hour day for 300 days per annum, we find that to produce, under such conditions, one horse power throughout a year requires 10,800 pounds or about five tons of coal. If we could utilize the available 19,000,000 horse power for purposes for which coal is now used, we could, therefore, save annually about 95,000,000 tons of coal, costing, at $3 per ton, $285,000,000. In other words, every horse power that can be developed by water and used to replace steam power, preserves say $15 worth of coal per annum.

If this saving is capitalized at 10 per cent, it is apparent that it would justify an investment of $150 per horse power in a water-power plant in excess of a steam plant, which, for 19,000,000 horse power, would justify an investment of $2,750,000,000 a sum nearly three times the capital stock of the United States Steel Co.[7]

There is little doubt that 5,000,000 horse power could today be developed by water if every encouragement were offered; this

[7] The above paragraphs in the text are simply intended to indicate the importance, from the conservation point of view, of preserving the non-renewable resources, and the approximate money value of that saving. It must not be inferred that in any given water-power project, an investment of $150 per horse power, in excess of the cost of an equiva-

would mean an annual saving of $50,000,000 in cost of coal alone. Suppose this coal were on the edge of a precipice, and were sliding off, to be lost forever, or, suppose our coal mines were burning up. A number of people rush forward, not to appropriate it, but to try to save it. "No," says the Federal Government to them, "you must not do that unless you will pay a charge for doing it."

The saving of this coal is conservation: the question of paying a fee to the Government for the privilege of doing it is not conservation at all. Government control is recognized in requiring the approval of plans, and if it is feared that at some time in the future private control of the power is likely to be a menace to the public interests, a provision may be made, as in the Connecticut River bill, for a taking of the property by the Government at the end of the specified term, upon payment of the fair value.

The conditions heretofore existing have greatly hindered the development of water power and consequently the triple conservation which it involves. The great stumbling-block, as shown by the foregoing, is the present General Dam Act, under which all developments in navigable streams must be made, and which provides for a franchise revocable at any time upon payment of compensation, with a fixed tenure not exceeding fifty years and with no provision for renewal or payment at the expiration of the term. It also provides for the construction of locks and the granting of land for approaches to them, for free power for operating them, and for lighting the Government grounds.

Moreover, under that Act it is necessary in each case for water-power projects to secure a special act of the Congress authorizing the work, subject to all the provisions of that Act, with such other requirements as may be insisted upon in each case. Every project, therefore, has to be threshed out on the floor of the Congress, as was the case in the Rainy River, the James River, the Coosa River, and the Connecticut River bills, which have hereinbefore been

lent steam plant, would be warranted. In any given case, of course, a water-power plant will only be justified if it shows a total operating expense which is smaller than would be shown by a steam plant delivering the same power at the same points, including fixed charges, reasonable dividends, and depreciations and amortization charges.

discussed. There is, therefore, a lack of a fixed policy in these matters. Moreover, a corporation developing a water power, is not only subject to Federal regulation, but also to State regulation, and these two may not be in harmony. The result is that comparatively few developments have taken place. The National Waterways Commission in its final report, says (pp. 38, 39):

"The nature of the condition which the Federal Government may constitutionally impose in its grant for the construction of a dam is still subject to some uncertainty. So far it has been the policy of the Federal Government to limit the duration of its grant to a period not exceeding fifty years. The acts, however, contain no provision for renewal or, in case a renewal of the grant is denied, for compensation for the property. The General Dam Act, and apparently all the special acts making grants for the construction of a dam in a navigable stream, so far made by the Government have also contained a clause providing that the Act may be altered, amended, or repealed at the will of the Congress. It is evident that under these conditions grants are not only insecure, but that no company operating under such circumstances could render the most efficient and economical public service."

There is no doubt that the present condition of things calls for a remedy by new legislation which shall give definite assurance to investors and which shall remove each case of water-power development, as it comes up, from the necessity of the enactment of a separate bill by Congress. The National Waterways Commission, in its final report, admits this in the following words (p. 54), referring to the provisions of the General Dam Act:

"Experience has shown that this provision is not well suited to encourage development of water power or to protect the public interest. Nothing is more discouraging to the investor of capital than uncertainty. . . . . The necessity of amortizing the plant, in addition to all other costs of rendering the services, will inevitably result in an increased charge to the consumer, which amounts to a tax, of doubtful equity, on the local community for the benefit of the General Government. This unnecessary burden could be avoided if Congress would enact legislation providing for a more equitable form of franchise."

The Commission also remarks (p. 41):

"The difficulty of securing needed capital has been another obstacle to water-power development. Testimony given before the National Waterways Commission tended to show that water-power development on a large scale has been attended with considerable financial risk. Many of the enterprises have been conspicuous failures, due to the cost of construction being greatly in excess of estimates, to unreliable data and miscalculations of stream flow, to the unsalability of the product because of its unreliability, to troubles growing out of the conflict of jurisdiction between States or between the United States and one of the States or a foreign Government, as well as to the ordinary troubles of manipulation and mismanagement."

Some illustrations[8] will make clear the benefits which would accrue to the Federal Government by the adoption of a more liberal policy.

Prior to January 30, 1912, the Federal Government expended at the Des Moines rapids on the Mississippi River, the sum of $1,458,103 for inadequate navigation facilities for boats of small draft; while its entire expenditures for strictly navigation improvement upon the river between the mouth of the Missouri and St. Paul prior to June 30, 1912, had been $12,184,987. Adequate improvements at the Des Moines rapids had been repeatedly refused under recommendation of the Government engineers because of the necessary expense. Since the year 1910, however, under authority of an Act passed in 1905, the Mississippi River Power Company has expended, as a private investment, upwards of twenty million dollars at these rapids, and has constructed a magnificent dam across the river with locks of deep draft. Mr. Brown says with reference to this (p. 7):

"All that the United States Government has done to bring about this wonderful accomplishment, has been the giving of consent by the Congress that private investors may go upon the bed of the stream and expend in three years double the amount of money that the United States Government has ever been able to expend upon the entire Mississippi River for naviga-

[8] Largely from Mr. Rome G. Brown's paper on "Improvement of Navigable Rivers," Senate Document 332, 63d Congress, 2d Session.

tion purposes above St. Louis, and to say by the same act that the Government would accept the tribute and gratuity from the private investor involved in the expense of initial construction and perpetual maintenance of operation of perfect navigation facilities at this point. But these are only a small and incidental advantage which this policy of the Government, adopted by Congress and acquiesced in by the Executive Departments up to and including the year 1905 (before the passage of the General Dam Act), brought to the people of the Mississippi Valley, and indirectly, to the people of the whole nation. The potential undeveloped energy equivalent to the annual consumption of 5,000,000 tons of coal, the energy which has been heretofore for centuries constantly present and wasting, is now conducted to three different states to operate existing industries and to build up others."

Similarly, the new dam across the Tennessee River at Hale's Bar, built under an Act of 1905 by private enterprise at an expenditure of $9,000,000, not only improves the navigation of the stream, on which and its tributaries the United States Government has expended in all less than $12,000,000, but makes possible an industrial development arising from the water power, of great advantage to the locality.

The Coosa River in Alabama is navigable in its upper and its lower portions, but is not navigable for an intermediate distance of about one hundred miles. Improvement of this portion by the Government has been considered impracticable on account of the expense. Since 1876 navigation improvements upon this stream have cost in all about $1,500,000. Under an Act of 1907, passed before the so-called conservationists became active, a water-power navigation dam is being constructed at the site known as Lock No. 12 in the comprehensive plan of development prepared by the Government engineers. This work will be completed without expense to the Government at a cost of over $2,000,000, or an amount in excess of the entire sum heretofore spent by the Government upon the entire river. It was a similar improvement at Lock No. 18 which was proposed to be undertaken under the Coosa River bill in 1912. This construction would have saved the United

States an initial cost for the dam of over $1,600,000, which, at 5 per cent, together with the cost of maintenance and operation, would mean a contribution by the private investors of between $80,000 and $90,000 per annum toward the navigation project. Nevertheless, permission for this contribution toward rendering the river navigable was prevented by the veto of President Taft. The enactment of this bill would have saved the Government in interest on the investment and for maintenance between $8 and $9 per horse power per annum, and it would have been the means of saving or conserving some 100,000 tons of coal annually. These benefits were prevented by the veto of this bill. What benefit did this veto confer upon the people?

On the Connecticut River there is now navigation to Hartford, Connecticut, and there has for many years been a demand that navigation should be extended to Holyoke, Massachusetts. Government engineers have reported upon this project, but it has been found that the expense of constructing the dam would be too great to allow the improvement being made. Had the Connecticut River bill been passed in 1913 in the form recommended by those who believed that the Government had no legal right to exact compensation, this improvement in navigation would have been effected, together with a further saving of coal and development of industry. Secretary Stimson himself stated the advantages which the Government would obtain by the construction of the dam as follows:

"It is estimated that the total enterprise will cost in the neighborhood of five million, five hundred thousand dollars, of which about four hundred and seventy thousand dollars will be required to be spent in constructing a lock and channel exclusively in the interest of navigation. The Government will thus at the outset get the benefit of an investment of nearly half a million dollars spent solely for navigation without reference to water power—or, in other words, an equivalent of an interest charge of nearly thirty thousand dollars per annum."

This benefit would accrue if no charge were received for power. It would seem as if such benefits would be sufficient without asking

for more, and without subjecting the company to a dual control by the Federal Government and by the State of Connecticut through its Public Service Commission. It is common, in these days of criticism, freely to accuse individuals and corporations of *rapacity,* because they secure large returns for themselves, even though they develop great industries and create even greater wealth for others. Is it proper to denote the above case as an instance of Government rapacity? And does it result in gain or loss to the public?

Mr. Brown quotes another illustration, and remarks upon it as follows (pp. 12, 13):

"The Long Sault Development Co. stood ready up to about a year ago to invest $50,000,000 in improvements for navigation and power uses on the American side of the St. Lawrence, near Massena, N. Y. Against this enterprise the propaganda of obstruction threw itself, with the result that no possible working conditions could be obtained. At a sacrifice of over $1,000,000 spent in engineering and promotion that company has now abandoned the proposed enterprise forever, and instead is now constructing upon the unnavigable reaches of the Tennessee River, under State encouragement and State control, water powers for the manufacture of aluminum products. It has chosen the more expensive, but more secure, investment, safeguarded by the cooperation of the State of Tennessee.

"As against utilizing the wasting powers upon the navigable streams of Alabama and Tennessee the French Aluminum Co., driven from the large water powers of the navigable streams by fear of the existing conditions of uncertainty and of hazard to investment under Federal supervision, has chosen to expend its $5,000,000 and more of capital in hydro-electric developments upon the Yadkin and other small streams in North Carolina and to keep its investments free from the present announced uncertainties of Federal control. For the same reasons developments have been made upon the small streams of Georgia and other parts of the country, and thousands of miles of transmission lines carrying light and energy have artificially built up new empires of industry in the remote country districts adjacent to the small streams, while the natural facilities for navigation improvement and the latent energies of the large highway streams are wasting from non-use."

Monopoly

Much is said, in conservation discussions, regarding the imminent danger and economic disadvantages of monopoly in water power. Much of the elaborate report of the Commissioner of Corporations of March 14, 1912, is devoted to showing that a great part of our developed and undeveloped water power is controlled, as he believes he proves, by a few large corporations. This question must, therefore, be referred to briefly.

The great disadvantage of water power is its variability from day to day and from month to month. Every stream varies in flow from time to time, the relation between its maximum and its minimum being in some cases, even for large streams, as much as 500 to 1 (see table on p. 178). There is, therefore, a manifest advantage in linking up sources of power in different watersheds; and with modern methods of electric transmission, sources as far distant from each other as 600 miles may be so connected; for when one stream is at its lowest another may be far above its minimum stage. The inequalities of precipitation over a large area may, therefore, be taken advantage of. Moreover, if one stream be regulated by reservoirs, and its power connected with that from another not so regulated, the reservoirs may be so controlled as to be very advantageous to the combined power. Again, if one source of power which operates plants having mainly a day load is connected with another serving plants having mainly a night load, duplications of machinery may thus be avoided, and greater efficiency secured; in addition to which there will be a saving by eliminating multiple management and a greater centralization of control.

From the point of view of efficiency, therefore, a considerable degree of monopolistic control is desirable, and under the public regulation now generally in effect, does not seem to present any real danger. Indeed, having in mind the importance, from the conservation standpoint, of encouraging the greatest possible development, and the most economical use, of water powers, there

would seem to be less danger from monopoly in this industrial field than in others where concentrated control does not offer these advantages. This view is taken by many conservationists. Secretary Fisher, for example, has expressed himself as follows:

"I do not think there should be any provision in these grants against so-called combinations or monopolies, but do believe there should be no assignment of the grant without the permission of the Government. I think hydro-electric development is essentially monopolistic, and should be essentially monopolistic, in its character. That is why I think it should be effectively regulated. I think they should have the advantages of the control of the market and freedom from harassing and vexatious competition if we are going to put them under the disadvantages of effective public regulation."

In the case of water power, as in other cases, what the public is really concerned with would seem to be the efficiency of the service and the *rates charged for power,* and the only serious danger to be apprehended from an unrestricted monopoly would be the power to impose exorbitant rates or a poor service upon the people. The National and State Governments appear to have ample authority to regulate this matter and prevent any such unreasonable charges or unsatisfactory service.

From the point of view of conservation alone, it would seem unquestionably better for the public that water powers should be developed and the power sold even at or above the price of steam power, rather than that they should not be developed at all; for every horse power derived from falling water conserves so many tons of coal annually. It would seem, therefore, that speaking solely as conservationists of water power, we need have nothing to do with the question of monopoly and no fear of it. If we wish to deal with it, or if we fear it, it is not as conservationists. However justified or unjustified our fears may be, they arise from another source than the desire for conservation.

It is sometimes urged that the prevention of a monopoly of water power is of great importance for the reason that, as our supplies of coal and other fuel, which are non-renewable, become

exhausted, the price of steam power will rise higher and higher, until, when those supplies are entirely exhausted, falling water will be the sole practicable source of power. With reference to this, it should, however, be remembered that there are other contributing factors, which tend to make the cost of steam power fall rather than rise, and that of recent years, notwithstanding the gradual and indeed rapid exhaustion of our coal supplies, the price of steam power has actually fallen rather than risen. These causes are found in the development of the steam engine, the steam turbine, and the gas engine, and in other mechanical improvements which permit a more economical utilization of fuel. Thus far these causes have more than counteracted the exhaustion of coal and its higher price. If the time should come when falling water were the sole source of power, then a monopoly of this source, if unrestricted and uncontrolled, would of course be undesirable.

In view, therefore, of the fact that the states can regulate rates, can control combinations of capital, and can take by eminent domain, it appears that, from the point of view of conservation alone, a discussion of the real or imaginary evils of monopoly is merely academic and out of place, and that as conservationists our aim should simply be to urge that every legitimate and proper inducement be offered to capital to develop the water powers of our streams without reference to the question of monopoly.

Even if there is grave danger of a water-power monopoly, as conservationists claim, such danger must be met, it would seem, by laws against monopoly, and not by making a charge for something which the government does not own. This is particularly true considering that the rights of the riparian owner to the use of power on navigable streams are liable at any time to be diminished or destroyed entirely on account of the requirements of navigation.

Finally, in considering this entire water-power discussion, it is very important to avoid the attitude of mind taken by so many in these days, which assumes that average business morality is less than average public morality. In times of old, it was a popular adage that "the king can do no wrong," though perhaps, rather than

popular, it was a belief entertained mainly by kings themselves. Today there is a similar popular impression that the Government can do no wrong. Where the people are sovereign, they are very apt to imitate other sovereigns in assuming themselves incapable of error. It was a maxim of Robespierre's, which dictated his entire infamous career, and which led to his brief period of power and his ultimate ruin, that "The people are never wrong."

Both impressions are equally erroneous. Government bureaus and officials in a democracy may be guilty of just as flagrant abuses of justice as kings or individuals. Mr. Frederick S. Titsworth of Denver, in a paper entitled, "Notes on the legal aspects of the conservation problem," says of the Government policy regarding public lands:

"During all this period; in fact, from the time of the acquisition of the public domain until a comparatively recent date, the Government was making the most strenuous efforts to dispose of the public lands to settlers and others. Enormous tracts were given as bounties to railroads, in order to induce construction over tracts of barren, uninhabited, waste lands; bounty land warrants were issued to soldiers and sailors who had served their country in times of war, and to their families; settlers were induced to take up lands by purchase from the Government under the Pre-emption Laws, Desert Land and Homestead Acts; and miners and prospectors were induced to search for and develop mineral deposits. It was the policy of the Government, expressed in these and many other ways, to dispose of the natural resources of the country practically free. The existing laws were most liberally construed, and every inducement was offered to attract settlers and invite the expenditure of money for the development of natural resources by holding out the hope of great reward. We are compelled to note that this policy has been radically changed in recent years. *Not only is it becoming more and more difficult to acquire title to the public domain, but the most unjust and untenable methods have been resorted to by Government officials to deprive owners of lands which they acquired in good faith, and to prosecute them criminally for acts committed in technical violation of existing laws, although done with full knowledge of the Government officials who had, at that time, control of the disposition of public lands.*"

As a digression from our subject, but as illustrating what many well-informed people consider an instance of Government unfairness, the following may be adduced: Mr. Howard Elliott, Chief Executive of the New York, New Haven & Hartford Railroad Company, in a report to the stockholders, dated April 11, 1914, makes the following statement:

"*Mail and Parcel Post.* The company is underpaid for the carriage of mail and parcel post. For the carriage of mail and for other services performed by this railroad for the Post Office Department, the government is now paying about $725,000 per annum. This amount includes $21,000 for the parcel post. This is 9 per cent less than the payments made for the mail service during the four-year period ending June 30, 1909, when the parcel post was not in operation. A study by chartered accountants made three years ago indicated that $1,400,000 was approximately the sum to which the company was entitled for carrying the mail. Instead, it was receiving about half that sum and since then the parcel post has been added with no corresponding increase in pay, on account of which the railroad is receiving at least $700,000 per year less than it is fairly entitled to for carrying mail and parcel post. In addition, the railroad suffers a further loss in its express earnings because of the effect of the parcel post on the business of the express companies. Express revenues are also adversely affected by the lower rates prescribed by the Interstate Commerce Commission, effective February 1st, 1914.

"The New York Times, in an editorial in October, 1913, said, referring to the parcel post:

" 'Every receiver of a postal parcel, carried at the cost of the railways whose services are not paid for is a receiver of stolen goods.'

"The Chicago Inter-Ocean, in commenting on this, said:

" 'Any man who, merely because he has the power, compels another to give him unpaid service, is a robber. He has taken from the other his time, his strength, or his property in some form, without making due compensation. If ten men thus combine to rob eight, the immorality remains. Because several millions have combined "through Government" thus to rob their fellow citizens who happen to own railroads, the wrong of it is not made right.' "

Mr. Elliott remarks in another address, referring to the above:

"This is strong language, but is it not true? Here are the railways, struggling to make both ends meet, and the Government deliberately takes service from them worth, exclusive of the parcels post, at least $15,000,000 per year, and no pay. What kind of an example is this for the great United States Government to set to the younger men of the country?"

Mr. Titsworth in another part of the paper above referred to, says:

"The most dangerous feature of the movement promulgated by the enthusiastic conservationists is the injection by them of insidious and wicked appeals to the people to help the poor man and throttle the grasping, soulless corporations. That sort of argument has no possible bearing on the conservation problem. Corporations and trusts should be controlled, and monopolies should be prevented, and they will be, in due season. In the meantime, whether they are wealthy or bankrupt, they are entitled, under existing laws, to as much consideration, being creatures of our own invention, as the man who, through lack of ability, misfortune or environment, has not lifted himself from the plane of manual labor. Nothing can be gained, and much wrong can be done by condoling the poor man and slandering the man with the dollar. This western country was never settled, and never could have been settled, with thirty cents and an infant class. Our enterprises have been fostered and made successful by hardy pioneers who did not waste their time deprecating the fact that their brothers in the east had more money than they, but busied themselves with indomitable energy in utilizing the resources which nature had placed at their disposal. One hears and reads so much socialistic buncombe nowadays that the thinking man has broken out of the ranks of the reformers, where he would otherwise have remained a proficient worker for good."

While instances like the above may not be attributable to any guilt or even wrong intention on the part of any individual, but rather to a system or to a division of responsibility, the result is the same. Injustice may be done even with the best intentions, due to misinformation, delay, the inertia of system, or other causes. Such cases, however, serve to bring out the idea which the writer wishes to emphasize in this connection, namely, that both sides in

this, as in any controversy or contract, should be treated with equal consideration, and should be credited with equally good intentions.

The state of mind which assumes that the Government is always just and fair, while individuals and corporations are corrupt and prejudiced, is a most untrue and unfortunate one. Probably we shall not be far wrong in assuming that human nature is precisely the same, whether in a government bureau, a king's palace, or a corporation directorate, and that there is no alchemy which can immediately transform a man into a saint or a sage when he is appointed to a cabinet or elected to public office, even the highest, any more than when he is chosen president of a corporation.[9]

[9] In connection with the Adamson bill, which is before the present Congress, and which, as reported by the Committee on Interstate and Foreign Commerce, remedied many of the admitted defects in present water-power legislation, the newspapers have published articles claiming that this bill was dictated by the "water-power interests" and on that account was, of course, improper and in violation of the people's rights. For instance, a Boston paper in July, 1914, published a long article from its Washington correspondent arguing that this bill was not satisfactory, and containing the following statement (the italics not being in the original):

"In view of the economic and *political* importance of the water-power question a careful analysis of the *various sources* of the Adamson Dam bill, its legislative and conference *history* has been prepared. That analysis indicates that the Adamson Dam bill in important parts was approved, if not actually written by the attorneys for the water-power interests who have always fought the conservation measures and theories for which the President *pretends* to stand. This analysis speaks for itself. It is as follows:

" 'The Adamson Dam bill, debate on which began in the House July 18, is a composite measure the vital provisions in which are identical with provisions in bills advocated by the water-power interests or based on suggestions made by the water-power conference to congressional committees. The history of this bill shows that it is not the people's water-power bill as was indicated in press dispatches when the measure was finally perfected after the last of the series of White House conferences. Not unfairly, the Adamson bill might be called the Water-Power People's Power bill.' "

The proper way to consider the Adamson Dam bill, or any bill, would seem to be to study it on its merits, independent of its sources. If its provisions are inconsistent with the public good, then it should not be passed; if they are consistent with those interests, then it should be passed, independent of its "sources."

Any one who wishes thoroughly to understand this water-power question is earnestly urged to read the references to this chapter in the bibliography, Appendix VII. It may also be well to recall the words of Lecky, who says in one place: "The men who in former ages would have sought by Byzantine flattery to win power through the favor of an emperor or a prince, will now be found declaiming on platforms about the iniquity of privilege, extolling the matchless wisdom and nobility of the masses, systematically trying to excite their passions or their jealousies and trying to win them by bribes and flatteries to their side." (Democracy and Liberty, vol. 1, p. 30.)

In view of the facts and arguments which have been given in preceding pages, the conclusion seems clear that a great part of the conservation talk which is now so common, particularly with regard to water power, will mislead and confuse the public and perhaps further individual political aspirations rather than promote real and scientific conservation.

CHAPTER V

WATER POWER ON THE PUBLIC DOMAIN

A large portion of the territory of some of the western states is still a part of the public domain. How extensive this area is, will be seen from the following table:

TABLE SHOWING APPROXIMATELY THE PERCENTAGE OF THE AREA OF FAR WESTERN STATES OWNED BY THE FEDERAL GOVERNMENT[1]

State	Total Acreage owned by United States	Percentage of total
Arizona	67,097,293	92.00
California	53,276,547	52.58
Colorado	37,702,033	56.67
Idaho	45,218,919	83.80
Montana	61,049,263	65.80
Nevada	62,219,423	87.82
New Mexico	49,315,409	62.83
Oregon	32,229,745	51.90
Utah	43,564,645	80.18
Washington	17,684,198	40.00
Wyoming	42,613,499	68.00

These lands are held by the Federal Government as proprietor, not merely as sovereign; and with respect to them, outside of its limited exclusive jurisdiction, it is subject, as any other proprietor, to the laws of the State within which the lands lie. For instance, a State may, by the power of eminent domain, condemn rights of way across the public domain, and the proprietary right of the

[1] Senate Document No. 243, 63d Congress, 1st Session, entitled "Conservation of National Resources," by W. V. N. Powelson. Note that Arizona is 92 per cent "preserved," leaving but 8 per cent of area of the State to pay taxes and do business.

United States can in no respect restrict or modify this exercise of the sovereign power by a State (U. S. v. Railroad Bridge Co., 6 McLean, 517; Lewis, Eminent Domain, 2d Ed., Sec. 264); but it cannot condemn an area set aside by the Federal Government for a special purpose, for example, for a fort (U. S. v. Chicago, 7 How. 185).

Where the Federal Government owns the riparian rights, whether or not it can control the water, except to preserve the interests of navigation, it controls absolutely and directly the development of the power, because to utilize it the riparian land would be necessary. This power can, therefore, be developed by private individuals only upon such terms as the Government may impose. In such cases the Government may be said to own the power, as it possesses the right of the riparian owner and also the right to control navigation. Where Government land has to be overflowed by the pond created by a dam located on private land below, or where only rights of way are necessary for transmission or pipe lines to cross Government land, the Government indirectly controls the power; for it has the technical legal right to impose any burden as a condition for permitting the incidental, but indispensable, use of the land, however small that use may be. In the latter case it does not own the power, but it is in a position arbitrarily to control utilization, or to prevent it altogether.

In more legal phraseology, in view of the constitutional provision and the decisions of the courts, it is clear that the Federal Government, acting through the Congress,

"has the power to lease its riparian lands, with the waters appurtenant thereto, situate within the several States, for such a period, on such terms, and for such rent as Congress in its discretion may prescribe, but the lessee would, at most, only acquire the common-law usufruct in the water of the appurtenant stream, as defined by Chancellor Kent and Chief Justice Shaw.

"If the utilization of the water in a stream is sought beyond such usufruct and for other purposes, authority therefor must be obtained from the State where the residuary power over the water resides."[2]

[2] Report of Sub-committee of the Committee on the Judiciary, United States Senate, 62d Congress, 2d Session, 1912, pp. 10, 13.

Mr. Rome G. Brown states the case more fully as follows:

"Where the Government owns riparian land, it owns also all of the riparian rights appurtenant to that land; it has both the sovereign and the proprietary title. In passing such riparian land to private ownership, by patent or otherwise, it may legally and properly determine for itself its policy, and declare that policy by legislative enactment, as to whether it will grant the ordinary unqualified fee, or whether, by the grant itself, or by statutes the terms of which shall be part of the grant, it shall reserve to itself, as grantor, some interest of ownership or control, which, without such reservation, would pass to the grantee. Its power to do this is just as great as, and is no different from, that of any grantor in determining what shall be the extent and terms of a grant in any deed which he passes to a purchaser of any tract of land, riparian or otherwise. As to such Government riparian lands, it is within the discretion of the Congress to determine its policy and within its power to enact and enforce statutes declaring such policy. It saves or reserves to itself something out of that which it has, instead of passing the entire property to private ownership. It thereby acts within the limits of that which in fact is a policy of 'conservation,' and of that which only can properly be so termed."

The usual form of Government permit under such circumstances will be discussed later.[3]

The sub-committee of the Senate Judiciary Committee adds:

"The rights of the Federal Government as riparian owner is that of a riparian owner at common law. (Sturr v. Beck, 133 U. S. 541; Lux v. Haggin, 69 Cal., 336.) This right vested in the Federal Government when it acquired its public domain and of this right it is not divested on the admission of a State into the Union, for this right is expressly reserved by the Constitution. The title of the Federal Government to the public lands in the States where the rule of prior appropriation prevails antedates the admission of those States into the Union, and over that title the Constitution reserved plenary power of disposal and regulation to the Federal Government. It is only when the Federal Government has entirely parted with that title and it has passed into other ownership that the power of regulation on the part of the Federal Government becomes extinct. The water on the riparian land of the Federal Government is an appurtenance of the land of

[3] Limitations of Federal Control of Water Powers, p. 7.

which it cannot be divested without its consent, no more than of its riparian lands."[4]

This case, where the Federal Government has complete ownership of the water power, is very different from that where it only has power to control navigation, and the policy of the Government may properly be very different also. To understand the difference clearly, reference must be made to the conditions under which power is used and the price which it will bring.

In most large power developments, supplementary steam power is installed, to be used when there is not sufficient water to develop the full power of the hydraulic machinery. The water power and steam power are used together. If this is not the case, the water power in any case is likely to come into competition with steam power generated by other parties. It is, therefore, clear that it is not possible to fix a price for the water power independent of the price of steam power. Even if the auxiliary steam power were kept separate and used for a different portion of the property, the price for the two must be the same. If the water power were used for supplying one portion of an electric railway system, and the steam power for supplying another, the rates of fare could not be made different on the two portions. If this were done, inextricable confusion would result. Moreover, if it were attempted, and the water power were cheaper than the steam power, the water-power company might simply organize as a separate company, selling the water power to the street railway company at a cost equal to that of steam. It is generally conceded that in such a case there must be one price for power, whatever its source. This price will, in practice, tend to closely approximate the price at which steam power can be sold. This is very clearly pointed out in the report of the Commissioner of Corporations, Mr. Herbert Knox Smith, of March 12, 1912.

From the point of view of conservation, it is, of course, far better for the public that water power should be used instead of

[4] Report of Sub-committee, p. 8.

steam, even at the same or a somewhat greater cost; and this, too, even if such use results in unduly large profits to the water-power owners; for it saves an equivalent consumption of coal, and so tends to prevent the rise in its price which must inevitably result from exhaustion of the supply. Here again, from the conservation standpoint, *any* use is better than *no use at all.* If the water-power company owns the power, as riparian owner of the power site, it has a right to all the profit it can make, no matter how large, and it will naturally sell power at a price close to that of steam power. To this the public has no right to object, from the conservation standpoint. They are gainers if the cost of the water power to them is anything less than steam power would cost.

If, however, the Federal Government, or a State, that is to say, the public, owns the power site, the case is quite different. Here is a real asset of the Government, which should not be given away. It may conceivably be much more valuable in the future, and this value should be reserved to the people. Moreover, the people should share to some extent in any value which the site may possess in case it can furnish power at a cost less than that of steam. Since, however, the price for water power cannot be regulated at the point of consumption, but must there be the same as that of steam power, it is clear that the only point at which the share of the public can be collected is at the site, by the imposition of a charge for the power independent and in addition to a fair rental value of the land. If the Government should develop and operate the power, the public treasury would get the benefit of any profit which might arise owing to the power being more cheaply produced than steam, but sold at the same price. If the Government does not do this, the only way in which the public can gain any benefit is by a charge at the site.

Here, then, the writer is in full agreement with the so-called conservationists. In the case of water powers on navigable streams, he disagrees with them because he does not believe the Federal Government has any ownership or right beyond that of protecting the interest of navigation. It has nothing to sell. In such cases,

he does not see any reason why there should be any Government charge for power beyond a mere license fee based upon the actual cost of the necessary investigations and supervision, or why there should be any limit to the franchise. If the riparian owner has the right to use the power at all, he has the right to use it in perpetuity, subject always to the requirements of navigation. But where the Federal Government is the riparian owner, it is clear that there should be a reasonable charge for power, and that the term of the grant to use it should be either (1) for a fixed term, long enough to secure development, with provision for subsequent renewal under revised charges, or for purchase by the Government at a fair price at the end of the term, or (2) indeterminate, with provision for a taking by the Government, with compensation, at any time after a fixed period, long enough to secure development, within which period there should be no alteration in the charges. It is proper also that at stated periods after the initial period, and shorter than the latter, the schedule of charges should be revised.

The case is quite different when the Government is not the owner of the power site, and in which the public domain is only incidentally affected, as for instance, where some portion of the public domain would be flooded by the pond created by the dam, or where Government land is crossed by flumes or transmission lines. This case, however, under present regulations, is treated just as where the Government owns the site itself.

Suppose a private riparian owner wishes to develop a large power to be transmitted long distances. If its right of way crosses but ten feet of Government land, it is subject to Government control, and has not only to pay according to the power transmitted, but is subject to all the other restrictions which might be imposed if the entire site were owned by the Government. The same is true if an acre of Government land is overflowed by the pond.

There seems no reason in equity why, in such cases, the Government should have any rights or privileges other than those possessed by any land owner, or why the riparian owner who is developing the power should not have the right, if conferred by the State in

which the land is situated, of condemning Government land for flowage, or for a right of way for his flume or transmission line.

In the case of water powers where the site is on the public domain, then, it is sound public policy for the Government to make a charge for power, and to safeguard the future interests of the public in every reasonable way. The main controversy arises in regard to the form and condition of the permit and the rates charged.

One of the most serious obstacles to the development of water powers on the public lands is that the Government permit which must be obtained is now, by law, revocable at any time at the will of the Department by which it is granted, and is also subject to such conditions as that Department may impose not only when the permit is granted, but subsequently thereto. Indeed, the permit, under certain circumstances, may be automatically revoked, as by entry by a third person under the Homestead or Mining Laws (Acts of February 26, 1897, June 4, 1897, February 15, 1901, and February 1, 1905). Anybody developing power on Government lands is thus absolutely at the mercy of the Federal Government and must rely entirely upon the fairness of a Government official. This feature, while it has not served to prevent the investment of private capital in such enterprises, prevents such investment to anything like the extent to which it would be otherwise possible. Considering the precariousness of water-power projects in any case, an investor demands and should have some guarantee of a tenure sufficient to allow of adequate profit on the undertaking.

This is particularly true regarding rights of way and flowage rights. It is unreasonable to expect that investors will knowingly put their money into water-power developments if the fact that a small part of the transmission line lies upon Government land subjects the entire development to the danger of instant revocation of its rights upon the whim of a Cabinet officer. Yet it might be impossible or very difficult and expensive to avoid crossing Government lands.

Another trouble experienced in water-power development

involving the public domain is the multiplicity of authorities to be dealt with. A public utility company desiring to make such a development on a navigable stream must first secure consent by a special Act of Congress; then secure the approval of the plan by the Secretary of War and the Chief of Engineers. If the transmission line crosses Government land, or if any other use of Government land is necessary, it must secure a permit from the Secretary of the Interior. If it elsewhere crosses a forest reserve, it must secure another permit from the Secretary of Agriculture. It must also procure from the Secretary of Commerce his approval of such fishways as he may deem necessary. When the power is used, it is subject to the Public Service Commission of the State in which it is utilized. If this is a different State from that which contains the power site, it may also be subject to the Interstate Commerce Commission. It may also, conceivably, be necessary, first of all, to appropriate the water in accordance with the laws of the State in which the site is located. The project may, therefore, be subject to the action of a State Board, of the Congress, of three or four members of the Cabinet, of the Chief of Engineers, of a Public Service Commission, and perhaps of the Interstate Commerce Commission. Surely this is over-regulation.

Some of these difficulties have been recognized by the Government officials,[5] and at least one Federal permit is stated to be irrevocable except for breach of conditions. It is evident, however,

[5] See report of the Secretary of the Interior, June, 1911, in which the following statements are made:

"The present laws relating to water power are hopelessly inadequate. The protection of the public interest is supposed to be accomplished by the statutory provision that permits for the development of water power shall be revocable at any time at the will of the administrative officials. This is thoroughly unsound both in principle and in practice.

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"The result is that such capital as is invested in water-power development under Federal permit, claims to be entitled to extraordinary returns on account of the extraordinary risk theoretically involved.

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"The result of the whole matter is that we have far less development than would be possible under a proper system, and the development which we do have proceeds under what seems a legitimate excuse for exacting a larger return than should be necessary."

that one administration has no legal power to bind its successors, or even itself, and that a future administration might at any time legally revoke such permit.

The provision in some permits for fixed payments to the Government and for a revision of the terms of payment at intervals of ten years is, in many cases, a serious deterrent to development. Capital will not ordinarily be largely invested on such terms.

Another serious deterrent to investment is the provision that in case of a taking by the Government the price paid, if not agreed upon, shall be fixed by the Government, or by a member of the Cabinet. A Cabinet officer cannot be considered in this connection except in a strictly impersonal sense. We may be willing to implicitly trust John Smith, but there is no sufficient reason why we should implicitly trust the Secretary of War, whoever he may happen to be at the time. Capital should no more be expected to trust the Government in this way than the latter should implicitly trust the former. Neither should be deprived of recourse to the courts.

Proceeding under the Acts of the Congress relating to this matter, the Government Departments have formulated regulations and rates for power to be incorporated in permits. A sincere endeavor has evidently been made by the Government bureaus to prescribe reasonable terms, so far as the law will allow, but no form yet suggested appears to be entirely satisfactory. From an economic point of view they all seem open to criticism. If fixed charges are to be made, such charges should, apparently, be less the lower the rates made to customers, and in order to encourage the development of power, the charge should in general be less the greater the proportion of the total potential power utilized. The schedule of charges should not discriminate against economical and efficient management, but should reward it. But the charge should equally clearly bear some relation to the cost of delivering power to the consumer. This varies greatly in different cases, dependent upon many technical conditions.

It is very difficult, if not impossible, to reconcile all these

elements, some of which are conflicting. For instance, the load factor (that is the ratio of the average power used during twenty-four hours to the maximum power consumed at any one time) varies very greatly in different industries. It is very small in the case of a store using electric light only a few hours a day, and large in a factory using power continuously. These variations must be reflected in the generating and transmitting plant, which must be prepared to deliver the maximum power required at any instant. A customer whose load factor is high may be more profitable to the company, even at low rates per kilowatt hour, than another customer with a lower load factor at higher rates. Yet this fact is not taken account of if a fixed fee is charged by the Government, which is made lower the lower the average rate charged to customers.

All these difficulties will be avoided if the Company is allowed to earn and distribute in dividends a specified rate on the capital property invested, dividing with the Government in some defined ratio if dividends in excess of the allowed rate are distributed, as elsewhere recommended in this book.

It is sometimes provided that a Company operating under a Government permit shall not sell more than 50 per cent of its power, or some other percentage, to any one concern. Such a provision is contrary to the public interest, as well as to the interest of the investor. It may be most desirable to supply the entire product to one concern, as, for instance, to a land company for irrigation, or to a railway company for electrification.

These provisions will be illustrated by an examination of the regulations in force under the Department of the Interior and the Forest Service.

Regulations Governing Permits for the Development of Water Power in the National Forests

Under the regulations of the Forest Service, three forms of permit are issued: (1) Free Permits, (2) Preliminary Permits, and (3) Final Permits.

Free permits are issued "for small water-power plants for domestic purposes, irrigation use, mining, operation of sawmills, etc., in which the average annual use will not exceed 100 horsepower."[6] "Applicants are required to file maps and notes of survey sufficient only for proper location of the lands occupied and for the protection of the permittees against reapplication for the land by others."[7]

Preliminary permits are issued "where the power project is one of considerable size, and more or less expensive investigations and surveys are necessary. To secure this form of permit the applicant is required to present merely a sketch map of the proposed location and to file such information respecting water supply as he has readily available. The preliminary permit gives the holder priority as against subsequent applicants, for the time necessary to make investigations and prepare the maps and plans required for final permits,"[8] which are issued "only in case it appears that the proposed occupancy and use will be in general accord with the most beneficial utilization of the resources involved and consistent with the public interest,"[9] and do not interfere in any way "with works operated or constructed or to be constructed under an existing final power permit."[10]

Permits are by law subject to revocation at any time by the Secretary of Agriculture, but "it is not the policy of the department to revoke permits within a period of 50 years if the permittee observes the conditions under which the permit is granted."[11]

The charges under a preliminary or final permit for projects involving a total capacity of more than 100 horse power, except for transmission lines used in connection therewith, and except for municipal purposes by a municipal corporation, or for irrigation, or for temporary construction of project works, or for logging or

[6] Report of the Forester, November 11, 1913, p. 40.
[7] *Ibid.*
[8] *Ibid.*
[9] National Forest Manual, 1913, p. 8.
[10] *Ibid.*
[11] The Use Book—Issued by the Secretary of Agriculture, July 1, 1913, p. 71.

manufacturing National Forest timber, are (unless otherwise ordered by the Secretary) at the following rates per horse power per year, in advance, calculated on the horse power in what is termed the "rental capacity of the power site."

For the unexpired portion of the calendar year and for the first full calendar year of the period prior to actual operation, covered by preliminininary and final permits and similarly for the operation period . . .	$0.10 per h. p.
For the second full calendar year of each of said periods .	0.20
For the third year	0.30
For the fourth year	0.40
For the fifth year	0.50
For the sixth year	0.60
For the seventh year	0.70
For the eighth year	0.80
For the ninth year	0.90
For the tenth and each succeeding year	1.00
For transmission lines the charge, payable in advance, is $5.00 per year per mile, or fraction thereof, except for municipal purposes by a municipal corporation, for irrigation, or for temporary construction of project works or for logging or manufacturing, by the permittee, of National Forest timber. No mileage charge is made for a transmission line if it is covered by the same permit that covers the generating plant. Under such conditions the charge based upon "rental capacity" is considered as compensation for all the works covered by the permit.	

The estimated rental capacity "may be adjusted by the Secretary (a) to provide for changes made during construction, (b) annually to provide for changes in ownership of lands in reservoir sites and on water-conduit lines, and for changes in length of primary transmission, (c) to provide for changes in nominal stream flow whenever such flow is increased or decreased because of additional storage or otherwise; or (d) whenever not less than ten (10) years after the determination of the last preceding esti-

mated value thereof, the permittee shall apply for or the Secretary give notice of a redetermination of the rental capacity of the power site."[12]

There is no charge to municipal corporations using National Forest lands for municipal purposes, nor to other permittees for irrigation as auxiliary to irrigation works owned and operated by them, or for temporary construction and development of power for permanent project works by the same permittees or for logging operations or the manufacture by the permittee of National Forest timber.

The Secretary may review the rental rates, and impose new ones at any time not less than ten years after the issuance of the final permit, or after the last revision of rental charges thereunder; but it is provided "that such rental rates shall not be so increased as to reduce the margin of income (including appreciation in land values) from the power project under permit, over proper actual and estimated expenses (including reasonable allowance for renewals and sinking fund charges) to an amount which, in view of all the circumstances (including fair development expenses and working capital) and risks of the enterprise (including obsolescence, inadequacy and supersession) is unreasonably small, but the burden of proving such unreasonableness shall rest upon the permittee."

To discuss in detail this provision would lead us too far, but the writer must remark that he considers it fundamentally wrong, and unjust to the investor, to include appreciation of land values as income. This, of course, refers to lands owned by the permittee, not to the land, the use of which is granted by the permit. The increase in value of this land is not income. The investor does not and cannot receive it. The land must be held and used for the purposes of the corporation, which might be making no money and paying no dividends, and yet according to the above provision the Government charge might be increased because its lands had become more valuable. Or, a prosperous concern, paying reasonable

[12] National Forest Manual, 1913, p. 11.

dividends on a fair cost might, under the revision of rates provided for, if appreciation of land is considered as income, have the Government charges increased so as to wipe out the dividends completely and thereby largely destroy the property of the investor.[13]

[13] Although this is not the place to enter into an extended discussion, it may be profitable to consider more carefully this particular question. It is generally recognized that a going concern should be allowed to earn, if it can, a sufficient income, not only to pay expenses of operation, taxes, a reasonable return on a fair investment, and a reasonable surplus for emergencies (see Chap. VIII), but also an additional sum sufficient to provide for depreciation and amortization. By depreciation is here denoted the loss in value of physical property arising from its being partly worn out, or by the fact that a portion of its useful life is past. The reason for allowing for depreciation reserves in current earnings, arises from the fact the stockholder at some time in the future must put his hands in his pocket and find the cold cash there to enable him to replace any given item of physical property when it is worn out. It would not be proper that this replacement should be done with new capital; it must, in general, be done with money set aside from earnings, and without increase of capitalization.

Now land is an item of physical property which, in general, does not diminish, but on the contrary increases in value or appreciates. In the minds of many writers and many who have to do with these problems, there is a necessary antithesis between depreciation and appreciation, and they have argued that if depreciation is allowed in earnings, appreciation should also be allowed for as income. There is, however, no necessary antithesis. Appreciation of land might properly be allowed as a part of income provided it came to the stockholder in cold cash, just as he must provide for the depreciation which leads to renewals in cold cash. But the appreciation of land does not, in general, come to the stockholder—at least so far as concerns land necessary to be held and used for the purpose of the corporation. There are only two ways in which the stockholder could really get in cash this appreciation of land:

(1) If the concern should sell its entire property to another corporation for an amount equal to its first cost plus the appreciation of land, then the stockholder would get this appreciation. If such appreciation is to be allowed as income, as in the above regulations, then the new corporation buying the property must, of course, be allowed to earn a return upon the price paid. That is to say, appreciation of land would be capitalized from time to time at each sale of the property, and these sales would have to be frequent in order that the stockholder might really get this appreciation in cash without undue delay. Such continued transfers of the property would, of course, not be desirable either from the public or the private point of view. A corporation should develop a property for the purpose of keeping and using it for the service of the public; not for the purpose of selling it to somebody else within a short time.

(2) The second way in which the stockholder might really get the appreciation of land, would be for the corporation to declare at intervals stock dividends equal to this appreciation, but in this case the stock received by the stockholder would not be real income unless it could be converted into cash—that is to say, unless it could earn a return. Here again, therefore, the recognition of appreciation of land as income, fairly interpreted, means that this appreciation is to be capitalized at short intervals. Now, although this is the logical result of treating appreciation of land as income, the regulations of the Forest Service provide (Par. S) that in case the property is taken by the United States, or by a state or municipal corporation, only the *original cost* shall be paid for the tangible

This idea of considering appreciation of land as income, which has been advocated by some members of Public Service Commissions, seems to involve the result that, although an industrial concern, by utilizing power and producing industrial development, causes an increase in population, and an increase in land values, it is not to be allowed any benefit from the appreciation of its own land values, but is to be penalized therefor, by being obliged to consider such increase as income, although it cannot be realized, and the investor does not get it. It is difficult for the writer to conceive of anything more opposed to the spirit of true conservation, or anything more fallacious, than such an economic theory. It may be further stated, that the Supreme Court of New York

property, if such original cost can be determined. In other words, it is distinctly stated that the stockholder is *not* to be allowed to receive the appreciation of land.

This discussion clearly shows the confusion involved regarding economic principles in the regulations referred to. It may be added that the writer does not believe in capitalizing appreciation of land, in the case of a concern subject from the outset to state regulation, as in the case of a corporation organized under one of the permits such as is being discussed, provided the corporation is allowed to earn operating expenses, taxes, depreciation and amortization charges, and a fair return on all money properly invested, this fair return to be determined for each case in view of the circumstances of that particular case; and he considers it fundamentally wrong and inequitable to consider appreciation of land as income. Furthermore, to provide, as is done in these regulations, that appreciation of land is to be considered as income but is not to be allowed to come to the stockholder, in view of the fact that when the property is taken the original cost only is to be paid, seems to be nothing more nor less than legalized confiscation.

The plan of calling appreciation of land income perhaps receives weight in some minds on account of the use of the method of reproduction in making valuations of property for the purpose of fixing rates. Under this method the cost is estimated of reproducing the property today as it stands, using average prices which have prevailed during the past few years. Many of those who have advocated such valuation under the impression that our corporations were greatly overcapitalized, have been surprised to find that in many cases the valuation is far in excess of the capital, partly owing to the great appreciation that has taken place in land; and they seek to avoid this result by endeavoring to put in the land at its original cost or by some other plan, and also by maintaining that appreciation of land is income. Furthermore, there are many who claim, as the present writer does, that in such valuations for rate-making purposes, depreciation should *not* be deducted. This leads those on the other side to maintain still more strongly that appreciation of land should not be allowed in the valuation, or else treated as income, again under the mistaken idea that there is an antithesis between *de* and *ap*. Here again there seems to the writer to be confusion regarding simple economic principles. In using the cost of reproduction method for valuations, unit prices are taken as of the present time. Articles which cost more than at the time of original construction are marked up from the original cost; those which cost less are marked down. Appreciation *in cost of reproduction* is set off

has decided against the legality of such a provision, using the language

"So long as the land is held and used for such purpose (the original purpose) increase in value cannot be considered as income and available for the payment of debts, taxes, or dividends."[14]

Moreover, to make it possible for the Secretary to impose in his discretion new charges ten years after the issuance of the permit is unnecessary, and in many cases would be a serious deterrent to the investment of capital. Few engineers would advise a client to put money into an enterprise the returns from which were liable to be adjusted by an unknown Secretary within so short a period, especially when subject to the other provisions recited above.

In order to understand clearly the basis of the above specified rates for power, the meaning of the term "rental capacity of the power site" must be defined. This depends upon the following definitions: "The 'nominal stream flow' means the sum of (a) the flow determined by averaging the values estimated for the natural mean flow for the two-month (calendar) minimum-flow period in

against depreciation *in cost of reproduction,* and properly so; but what is generally known as depreciation—that is to say, the loss which comes from wear and leads to renewals—is an entirely different thing, and cannot be considered as antithetical to the appreciation of land.

The writer may also add, that in a valuation of public utility corporations for rate-making or capitalization purposes, the "original-cost method," if it is applicable, is, in his opinion, in general preferable to the "cost-of-reproduction method." The money properly invested, including all proper charges to capital, with overhead charges, interest and deferred dividends, should by this method be taken into account. But in most cases the original-cost method cannot be used, because the data are not available. Hence recourse must be had to the cost-of-reproduction method, in which, of course, appreciation of land must be allowed. This method is used as the only one available, and a new start is made, under which bookkeeping methods are unified, and provision made for *thereafter* keeping track of all proper capital charges. However, *one method only* must be used; it would be inequitable to apply both methods in one valuation; either one or the other must be used. Further, in the case of railroads, the same method must be used for all existing roads, otherwise no proper basis of comparison would be obtained; and, since the original-cost method is almost always inapplicable to an existing railroad, the cost-of-reproduction method must be used throughout. Once used, however, there need be no question, in the future, as to appreciation of land.

[14] Kings County Lighting Company v. Public Service Commission, State of New York for the First District.

each successive five-year period or major fraction thereof, and (b) the stream flow made available from storage not by the project works," that is to say, the flow released from storage reservoirs not owned by the permittee or not covered in the permit under consideration, which will be available at the permittee's intake to increase the natural mean flow at time of low water, and hence to add to the amount available for his use. In other words, the intent is to obtain the estimated average unregulated flow during the lowest period of two months, and to add to this the average flow made available during this same period from storage outside the works comprised in the project itself, that is, by reservoirs other than those created by the dams included in the project.

The "load factor" is, of course, as is well understood, the ratio of average to the maximum power output.

The "total capacity of the power site" is the net average horse power which it will furnish, with a wheel efficiency of 70 per cent, when the flow available is the "nominal stream flow" plus any flow made available by the project works. This allows for the additional storage or pondage due to the intake dam or other storage reservoirs included in the project, and the load factor of the system. It appears to be intended to represent the average horse power which the system can furnish during twenty-four hours, with a wheel efficiency of 70 per cent, during the average lowest two-month period, assuming the flow during this period to be constant.[15]

The "rental capacity" of the power site, upon which the charges

[15] The definition given in the Regulations of the Department is: "'Total capacity of the power site' means the continued product of (1) the factor 0.08*; (2) the average effective head, in feet; (3) the stream flow estimated to be available at the intake (in second-feet and in amount not to exceed the maximum hydraulic capacity of the project works considered as the sum of (a) the nominal stream flow and (b) stream flow made available from storage by project works); and (4) a factor not less than the average load factor of the power system, representing the degree of practicable utilization of the stream flow estimated to be available, and based on the extent of fore-bay storage and the load factor of the power system."

* The factor 0.08 represents the horse power at 70 per cent efficiency of a second-foot of water falling through a head of 1 foot.

are based, is determined by making the following deductions from the total capacity of the power site:

(a_1) If the pond created by the dam when at its average level overflows some lands that are not National Forest lands, then the ratio of the area of such lands to the total area so submerged is multiplied by the ratio of the average height that the water is raised by the dam to the total average effective head from the intake to the tailrace outlet; this resulting fraction of the nominal stream flow is deducted therefrom.

(a_2) If the canal or flume ("water-conduit") leading from the pond to the power house passes for a portion of its length over lands which are not National Forest lands, the ratio of such length to the total length of the canal or flume from intake to tailrace outlet is multiplied by the ratio of the average effective head obtained from the canal or flume (that is, the total average effective head from intake to tailrace outlet, less the average height that the water is raised by the dam itself) to the total average effective head; this resulting fraction of the nominal stream flow is deducted therefrom.

(b) If the project involves reservoirs other than the pond above the intake dam, which reservoirs are not wholly on National Forest lands, then the ratio of such reservoir area which is not on National Forest lands to the total area of such reservoirs is computed and the resulting fraction of that portion of the stream flow which is made available by storage from the project works (that is, in general the storage in the pond above the intake dam and from all other dams included in the project) is deducted therefrom.

(c) "From the total capacity of the power site which remains after deductions (a) and (b) have been made will be made a further deduction which, in per cent, shall be the product of the square of the distance of primary transmission in miles and the factor 0.001, but in no case shall deductions (c) exceed 25 per cent."

An example will illustrate the application of these provisions. Suppose a project to present the following data:

(1) A reservoir for storage purposes only, called "Reservoir A," from which a stream flow of 300 cubic feet per second may be made available. This reservoir covers six square miles, of which three square miles are not National Forest land.

(2) A combined storage and diverting reservoir, called "Reservoir B."

(a) The dam raises the water an average of 50 feet.

(b) The stream flow made available from Reservoir B is 200 cubic feet per second.

(c) The area of this reservoir when full is four square miles, of which 1.5 square miles is not National Forest land; when the water level has been raised 50 feet, it is three square miles, of which one square mile is not National Forest land (all below 50 foot level).

(3) The conduit is an open canal from dam to forebay. The total length from intake to tailrace outlet is 20,000 feet, of which 5,000 feet are not on National Forest land.

(4) There is a forebay reservoir at the head of the pressure pipes leading to the power house, having a capacity sufficient for four hours' operation of the plant at full load.

(5) The total average effective head, from pond to tailrace outlet, is 120 feet.

(6) The nominal stream flow is 1,000 cubic feet per second, consisting of

(a) From the natural flow, 900 c. f. p. s.

(b) From storage in reservoirs not owned or controlled by the permittee, or not included in the permit under consideration, 100 c. f. p. s.

(7) The distance of primary transmission is 50 miles.

(8) The plant is to be used as an addition to an existing system, the average daily load factor of which is 55 per cent. Typical daily load curves of the system are available.

Now, if the load factor were 100 per cent, the total capacity would be $0.08 \times 120 \times 1500 = 14400$ h. p. But the factor (4) of the definition of "total capacity" of the power site must be introduced. This factor is *not less* than the load factor of the power system, but as this load factor simply depends upon the variation in supply during the day, the factor (4) will be greater than this if regulating storage is available, either in the pond above the intake or in the forebay. The "per cent of practicable utilization" must in any case be estimated from all the data available. Let us suppose that in the present case investigation indicates that 70 per cent will be available. Then we have

"Total capacity of power site" $= 14400 \times 0.7 = 10080$ h. p.

The stream flow of 1500 second-feet is made up of three parts: (1) the nominal stream flow, 1000 second-feet, which is entirely independent of the project in question; (2) the stream flow made available from storage from Reservoir A, 300 second-feet; (3) that made available from storage by Reservoir B, 200 second-feet. The total capacities corresponding to these three parts are:

(1) Nominal stream flow	6720 h. p.	3360 h. p.
(2) Storage in Reservoir A	2016 h. p.	3360 h. p.
(3) Storage in Reservoir B	1344 h. p.	

The deductions are then made as follows, as the writer understands the practice of the Forest Service:

(a_1) applied to the 6720 h.p. only.

Proportion of average effective head obtained from dam . $\frac{50}{120}$

Proportion of submerged land in Reservoir B below flow line, fixed by average effective head, which is not National Forest land . . . . . $\frac{1}{3}$

The deduction in per cent is, therefore, $\frac{50}{120} \times \frac{1}{3} = \frac{50}{360}$. 13.9%

(a_2) applied to the 6720 h.p. only.

Proportion of average effective head obtained from water-conduit line . . . . . $\frac{70}{120}$

Proportion of length of conduit which is not on National Forest land . . . . . $\frac{5000}{20000}$

The deduction in per cent is, therefore, $\frac{70}{120} \times \frac{5}{20} = \frac{35}{240}$. 14.6%

(a_1) + (a_2) = 28.5% ; 28.5% of 6720 = ... 1915 h. p.

(b) applied to the 3360 h. p. only.

The per cent of total area of reservoir sites, when full, not National Forest land, is

of Reservoir A . . . . . 50 %

of Reservoir B 37.5%

The deductions are therefore

Reservoir A, 50 % of 2016 h. p. = 1008 h. p.

Reservoir B, 37.5% of 1344 h. p. = 504 h. p.

Total deduction (b) . . 1512 h. p.

Total deductions, a = ...	1915 h. p.
Total deductions, b = ...	1512 h. p.
	3427 h. p.
Total capacity of power site remaining	6653 h. p.
(c) $50 \times 50 \times 0.001 = 2.5\%$; 2.5% of 6653 = . . .	166
"Rental capacity of power site"	6487 h. p.

The hydraulic engineer will note that several assumptions are made in the foregoing, but they are reasonable, and it seems scarcely possible to make better ones. For instance, it is assumed that the flow obtained from storage is in proportion to the area flowed, which is clearly not always true, since the depth over the area flooded is an element. In other words, *capacity* rather than *area* should, strictly speaking, be the criterion.

The general principles which have dictated these rules for deductions are apparent. It seems to the writer, however, that the wording of the rules and their application, are not entirely free from ambiguity.

Deduction (a) is clearly and properly intended to take account of two facts; (1) that the pond at the intake overflows some lands which are not Government lands and (2) that the conduit passes over lands some of which are not Government lands.

Deduction (a_2), which takes account of the fact that a conduit passes partly over private lands, is applied only to the nominal stream flow, excluding that portion which is due to the storage developed. The water derived from such storage flows through the conduit line equally with the natural flow and would seem to be equally entitled to a deduction on account of the fact that a portion of the fall utilized is gained by passing through private land.

The writer would be inclined to make deductions as follows:

Determine what portion of the total fall available (f) is due to the construction of the dam (f_d) and what portion is due to the conduit line (f_c). The sum of (f_d) and (f_c) = f. Then the fraction $\frac{f_d}{f}$ of the total power is due to the dam, and the fraction $\frac{f_c}{f}$ is due to the conduit line. Then the deductions might logically be as follows:

(a_1) Total capacity $\times \frac{f_d}{f} \times \frac{\text{area of private lands submerged by main dam when full}}{\text{total area submerged by the main dam when full}}$

(a_2) Total capacity $\times \frac{f_c}{f} \times \frac{\text{length of conduit line in private lands}}{\text{total length of conduit line}}$

(b) Capacity due to stream flow from storage reservoirs not by project works $\times \frac{\text{storage area from such reservoirs on private lands}}{\text{total such storage area}}$

(c) As stated above.

Thus, in the example above, it is clear that $\frac{5}{12}$ of the total power is due to the dam, and $\frac{7}{12}$ is due to the fall in the canal or "water-conduit." Of the $\frac{5}{12}$, three-eighths should be deducted, because this fraction of the pond when full, covers land not in the National Forest: of the $\frac{7}{12}$, one-fourth should be deducted, because this fraction of the conduit is not on Government land. Further, $\frac{3}{15}$ of the total power is due to storage above the intake pond, and of this fraction $\frac{1}{2}$ should be deducted because this fraction of the reservoirs is not on Government land. The total deductions are therefore

$$\frac{5}{12} \times \frac{3}{8} = \frac{15}{96}$$

$$\frac{7}{12} \times \frac{1}{4} = \frac{7}{48}$$

$$\frac{3}{15} \times \frac{1}{2} = \frac{3}{30}$$

$$\frac{15}{96} + \frac{7}{48} + \frac{3}{30} = 0.402$$

The deductions (a) and (b) should therefore be

$$10080 \times 0.402 = 4052 \text{ h. p.}$$

leaving 6028 h. p.

Deduction (c) will be 2.5 per cent of 6028 = 151 h. p., leaving as the rental capacity 5877 h. p.

As to the actual rates charged according to these rules, it cannot be fairly claimed that they are unreasonable or that, in themselves, they in the slightest degree discourage development. On the contrary, they are very small, the maximum charge being $1.00 per h. p. per annum, or, for constant power, 0.015 cent per kw. hour. The plan of beginning with a very much smaller charge and increasing gradually is an excellent one and encourages development. "The total receipts of the Forest Service for the year ended June 30, 1913, on power plants having an aggregate capacity of 783,600 h. p. were only $48,664.11, equal to 6.2 cents per h. p. per annum, or 0.9 cents per 1000 kw. hours,"[16] surely a small charge.

[16] Report of the Forester, November 11, 1913, pp. 40-41.

An application for a final permit must be accompanied by complete plans of the proposed works and by information enabling all these estimates, above referred to, to be made, "accompanied by complete statements in detail of all data on which they are based, including stream measurements, rain-fall, stream flow, and evaporation records, drainage areas, total static head and losses in head, probable maximum, minimum and average power output, load curves of the power system, efficiencies of machinery, probable points of delivery of power, and all other pertinent information." The permit will be issued only if the plans show a reasonably complete development. The maps and plans are made a part of the permit and the work must be constructed in accordance with them. To further prevent speculative holding of power sites, the permit requires the permittee to begin the construction of the project works within a reasonable specified time, to continuously and diligently prosecute the construction thereof and to complete the construction and begin the operation within a further specified period or periods from the date of execution of the permit. Furthermore, a small annual charge is exacted during the period preceding operation, these payments being credited to the permittee against subsequent charges after operation begins. In this manner the public is protected against speculators who might otherwise hold power sites indefinitely without development, while the additional charge to the developer consists only in the interest upon his payments made during the time of construction.

It is also required that the permittee shall operate the works continuously unless such operation is prevented by unavoidable accidents.

The permit also requires the permittee to conform to various other requirements, as for instance:

(F)[17] On demand of the Secretary to install free of expense meters, measuring weirs, or other devices for the determination of the amount of power developed, the flow of the streams, and the utilization of storage.

[17] These letters correspond, where practicable, with those in the official regulations.

(G) To keep its books open at all times to the inspection and examination of the Secretary or other agent of the Government.

(H) On demand of the Secretary to maintain an approved and uniform system of accounting, and to render annually such reports of the business as the Secretary may direct. If the laws of the State in which the power business is transacted require periodical reports under a uniform system of accounting, copies of such reports will be accepted by the Secretary.

To protect and keep in good order all Government property concerned and to repair any damage done in connection with the power project.

To do everything reasonable in coöperation with the Federal Government to prevent and suppress forest fires; and to pay the full value of all timber cut, injured or destroyed, and the full value resulting from any other damage in connection with the project works.

(Q) "To sell power to the United States, when requested, at as low a rate as is given to any other purchaser for a like use at the same time and under similar conditions, if the permittee can furnish the same to the United States without diminishing the quantity of power sold before such request to any other customer by a binding contract of sale: *Provided*, That nothing in this clause shall be construed to require the permittee to increase permanent works or to install additional generating machinery."

(R) "To abide by such reasonable regulation of the service to be rendered by the permittee to consumers of power furnished or transmitted by the permittee, and of rates of payment therefor, as may from time to time be prescribed by the State or by any duly constituted agency of the State in which the service is rendered; but if such regulation is not exercised by the State or by any duly constituted agency thereof, that the Secretary may upon the filing with him of formal complaint by the State, by a municipality, or by not less than twenty-five (25) customers or prospective customers of the permittee, cause an inquiry to be made concerning the service or rate of payment complained of, and if it shall appear upon such inquiry that the service or the rate of payment complained of is unreasonable, the Secretary may fix the character of the service, and may name the rate of payment which shall be rendered or charged."

(S) "Upon demand therefor in writing from the Secretary to surrender the permit to the United States or to transfer the same to such State or municipal corporation as the Secretary may designate, and on the condi-

tions specified in this paragraph; also to give, grant, bargain, sell, and transfer with the permit (upon such demand and upon said conditions) such works, equipment, structures, and property then owned or held and then valuable or serviceable in the generation, transmission, or distribution of electrical or other power, and which are then dependent in whole or in part for their usefulness upon the continuance of the permit, as may have been determined by agreement with the Secretary and embodied in the aforesaid stipulation. *Provided, however,* that such agreement and such stipulation shall include only complete units of construction or of development; and *Provided, further,* that if such agreement or stipulation shall not include all such aforesaid works, equipment, structures, and property, as are dependent in whole or in part for their usefulness upon the continuance of the permit, the permittee shall waive all right to demand or receive consequential damages for the severance of any property taken under the provisions of this paragraph from any property not taken. The Secretary may require such surrender if the United States shall desire to take over the permit and properties, or he may designate as such transferee any State or municipal corporation which shall desire such transfer; *Provided, however,* That no municipal corporation shall be so designated unless by proceedings in a court of competent jurisdiction it shall have been determined that such a municipal corporation has the right to acquire such property; *And provided further,* That no municipal corporation shall be so designated unless it also has the power to acquire the said property and rights of the permittee in accordance with the following conditions. Such surrender or transfer shall be on condition precedent that the United States or such transferee shall first pay to the permittee the reasonable value of all said works, equipment, structures, and other tangible property, and in addition thereto a bonus of three-fourths of one per cent of such reasonable value for each full year of the unexpired term of the permit. Such reasonable value shall not include any sum for any permit, franchise, or right granted by the United States, by any State, or by any municipal corporation in excess of the amount (exclusive of any tax or annual charge) actually paid to the United States or to such State or municipal corporation as the compensation for the granting of such permit, franchise, or right, or any sum for any other intangible properties or values whatsoever, it being the intent of this paragraph that all such intangible values shall be covered by the bonus herein provided for. Such reasonable value shall be determined

by mutual agreement between the parties in interest; and, in case they can not agree, by a board of arbitration of three members, one of whom shall be named by the permittee and one by the transferee; the third shall be either the Secretary or some representative whom he may name. The reasonable value, for the purposes of such determination, of such works, equipment, structures, and other tangible property shall be the actual and necessary cost thereof, or, if such original cost can not be determined with reasonable certainty, shall be the cost of reproduction of such works, equipment, structures, and other tangible property under substantially the same conditions as existed at the time of the original construction and at prices for labor and material which shall be the average of such prices for the five years next preceding the date of valuation, less a percentage of such original or such reproduction cost equal to the per cent of physical and functional depreciation of the existing works, equipment, structures, and other tangible property."

(T) In respect to any regulation by any public authority of the service rendered by the permittee, or the price to be charged therefor, no value is to be assigned to the franchise itself upon which the permittee is to be entitled to earn a return.

The permit is not to be transferable except with the approval of the Secretary.

There shall be an annual rental charge of $5.00 for each mile, or fraction thereof, of National Forest land crossed by power transmission lines, and in respect to such transmission lines there shall be similar provisions to those relating to power development itself.

The permit is forfeitable for breach of conditions.

The permit is by law revocable at the pleasure of the Secretary, the permittee to have a reasonable time, not exceeding ninety days, within which to show cause why such revocation should not be made.

Present regulations indicate that the present administration favors the granting of fifty-year permits, or indeterminate permits. So long as the Act of 1901 remains in force, however, all regulations are subject to it and any subsequent Secretary may revoke a permit at pleasure, even though his predecessor, or he himself, has granted it for fifty years, or for an indeterminate period.

By a recent regulation the Secretary is authorized to grant an indeterminate permit in lieu of a fifty-year permit, subject to the right of the

United States, or the State, or of a municipal corporation to purchase, subject to termination for cause, and to revocation as provided by the Act of 1901, and subject also to the provision for a readjustment of terms at intervals of not less than twenty years.

From the above summary of the requirements of the Forest Service, it is evident that the charges are very reasonable, or even very low. The main difficulty in connection with the development of power in the National Forests is due to the fact that every permit is revocable at the pleasure of the Secretary, that the permittee is in some other respects subject to the unrestrained power of the Federal Government, to such a degree as to make such projects unattractive, and that appreciation of land is to be treated as income. The Secretary may at his pleasure revoke a permit, or use this power of revocation to impose new and burdensome restrictions as a condition of future tenure. An unprincipled Secretary, or one unduly dominated by theories as to the prerogatives and rights of the Government, might easily take advantage of this power, and he could do this much more easily after the works had been constructed, the investment made, the securities issued, and a going concern established; for under such conditions the permittee would be obliged to accept any additional burdens which might be imposed rather than sacrifice the entire investment. It is stated that such permits have been granted by one Secretary and after the works had been constructed and placed in operation a new Secretary has insisted upon the acceptance of new conditions or the revocation of the permit. It may, therefore, be stated that any one now investing in power enterprises on the Government domain places himself entirely at the mercy of the Federal Government. This fact may not be clearly realized by investors, and it may be suppressed by bankers who are only anxious to dispose of the securities, but it is certainly a condition of things unfavorable to development.

It is urgently to be desired, in the interest of real conservation, that the law of 1901 should be amended so as to allow the Secretary to issue unalterable permits, either indeterminate or running for a sufficient number of years, on definite terms and without revision, as to make such developments as attractive as possible to capital.

Regulations Governing Permits for the Development of Power on Government Lands not in the Forest Reserves

(Subject to the Secretary of the Interior)

Permits issued by the Department of the Interior for the development of power on Government lands not located in the Forest Reserves have varied in their terms from time to time, containing many provisions similar to those of the Forest Service and others of a different character. One of the most recent of these permits is that issued July 29, 1913, granting to the International Power & Manufacturing Company of Spokane, Washington, the right to construct, operate and maintain a dam across Clark Fork or Pend d'Oreille River for the development of water power, electrical power and other purposes. (Sen. Doc. 147, 63d Congress, 1st Sess.) This permit is indeterminate as to time, but revocable, after notice and opportunity for a hearing, for violation of terms or of the general regulations, but also flatly revocable at the discretion of the Secretary according to the Act of February 15, 1901. It contains, however, a number of provisions worthy of mention:

1. The project works, except the installation of hydraulic and electrical machinery, shall be begun within one year and completed within three years.

These periods were those suggested by the applicant, and it is the practice of the Department to fix such periods as seem reasonable for each particular case, and with regard to the wishes of the applicant. This is eminently reasonable. There may be a great difference between different projects as to the length of time reasonably necessary.

With reference to this requirement, however, it should be remembered that after such a permit is obtained, a project of this kind must be financed. This financing may require considerable time if the project is a large one, and delays may occur through business depression, war, or other causes, which would make it impossible to begin the work of construction within a year after the granting of the permit. Similarly, three years may prove to

be entirely insufficient for the completion of the work. It required nine years to finance the development at Keokuk, and eight years to construct the dam at Hale's bar on the Tennessee River. It would seem wiser to state definitely in the permit that these limits would be extended by the Secretary, if good reason were shown, rather than to subject the permittee to possible revocation of the permit for violation of terms, for if the permittee earnestly and diligently seeks to finance and construct the works, he should not be subject to the loss of his permit for failure to accomplish his purpose within a specified time. In the case of the very permit under consideration, the project could not be begun within the time limit, and this limit has been extended by the present Secretary for another year.

2. "Machinery of 50,000 h. p. rated capacity shall be installed within three years, and additional machinery shall be installed as the conditions of the market will warrant or as the secretaries or any duly authorized State agency may direct."

The initial installation, the writer is informed, was suggested by the applicant. The last part of this regulation, however, which provides that the rate of installation of machinery shall be regulated, not by the Company, but by the Secretaries of the Interior and of Agriculture, or by some similar State authority, removes the control of the Company with regard to this important matter from the Company itself, and places it under public authority, and seems open to criticism. The permittee would no doubt install additional machinery if, in its opinion, it would be profitable. Of this it would seem that the permittee would be the best judge. The provision either means nothing, or it means that the public authorities would force an enlargement of the plant which the permittee distinctly considered unprofitable. If such a difference of opinion should arise, would it not be wiser for the Government to take the property, pay for it, and dispose of it to another owner who would agree to make the enlargement?—or to have the matter adjudicated by the courts?

3. The permittee is required, after the completion of the works, to operate them continuously, unless this requirement is temporarily waived by the written consent of the two Secretaries, upon full and satisfactory proof that such operation is prevented by unavoidable accidents or contingencies.

With a reasonable administration, this requirement may not be onerous. With an unreasonable administration, it might cause serious embarrassment. However, this provision is probably necessary in the public interest.

4. No compensation will be required prior to the year 1923, "but on or before the first day of February in each year, beginning with 1924, the permittee shall pay, by certified check to the order of the Secretary of the Interior, or in such other manner as the Secretaries [of the Interior and of Agriculture] may direct, an amount calculated from the total capacity of the power site at rates per horse power per year varying directly as the square of the average price for electric energy charged to customers and consumers of the permittee as determined in subsection (c) hereof and varying inversely as the square of the proportional development of the power site, as shown by the following table:

	If the Percentage of Development of Power Site is						
When the average price in cents per kilowatt hour charged by the permittee is as shown by this column.	Over 90	90 and over 80	80 and over 70	70 and over 60	60 and over 50	50 and over 40	40 or less
	Then the Rates of Compensation to the United States per Horse Power per Year will be as Shown Below						
0.2 and less.....	$ .05	$ .06	$ .08	$ .10	$ .14	$ .20	$ .31
0.3 and over 0.2....	.11	.14	.18	.23	.31	.45	.70
0.4 and over 0.3....	.20	.25	.31	.41	.56	.80	1.25
0.5 and over 0.4....	.31	.39	.49	.64	.87	1.25	1.95
0.6 and over 0.5....	.45	.56	.70	.92	1.25	1.80	2.81
0.7 and over 0.6....	.61	.76	.96	1.25	1.70	2.45	3.82
0.8 and over 0.7....	.80	.99	1.25	1.63	2.22	3.20	5.00
0.9 and over 0.8....	1.01	1.25	1.58	2.06	2.81	4.05	6.33
1.0 and over 0.9....	1.25	1.54	1.95	2.55	3.47	5.00	7.81
1.2 and over 1.0....	1.80	2.22	2.81	3.67	5.00	7.20	11.25
1.5 and over 1.2....	2.81	3.47	4.40	5.74	7.82	11.25	17.60
2.0 and over 1.5....	5.00	6.17	7.82	10.00	13.80	20.00	31.25
3.0 and over 2.0....	11.25	13.87	17.58	22.95	31.25	45.00	70.40
4.0 and over 3.0....	20.00	24.70	31.25	40.80	55.60	80.00	125.00
5.0 and over 4.0....	31.25	38.60	48.80	63.80	86.80	125.00	250.00
6.0 and over 5.0....	45.00	55.60	70.40	91.80	125.00	180.00	281.25

This method of regulating charges has been criticized by hydraulic engineers, on the incorrect assumption that it is a method generally applied

by the Department. As a matter of fact, a flat rate of compensation is applied in cases where the power is not sold, but is all used by the permittee for its own purposes. Where power is sold, the rule of squares is used, the starting point being fixed *for each case* after careful study of the local conditions, and after practical agreement with the applicant. In the case in question, the schedule adopted calls for a payment of five cents per annum per horse power on the basis of full development, the plans of the company calling for a known use which would involve a price of 0.2 cents or less per kilowatt hour. The cost of developed power was estimated at a very low figure, because of favorable physical conditions, and the total power was about 112,000 horse power.

However, as this method and rate of charging may be imitated elsewhere, it may be desirable to give the arguments which might be urged against it if generally applied.

It will be noted that the rates increase as the square of the average price for electric energy charged to consumers, and therefore may conceivably reach very large figures. The striking thing in this table is that the compensation required bears no relation to the cost of developing and supplying the power. The charge is the same no matter what it costs the permittee to deliver current to its customers. It is almost self-evident that such schedule of charges, if generally used, would be inequitable. It might be fair to consumers in one locality and entirely unfair to those in another. In one case the power might be utilized close to the power site and the cost of delivering the power would be small. In another case, long transmission lines might be required, involving considerable transmission losses, and a large investment, with corresponding operating and depreciation cost, which might be even greater than the cost of generating the power at the site. This increased cost of delivering the power might necessitate much higher rates to customers than if the point of utilization were close to the power site, yet the Government fee would increase as the square of the rate charged to consumers, and would be much greater than in the latter case. Moreover, independent of long distance transmission, the cost of development of water powers varies enormously in different cases, so that in one case current may be supplied at a low rate and yet make a fair profit upon the investment, while in another case, a much higher rate would have to be charged. Such a schedule of Government charges if generally adopted for all permits, would distinctly discourage the development of any water

powers except those most favorable for development, which could be utilized close to the site, and would, therefore, be contrary to the true principles of conservation.

Suppose, for instance, that one water-power development costs $100 per h. p., while another costs $300 per h. p. In the latter case, a much higher rate for power is necessary in order to obtain a return upon the investment than in the former case. This would be due to no fault on the part of the permittee, but to the necessities of the case.

The question would be further complicated by the possibility of requiring auxiliary steam power. Suppose there were two water-power plants with machinery capable of developing the same amount of power, but that in one of these, on account of greater variability in the flow of the stream, auxiliary steam power would be required to supplement the water power in certain seasons. In the latter case the cost of operating the plant, as well as the initial cost of development, would be greater than in the former case, and consequently, the rates charged to consumers must be higher. If these rates must be twice as high, then the Government tax would be four times as great if the same schedule were used in both cases. These facts are very important in view of the fact that in general the largest item in the cost of any water power is interest on the investment.

Again, the above schedule of charges, (it is claimed) since it makes no allowance for the cost of delivering power, does not take into account the *varying* load factor of different consumers. Some consumers may use the power continuously with a load factor of 100 per cent. Others, using power for lighting in residences or in stores, may use power with a load factor as low as 10 or even 5 per cent. The generating machinery and transmission lines must be capable of delivering the maximum amount of power required at any time, and it is therefore clear that the cost of supplying power to any one customer will be greater the lower the load factor of that customer, and consequently the charges for power must vary in the same manner. The Government charge, however, takes no account of all this. In other words, the greater the cost to the Company in furnishing power, the greater the tax. This might be reasonable if the profits were proportionate to the rates charged, but as above shown, it costs more to supply the same power with a low load factor than with a high one, and it may frequently be more profitable for a company to sell power to consumers having a high load factor at low rates per kilowatt hour, than to other consumers having a

low load factor at higher rates per kilowatt hour. Any such general system of government charges, therefore, would discourage the permittee from extending its system to consumers who necessarily use power under a low load factor, and would also discourage a development of water powers under conditions and for a kind of business where the load factor would be necessarily low.

To illustrate this, let us assume that it requires an investment of $200 for each kilowatt which must be delivered to consumers, a figure not at all excessive. Let us assume, further, three classes of consumers, namely:

1. Those using power continuously with a load factor of 100 per cent;
2. Those using power with a load factor of 50 per cent;
3. Those using power more intermittently, or with a load factor of 20 per cent, or for less than five hours a day.

Let us further assume that the total annual energy consumed in a year by each of these three classes is the same. Then we should have:

Case 1. Maximum demand, one kilowatt, investment $200. Total energy delivered annually, 1 kilowatt for 24 hours a day for 365 days, or, 8,760 kilowatt hours.

Case 2. Maximum demand, 2 kilowatts, investment $400. Total energy delivered annually, 2 kilowatts for 12 hours a day for 365 days, or, 8,760 kilowatt hours.

Case 3. Maximum demand, 5 kilowatts, investment $1,000. Total energy delivered annually, 5 kilowatts for $2\frac{4}{5}$ hours per day for 365 days, or, 8,760 kilowatt hours.

If we assume as an illustration, that the annual charges for interest, taxes, and depreciation in each case, amount to 12 per cent of the investment, then we find that to pay the fixed charges requires in Case 1, 2.75 mills per kw. hour; in Case 2, 5.5 mills; in Case 3, 1.37 cents. The annual fixed charges of the plant will be the same per unit of maximum demand, and will, therefore, be twice as high in Case 2 as in Case 1, and 5 times as high in Case 3 as in Case 1.

The criticisms just explained are mostly without justification. The fact that the schedule rates are varied according to the circumstances of each case, and after conference and agreement with the applicant, removes the criticism based upon varying cost of development, and the possible necessity for auxiliary steam power.

The fact that the Government charge is applied to the *average* power used, based upon the rental capacity of the power site, and that this rental capacity involves a consideration of the average load factor, removes the criticism based upon the variability of this factor for different consumers. The only legitimate point left open for criticism is the *general principle* of varying the Government charge as the square of the average price charged by the permittee. The ultimate uses that will be made of a large power may be largely conjectural, and it is not inconceivable that as the years go by those uses may be very different from those anticipated at the outset. Instead of being used near the site, the power may be transmitted long distances, involving greater cost of delivery. Since the rule of squares takes no account of the actual cost of delivery, it seems to be inherently inequitable, and it is a reasonable question whether some other method is not preferable. This criticism, however, is met, in theory, by the provision for periodical revision of the Government charges, and the considerations here adduced show that such a provision may be desirable even in the interest of the permittees; not only does it give opportunity for the Government to impose larger charges and take advantage of the fact that the permittee, having made his investment, is helpless, but on the other hand, it gives the Government the opportunity to make the charges fairer to the permittee if changed conditions render the old rates inequitable. This entire discussion, however, indicates the advantage of selecting some method by which the latter object may be accomplished without either party putting itself so entirely at the mercy of the other. Such a method would be the imposition of a fixed rental for the land, and a division of earnings above a stated per cent, thus making the Government in a sense a partner in the enterprise, as elsewhere advocated in this report, and as adopted by the Government in the proposed permit for the dam at Windsor Locks, Conn., which was in this respect, in the writer's opinion, the fairest permit he has seen.

5. While the permit requires no Government compensation prior to 1923, yet after that time, at intervals of ten years, the

Secretaries may review the rates, under the conditions quoted previously from the rules of the Forest Service, appreciation of land being treated as income.[18]

The permit provides that in determining the total annual receipts of the permittee in electric energy used by the permittee, or by any consumer consisting of an association or corporation in which the permittee has any interest, such power shall be included at a price "not less than 0.2 cent per kilowatt hour, nor less than the cost per kilowatt hour of generating, transmitting and delivering such energy to the point of use, taking into account proper operating and maintenance expenses, fixed charges and reasonable allowances for renewals and sinking fund." This is proper and fair. This minimum price is fixed for each case with reference to the conditions existing.

Unless otherwise authorized by the Secretaries, the maximum price charged to customers for power "Shall not exceed 6 cents per kilowatt hour, and the maximum price at which such electric energy in excess of 2,000 kilowatt hours per annum with an average annual delivery of more than 35 per cent of the connected installation within the year, may be disposed of to customers or consumers, shall not exceed 2 cents per kilowatt hour, said maximum price being determined by dividing the total annual charge to the purchaser by the total annual delivery to him of electric energy."

This provision is interpreted to mean:

1. A purchaser of energy receiving less than 2,000 kilowatt hours per annum may be charged up to 6 cents per kilowatt hour regardless of load factor.

2. A purchaser receiving less than 35 per cent of the energy indicated by his connected installation may be charged up to 6 cents per kilowatt hour regardless of the amount of energy received.

3. All other purchasers may not be charged in excess of 2 cents per kilowatt hour.

These prices are not of general application, but are fixed for each case.

[18] See pp. 118-121 for criticism of this provision.

The permittee is not allowed to contract for the delivery to any one customer of electric energy in excess of 50 per cent of the total capacity of the power site. Nor can the permittee deliver to any customer, or use in its own operations, any excess of 50 per cent of said capacity if there are pending unfiled applications for energy from other customers.

This provision appears especially unwise in view of the fact that many water-power developments may necessarily contemplate using the entire output for one enterprise. The company may have a single customer in sight who is willing to contract for the use of this entire output. It might be extremely desirable that the water power should be developed for the sole purpose of supplying power to an irrigation company for pumping water, to a street railway company, to a steam railroad company for purposes of electrification, or to some manufacturing concern.

The object of the provision, apparently, is to guard against the creation of a monopoly, or to discourage the sale of the entire output to a transmission company with the object of obscuring accounts and avoiding by a technicality the jurisdiction of public service commissions. It seems fairly evident, however, that many water-power developments will be prevented if the output is not allowed to be used for one specific purpose, and there must be some other legal way of avoiding any obscuring of accounts, particularly as the permit requires the books and records of the permittee to be open to the inspection of the Secretaries.

This permit also contains the provisions quoted from the regulations of the Forest Service under headings F-U. There is no bonus under T as in the regulations of the Forest Service, and a reasonable value of the property is not, as in the regulation of the Forest Service, the original cost, if this can be determined, but "shall be determined by mutual agreement, and in case they cannot agree, by the Secretaries under the rule which, except as modified by the requirements of this section, shall be the then existing rule of valuation for power properties in condemnation proceedings in the state in which the properties to be surrendered or transferred are located."

The permit is indeterminate until the United States or any state or municipal corporation exercises its option to purchase. It is revocable, however, for non-payment of charges or for violation of any of the provisions, and also under Act of Congress it is revo-

cable at any time at the option of the Secretary of the Interior. In reality, therefore, it is not indeterminate as to time, for no Secretary can bind his successors.

The permit is to be modified at intervals of not less than twenty years to conform to changes in regulations fixed by the Secretaries.

There is apparently no provision in this permit for an appeal to the courts from a decision of the secretaries, whose decision is final; nor that the Government or transferee is to assume outstanding leases. If water powers are developed for irrigation purposes, the irrigable land cannot be disposed of unless there goes with it a perpetual right to water. In this and other ways water-power companies are frequently obliged to make long term contracts. The permit makes no provision for such leases, but provides that the Government or a state may take the power at any time.

Taken as a whole, therefore, it cannot be said that this permit is definitely favorable to power development. In the hands of an unreasonable administration, it might be used to the detriment of the permittee. The requirements that additional machinery shall be installed as the secretaries may direct, that the work shall be operated continuously unless permitted to do otherwise by the secretaries, that the maximum price of current is fixed, and the various other provisions which have been criticised above, indicate once again that the power company accepting a permit of this kind simply puts itself in the power of the United States Government and relies upon its fairness.

Summary

This portion of the subject will be brought to a close with a summary of the conclusions regarding the development of water power on navigable streams and on the public lands which seem reasonable to the author.

1. The two elements to be constantly kept in mind in considering the conservation of water powers are:

(a) To encourage the greatest possible development.

(b) To ensure this development in a manner consistent with the public interest.

2. Conservation of water means use, and use means investment. While any amount of restrictive legislation and depart-

mental regulations may be imposed, no legislature, congress or department has the power to force a single dollar of private capital to invest in the conservation of water power against its consent. The standpoint of the investor, equally with that of the general public, must constantly be kept in mind.

3. In order to induce the investment of private capital in water-power enterprises, three things are essential:

(a) Definiteness in the contract entered into.

(b) The prospect of a sufficiently attractive return, commensurate with the risk involved.

(c) The protection of the courts in case of dispute.

Without these three things any extensive utilization of water powers by private capital cannot be brought about.

4. Effective protection of the public interest requires that the perpetual title to a water power now on the Government land, and, therefore, belonging to the people, should not without reservation be transferred to a corporation or a private individual. This fundamental point being safeguarded, the public interest will be best subserved by establishing regulations so attractive to the investor that the available water power of the nation will be developed and utilized at the earliest practicable date. In any case, the primary object, whether of the Federal Government or of the States, should not be revenue or restriction, but should rather be the encouragement of a properly regulated water-power development. To grant water-power privileges under such onerous terms or regulations that development is hindered is an injury not only to the people of the State but to the people of all the States, because all are concerned in the preservation of the non-renewable resources.

5. Conservation of water power involves a double conservation—a conservation of the water power and a conservation of equivalent non-renewable fuel. Development of water power on navigable streams by private parties, if properly planned, also involves a direct benefit to the Federal Government in that it improves navigation, and thus is a direct money contribution to the Government, to the extent that it renders unnecessary such

Government expenditure as would otherwise be necessary or desirable.

6. The only power of the Government with respect to the development of water power on navigable streams arises from its power to regulate commerce, as provided in the Constitution. Inasmuch as the needs of commerce may vary from year to year, and are generally increasing, this power subjects a private water power on such streams to the possibility of being impaired or even entirely destroyed by the necessities of navigation, which may require the use of the entire flow of the stream, as in the case of the Sault Ste. Marie River.

7. If the Government at its own expense builds a dam to render a river navigable, the surplus water power developed is a by-product of the navigation works. It is most desirable in the interests of conservation that this water power should be utilized. If the Government has not only built the dam, but has acquired all the riparian land and rights affected, it has become the riparian owner, and it should, therefore, charge a reasonable compensation to private parties using the surplus power so rendered available.

Where the Government has not acquired the riparian rights, and has, therefore, left in the private riparian the technical ownership of the surplus water power which is not required for navigation, the Government cannot sell or lease such surplus power regardless of the rights of such riparian; but the riparian having been saved expense in its development should pay to the Government a consideration—not for the surplus power itself but for the extra advantages which the Government works afford to him for its utilization.

Some authorities, however, declare that in neither case has the Government a legal right to make such charge, but has only the right to regulate the use of the water power in the interests of navigation.

8. At dams on navigable rivers, constructed by public service corporations or private parties, it is proper and necessary that the plan of development should be subject to Government approval, in order to ensure that the project will not interfere with the proper

development of the stream for navigation. It must also be provided that the operation of the plant should not interfere with navigation. It should, therefore, be required that before the right to construct a dam and utilize water power upon any navigable stream is granted by the Federal Government, there should be a survey of at least that portion of the stream, the regimen of which would be affected by the proposed construction; and a further requirement that the dam and works should be built in such a manner and of such dimensions as not to interfere with the ultimate proper development of the stream as a navigable waterway.

The General Dam Act, which applies to this case, provides that the grantee should, when required by the Secretary of War to do so, construct at his own expense, locks, booms, sluices, etc., suitable for navigation, and should furnish power and water for operating them, and also light the Government buildings and grounds. There does not seem, in the interests of conservation, any sufficient reason for these provisions. If, however, the construction of the dam renders the subsequent construction of locks and other appurtenances more expensive than they otherwise would have been, such additional expense should be borne by the riparian owner.

This case differs from the one considered under (7) in the fact that the power development may be of great benefit to the Government in aiding the navigability of the stream, and that the Government pays nothing for these works, but secures the benefits of the dam and the pond above it, and the flowage rights, without any expense. Projects of this kind would, therefore, materially aid the Federal Government in securing the navigability of our inland waters, and if we can imagine the case in which a stream were fully utilized for water power by a series of dams, each backing the water up to the next and all provided with locks, the water-power development would at the same time render the stream completely navigable, without any expense to the Government.

The so-called conservationists claim that the Government should exact compensation for the use of power at private dams constructed by authority of Congress on navigable streams. Con-

sidering, however, the fact that the legal power of the Federal Government extends only to the regulation of navigation; that the preservation of the Government rights, whatever they may prove to be, is recognized by the principle that the Government must give a permit and fix its terms; that a proper license fee should be paid, not for power, but for Government property utilized or for expense incurred by the Government for supervision or inspection; and that the Government receives great benefit, free of cost, by the construction of the works; it seems clear that in the interests of real conservation, as well as in equity, it should exact no charge for power from dams which it does not itself construct and own. The best legal authorities declare that the Government has no legal right to make such charge. As a matter of fact, in many cases the obligation might really be on the part of the Government, in view of the benefit derived, and if real equity were sought it should in such cases not only make no charge but should pay a substantial sum as a contribution to the cost of constructing the dam. The regulation of the power from such dams, whether used by public service corporations or by private individuals, should be left to the respective States, where, according to the authorities, it seems legally to rest.

If, as seems clear, riparian ownership carries with it the right to develop and use the power, subject only to the paramount right of the Federal Government to regulate commerce, then any charge by the Government for the use of power which does not interfere with navigation, except as reimbursement for expense, is a violation of what Talleyrand termed "the eternal basis of social justice, viz., the respect for property."

9. The General Dam Act of 1910 provides for a fixed tenure of fifty years, subject to revocation for violation of terms, and subject also to a taking by the Government at any time with compensation, but without any provision for renewal at the end of the term or for compensation at that time. These provisions make such projects unattractive to private capital, and thus development is hindered or made precarious and the whole public

suffers accordingly. There should be provision for extension or renewal, and if at the end of the term such extension or renewal is desired by the permittee and not granted by the Government, there should be provision for full compensation to the permittee for the fair value of the property. The permit should not be subject to any change or revision of terms within the fifty-year period, nor should a violation of its terms on the part of the permittee necessarily lead to its revocation, for this might visit upon innocent stockholders the penalty for a misdemeanor of an official, who would escape without punishment. The punishment of the guilty official would in many cases be the proper remedy, and the Secretary should have discretion to use this means rather than to revoke the permit, and any revocation should be subject to review by the courts.

According to the Act of 1901 permits for the development of water power on the public domain are revocable at any time at the pleasure of a member of the Cabinet, notwithstanding the fact that the permit itself may be for a fixed or an indeterminate period. The Act in question should be amended so that permits should not be revocable at the pleasure of the Secretary, but only for adequate cause, and subject to review by the courts.

10. The General Dam Act of 1910, although it purports to provide the general conditions under which a dam may be constructed and maintained by private parties on navigable streams, nevertheless has generally led to a separate act of Congress for each water-power development, compelling a discussion of the terms and conditions on the floor of Congress. This Act should be amended and replaced by one containing provisions so full and definite that no special legislation should thereafter be required, but that the Secretary of War and the Chief of Engineers, after a study of the engineering conditions in each special case, could issue the permit subject to the general provisions of the Act. Above all things the Act should be so definite that private capital would know at the beginning exactly what burdens were to be imposed upon it.

11. In the case of water powers in which the power site or

the right of way for transmission of pipe lines is on Government land, the Federal Government should unquestionably require, as a condition of the permit, a proper charge for the use of the Government property, and such other requirements as will fully protect present and future interests of the public, including the right to take the property at the expiration of the permit, upon payment of full compensation. In certain cases where transmission lines or conduit lines cross Government lands, or where small portions of such lands are included in flowage areas, the power site itself being on private land—in other words, in cases where the Government interest is relatively small and only incidental—it would conduce to development if the permittee could acquire its right of way or its flowage rights and own them in fee, paying the Federal Government for them in full, so that it would own these portions of its property absolutely and be subject to no further complications with respect to them.

12. The radical distinction between public-service corporations and private individuals must be borne in mind. The former are by law subject to public control as regards rates and service, and, therefore, a permit granting a right to such a corporation need not contain any stipulations as to the rates charged to consumers for the service rendered.

Most of the states now have public-service commissions, and those that have not will undoubtedly provide them when the inhabitants thereof consider that the proper time has arrived. The public being thus safeguarded, there is no valid reason why a public-service corporation doing an intrastate business solely should be subject to any control other than that of the State, to which it is necessarily subject in any case.

There is good ground for advocating the granting of Government permits, whether on navigable streams or on the public domain, only to public-service corporations, and then leaving their entire control to the respective States where it appears legally to rest, except for a reasonable charge or fee to be paid to the Government—not for power, but for expense of supervision or inspection.

The regulation of service and charge is a State, or local, function. It should be exercised by the Nation only in interstate industry.

13. If, however, independent of moral or legal considerations, compensation were to be exacted by the Federal Government, or by the states, for power developed at dams constructed by private parties across navigable streams, and also in fixing the charges to be exacted for powers developed on the Government domain, the best method of fixing the compensation, and at the same time protecting the interests of the public and encouraging development, would be, in the case of public-service corporations, to allow the corporation to earn up to a definite percentage upon the money properly invested, such percentage to be dependent upon circumstances and different in different parts of the country; any earnings above such percentage, if paid out in dividends, to be divided with the Federal Government (or in the case of a grant by a State, with the State) in some definite manner, the rate of division to be subject to revision at periodical intervals, the first period being the longest and long enough to make the development financially attractive. Under such a method the books of the concern should be open to Government inspection.

In the case of private concerns, the above method is inapplicable and the best plan will have to be arrived at by agreement. This difficulty would be avoided if every user of water power under a Government permit were required to incorporate as a public utility corporation.

14. Notwithstanding the fact that electricity is playing every day a more important part in our social and industrial economy, and the fact that the development of hydro-electric properties should be proceeding rapidly, there seems no doubt that present Federal laws, and the permits hitherto issued under them, have brought about a condition of stagnation instead of aiding and promoting the development of water power. These laws constitute in many cases a practically insuperable obstacle, and while many developments have been made under these laws, many more possible developments have been postponed. Several Secretaries of the

Interior have called attention to these facts, and to the urgent need of a revision of the laws regulating the use of water power. Water-power developments if undertaken today on the public lands or on navigable streams are attended by serious financial difficulties.

There are, in general, three forms of franchise or concession, namely, the perpetual, the fixed term, and the indeterminate. For reasons which need not be discussed here and with which nearly all will agree, the perpetual franchise may be considered a thing of the past. The fixed-term franchise, which grants rights for a limited period of years, without provision for renewal or for compensation at the end of the franchise term, has proved to be impracticable; for under such a franchise financial organization is either impossible or too expensive, and especially during the last part of the term profitable operation becomes almost impossible. Securities under the fixed-term franchise can be marketed only at high rates of interest and discount, the fixed charges under which make a great drain upon annual earnings. Such a franchise also necessitates the creation of an amortization fund which will, at compound interest, equal the investment at the end of the franchise period. Moreover, under this form of franchise, it is impossible for the operating company, especially during the latter years of the term, to make contracts for the sale of power covering long periods. Long-period contracts are becoming more and more common and necessary in everyday public-service operation, and the crude fixed-term franchise operates in direct opposition thereto. To cover all of these difficulties, the modified fixed-term franchise is advocated by many. Such a franchise provides for right of renewal at the end of the period, for purchase of property improvements in the event that the extension is denied or the title thereto transferred, and finally for the assumption of contract obligations entered into by the grantee for periods extending beyond the close of the franchise term. Such provisions may largely obviate the financial and other difficulties and uncertainties that usually attach to the fixed-term franchise.

Under all conditions that prevail with reference to publicly

owned water powers, whether by the Federal Government or the states, the indeterminate franchise is the form which most readily adapts itself to changing conditions, and under which the greatest and most satisfactory measure of control may be secured by the public.

The indeterminate franchise which seems to be the best, would have no fixed-term limit. For an initial period sufficient to allow the grantee to properly finance the project, and not less than fifty years, the franchise should be irrevocable except for cause, subject to review by the courts. Said franchise would, after that period has elapsed, be subject at any time to revocation by the Government and transfer to some transferee designated on due notice to the grantee of such intention and on payment of compensation equivalent to the fair value, exclusive of franchise, of the property and necessary appurtenances, or of so much of it as is dependent upon or intimately connected with the water-power development, and without value when separated therefrom, including overhead charges, and all other legitimate charges necessary for the development of the property and business, but such value should not include properties such as railroads, lighting systems, etc., which are of themselves separate industries. In such transfer all reasonable contracts for the sale or delivery of power made by the grantee previous to such notice of transfer should be assumed by the transferee, so that said grantee could operate and maintain the power business during his occupancy of the property under conditions that would ensure confidence on the part of investors, as well as of users of power.

The franchise should require reasonably prompt development, but not of the entire economically available power. A reasonable potential supply to provide for future growth of the business should be permitted to remain undeveloped until such time as needed, even if it should consist of sites left entirely undeveloped but suitably situated for connection with the system. The permit should not be transferable without the approval of the Government except by trust deed or mortgage issued for the purpose of financing the

business of the grantee, unless the transferee has the capacity required of the original grantee; and in any case all successors to the original grantee in interest should be subject to all the conditions of the permit and of the Acts of Congress under which it is issued. These provisions would probably remove all danger of purely speculative holding of undeveloped power sites, or of unreasonable monopoly.

15. The grantee, if a public-service corporation, should at all times be subject and amenable to the lawful regulation of its charges for service and of the character and quality of its service; such regulation to be by any governmental body at the time having authority in the premises, but such regulation should, if possible, be by only one governmental body.

Permits for power developments on navigable rivers, for public-service corporations doing an intrastate business only should thus be subject to no charge for power, or regulation of service, by the Federal Government, but should be subject only to the jurisdiction of the state in which it is located.

It should be remarked that many of the criticisms herein made on the present laws and regulations relating to the development of water power, are fully recognized by the officials of the Departments of the Interior and of Agriculture who have the administration of these matters. Indeed, a reform of the existing laws has been urged by several Secretaries, and many of the suggestions made by the writer of these pages would, he believes, be cordially approved by many of the officials in the Departments referred to. The officials now in charge of these matters are, in the belief of the writer, and in some cases to his personal knowledge, fully aware of the importance of developing water power, and quite willing to make the Government terms liberal and of such a character as to encourage investment. Unfortunately, as the writer has endeavored to point out, the present regulations do not attain this object, largely due to the revocable feature of the permits, which is required by law, but particularly due also to some other features, about which there may be differences of opinion. In particular,

the provision requiring a readjustment of rental at stated intervals, and further providing that in any such readjustment, appreciation of land values may be taken as income, is alone quite sufficient, in the judgment of the writer, to make an investment under such a permit unwise.

The onerous restrictions which have been criticised in this chapter will not, of course, entirely prevent water-power development, although, in the opinion of the writer and of many other engineers, they are quite sufficient to do so if they were thoroughly understood by investors. Undoubtedly, however, they do hinder development, increase the cost of financing, and render necessary a higher rate of interest than would otherwise be requisite. They therefore discourage true conservation in the sense of use.

CHAPTER VI

TECHNICAL ASPECTS OF CONSERVATION BY STORAGE

We have seen that the conservation of water is accomplished by its maximum possible utilization as a source of power and for purposes of irrigation and water supply, and not, as in the case of the non-renewable resources, by a restriction of its use or by its withdrawal from use, which is directly contrary to the principles of true conservation.

In the consideration of this subject, then, we must not only have in view the maximum possible use as distinguished from the most restricted use possible, but we must also bear in mind the five related problems: (1) the use of water as a source of power; (2) the use of water as a source of water supply for communities; (3) the use of water for irrigation; (4) the promotion of river navigation; and (5) the prevention of damage due to floods.

Now, it is easy to see that the best and most satisfactory use of water for any of these purposes will be secured when the flow can be regulated according to the demand. Indeed water, instead of being a beneficent agent in the service of man, is often one of his worst enemies, as for instance, when destructive floods occur causing great damage and loss of life. Such occurrences, however, are due entirely to the variability of the flow.

It is true that in the case of most, if not all, uses of water, the demand varies from season to season (as for irrigation, when the greatest demand is in the season of growing crops), or from month to month, or from day to day. Most water powers use power only during the day time; the demands of navigation vary from month to month, and the use of water for domestic supply varies according

to season and hour. The conservation of water, therefore, requires its storage and the regulation of its flow.

Streams, as we all know, differ greatly in their steadiness. Some, which are fed from perennial springs or from large lakes, or from artificial reservoirs in which surplus waters can be stored and allowed to escape when the stream would otherwise be low, are very uniform in their flow, varying but little from month to month throughout the year. Other streams, particularly those without lakes in their watersheds, and draining steep and rocky districts, are very irregular in their flow and are called flashy streams.

The most striking instance of a large stream having a regular flow, is the St. Lawrence, while many smaller streams in districts

Fig. 3. Shoshone Project, Wyoming
Sunset on Lake
(U. S. Reclamation Service)

where lakes are common, as for instance, in the State of Maine, show the same characteristic in the same or less degree.

The steadiness of a stream is indicated by the ratio of the ordinary yearly maximum in flood to the minimum in the dry season. The nearer the ratio is to unity, the more steady the flow.

The variability of the flow of a stream at any given point is dependent upon the following physical conditions, namely:

1. The size of the drainage area above the point considered.
2. The shape of this area.
3. Its geological character.
4. Its topographical character.
5. The surface conditions, such as the extent of forested area within the drainage basin, the area of swamp land, the area under cultivation, etc.
6. The extent and location of lakes or artificial reservoirs, and their manner of control.
7. The meteorological conditions affecting the drainage area.

The bearing of these elements may be briefly considered:

1. A little reflection will make it apparent that, speaking generally, and other things being equal, the larger the drainage area the more regular the flow will be. A large stream is, of course, fed by many tributaries. While all will in general be lowest during the same season of the year, local showers and other conditions will affect different tributaries differently. Topographical, geological and other conditions will also vary throughout a large drainage area. When one tributary, therefore, is at its lowest, the others will very likely not be quite at their lowest, and there will, therefore, be a more steady flow than in the case of a small stream. We all know small streams that run almost dry at some periods of the year and are raging torrents at others; and we all know from common observation that a large stream, while it may get very low at some seasons, does not have such excessive fluctuation.

2. The shape of the drainage area and the arrangement of tributary streams have some effect on the regularity of flow, although they have a greater effect upon the magnitude of a flood

at any given point. These elements, however, are so intimately connected with the other elements affecting the flow, that it is difficult to lay down any general rule. The effect of shape is not of great importance, and there are many exceptions to any rule which can be laid down. The most that can be said, however, is that it has some bearing.

3. The geological character of the watershed improves the regularity of flow when it favors the absorption of the rain-fall into the ground and its storage there as ground water flowing slowly through the soil and giving rise to springs which feed the streams with tolerable constancy. On the other hand, if the geology of the district favors a rapid discharge of the rain water from the surface into the river channels, irregularity of flow will be promoted. A rocky country with a thin soil, especially if composed of impervious, non-absorptive rocks, with steep slopes, will afford a rapid discharge of surface waters, and will render the streams very variable, especially if the rain-fall is likely to come in sudden heavy storms. A deep, porous soil, especially if forested or cultivated, on the other hand, will facilitate the absorption of the rain water and the regularity of the streams, although it may diminish the total runoff, on account of the large proportion of the rain-fall which is evaporated or which, after reaching the ground water, never comes to the surface again, but reaches the sea by subterranean channels.

4. Where the topography of the country is broken and mountainous, with steep, rocky slopes, especially if accompanied by a thin soil and the absence of forests, the stream draining such an area will generally be very variable. The falling rain will be shed almost immediately into the river channels, and the streams will alternate between periods of flood, and periods when there is scarcely any water at all in them. On the other hand, a flat country with an absorbent soil will not discharge the water into the streams rapidly but will facilitate its absorption into the ground and will, therefore, conduce to regularity of flow.

5. In the next lecture, the relation of forests to stream flow will be considered in some detail. It may suffice here to state

simply, that, according to the best opinion, the presence of forests, especially upon steep slopes, tends to make the flow of streams regular, although it may diminish the total amount of water which they carry off. Forests are in general regulators of flow, like lakes and reservoirs.

FIG. 4. SALT RIVER PROJECT, ARIZONA

Roosevelt Reservoir, covering 25 sq. m., with an average depth of about 200 feet and containing enough water to cover the State of Delaware a foot deep

(U. S. Reclamation Service)

6. With reference to natural or artificial reservoirs, their regulative effect is obvious. A large lake requires a large quantity of water to raise its level but a small height, and the flow from its outlet, therefore, will remain tolerably uniform while immense quantities of water may at the same time be pouring into the lake from its tributaries. If the outlet from the lake is controlled by

FIG. 5. HUNTINGTON LAKE, IN SIERRA NEVADA MOUNTAINS
BIG CREEK DEVELOPMENT, PACIFIC LIGHT AND POWER CORPORATION
(Stone and Webster Eng. Corp.)

artificial works, and the lake is large enough, the flow into the stream below may be made absolutely uniform. A drainage area, therefore, containing many lakes, of large size and not situated on the extreme headwaters, may, therefore, be very regular. A lake receives the waters from its drainage area as they come from its tributaries, and discharges them with much greater, or even with practical uniformity. The larger the drainage area of a lake, therefore, as well as the larger its size, the greater will be its regulative effect. Even a large lake on one of the extreme headwaters may have little regulative effect. Its drainage area may be so small that the rain-fall and surface flow entering it may be barely sufficient to balance the evaporation from the lake surface, and consequently the outward flow from it may be very small. The regulative effect of a reservoir upon the flow at any given point will be greater the nearer it is to the point.

7. The regularity of flow of the stream is, of course, clearly dependent upon meteorological conditions, that is to say, upon the rain-fall and its distribution, the temperature, evaporation, etc. A uniform distribution of the rain-fall—or rather, a distribution with the greatest rain-fall in the warmest months—together with the absence of great quantities of snow which are likely to be carried off in the early spring at a single thaw, are meteorological conditions favorable to constancy of flow. The greatest floods upon most of the rivers of the United States generally occur in the spring, when a heavy rain-fall comes at a time when the ground is covered with snow so that the melting snow is added to the rain itself.

The flow of the stream is indicated by what is called its hydrograph, which is a curve in which vertical distances represent the quantity flowing, and horizontal distances represent periods of the year. Some typical hydrographs will clearly illustrate how different streams are with respect to regularity.

The Willamette River at Albany, Oregon, drains an area of about 4,860 square miles, with practically no lakes. The total rain-fall of about 52 inches is distributed with 12 inches in the spring, 4 inches in the summer, 12 inches in the autumn, and 24 inches in the

winter. Notwithstanding the fact that there is no snow-fall in the district drained, the river is highest in the winter or early spring. The maximum monthly flow is at the rate of about 11 c. f. per s. per sq. m.; the minimum at the rate of about one-half c. f. per s. per sq. m., the ratio being about 22.

Compare this now with the Black Warrior River at Tuscaloosa, Alabama, which drains about 4,900 square miles, or almost exactly the same as the Willamette at Albany, Oregon, and is also without any lakes. In this case the rain-fall of 48 inches is almost uniformly distributed, with 13 inches in the spring, 12 inches in the summer, 10 inches in the autumn, and 13 inches in the winter. The maximum monthly flow in this case is about the same as that of the Willamette, or at the rate of about 11 c. f. per s. per sq. m., but the minimum is much lower than in the case of the Willamette, falling to about 0.03, the ratio of the two being nearly 400.

Just what should cause such a great difference between two streams is often most difficult to determine without a thorough examination of the watershed. The small summer rain-fall in the case of the Willamette would lead one to suppose that the stream would fall much lower at its minimum than the Black Warrior, whereas the reverse is the case. The difference is probably due to the difference in geological and topographical conditions. There is also more evaporation in the case of the Black Warrior, especially in the summer and autumn when the stream is lowest.

Compare these now with the Androscoggin at Rumford Falls, Maine, which drains an area of about 2,320 square miles, in which are a number of large lakes having a total area of some 140 square miles. The rain-fall here is about 46 inches, with 11 inches in the spring, 11 inches in the summer, 14 inches in the autumn, and 10 inches in the winter. This is a favorable distribution for uniformity of flow, the maximum rain-fall occurring when the evaporation is greatest. The result in this case is a maximum monthly flow at the rate of about 7.45 c. f. per s. per sq. m., and a minimum of 0.378, the ratio of the two being about 20, or smaller than in either of the previous cases.

FIG 6
WILLAMETTE RIVER
MONTHLY DISCHARGE AT ALBANY ORE
SQ. FT/SQ. MILE DRAINAGE AREA 4680 Sq. miles

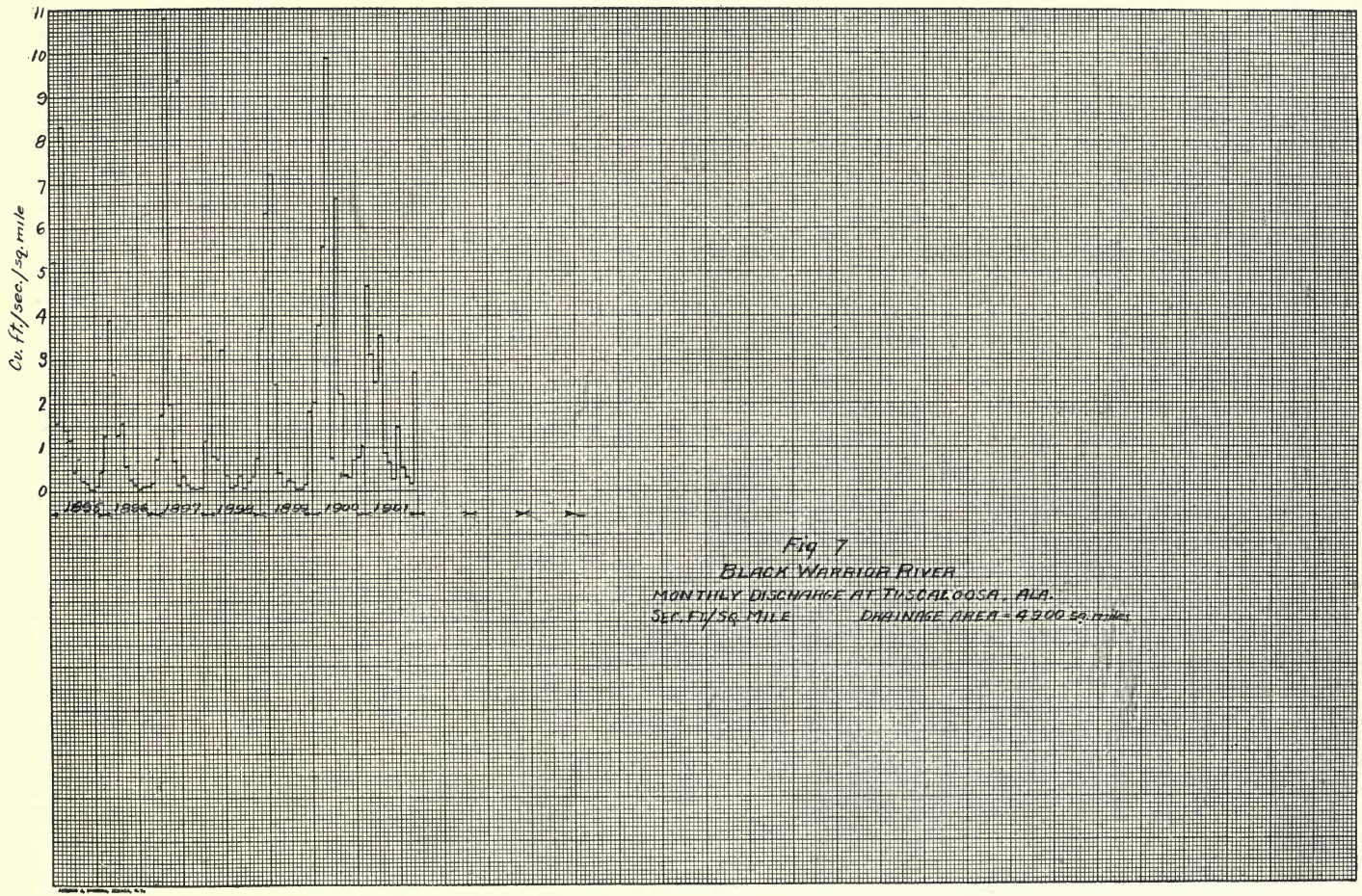


Fig 7
BLACK WARRIOR RIVER
MONTHLY DISCHARGE AT TUSCALOOSA, ALA.
SEC. FT/SQ. MILE DRAINAGE AREA = 4900 sq. miles

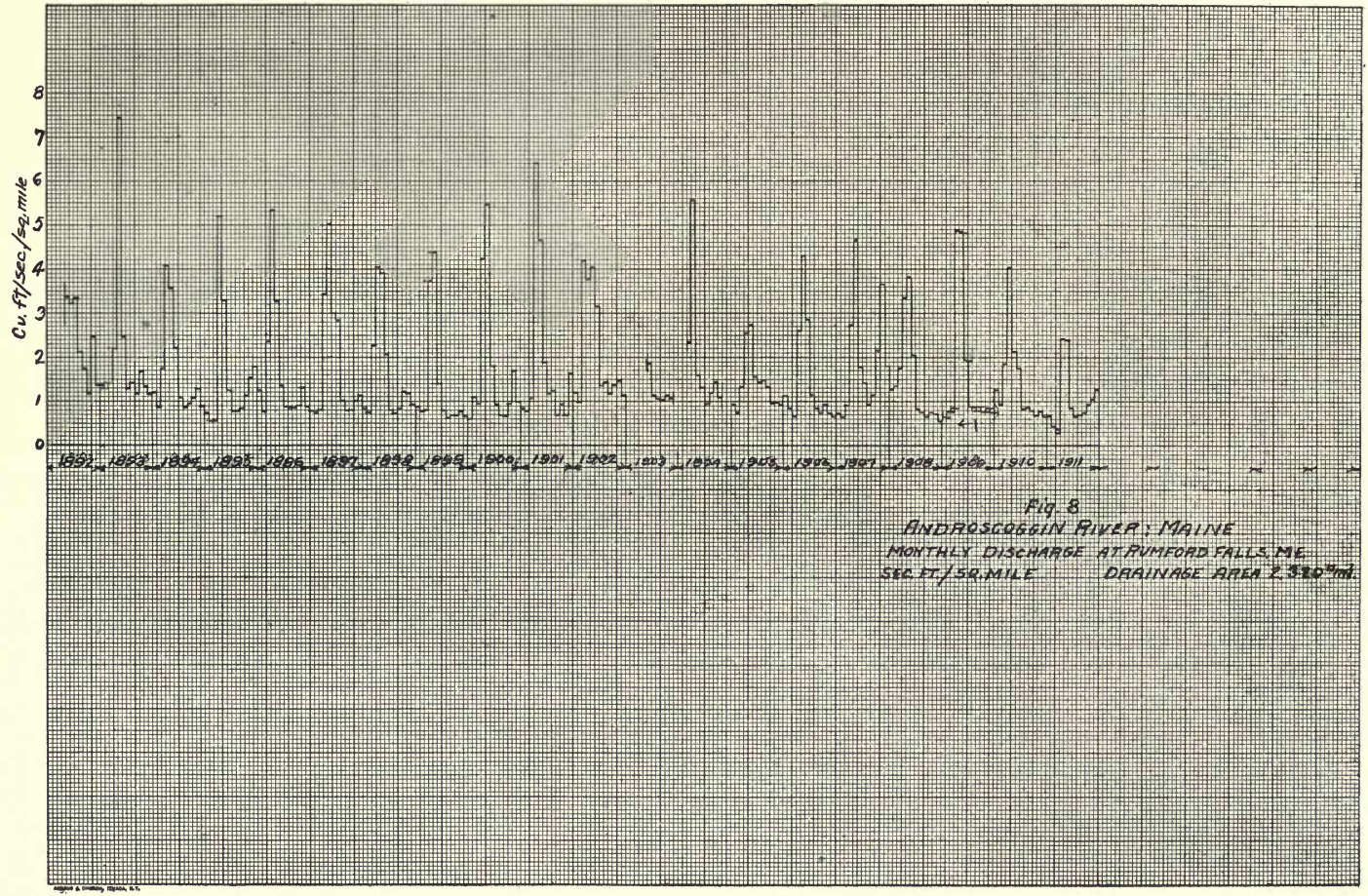


Fig. 8
ANDROSCOGGIN RIVER: MAINE
MONTHLY DISCHARGE AT RUMFORD FALLS, ME.
SEC. FT./SQ. MILE DRAINAGE AREA 2,330 sq. mi.

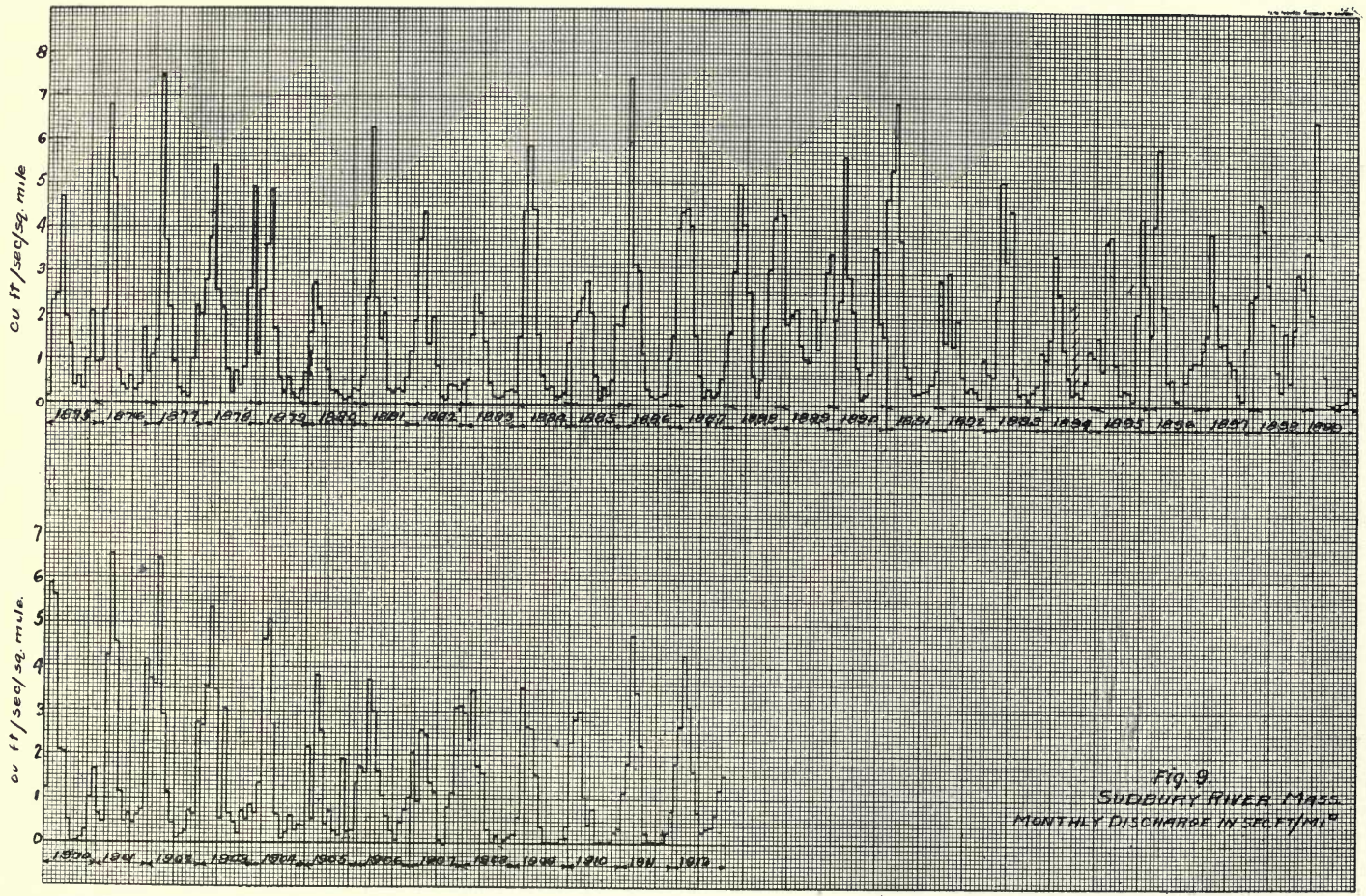


Fig. 9.
SUDBURY RIVER MASS.
MONTHLY DISCHARGE IN SEC. FT./MI.²

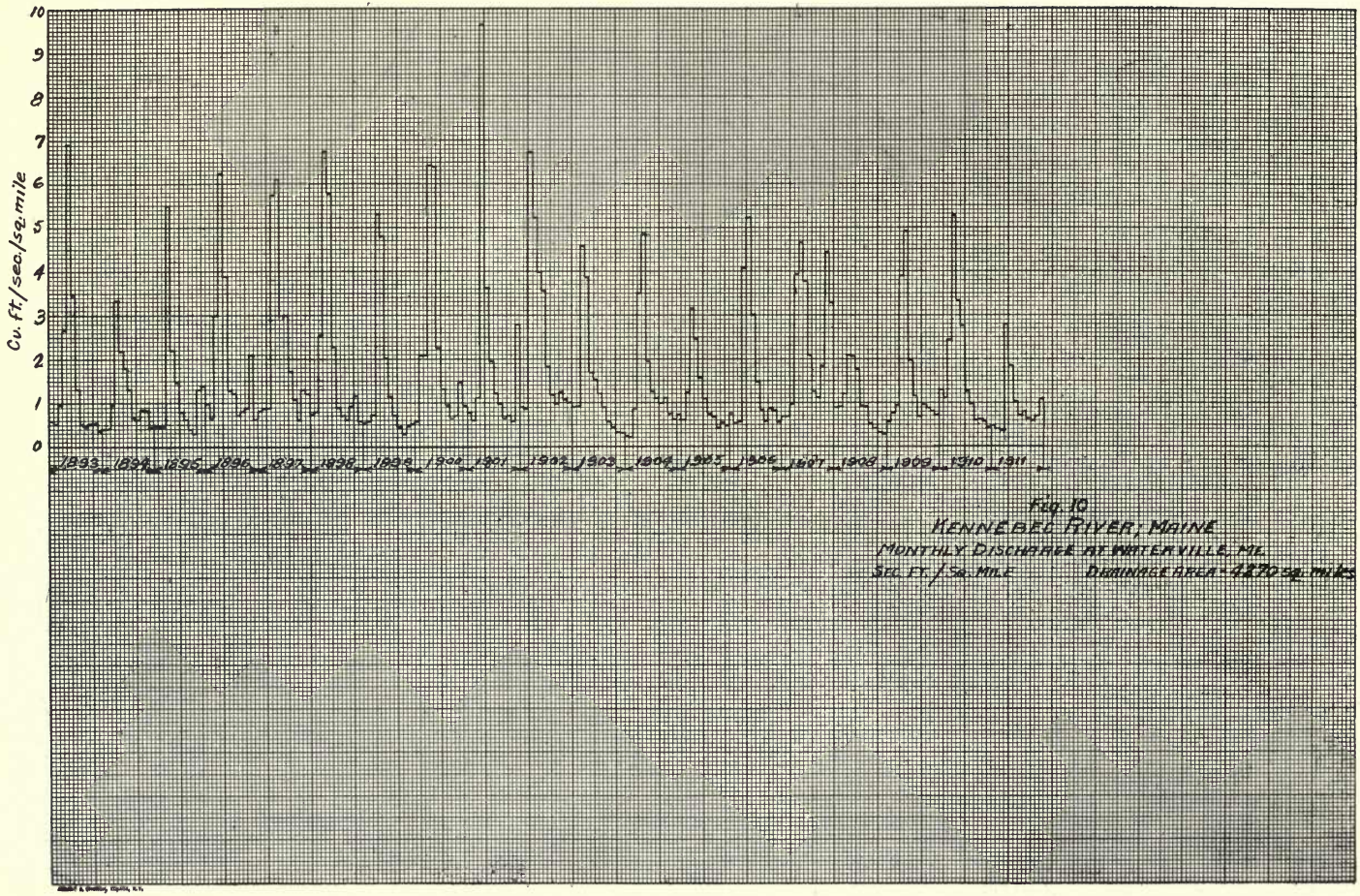


Fig. 10
KENNEBEC RIVER, MAINE
MONTHLY DISCHARGE AT WATERVILLE, ME.
SEC. FT. / SQ. MILE DRAINAGE AREA - 4890 sq. miles

Fig. 11
COLUMBIA RIVER
MONTHLY DISCHARGE AT THE DALLES, ORE.
Drainage Area = 237,000 Sq. mi.
Cu. ft./sec./sq. mile
Cu. ft./sec./sq. mile

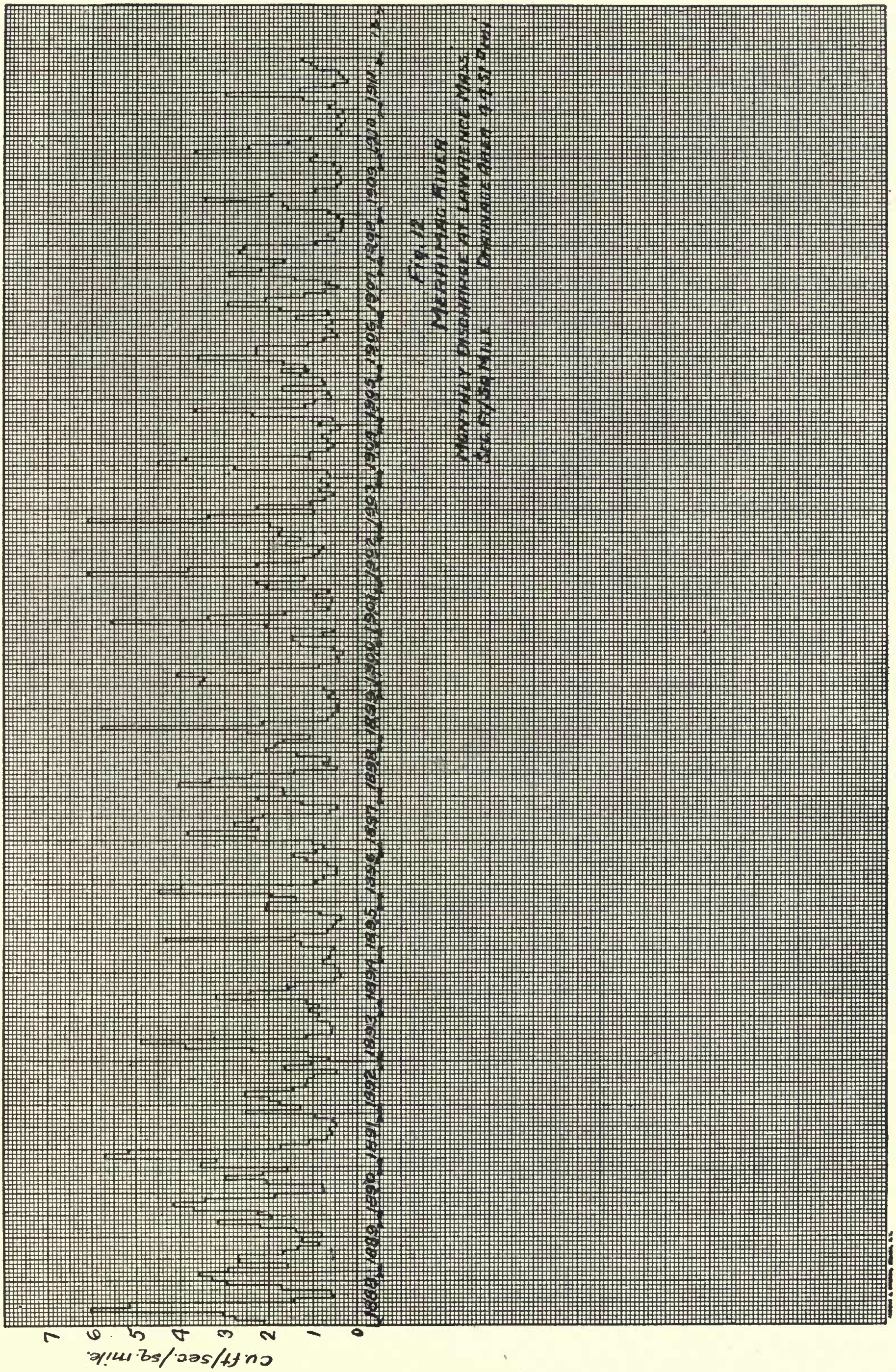


Fig. 12
Merrimac River
Monthly Discharge at Lawrence Mass.
cu.ft/sec./sq.mile.
0
1
2
3
4
5
6
7

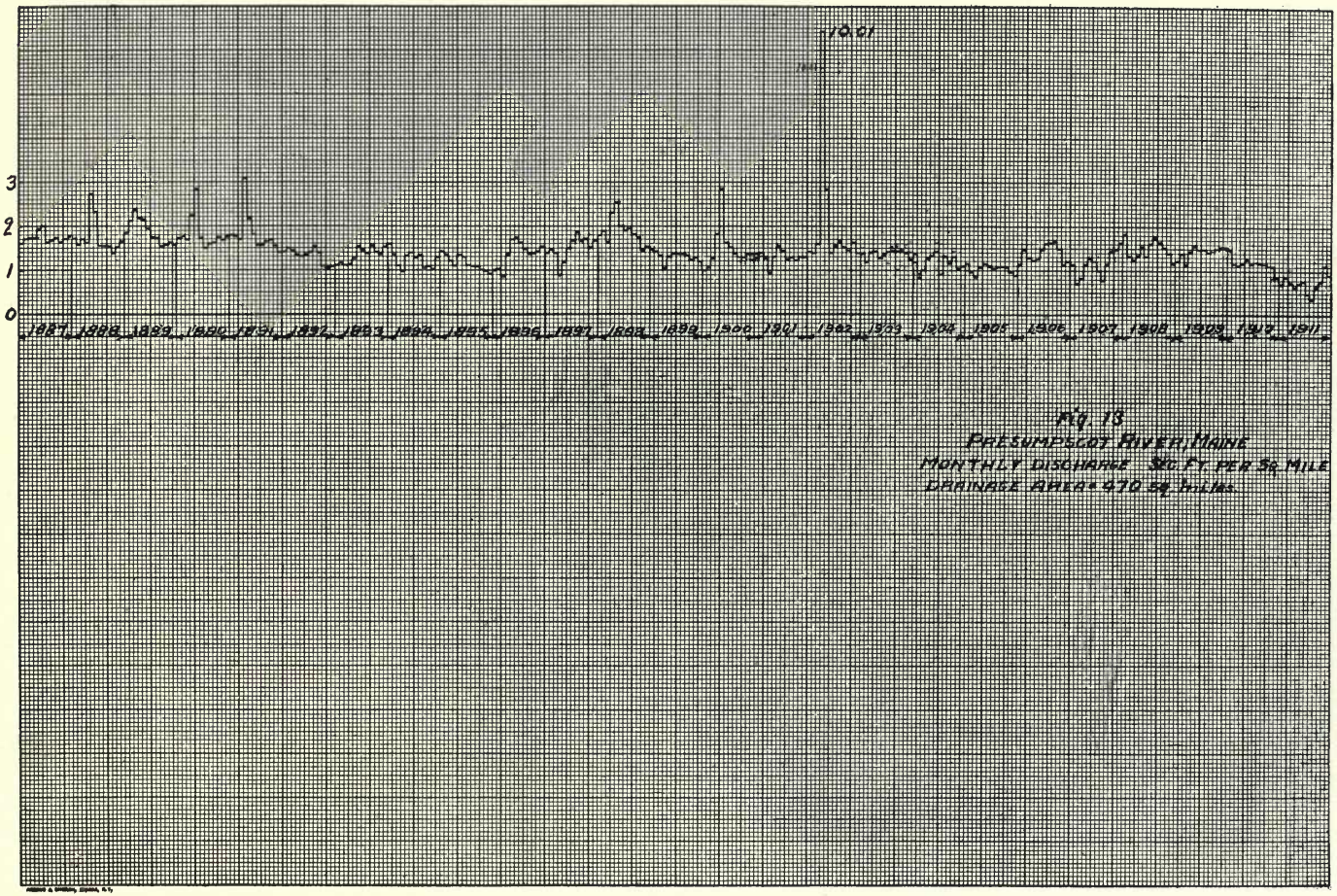
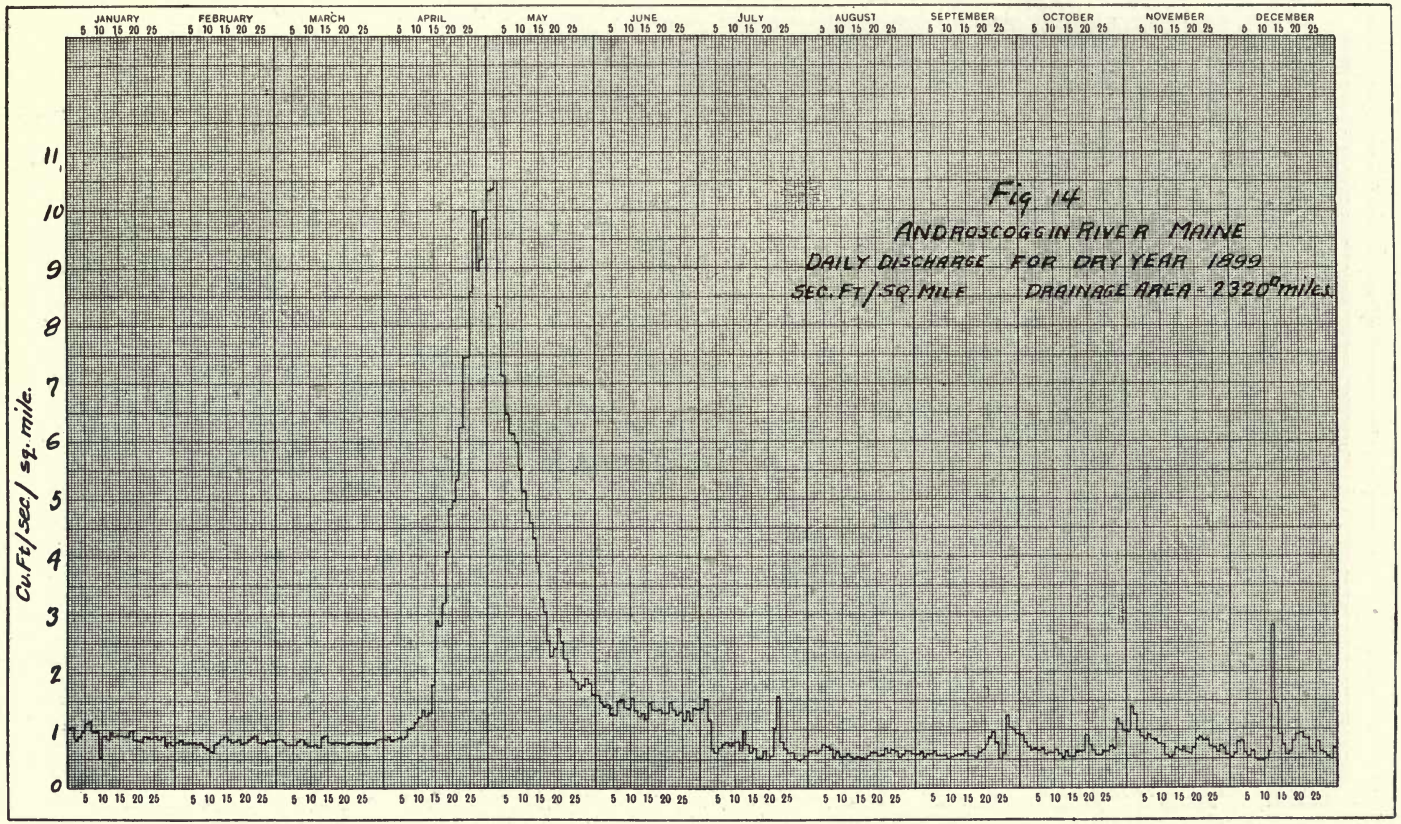


Fig. 13.
PRESUMPSCOT RIVER, MAINE
MONTHLY DISCHARGE SQ. FT. PER SQ. MILE
DRAINAGE AREA = 470 SQ. MILES.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5 10 15 20 25
Cu.Ft./sec./ sq. mile.
0
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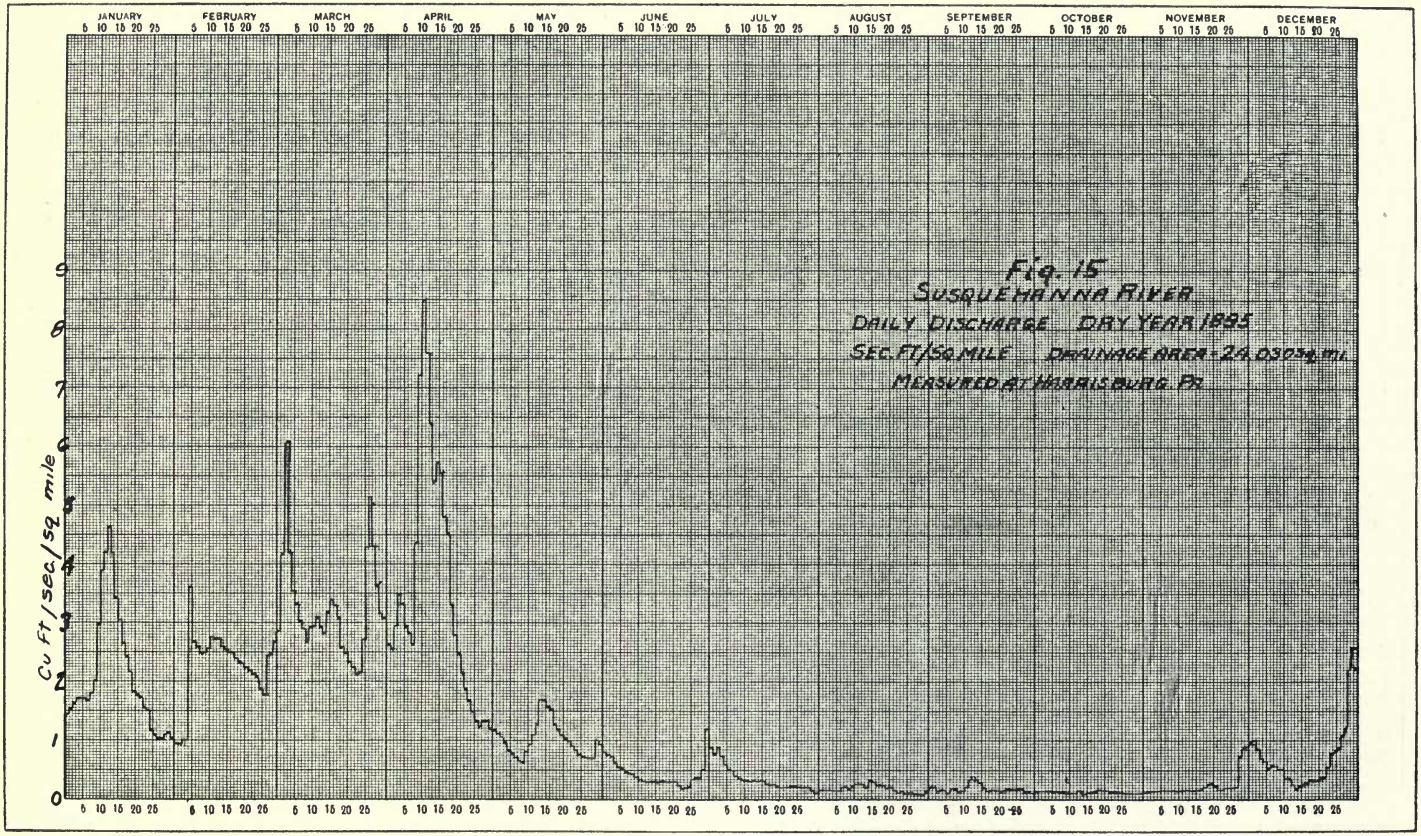
Fig 14
ANDROSCOGGIN RIVER MAINE
DAILY DISCHARGE FOR DRY YEAR 1899
SEC. FT./SQ. MILE
DRAINAGE AREA = 2320 miles.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Cu Ft/sec/sq mile
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Fig. 15
SUSQUEHANNA RIVER
DAILY DISCHARGE DRY YEAR 1895
SEC. FT./SQ. MILE DRAINAGE AREA - 24,030 SQ. MI.
MEASURED AT HARRISBURG, PA.

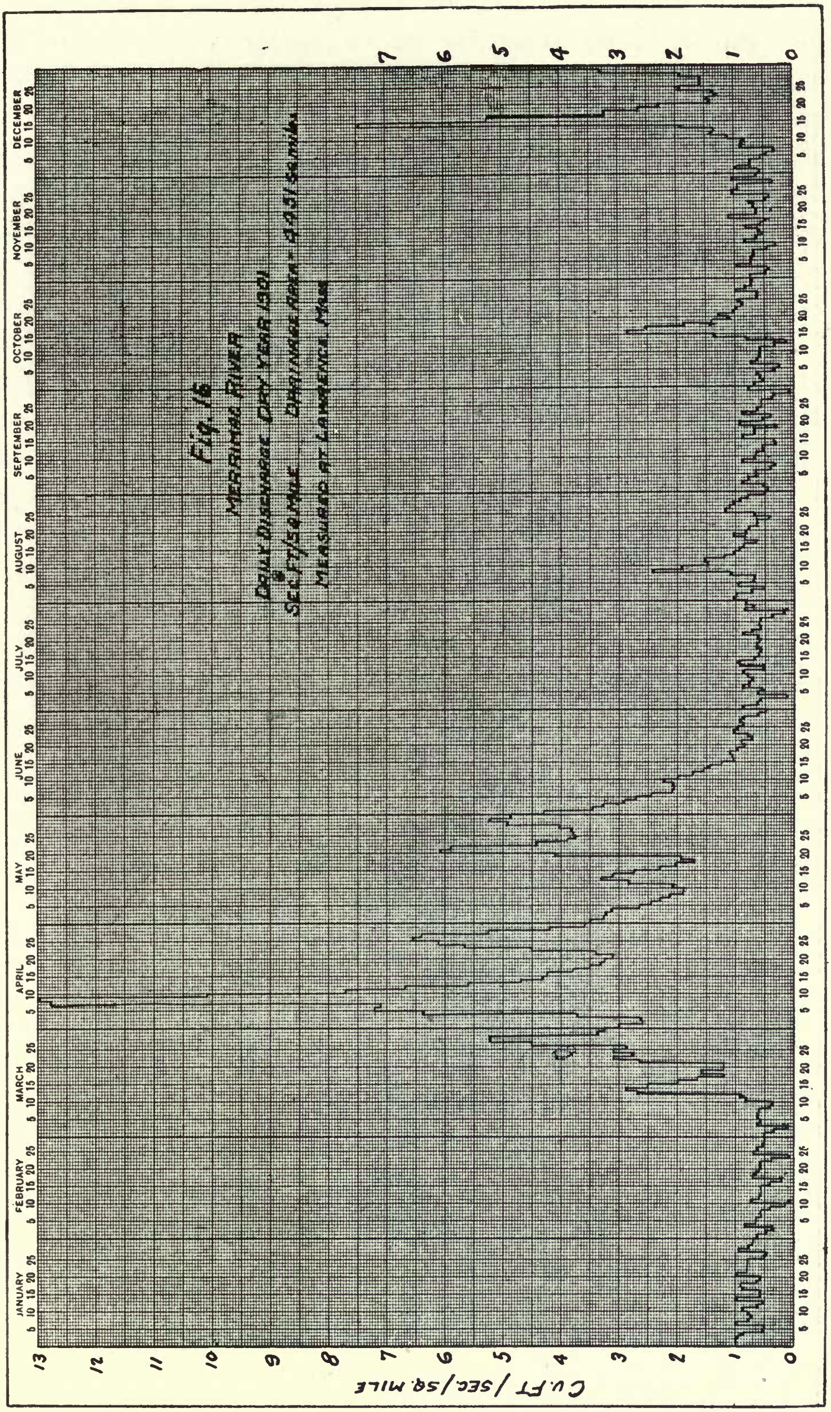
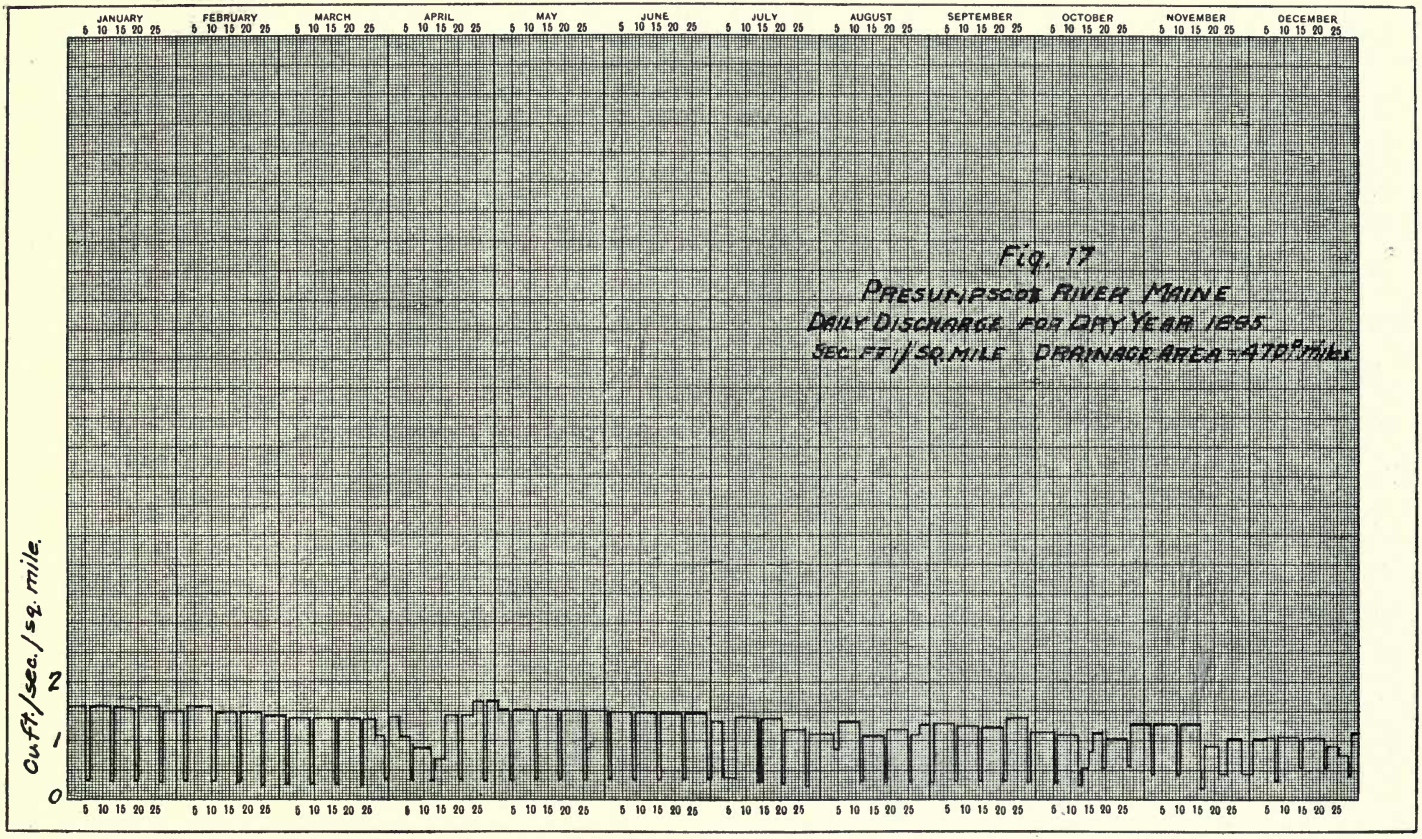


Fig. 16
Merrimac River
Daily Discharge Dry Year 1901
Sec.Ft/Sq.Mile
Drainage Area
Measured at Lawrence Mass
Cu.Ft/Sec./Sq.Mile
January February March April May June July August September October November December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5 10 15 20 25
cu ft./sec./sq. mile.
2
1
0
Fig. 17
PRESUMPSCOT RIVER MAINE
DAILY DISCHARGE FOR DRY YEAR 1895
SEC. FT./SQ. MILE DRAINAGE AREA = 470 Sq. Miles

The next hydrograph shows the mean monthly discharge of the Sudbury River, a small stream in Massachusetts draining about 75 square miles, on which are a number of artificial ponds used for water supply. The maximum monthly flow is here at the rate of about 7.5 c. f. per s. per sq. m., while the minimum is very small. The rain-fall of 43 inches is almost uniformly distributed through the year, with a little excess in the autumn.

The Kennebec River at Waterville, Maine, drains an area of 4,270 square miles, in which are large lakes with an area of 400 square miles. The rain-fall of 44 inches is nearly uniformly distributed, with a slight excess in the autumn. The mean monthly discharge is at a rate varying from a maximum of 9.63 to a minimum of 0.216 c. f. per s. per sq. m., the ratio being about 45.

The Columbia River at The Dalles, Oregon, drains a very large area compared with the previous rivers which have been mentioned, namely, 237,000 square miles. There are a few lakes in the basin, but none of large size, so that their area is practically nothing in proportion to the drainage area. The rain-fall is about 5 inches in the spring, 3 inches in the summer, 3 inches in the autumn, and 5 inches in the winter. The mean monthly discharge varies from a maximum of about 4.8 to a minimum of about 0.25 c. f. per s. per sq. m., the ratio being about 20.

Compare this with the Merrimac River at Lawrence, which drains an area of 4,451 square miles in which are several large lakes with a total area estimated at about 103 square miles. The rain-fall is about 11 inches in the spring, 12 inches in the summer, 13 inches in the autumn, and 9 inches in the winter, and the mean monthly discharge varies from a maximum of about 6 to a minimum of about 0.266 c. f. per s. per sq. m.

A very regular stream is the Presumpscott River at the outlet of Sebago Lake in Maine. The drainage area above this point is about 470 square miles with a reservoir area of about 80 square miles. The rain-fall of 43 inches is nearly uniformly distributed. The mean monthly discharge when at its maximum does not usually exceed 3 c. f. per s. per sq. m., and is generally very much less,

although, according to the diagram, there was one year in which, on account of some extraordinary circumstance, the maximum reached 10 c. f. per s. per sq. m. The minimum value of the mean monthly discharge is about 0.365 c. f. per s. per sq. m. The ratio of maximum to minimum is here exceedingly small, generally between 8 and 9, although in the exceptional year referred to it was nearly 30.

It must be carefully borne in mind that the hydrographs thus far given represent the mean monthly discharges each month during a series of years. The ratios are, therefore, not the ratios between the maximum and the minimum quantities flowing in one instant or in any one day. In order to study these fluctuations, the average daily discharge must be followed throughout the same year. Such a diagram will come very close to giving us the ratio between the maximum and the minimum quantity flowing in any given instant, because during any one day the fluctuation will not be likely to be great, whereas within a calendar month the fluctuation may be very considerable.

The next hydrograph shows the daily discharge of the Androscoggin at Rumford Falls for the year 1899, which was a dry year. The uniformity of flow during the low season is especially noticeable. The river begins to rise about the middle of April, when the warm rains carry off large quantities of snow and ice. This period of flood lasts only about a month. During nearly nine months of the year, the flow is quite uniform, averaging about 0.75 c. f. per s. per sq. m. The maximum flow in this year was about 10.5, and the minimum about 0.5 c. f. per s. per sq. m., the ratio of the two being 21.

The Susquehanna at Harrisburg drains an area of 24,030 square miles. The hydrograph of daily discharge during the dry year 1895 is next shown. Unlike the Androscoggin, this stream has practically no lakes, and a further unfavorable circumstance is the distribution of the rain-fall, which, instead of having an excess in the autumn, has a deficiency, the rain-fall of 39 inches being distributed with about 10 inches in the spring, 12 inches in the

summer, 9 inches in the autumn, and 8 inches in the winter. Notwithstanding the larger watershed, therefore, the maximum discharge was nearly equal to that of the Androscoggin in the previous hydrograph, while the minimum was much lower than that of the Androscoggin, largely due to the regulating reservoirs on the latter.

The next figure is the daily discharge hydrograph for the Merrimac River for the year 1901. It shows a season of high water from about the middle of March to the middle of June, with several floods occurring in this period. The maximum average daily discharge was about 13 c. f. per s. per s. m.; the minimum is complicated by the fact that this river is lined with large manufacturing cities in the interest of which the flow from Lake Winnipesaukee is regulated. The hydrograph shows clearly the effect of the Sunday closing of mills, especially during the dry season. On this day the ponds are all filling up, and the minimum is an artificial one due to this circumstance.

This effect of Sunday closing is still more strongly shown in the hydrograph in the Presumpscott River, showing the daily discharge for the dry year 1895 at a point just below Lake Sebago. This lake is so large that the entire flow for a day may be easily stored in it without raising its level more than a small amount. The hydrograph, therefore, shows an almost absolutely uniform flow during the week, with a sudden drop on Sundays to almost a uniform minimum.

An example of a very variable stream is the Youghiogheny, a stream in Western Pennsylvania. This river, which drains an area of about 1,730 sq. m., much deforested, has a flood flow of 62,000 c. f. per s. per s. m. and an extreme dry weather flow of less than 20 c. f. per s. per s. m., a ratio of over 3,100 to 1. This stream is stated to have been the principal contributor to the flood of 1907 at Pittsburgh.

The following table gives the extremes of flow for a number of streams, and shows the great variability of the ratio. Many of these variations are no doubt due to incompleteness in the observations.

EXTREMES OF FLOW OBSERVED ON SOME AMERICAN STREAMS[1]

Stream and Locality	Drainage Area Square Miles	Mean annual rainfall. Inches	Discharge Cu. Ft. Per Sec. Per Sq. Mi.		Ratio	Remarks
			Max.	Min.		
Croton River, west branch, N. Y.	20.47	48.56	54.40	0.020	2,720.	30 years' record
Concord River, Mass.	361.0	....	12.32	0.170	72.5	.....
Croton River at Croton Dam, N. Y.	338.8	48.57	74.87	0.150	500.	.....
Great Egg Harbor River at May's Landing, N. J.	215.8	51.18	22.00	0.270	81.4	.....
Paulinskill at Hainesburg, N. J.	174.8	41.76	23.00	0.170	135.	Min. in 1890
Ramapo River at Pompton, N. Y.	159.5	46.22	56.10	0.140	401.	1882 and 1892
Tohickon Creek at Point Pleasant, Pa.	102.2	50.12	112.50	0.002	56,300.	1885 and 1894
Potomac River at Cumberland, Md.	920.	38.77	19.46	0.022	885.	.....
Androscoggin River at Rumford Falls, Me.	2,220.	40.39	25.00	0.475	52.6	1869 and 1897
Hudson River at Mechanicville, N. Y.	4,500.	41.61	15.50	0.189	82.	1869 and 1891
Kennebec River at Waterville, Me.	4,410.	....	25.20	0.006	4,200.	Maximum, 1896
Merrimac River at Lowell, Mass.	4,085.	....	19.83	0.310	64.	.....
Merrimac River at Lawrence, Mass.	4,553.	....	20.00	0.19	105.	Minimum, 1895
Potomac River at Dam No. 5, Md.	4,640.	38.77	22.15	0.078	283.	.....
Susquehanna River, west branch, at Williamsport, Pa.	4,500.	....	11.60	0.178	65.2	.....
Connecticut River at Hartford, Conn.	10,234.	44.53	20.27	0.510	39.7	.....
Delaware River, N. J.	6,750.	....	50.00	0.300	167.	.....
Potomac River	11,043.	38.77	42.60	0.170	251.	.....

Tables of this kind, however, should all be taken with some grains of salt. The drainage areas are all determined, not from actual surveys, but from measurements of maps, and the areas are subject to modification according to the map used. The quantities

[1] This table is taken from the very valuable report of Mr. E. Kuichling, the engineer for water supply of the State of New York, which is found in the report of the State Engineer on the Barge Canal, 1901, pp. 615-964.

Mr. Kuichling in this report made a compilation of data regarding the maximum and minimum discharge of streams in the United States, Great Britain, France, Germany, and other countries, which is probably the most complete table of the kind ever prepared, and from which most of the quotations published since that time have been taken.

of water are all determined by gaugings which are subject to error, and, as time goes by, higher maxima and lower minima are not unlikely to be discovered. For instance, in Mr. Kuichling's original table he gave the flow of the Merrimac River at Lawrence as being at its maximum 23.4 and at its minimum 0.016 cu. ft. per sec. per sq. m. The latter figure, however, is erroneous, and was due to the fact that Mr. Kuichling took the minimum flow for a single day. That day happened to be a Sunday, when substantially all of the water was held back by the ponds, and there was practically no flow in the stream, so that the 71 cu. ft. per sec. which corresponds to the minimum flow which he stated, simply represents leakage through the turbines. Similar mistakes have also been made in some other publications.

Professor Mead, in his book on Water-Power Engineering, published in 1908, gives the figures for the Merrimac River at Lawrence as a maximum of 20 and a minimum of 0.27 cu. ft. per sec. per sq. m. Since Professor Mead's book was published, there has been a week in 1911 when the flow averaged 0.19 cu. ft. per sec. per sq. m., as stated, and there has been a period of about two months during which the flow averaged about 0.3, one-third of this amount being drawn from Lake Winnipesaukee. The figures given in the table above for this case are those obtained from private information; otherwise they are the same as given by Mr. Kuichling.

It is interesting to compare the above table with the following, which was published in the report of the National Waterways Commission in 1912. The flow per sq. m. and the ratios have been computed from the original.

A comparison of these tables will indicate, in certain instances, the inherent uncertainty attending statements of this kind, depending upon so many and so variable phenomena.

Stream and Locality	Drainage Area Square Miles	Maxima		Minima		Ratio
		Cu. Ft. Per Sec.	Cu. Ft. Per Sec. Per Sq. Mi.	Cu. Ft. Per Sec.	Cu. Ft. Per Sec. Per Sq. Mi.	
Kennebec, Waterville, Me...	4,270	157,000	36.7	730	0.17	215.
Potomac, Point of Rocks, Md.	9,650	400,000	41.5	790	0.082	506.
Alabama, Selma, Ala.....	15,400	146,000	9.48	3,300	0.214	44.2
Tennessee River, Chattanooga, Tenn.....	21,400	357,000	16.7	4,800	0.22	74.4
Mississippi, St. Paul, Minn..	35,700	80,800	2.26	1,200	0.034	67.3
Brazos, Waco, Texas.....	30,800	132,000	4.28	3	0.00	44,000.
Yellowstone, Glendive, Mo...	66,100	107,000	1.62	3,750	0.057	28.5
Grand River, Palisades, Colo.	8,550	43,000	5.04	944	0.11	45.8
Salt River, Phœnix, Ariz....	.....	300,000	.....	0	0.00	∞
Sacramento, Red Bluff, Cal..	9,300	254,000	27.3	4,650	0.50	54.6
Willamette, Albany, Oreg...	4,860	188,000	38.7	1,870	0.375	100.5
Clark Fork, Newport, Wash..	24,000	155,000	6.45	5,700	0.238	27.2

The importance of a uniform flow and of the power of controlling the flow in the interests of conservation is clearly apparent from these curves. As regards navigation, almost all its difficulties are caused by variable flow; floods bring down vast quantities of débris from the mountains and deposit them in the navigable portions of the rivers, forming bars or rapids. When the stream is in flood and flowing swiftly, it can transport or roll along the bed larger particles of earthy or mineral matter than when it is flowing slowly. In times of flood, therefore, earthy matter is brought down from the swiftly flowing upper portions of the streams and is deposited in the more slowly flowing portions just as soon as the velocity is reduced so that it is unable to carry them. In times of flood, banks are undermined and washed away and the material is deposited in the main channels, and each flood causes some rearrangement of the river bars and consequent alteration of the navigable channels.

With reference to water power, the advantages of a uniform flow and of control are very great. The hydrographs which have been shown, indicate that when a stream is at its usual lowest in any given year, it may be discharging only a small fraction of what the flow would be if the total amount discharged annually should flow with absolute uniformity. A water power, of course, can only

depend permanently upon the smallest flow. If machinery is installed sufficient to utilize a greater flow than this, a portion of this machinery will be unable to operate during certain periods of the year, unless supplementary steam power is installed for use in such periods. It is an important question, in developing a water power, to decide how much power it will be economical to utilize. This, of course, will depend upon the use to which the power is to be put. If the business is one which does not require to be run with uniformity, an amount of power considerably in excess of the minimum may be economically developed and part of the machinery may be shut down when there is not enough water. If, however, power must be utilized continuously at the same rate, supplementary steam power will be necessary. It will also be an obvious advantage if immediately above or near the dam there is sufficient storage to enable the flow of the stream during twenty-four hours to be concentrated during the hours when the power must be developed, if this can be done without injury to riparian owners farther down the stream. It will be apparent that there is here a very important and somewhat complex engineering problem, requiring a knowledge of the necessities of the business, a careful study of the cost of developing and operating various proportions of water power, and of the cost of installing and operating auxiliary steam plants to be used when the water power is deficient. This is a good instance of the kind of economic problem which confronts the hydraulic engineer, upon the successful solution of which will depend his ability to save or to lose money for his employers.

Suppose a stream to have a flow during the lowest weekly period in a year which will afford 100 horse power, and suppose the average flow throughout the year would afford 1,000 horse power. If the surplus waters of this stream could be stored and the average flow made available, the power permanently available would be increased tenfold. If, also, the entire daily flow could, by means of storage, be utilized during say ten hours without much loss of head, the power would be increased more than twenty-fold. If such a regulation could be brought about economically, how

important it would be as a means of conserving water power and diminishing the consumption of coal!

In many water-power installations, a hydraulic plant is installed sufficient to utilize not only the minimum flow, but perhaps the flow which can be depended upon during only six months, leaving a deficiency during the remaining six months. In some instances, a greater or less proportionate development is made, depending upon circumstances.

The meteorological conditions which govern the flow of the stream are, of course, entirely beyond our control. We cannot make the rain come regularly nor can we distribute it over the basin according to our desires. We must take it as it comes. It is evident, therefore, that there is but one way of making the flow of a stream more regular, namely, by preventing the runoff from being discharged immediately or rapidly into the streams, but, on the other hand, causing its gradual discharge. This may be accomplished by two methods:

(1) By the construction of surface reservoirs;

(2) By so treating the surface of the ground that rapid discharge will be prevented. The last object may be accomplished by preserving and increasing the forested areas, especially on steep slopes, or by breaking up the ground on flat areas for cultivation.

The preceding considerations illustrate the importance of conservation of water by storage, to which this course of lectures is mainly devoted. If storage is sufficient and controlled, the flow may be made not only regular, but may be made to vary according to the demand, thus securing the maximum conservation possible. Unfortunately, however, the construction of storage reservoirs is often exceedingly costly, is frequently entirely impracticable, and, in any case, involves flooding with water lands which might be used for other purposes. The study of storage projects, therefore, like the study of the economical development of a water power, involves a balancing and comparison of advantages and disadvantages and of the relative costs. A reservoir can be constructed at a certain cost. The first question is, How much beneficial effect will this have

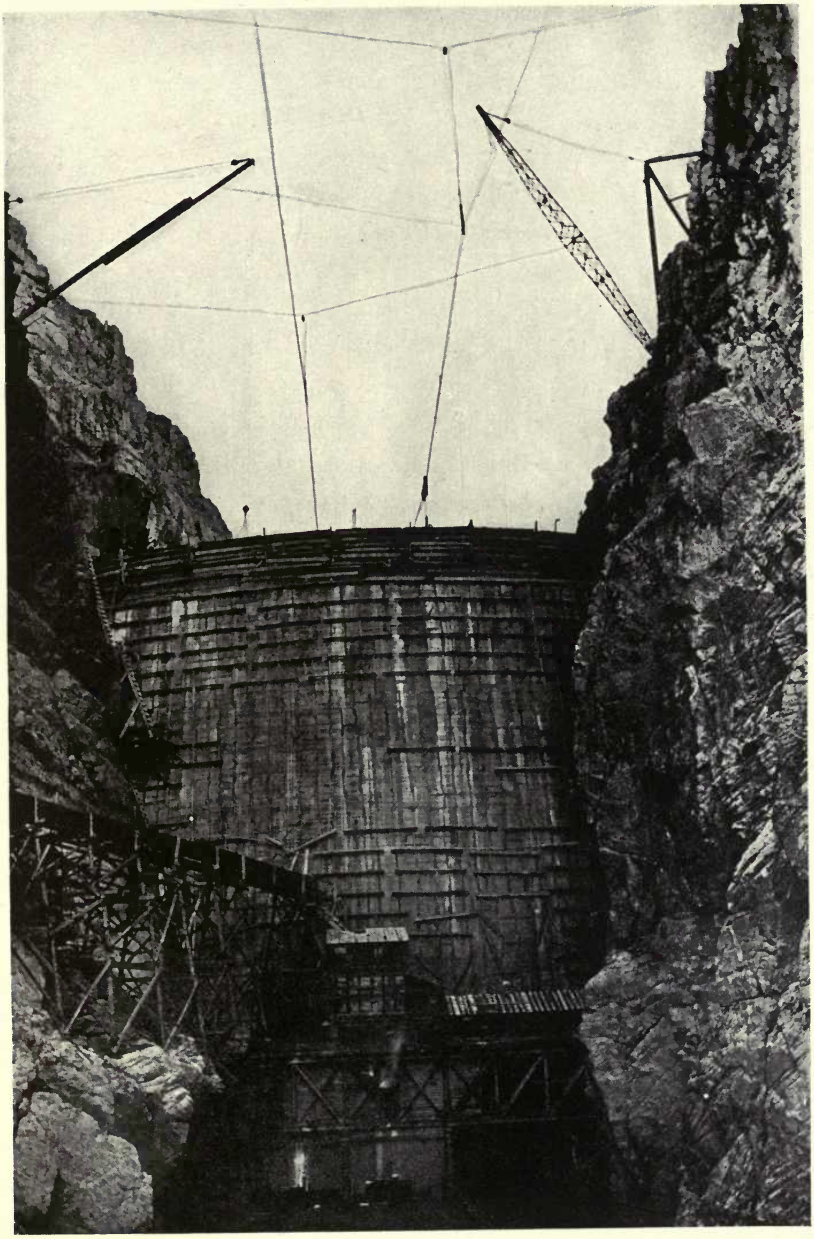


FIG. 18. SHOSHONE DAM, WYOMING

328 feet from bed to parapet, 85 feet long at bottom, 100 feet at top, and 108 feet thick at bottom

(U. S. Reclamation Service)

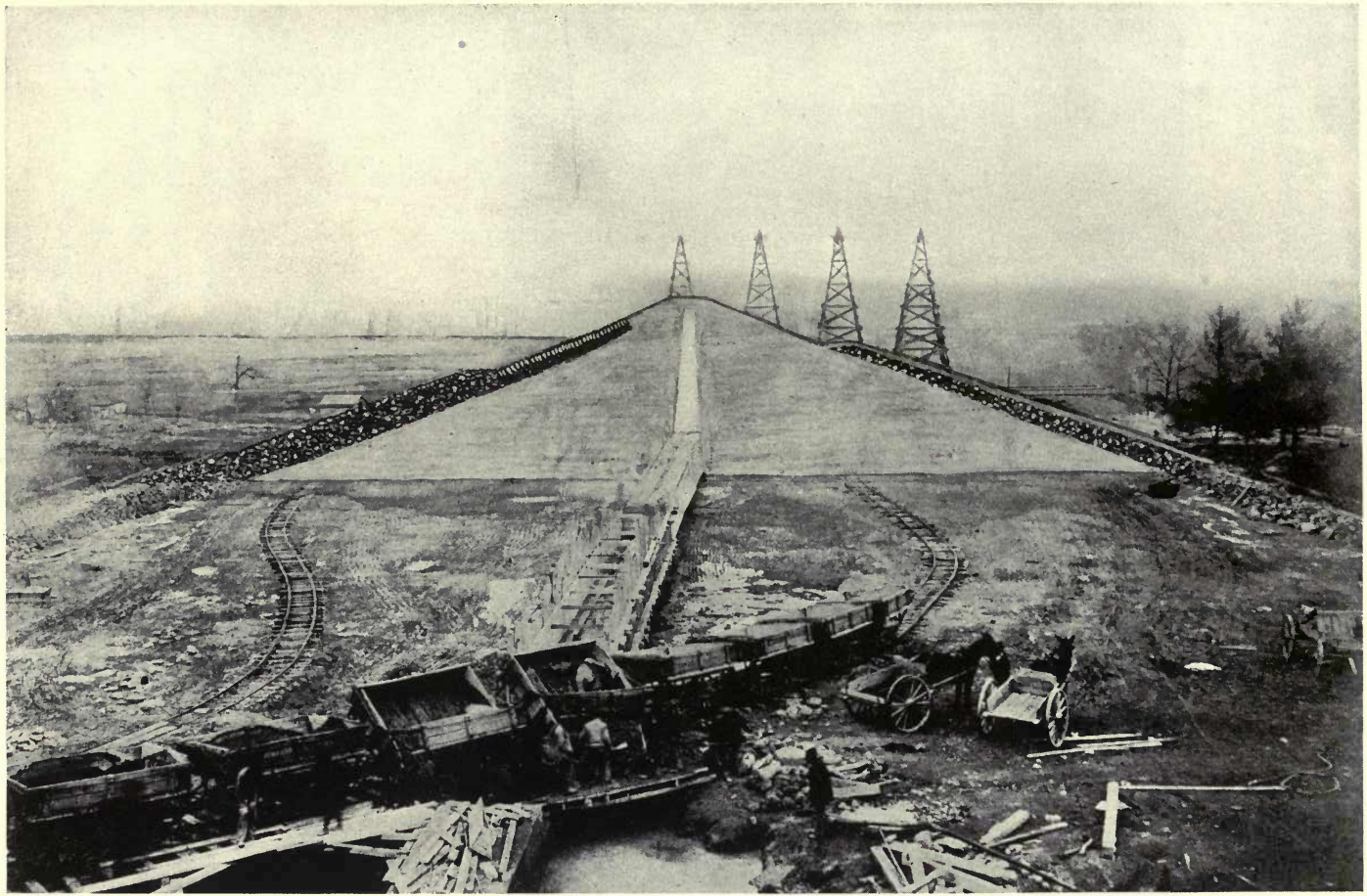


FIG. 19. DIKE IN NEW WORKS FOR WATER SUPPLY OF NEW YORK
(J. Waldo Smith, Chief Engineer)

upon the power to be developed? The second question is, Is this beneficial effect worth the cost? Here again, the skill and judgment of the engineer is of the greatest importance.

FIG. 20. PATHFINDER DAM, WYOMING
BED ROCK IN FOUNDATION
(U. S. Reclamation Service)

The character and extent of the technical investigations which are necessary in the study of a storage problem, are suggested by what has preceded. In the first place, topographical surveys are required of the watershed under consideration, in order to ascertain whether suitable sites for reservoirs can be obtained and whether there are favorable locations for dams. Sometimes (as in Fig. 18) a location will be found where a very short dam of considerable height between rocky banks will create a large reservoir, not only

large in area, but in capacity, and without overflowing valuable land. In other cases, no suitable site for a reservoir might be found, all possible sites requiring construction of long dams and the overflowing of areas valuable for agriculture or other purposes. In the construction of some storage reservoirs, as for instance, for the water supply of the city of Boston, entire villages have been overflowed, together with miles of railroads, requiring the re-location of the latter and of course the purchase of all the property submerged.

In connection with the topographical surveys, therefore, real estate and legal investigations may be necessary, together with complicated estimates involving costs and damages.

Geological examinations must also be made. At the site of a proposed dam, borings must be taken to determine the character of the underlying material in order to decide whether the dam can be made safe and what design shall be used. Other geological investigations may be necessary, for it may be found that the construction of a dam and the creation of a reservoir may sometimes cause an underground outflow from the reservoir in some other direction, which would seriously reduce, or perhaps destroy its value.

In addition to the above studies, careful hydrographic and meteorological investigations must be made. The rain-fall over the drainage area of the contemplated reservoir and of the stream affected must be carefully investigated by obtaining records from the nearest available stations, or by installing rain gauges and observing them for as long a time as practicable, comparing the results with those from the nearest gauges for which long records are available. In this manner, the amount and distribution of the rain-fall may be ascertained. The next thing to study is the runoff or the amount of rain-fall which will be discharged into the streams and will reach the contemplated reservoir. Similar investigations must, of course, be made with reference to the flow of the main stream whose power is to be developed.

On the basis of such investigations, a storage question may be

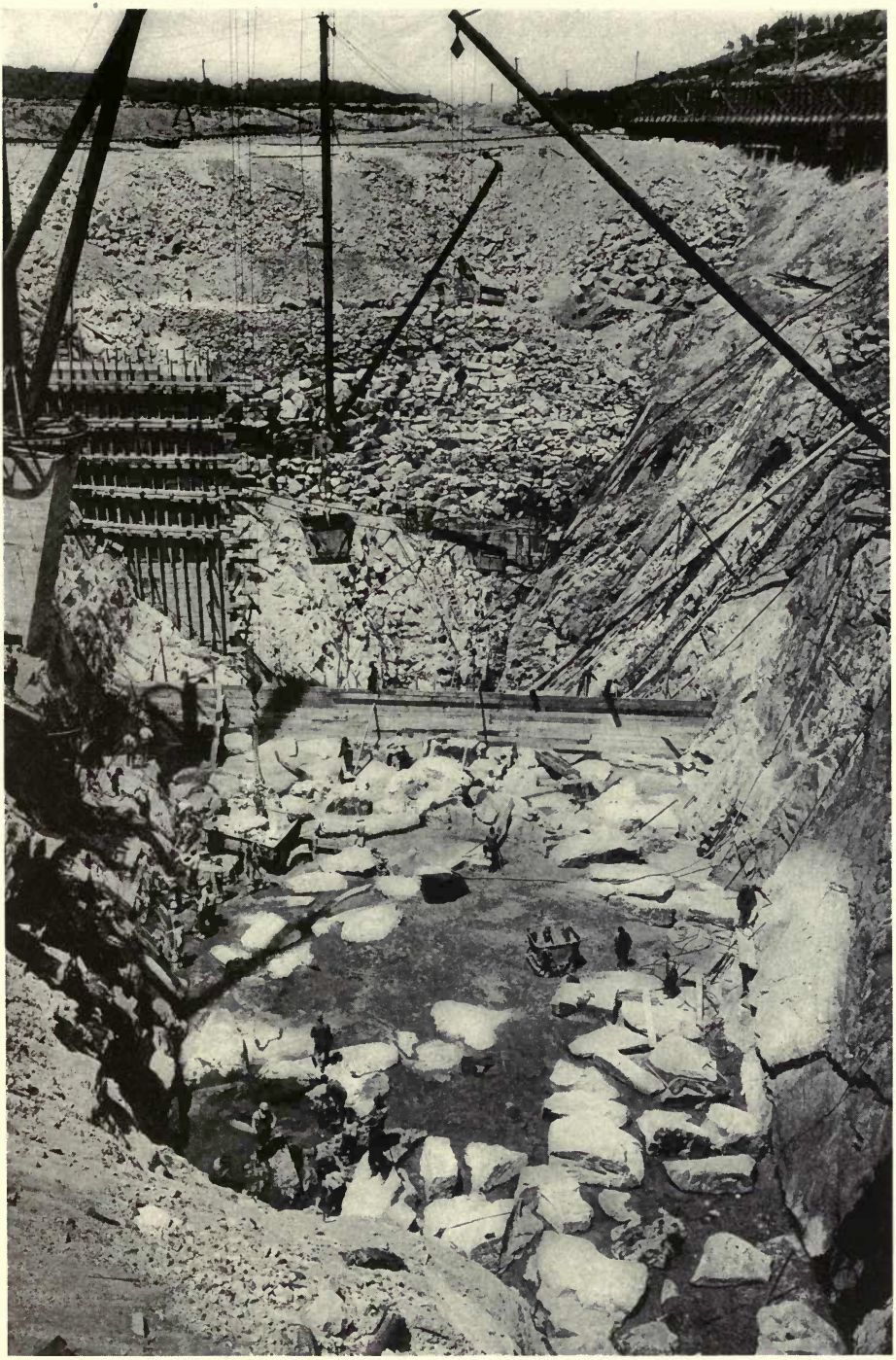


Fig. 21. Rock Gorge Uncovered in Excavating for Foundation of Kensico Dam, N. Y. Water Supply, being Filled with Cyclopean Masonry

(J. Waldo Smith, Chief Engineer)

attacked by the use of the methods known to hydraulic engineers, involving the construction of various curves and diagrams, and a reliable judgment may be thus formed as to the feasibility and economy of a storage project. It is not necessary here to go into further detail with reference to the technique of these various investigations.

Fig. 22. Mississippi River Power Co.
River Bed Exposed in Constructing Dam at Keokuk
(Stone and Webster Eng. Corp.)

One point, however, may be mentioned with reference to the gauging of streams, which is often overlooked. This is the circumstance that the amount of water flowing in a stream at a given point is not dependent alone upon the height of the water. This height determines the cross-section of the stream; but the average velocity with which the water flows past this cross-section depends upon the

slope of the surface, and this slope is not always the same when the water stands at the same height. When a flood comes down a river it comes in a flood-wave of greater or less extent. The face of this wave is steeper than the back. Therefore, when the river is rising and the water stands at a certain height on the gauge, the slope, and therefore the quantity of water passing, will be greater than when the apex of the flood has passed and the river stands at the same gauge-height as before, but with the water falling. For the same reason, the flow will not necessarily be greatest when the river is highest.

Most records of stream flow are determined by installing a gauge, measuring the quantity flowing at different times, at the same time observing the height on the gauge, and thereafter simply observing the gauge-height; the presumption being that the quantity flowing will be the same when the height is the same. This assumption being somewhat incorrect, all results deduced therefrom are to the same degree incorrect. The degree of approximation differs according to circumstances, and probably the averages obtained for mean monthly discharge are tolerably close to the truth, while the individual results as to the quantity flowing on any given day may be far more in error. As an illustration, Humphreys and Abbott in their studies on the Mississippi River, found that at Columbus the discharge might vary over 30 per cent at the same stage, depending upon the slope.

These preliminary studies and investigations having allowed the formulation of a definite storage project, the next step is the construction of the necessary works. These, in the case of a power plant, will generally consist of:

(a) the dam and head works, or intake into the canal or conduit which is to convey the water to the power house where the machinery is located;

(b) the conduit works, which may consist of an open canal, a tunnel, an open flume, or a pipe line, or a combination of all of these, sometimes with bridges or trestles for crossing streams or valleys;

(c) the power house with its forebay or termination of the conduit, its penstocks leading to the wheels, its turbines, generators, and other machinery;

(d) electric transmission lines from the power house to the point of ultimate utilization.

FIG. 23. BIG CREEK DEVELOPMENT, PACIFIC LIGHT AND POWER CORP., LOS ANGELES, CAL. DAM NO. 1 AND HUNTINGTON LAKE

(Stone and Webster Eng. Corp.)

It is, of course, impossible here to do more than mention these matters; the subject is a large and complicated one, and would require several treatises for its complete discussion. The subject of the treatment of dams alone would require a volume; the subject of water wheels another. Mention can only be made and illustrations given of a few features.

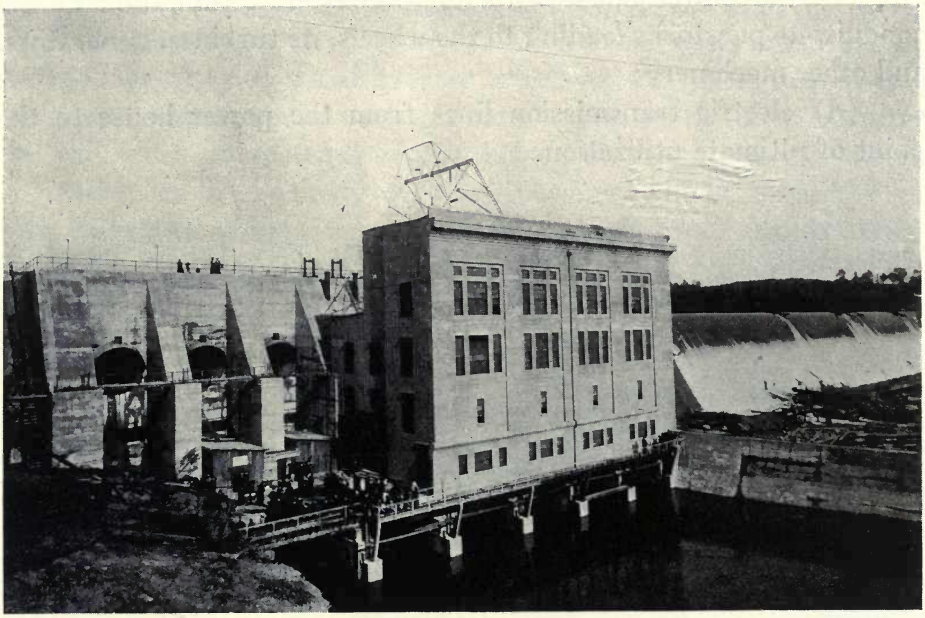


FIG. 24. COLUMBUS POWER CO., GEORGIA
GOAT ROCK DEVELOPMENT, POWER HOUSE AND DAM FROM ALABAMA SHORE
(Stone and Webster Eng. Corp.)

The dam, as already explained in chapter 2, may be high or low depending upon circumstances; it may also be of earth, of metal, or of masonry or concrete. In a majority of power projects today, the dam is constructed of concrete. Figures 23 to 41 illustrate a number of such dams. An important matter connected with their construction, as with the construction of most engineering works, is the foundation. It is, of course, essential that the dam should be carried deep enough to reach sufficiently solid material on which to rest, and that all danger of serious percolation of the water underneath the dam should be provided for. If the dam rests upon rock, as a masonry or concrete dam should, the rock must be stripped of the surface layer, which is generally broken and fissured, until a solid bed can be obtained. Not infrequently, however, there are fissures in this bed which must be filled by grouting with cement

or mortar, or else provision must be made underneath the dam for allowing the escape of such water as may percolate through such fissures. If the dam is of earth, a concrete core will generally be built in the center and carried down in a trench to a sufficient depth to cut off the greater part of the water percolating through the ground beneath. In connection with the dam there will generally be an overflow or spillway, generally of concrete, over which the surplus water not needed for power will flow. This spillway must be carefully designed so that it is capable of providing for the greatest flood without endangering the works, and it must be so shaped and provided with such an apron that the water flowing over it will not excavate or scour the channel below to a dangerous extent.

FIG. 25. A LOW AND INEXPENSIVE DAM ACROSS WHITE RIVER, WASHINGTON
(Stone and Webster Eng. Corp.)

Concrete dams such as have been illustrated, sometimes extend in a straight line across the stream, and sometimes are built in the form of an arch in cases where the walls of the valley or cañon are of rock and suited to withstand the resulting thrust. Some dams of this character have been made very thin, acting as they do partly

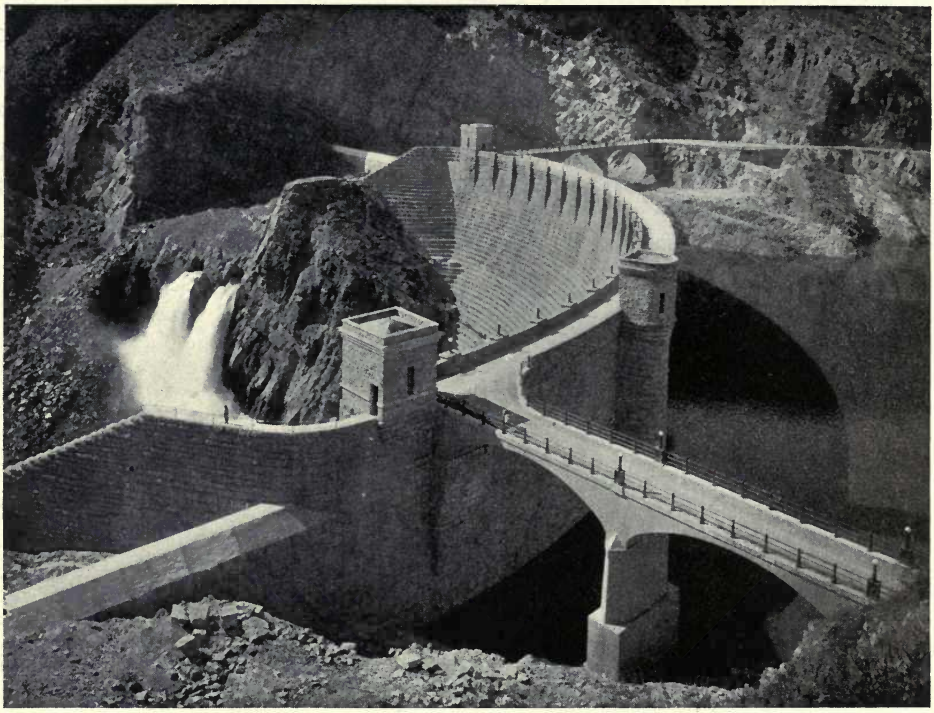


FIG. 26. ROOSEVELT DAM, SALT RIVER PROJECT, ARIZONA
284 feet high, 1080 feet long on top, reservoir capacity 1,280,000 acre feet
(U. S. Reclamation Service)

as horizontal arches. An illustration of such a dam is shown in Figure 33. Another instance is the Bear Valley dam in California, which has an extreme height of 64 feet and is composed of two sections vertically, the lower one being 16 feet high, 20 feet thick at the bottom and 12 to 13 feet at the top. On top of this rests the

upper portion, 48 feet high, which is 8½ feet thick at the bottom, narrowing to 3 feet thick at the top. The length of this dam is 300 feet, and it is constructed as a horizontal arch with a radius of 335 feet.

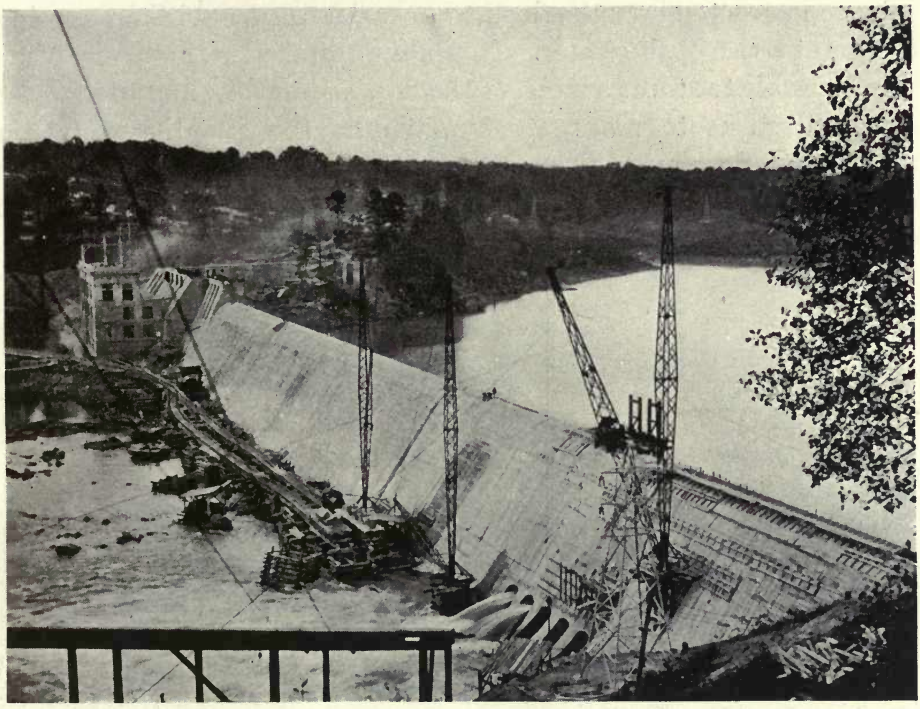


FIG. 27. COLUMBUS POWER CO., GEORGIA
GOAT ROCK DAM FROM GEORGIA SHORE
(Stone and Webster Eng. Corp.)

Most of the illustrations show the usual type of solid dam, but Figures 34 to 39 inclusive show the type of hollow concrete dam developed by the Ambursen Hydraulic Construction Co. Figure 39, shows the section of such a dam, with the power house within the dam itself.

In many water-power dams across rivers, the entire dam forms a spillway, the water flowing over the entire length from abutment

to abutment. In such cases provision is frequently made for varying the level of the crest by means of gates of some form, or flashboards which can be placed on the crest, and removed or raised or lowered as occasion may demand.

In times of flood such gates will be raised or flashboards removed so as to allow the flood to pass unimpeded without causing too great a rise of the water. In times of low water, however, when it is desirable to store as much of the flow as possible, and to increase the head so as to reduce to a minimum the quantity of water required to develop a given power, the flashboards will be put on or the gates lowered and the level of the pond above the dam correspondingly raised.

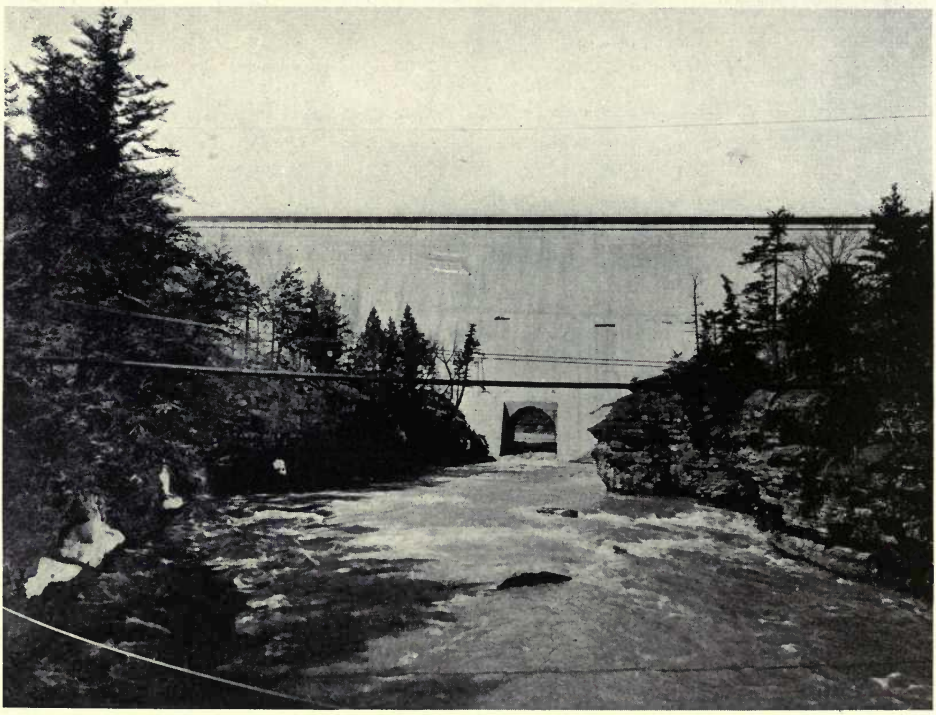


FIG. 28. ASHOKAN DAM, N. Y. WATER SUPPLY, SHOWING STREAM FLOWING THROUGH CONDUIT LATER FILLED WITH CONCRETE

(J. Waldo Smith, Chief Engineer)

FIG. 29. ASHOKAN DAM UNDER CONSTRUCTION
(J. Waldo Smith, Chief Engineer)

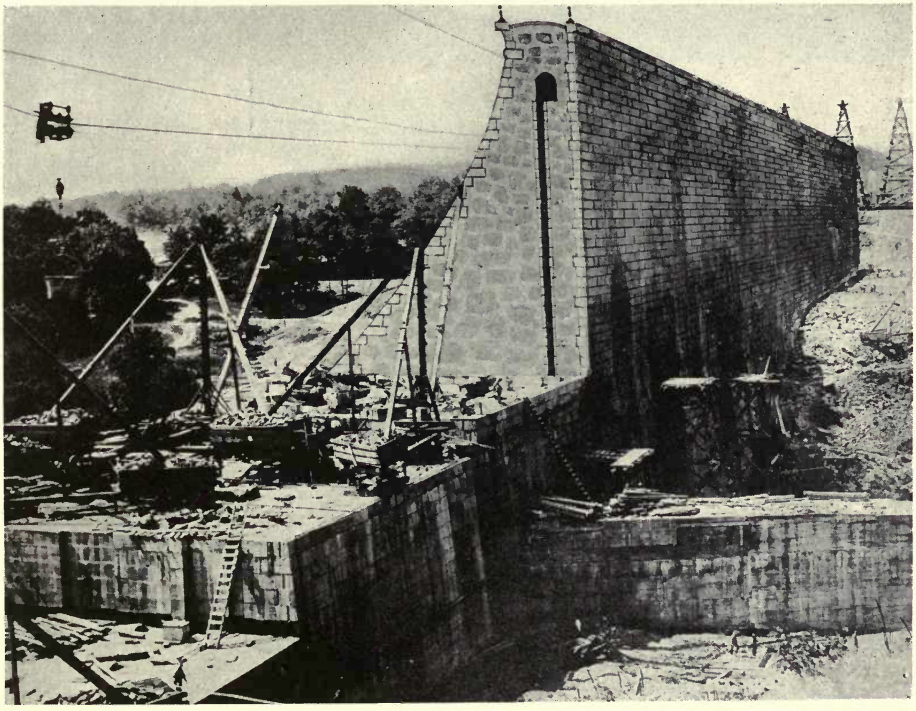


FIG. 30. ASHOKAN DAM UNDER CONSTRUCTION
(J. Waldo Smith, Chief Engineer)

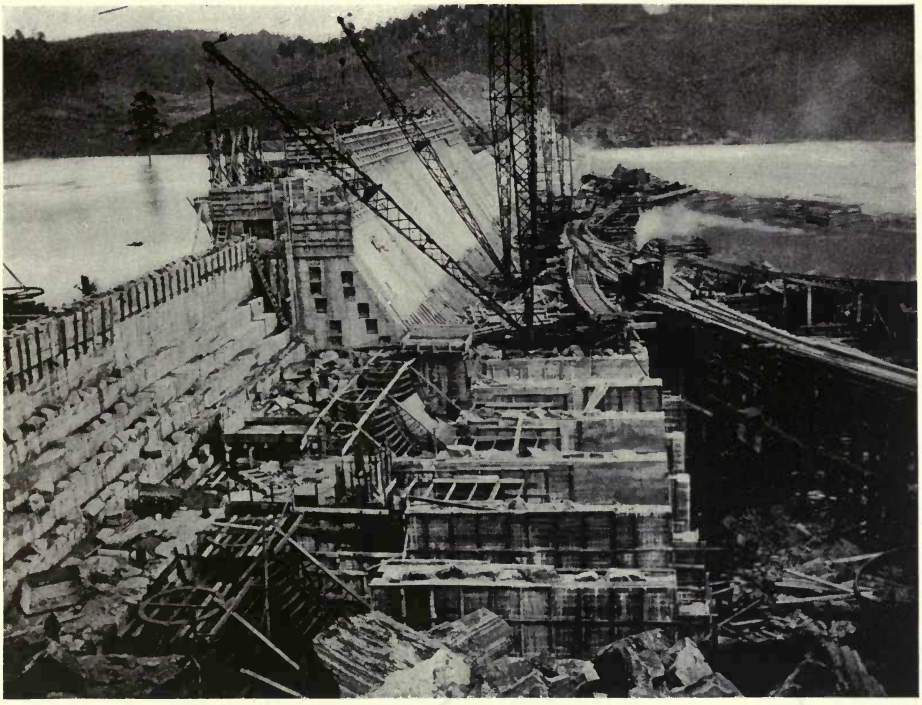


FIG. 31. COLUMBUS POWER CO., GEORGIA
GOAT ROCK DAM UNDER CONSTRUCTION
(Stone and Webster Eng. Corp.)

In some cases the power house, as already explained in chapter 2, may be located close to one end of the dam, in which case a short canal or forebay will be constructed, into which the water will pass from the pond, thence passing through screens into the steel tubes or penstocks which convey it to the water wheels, after flowing through which it escapes into the tailrace, perhaps through draft tubes, and thence to the river below. (See Figures 24 and 27.)

In other cases, conduits many miles in length may be necessary to convey the water from the reservoir to the power house. Figures 42 to 52 illustrate several forms of conduits. In some parts of the country they are made of wooden staves hooped at short intervals

and carefully made so as to be smooth on the interior. (Figures 42, 43.) In other cases, the conduit may be a steel tube or tubes composed of plates riveted together and supported either upon the ground or upon yokes placed at proper intervals. (Figures 46, 52.) Sometimes the conduit is an open canal or flume. (Figure 44.) Sometimes viaducts or bridges are required, as in Figure 49, and not infrequently tunnels or siphons. (Figures 50, 51.)

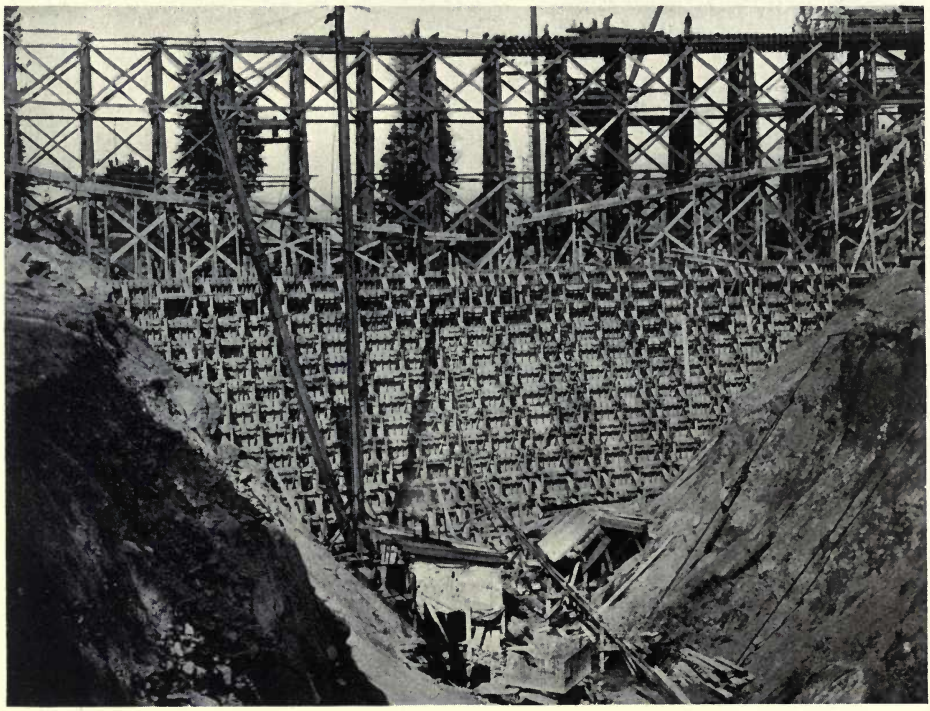


FIG. 32. DAM NO. 3, BIG CREEK DEVELOPMENT
PACIFIC LIGHT AND POWER CORP., LOS ANGELES, CAL.
(Stone and Webster Eng. Corp.)

From the lower end of the conduit the water flows to the wheels, sometimes taking a very sudden and rapid descent, as shown for instance, in Figures 54 and 57. Various auxiliary structures are required in connection with works of this character, and many

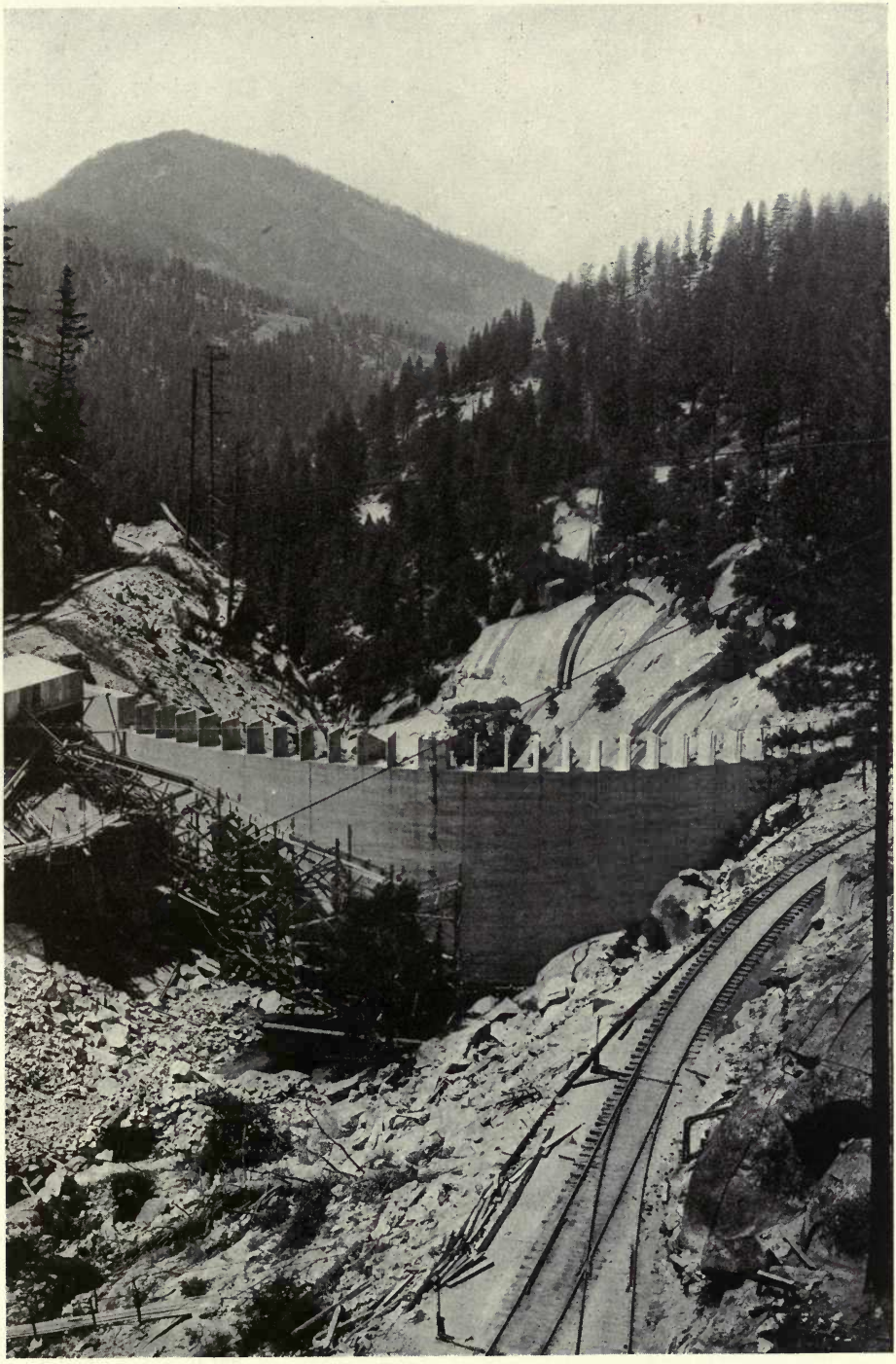


FIG. 33. DAM NO. 4, BIG CREEK DEVELOPMENT
(Stone and Webster Eng. Corp.)

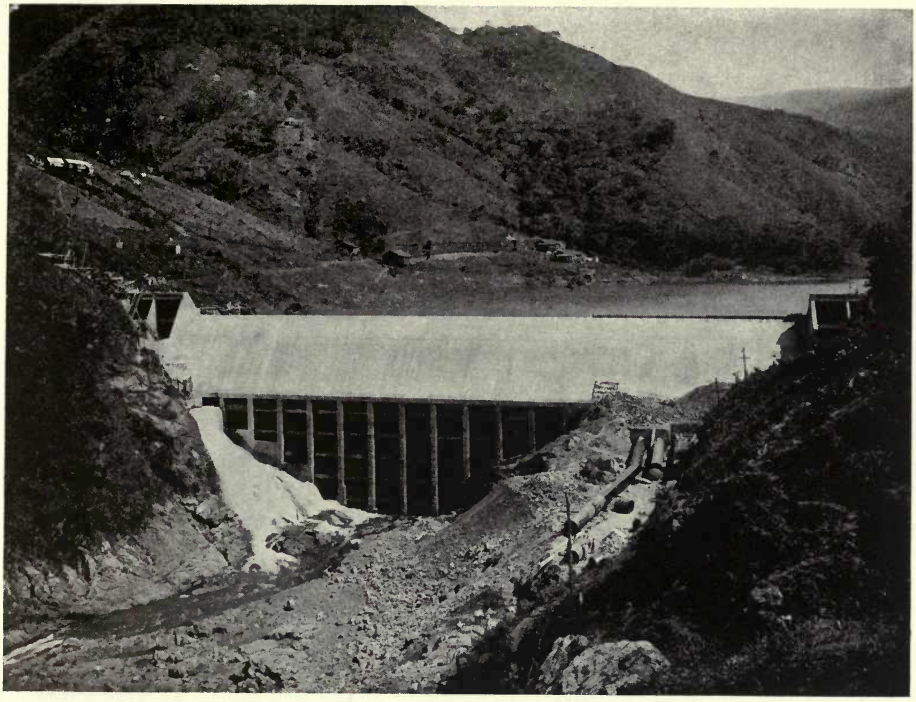


FIG. 34. COMERIO DAM, PORTO RICO LIGHT AND POWER CO.
(Ambursen Hydraulic Construction Co.)

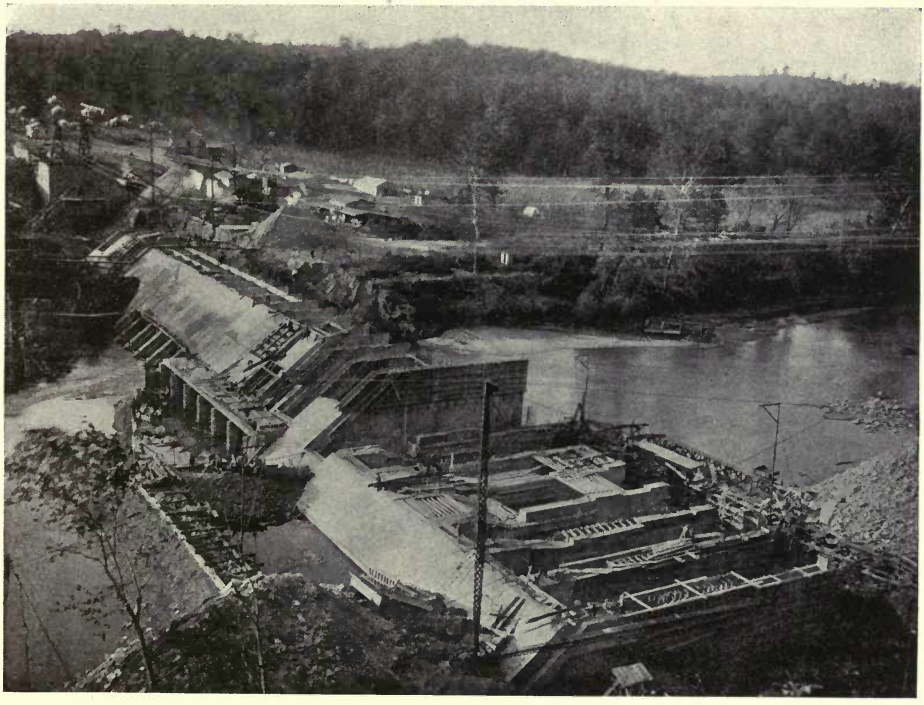


FIG. 35. OZARK DAM: CELLULAR TYPE
(Ambursen Hydraulic Construction Co.)

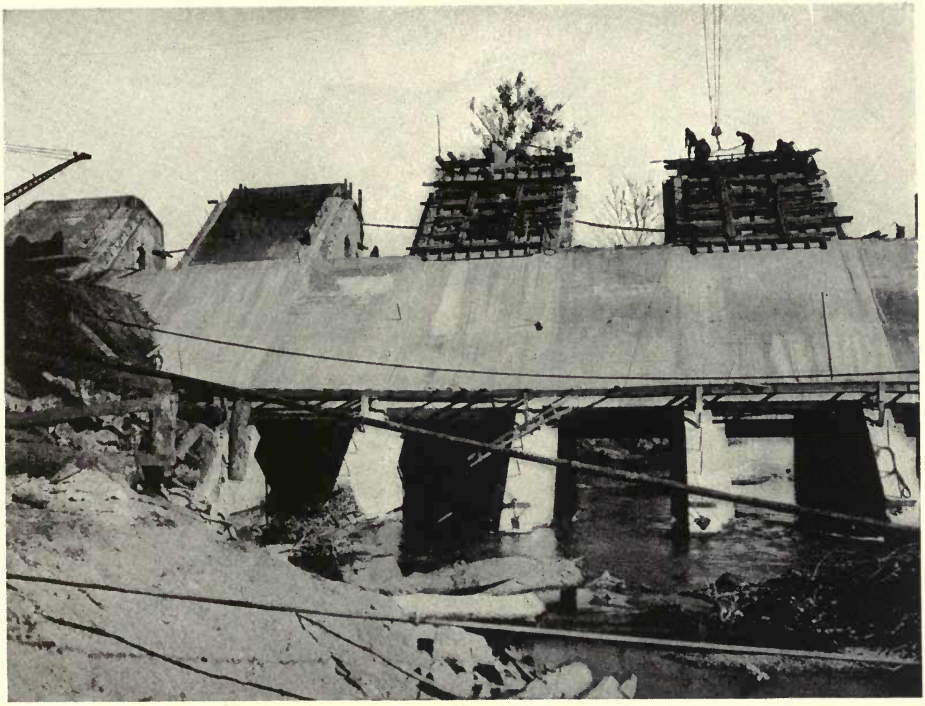
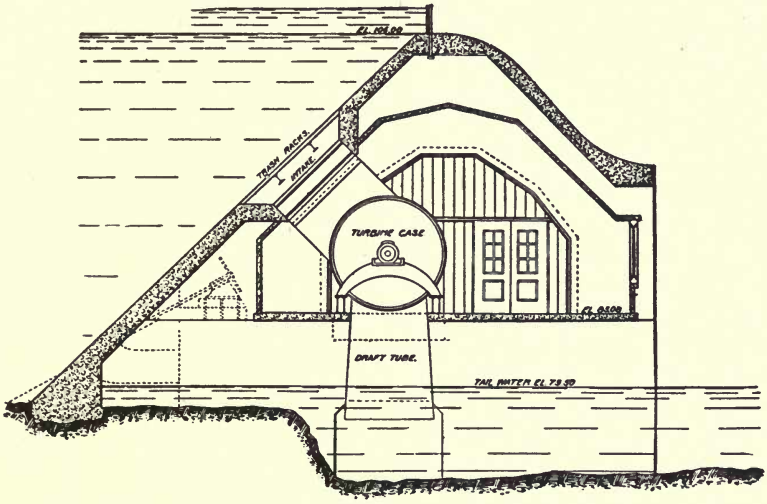


Fig. 36. Ozark Dam—Setting the Forms
(Ambursen Hydraulic Construction Co.)



SECTION THROUGH POWER HOUSE

Fig. 39. Dam at Ilchester, Md.
(Ambursen Hydraulic Construction Co.)

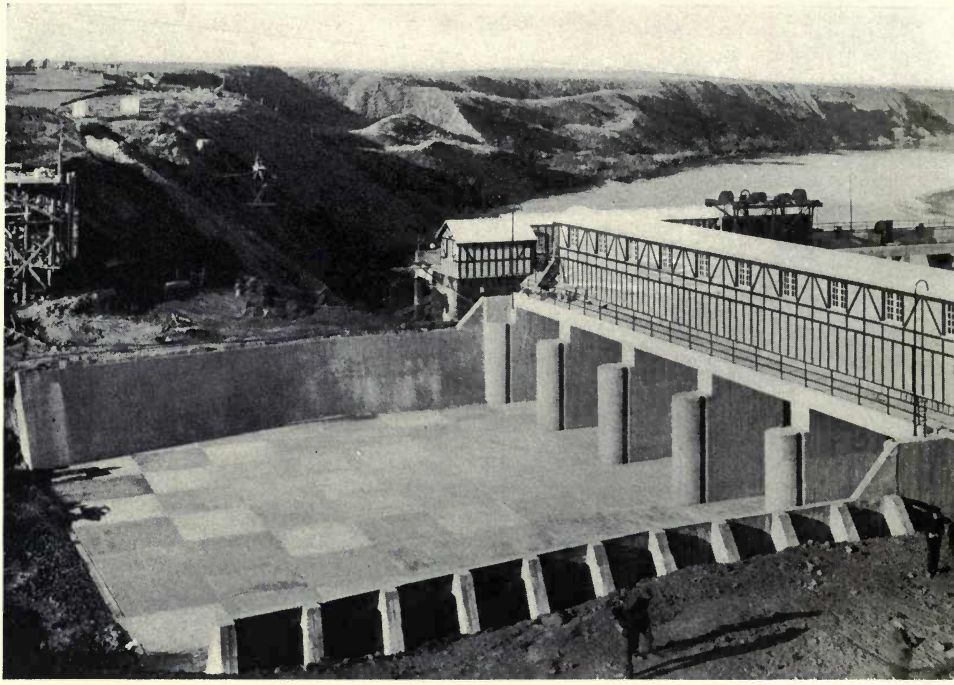


FIG. 37. BASSANO DAM, CANADIAN PACIFIC
(Ambursen H

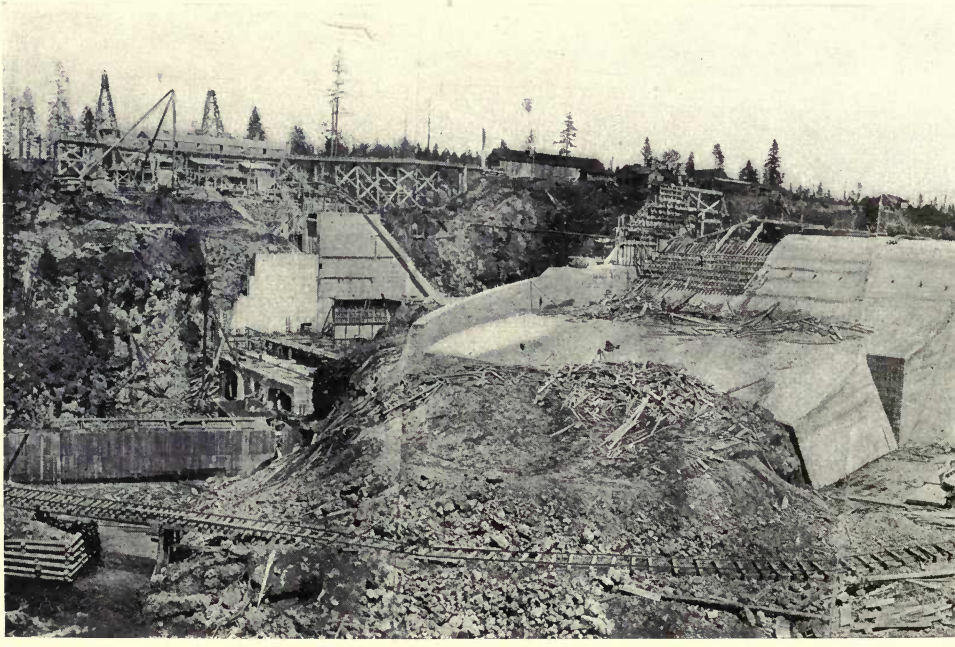
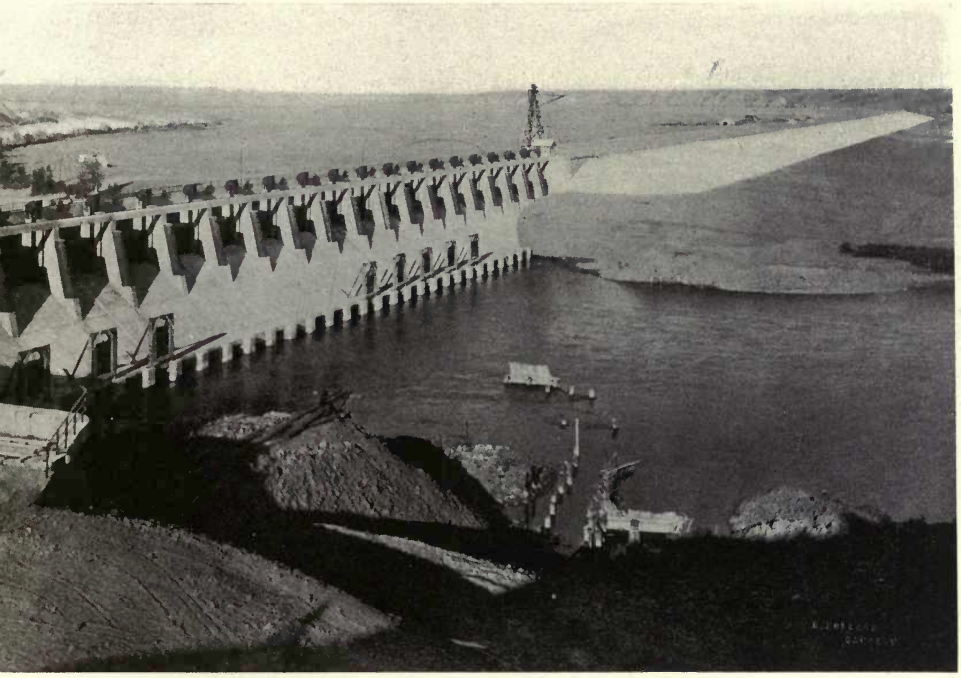


FIG. 38. ESTACADA DAM, ON CLACKAMAS RIVER—
(Ambursen H



RRIGATION SERVICE, SPILLWAY 700 FEET LONG
nstruction Co.)

AILWAY, LIGHT AND POWER CO., PORTLAND, OREGON
onstruction Co.)

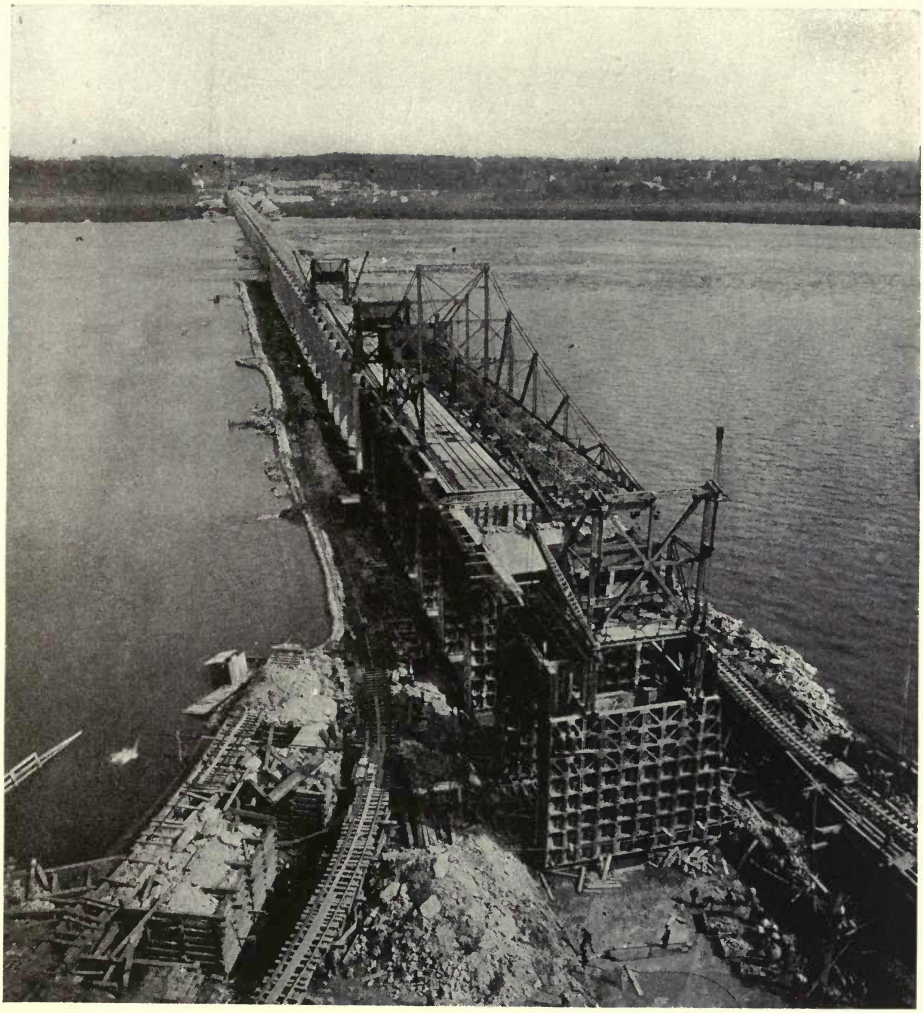


FIG. 40. KEOKUK DAM ACROSS MISSISSIPPI RIVER
(Stone and Webster Eng. Corp.)

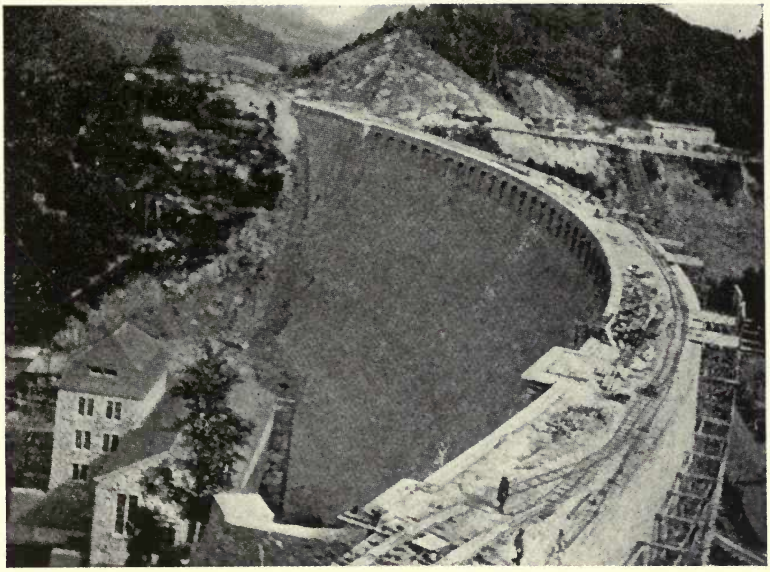


FIG. 41. MAUER DAM, GERMANY
203 feet high, 165 feet wide at base
(Journ. Eng. Soc. of Penn.)

FIG. 42. TRUCKEE RIVER GENERAL ELECTRIC CO. WOOD STAVE PIPE
(Stone and Webster Eng. Corp.)

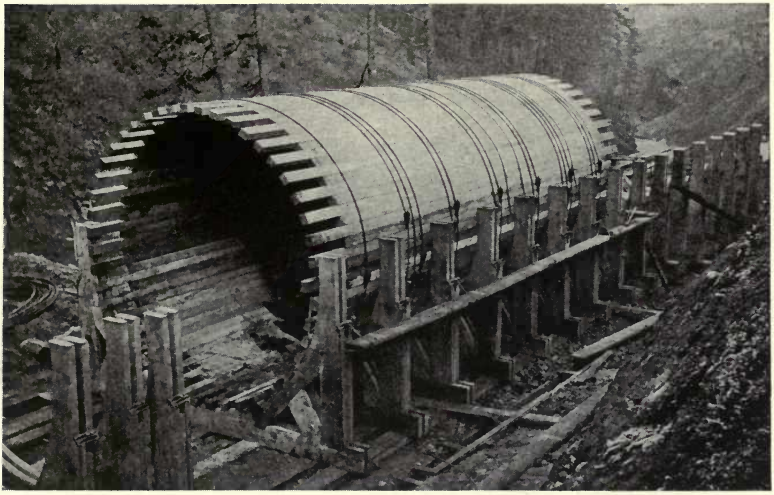


FIG. 43. WOOD STAVE PIPE, 13 FEET 6 INCHES DIAMETER
NORTHWESTERN ELECTRIC CO., PORTLAND, OREGON

(Stone and Webster Eng. Corp.)

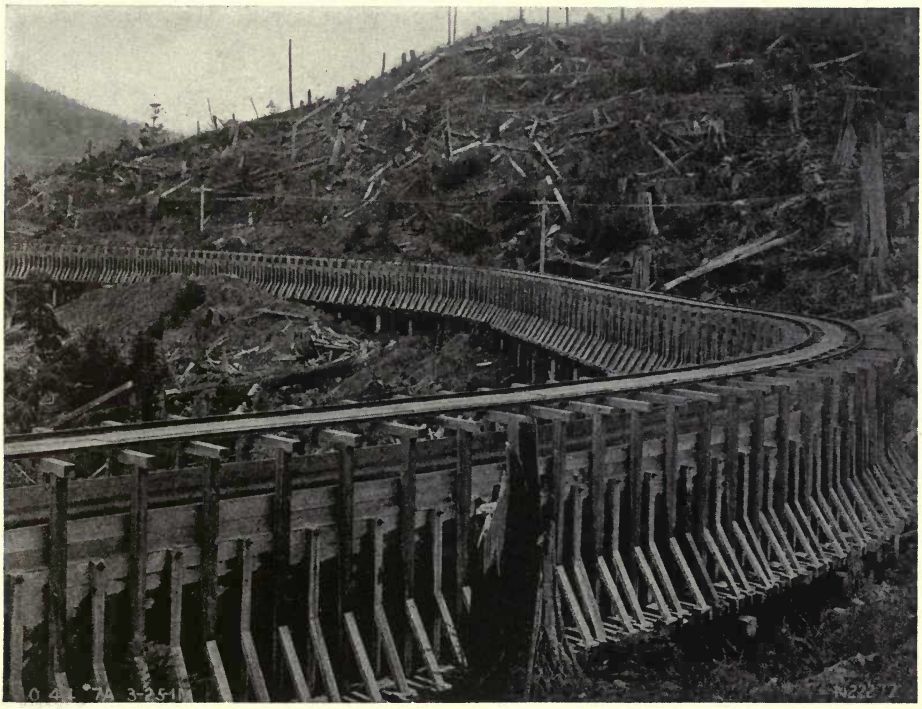


FIG. 44. WOODEN FLUME
PUGET SOUND TRACTION, LIGHT AND POWER CO., SEATTLE, WASH.

(Stone and Webster Eng. Corp.)

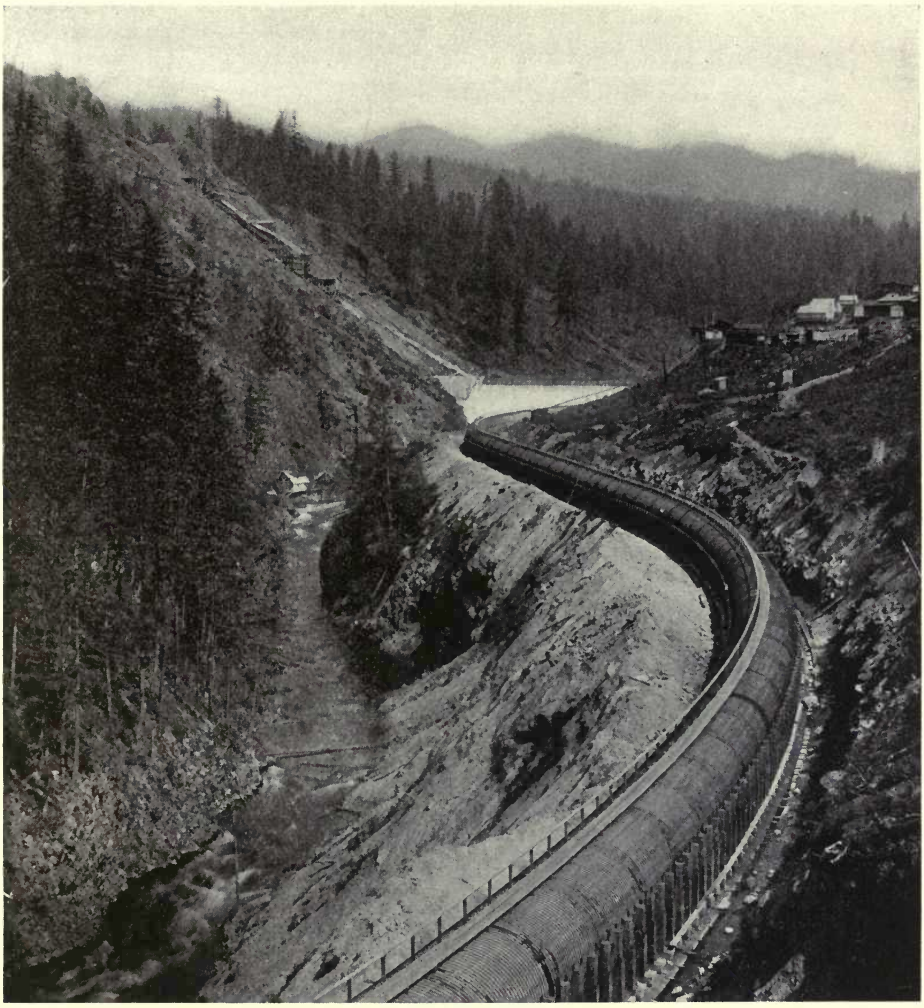


FIG. 45. WOOD STAVE PIPE LINE, 13 FEET 6 INCHES DIAMETER
NORTHWESTERN ELECTRIC CO., PORTLAND, OREGON—WHITE RIVER DEVELOPMENT
(Stone and Webster Eng. Corp.)

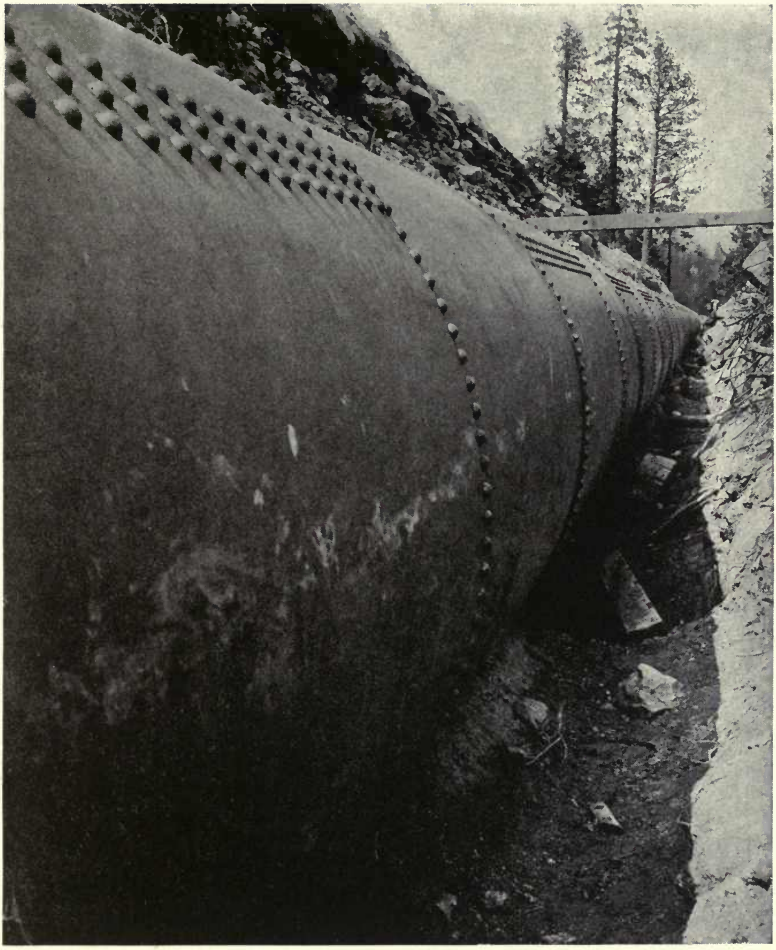


FIG. 46. STEEL PIPE LINE, 84 INCHES DIAMETER
BIG CREEK DEVELOPMENT, PACIFIC LIGHT AND POWER CO., LOS ANGELES, CAL.
(Stone and Webster Eng. Corp.)

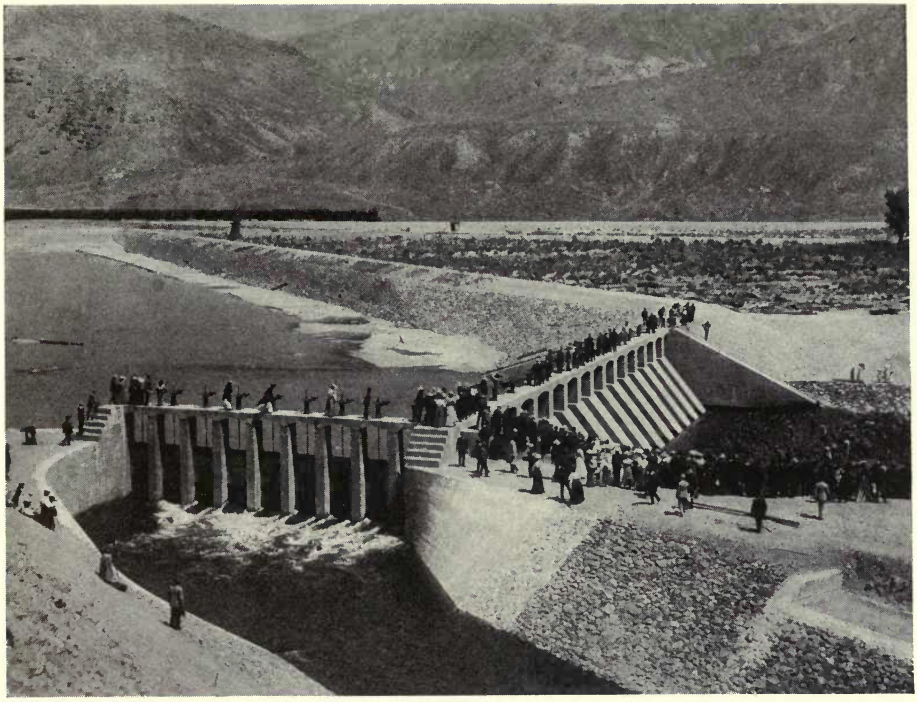


Fig. 47. Truckee-Carson Project, Nevada
Diversion Dam, Turning Entire Flow of Truckee River into Canal
(U. S. Reclamation Service)

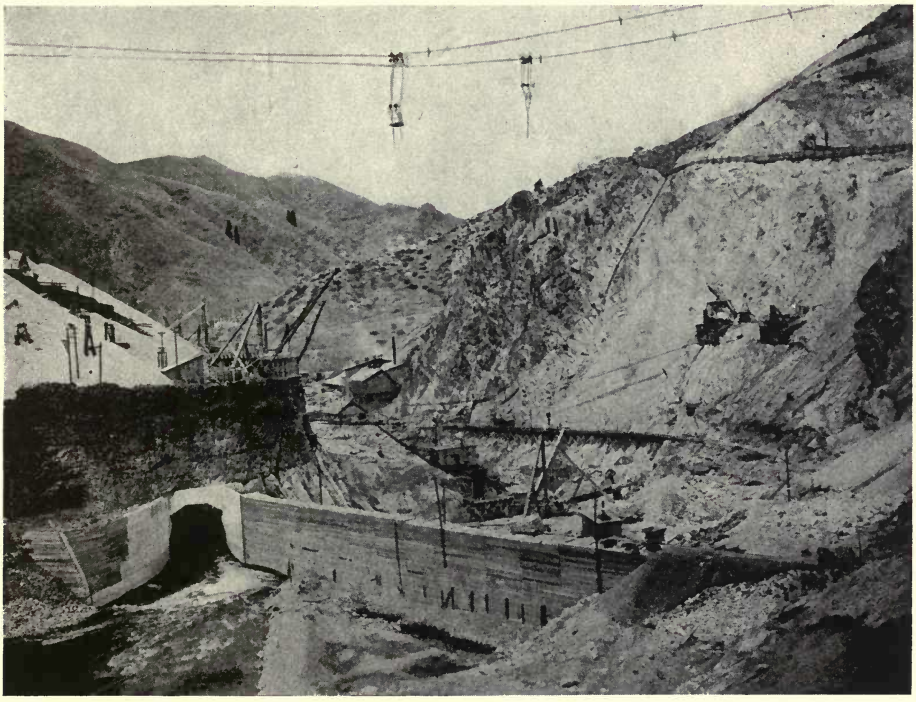


Fig. 48. Boise Project, Idaho—Tunnel Inlet
(U. S. Reclamation Service)

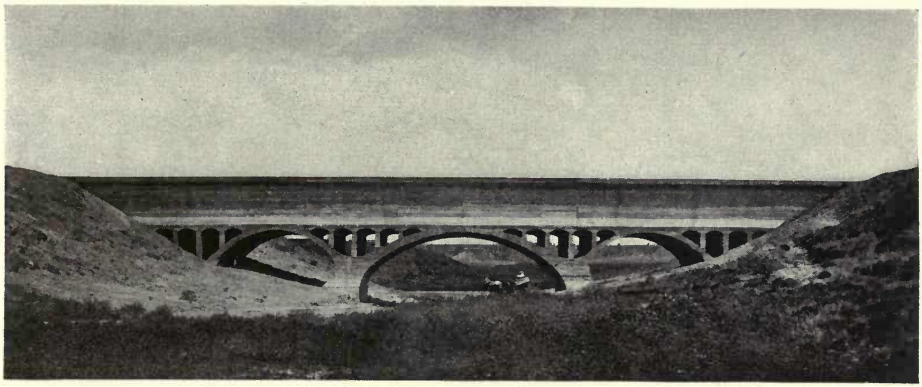


FIG. 49. SPRING CANYON FLUME, NORTH PLATTE PROJECT, NEBRASKA
(U. S. Reclamation Service)

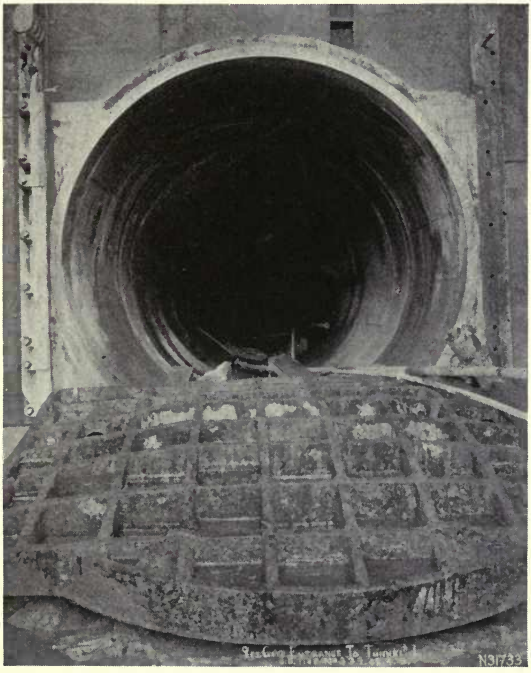


FIG. 50. GATE ENTRANCE TO TUNNEL, 9 FEET DIAMETER—BIG CREEK DEVELOPMENT
PACIFIC LIGHT AND POWER CO., LOS ANGELES, CAL.
(Stone and Webster Eng. Corp.)

FIG. 51. YUMA PROJECT, ARIZONA-CALIFORNIA
SIPHON UNDER COLORADO RIVER—1000 feet long, 14 feet diameter
(U. S. Reclamation Service)

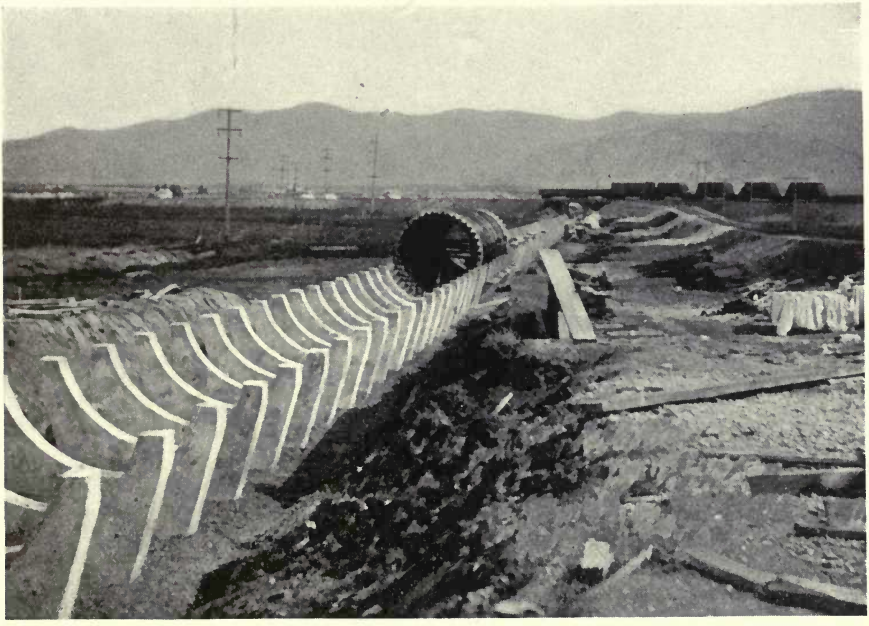


FIG. 52. CONCRETE YOKES FOR PIPE LINE
(Utah Power and Light Co.)

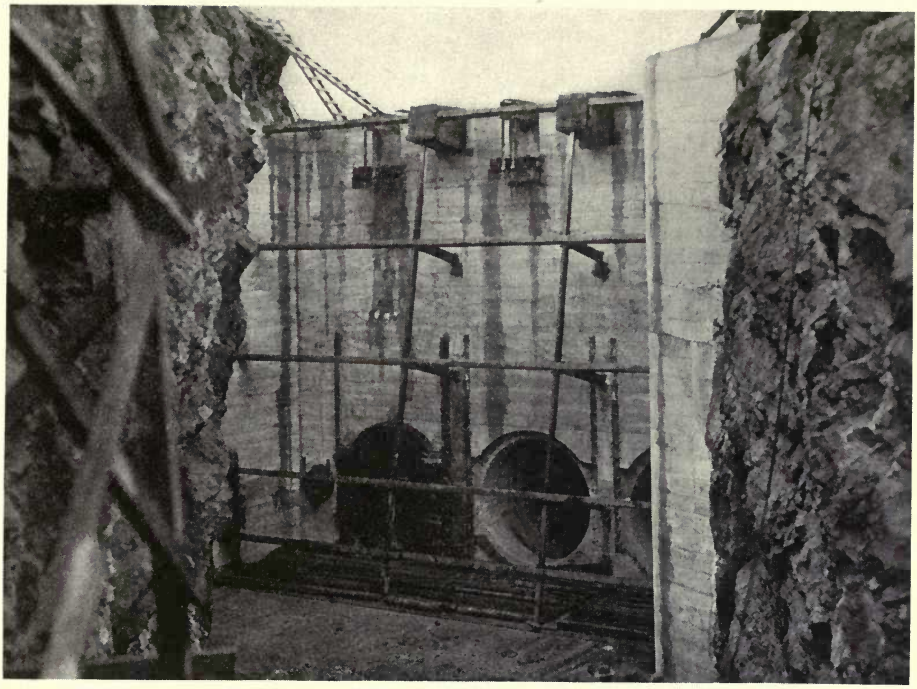


Fig. 53. Forebay and Entrance to Penstocks—Snoqualmie Falls Development
Puget Sound Traction, Light and Power Co., Seattle, Wash.
(Stone and Webster Eng. Corp.)

Fig. 54. Placing Forms for Anchors to Penstock—Big Creek Development
Pacific Light and Power Corp., Los Angeles, Cal.
(Stone and Webster Eng. Corp.)

Fig. 55. Laying Penstock on 80% Grade—Big Creek Development
Pacific Light and Power Corp., Los Angeles, Cal.
(Stone and Webster Eng. Corp.)

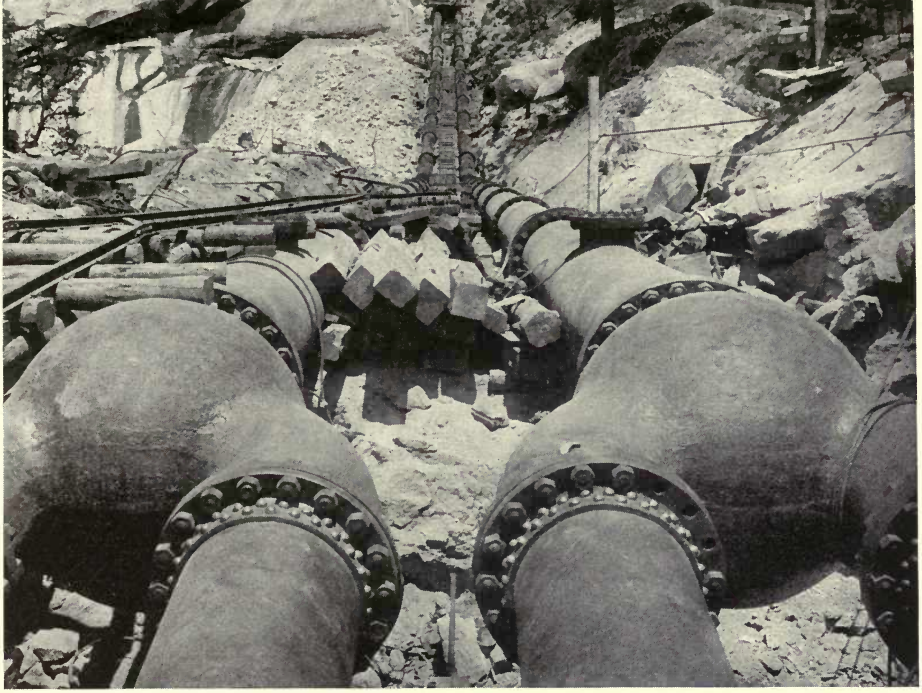


Fig. 56. Breeches Joint in Penstock—Big Creek Development
Pacific Light and Power Corp., Los Angeles, Cal.
(Stone and Webster Eng. Corp.)

Fig. 57. Power House and Penstock—Snoqualmie Falls Development
Puget Sound Traction, Light and Power Co., Seattle, Wash.
(Stone and Webster Eng. Corp.)

problems requiring a knowledge of hydraulics, mechanics, the strength of materials, etc., have to be solved. For instance, stand pipes are sometimes required, or compressed air reservoirs, to equalize the so-called water hammer which results when the gates at the wheels are closed. If a body of water moving in a pipe is suddenly stopped, as by the sudden closing of a gate or faucet, the energy of this moving mass is suddenly destroyed, and produces a shock or so-called water hammer, which may be sufficient to burst the conduit or pipe. Even the gradual closing of a gate may

FIG. 58. STAND PIPES ON MAIN PIPE LINES
WHITE RIVER DEVELOPMENT
PUGET SOUND TRACTION, LIGHT AND POWER CO.,
SEATTLE, WASH.

(Stone and Webster Eng. Corp.)

FIG. 59. POWER HOUSE WITH FOUR UNITS IN OPERATION—ELECTRON DEVELOPMENT PUGET SOUND TRACTION, LIGHT AND POWER CO., SEATTLE, WASH.

(Stone and Webster Eng. Corp.)

develop a certain amount of water hammer and waves of pressure will be generated in the conduit, extending from the gate back to the upper end. Even under ordinary flow in a long conduit, waves of this kind sometimes occur, due to various causes, and it has sometimes been observed that a large steel conduit will seem to breathe, as it were, changing its shape from an oval slightly flattened horizontally, to one slightly flattened vertically. This movement has sometimes been observed with the naked eye.

In the power house the machinery transforms the energy of the falling water either into direct mechanical energy, which is utilized in the immediate neighborhood, through ordinary mechanical transmission, in the operation of machinery; or it is transformed

into electrical energy, which is then transmitted, sometimes for many miles, at high electrical pressure, to the ultimate point of utilization. Figures 60 and 61 illustrate these transmission lines. Most people are probably now familiar with the aspect of such lines, which exist in many parts of our country and in some cases transmit electricity as far as 300 miles from the source. Power generated by the various plants at Niagara Falls is transmitted in this manner through the State of New York eastward as far as Syracuse; while in California, power generated in the mountains is transmitted in some cases 300 miles to cities where it is utilized for the operation of electric railways or for lighting or for other power purposes. In the Big Creek power development in California, built by the Stone & Webster Construction Company of Boston for the Pacific Light and Power Corporation of California, the power is transmitted about 241 miles to the city of Los Angeles.

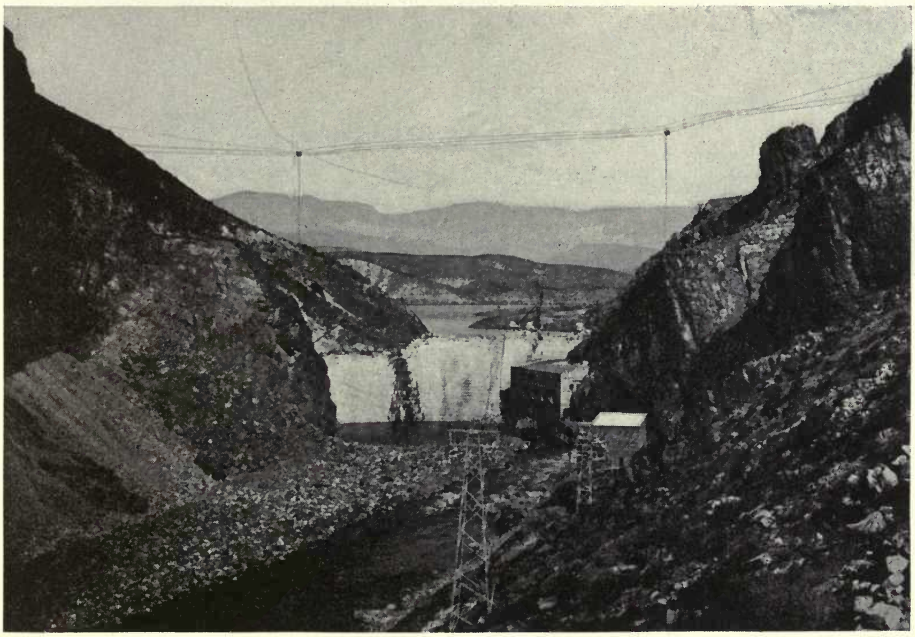


Fig. 60. Roosevelt Dam, Salt River Project, Arizona
(U. S. Reclamation Service)

The economic advantage of coupling up various water-power developments and markets into one unified system has been referred to in previous chapters. There are a number of examples of such systems serving large areas. In the neighborhood of Puget Sound the Stone & Webster Corporation have built and are now operating a number of plants, namely, the White River, the Puyallup, the

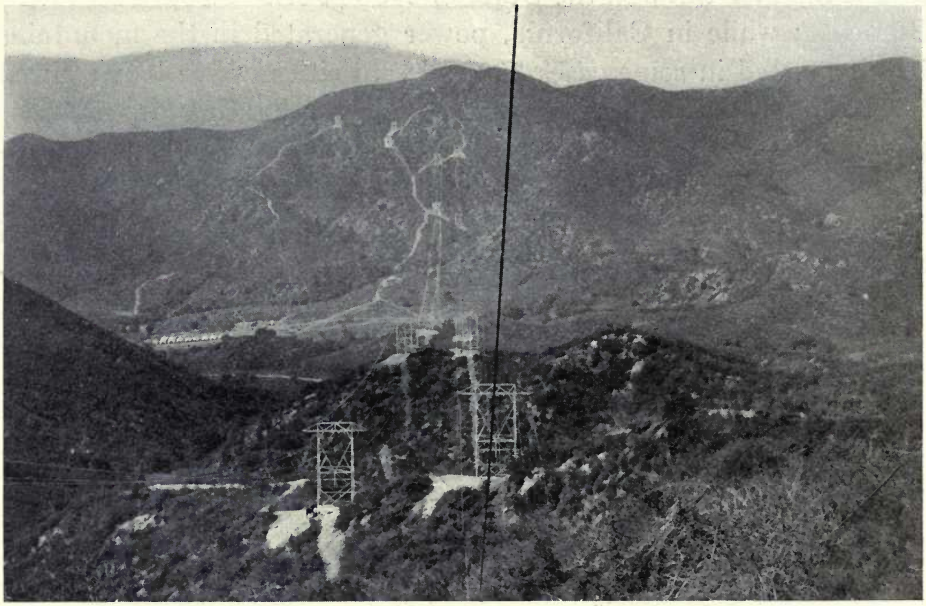


FIG. 61. TRANSMISSION LINE, TEHACHAPI MOUNTAINS—BIG CREEK DEVELOPMENT PACIFIC LIGHT AND POWER CORP., LOS ANGELES, CAL.

(Stone and Webster Eng. Corp.)

Snoqualmie, and the Nooksack plants. The first three of these deliver power to Seattle and Tacoma and adjoining cities, while the latter is a separate system supplying Bellingham. The Puyallup and Snoqualmie plants have a combined generating capacity of 30,000 horse power, but their storage capacity is limited and it was, therefore, necessary at first to meet the varying demand for power by auxiliary steam plants. Later, however, the White

FIG. 62. GENERAL VIEW OF DAM AND CONDUIT LINE—CONDIT PLANT, WHITE SALMON DEVELOPMENT
NORTHWESTERN ELECTRIC CO., PORTLAND, OREGON

(Stone and Webster Eng. Corp.)

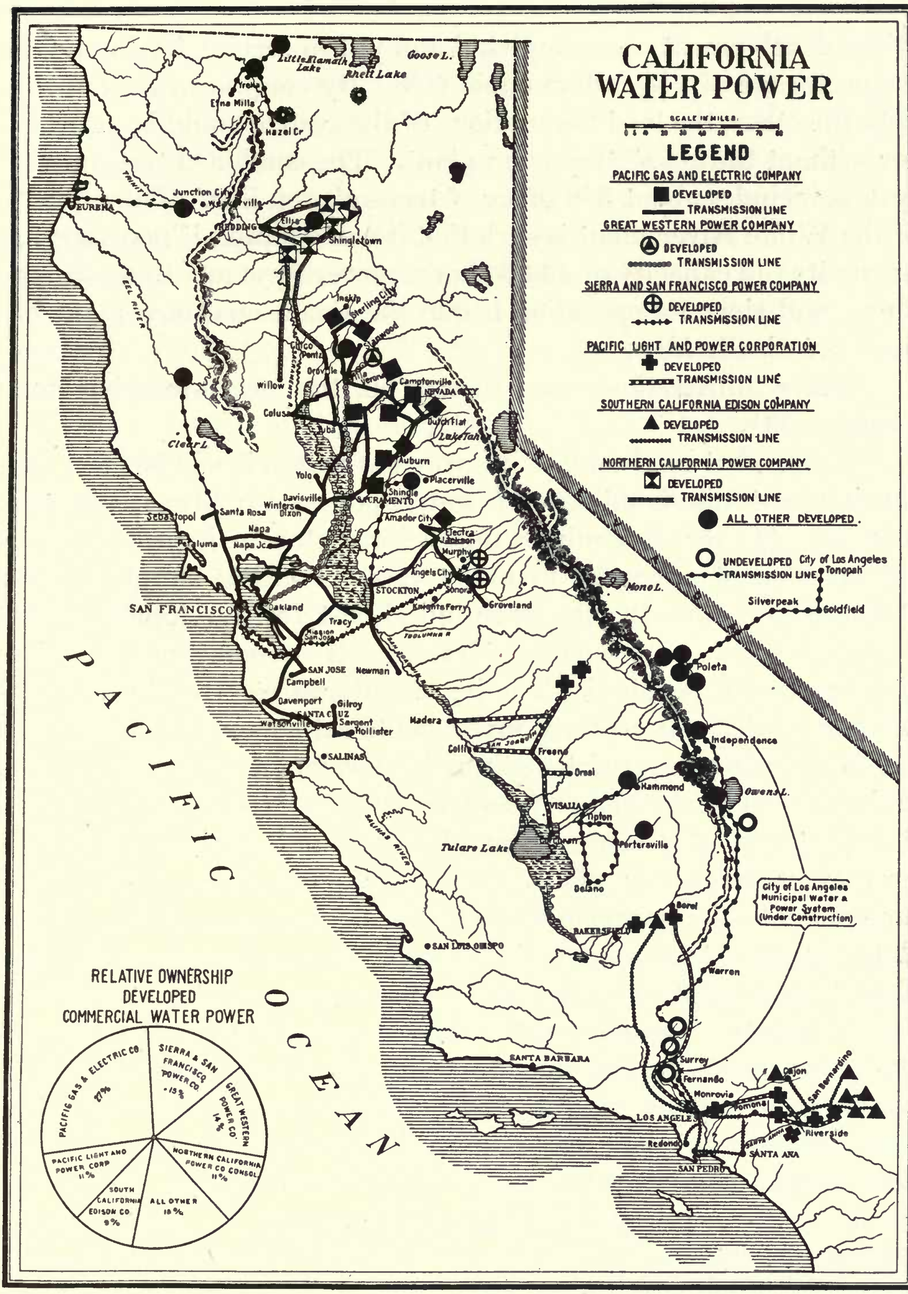


Fig. 63. (From Report of Commissioner of Corporations on Water-Power Development in the United States)

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River development was completed and put in service, having a very large storage of 2¼ billion cubic feet. By coupling this plant up with the other, the load fluctuations of the system could be provided for without the aid of the steam plant. The combined transmission system includes about 350 miles of transmission line. The capacity of the White River plant is such that it can operate, if necessary, at nearly its full capacity of 40,000 horse power for a month on storage alone, and since its operation began the steam auxiliary plant has been practically idle.[2]

Other illustrations are shown on the accompanying map (Figure 63).

From what has been said in previous pages, it will be clear that the inherent disadvantages of water power are principally two, namely: (1) its unsteadiness unless large storage is provided, and the consequent necessity in many cases of using supplementary steam power; and (2) its large initial cost for development. On the other hand, its principal advantage is economy of operation, since no fuel is required. The disadvantages referred to are sufficient to render water-power investments rather unattractive unless favorable conditions exist, both as to development and utilization, and freedom from undue interference by the public authorities. The first cost of a large steam plant is usually below that of the average water-power plant. The former requires only a small amount of land, a power house with the necessary machinery, and a short length of transmission line, for the steam plant may be located close to the point of utilization. It is less expensive, everything considered, to transport coal to the steam plant located close to the point of utilization, than to transmit electric power long distances from remote points of generation to point of utilization. The water-power plant may require a complicated system of works, with dams, conduit lines, a power house with its generating

[2] For a further discussion of these matters, see the interesting report of the Commissioner of Corporations on Water Power Development in the United States, March 14, 1912. In this report, charts are given illustrating the method of operating plants which are coupled up and used in connection with supplementary steam plants, showing clearly the economies which result.

machinery, transformer station, and perhaps many miles of transmission lines. Thus the initial cost of a water-power plant may vary from $50 to $400, or even more, per horse power of capacity, and will perhaps average, for large plants having long transmission lines, say $200 per horse power. This large initial investment frequently has the result that the principal item of expense in a water-power development is the interest on the cost, and this circumstance much increases the risk of such enterprises. The smaller the investment, manifestly the less the risk.

Moreover, should the investment prove a failure, the salvage is relatively greater in a steam plant. The land, being located near the point of utilization, generally in a city, can be used for other purposes, and even the buildings may be so used; while a water-power plant is useful only for its original purpose, although the power may, of course, be used in a different manner from that originally intended; while the land—often in remote regions—may be of little value in itself.

Furthermore, there is less opportunity for increase in efficiency of a water-power plant, due to advances in engineering science, than there is in the case of steam. A good water wheel utilizes 70 to 80 per cent of the theoretical energy of the falling water, and the loss due to electrical transmission at high voltages may be quite small. The margin between the efficiency obtained and the theoretical maximum is, therefore, not over about 30 per cent of the latter. In a steam plant, on the other hand, the best reciprocating engines in large units, develop not over 15 per cent of the theoretical energy of the coal, the best steam turbines but little more, the best gas engines about 21 per cent, while an incandescent lamp makes available in light only 1 to 2 per cent. Clearly, with such low efficiencies, the margin for possible improvements is very great. Nevertheless, the best modern steam plants, in large units, not only show comparatively small initial costs, but they generate power for surprisingly little, and the initial cost has been steadily decreasing within recent years. Not many years ago a steam plant was commonly estimated to cost in the neighborhood of $100 per

horse power of capacity. A recent large plant in New England with three units of 15,000 kw. each has cost as low as $53 per kw., or $40 per horse power, exclusive of the land, and this plant is stated to have generated power at about 3⅓ mills per kw. hour, exclusive of interest and depreciation. Another large recent plant is said to have cost for initial installation, including land, less than $50 per kw. Three and one-third mills per kw. hour for constant power 24 hours a day and 365 days in the year, means $29.20 per kw. annually, or about $22 per horse power. If to this we add 12 per cent on $53 for interest and depreciation on the initial cost, we find a total cost of $35.56 per kw., or $26.67 per horse power. At the Redondo Steam Plant of the Pacific Light & Power Corporation of California, the cost of developing power, using oil for fuel, has been stated to be four mills per kw. hour, while the Southern California Edison Company is reported to be generating steam power for less than this. It is clear, therefore, that at large steam plants, economically designed, steam power can be produced at a price of from $25 to $30 per horse power annually for constant power, including interest and depreciation.[3]

Water power, under favorable conditions, can be produced at lower prices than the above, provided the first cost is not too great. The Kern River plant of the Southern California Edison Company at Borel is said to generate and transmit power to Los Angeles for $1.28 per thousand kw. hours, which means $11.21 per kw., or $8.40 per horse power per annum for constant power. Of the above price, 33 cents is said to be for production, 58 cents for maintenance, and 37 cents for transmission. If we add to this interest and depreciation assumed at 10 per cent on an initial cost of $200 per kw. (although the writer has no knowledge of what the initial cost of this particular plant was) the total cost becomes $31.21 per kw., or $23.40 per horse power. This comparison indicates clearly the large part which the interest on the initial cost may form of the total cost

[3] The cost of steam power will, of course, vary very greatly, depending upon the manner in which it is used, the cost of fuel and labor, the question whether steam is needed in any case for other purposes, as for heating or for processes of manufacture, etc. The above figures are given simply to afford some general ideas on the subject.

of water power. Once safely financed and in operation, with a good market and fair treatment, water-power developments are very attractive on account of the greater convenience, the small operating expense, the small amount of labor employed, the consequent absence of labor troubles, independence of fuel supply, smaller depreciation, and the comparatively small amount of working capital needed. These advantages, however, may be more than offset if the permit is not definite, or if it is revocable, or if burdensome regulations and restrictions are likely to be imposed. If water power is to be developed, inducements must be offered to investors, including a reasonable assurance of fair treatment from the public authorities.

CHAPTER VII

FORESTS AND STREAM FLOW

Storage of water may be in surface or in subsurface reservoirs. Both are important. Any agency which stores the rain water, no matter where, and makes it possible to withdraw it gradually is an agency for conservation. I therefore invite your attention in this chapter to a brief consideration of a question of subsurface storage, a question also that involves the application of the principles of scientific investigation to a problem which, at the present time, is of great importance in the conservation of water and also of other natural resources. An examination of this question will, it is believed, also indicate how easy it is to fall into error by the use of incorrect methods of reasoning, and how men who are supposed to be authorities and who may have the best of intentions, may yet succeed simply in deceiving themselves and the public.

A point which it is very important to keep constantly in mind, and which will be exemplified in the study of this subject, is that good intentions, or the possession of authority, are not sufficient to justify conclusions, and that we must constantly be on guard against error, and must exercise, in every question presented to us, our own power of logical thinking, taking as little as possible on authority. Most of us are too confiding; we are apt to believe what some one tells us, if we think he ought to know, even though the question is one upon which we are perfectly capable of forming an independent judgment; and we are also apt to think that an honest man in a position of authority must be correct in his views.

As a matter of fact, however, a careful reading of history will convince one that probably as much harm is done to the interests of humanity by those who are honest in their opinions as by those who

are dishonest; probably for the very reason above referred to, namely: that we take an honest man too seriously; that we believe what he says, and very likely follow his advice. A dishonest or insincere man we are apt to distrust, and though he may influence some people, or for a time a good many people, his influence is not generally serious or long felt; but an honest man with good intentions, if ignorant of some elements of the problem with which he deals, or if incapable of logical reasoning, may for a long time exercise a great influence and mislead a large number of people. Reformers, for example, are not infrequently of this class; their perspective is not correct; they see things out of proportion; they exaggerate some elements of the problem and fail to see others equally important. For these reasons, though their ideals may be high and their purposes good, they in many instances do harm instead of good. Give a good but ignorant and illogical man sufficient power, and there is no limit to the harm he may do; and by ignorant, is not meant uncultivated or unlearned, but ignorant of important elements affecting the problem.

Even so-called scientific men are not all logical thinkers. It would be most interesting if some competent person would write a book entitled "The Mistakes of Scientific Men." It would, without question, be most entertaining. Probably there is scarcely a great step which has been taken in the scientific progress of the world that has not been pronounced impossible by those who might be supposed to be authorities on the subject. In a recent autobiographical work may be found an account of a lecture given by the professor of physics in one of our leading universities some fifty years ago. The professor was a very eminent man and a leader in his special line. He demonstrated to his students in that lecture that it would be scientifically impossible for telegraphic messages to be conveyed from one side of the Atlantic Ocean to the other. The next morning the papers contained an account of messages which had the previous day been transmitted by the newly laid Atlantic cable, between the President of the United States and Queen Victoria.

Some thirty years ago there was published in a German engineering periodical a lengthy discussion of the subject of aërial navigation by a prominent professor in a German engineering school. In this paper it was mathematically demonstrated that it would not be possible for a human being to navigate a machine in the air, because the weight of the necessary apparatus could not possibly be small enough to be sustained without falling.

When the first experiments were in progress in the neighborhood of Boston, relating to the use of the telephone, an account of these was sent to some Americans in Europe. They spoke of it to a prominent professor in one of the universities, who told them that it would be physically impossible to transmit speech in that way.

In view of such instances, it is easy to understand the confidence of the visionary, whether in science or in politics, who discards all fundamental principles and the opinions of all scientific men, and sets himself to solve problems such as that of perpetual motion, which he persistently believes he can work out. Truly, nothing is more important than a well-balanced mind, which sees things in their proper proportion, which grasps all the elements of a problem, and which is capable of logical reasoning or what we call straight thinking.

But this is a digression.

The problem to which your attention is invited in this chapter, is the relation between forests and the flow of streams, and the object is to endeavor to show the necessity of preserving our forests, and especially those on the steep mountain sides. It will be remembered that for several years there was presented before Congress a bill providing for an appropriation to enable the Government to purchase forest lands in the White Mountains and in the Southern Appalachians. The timber in these steep mountain regions is being rapidly cut, and the result is that not only is there a steady and rapid exhaustion of our timber resources, but there is a rapid erosion of the soil and a consequent silting up of the streams.

Important as it may be to conserve our timber supply, the Government, however, has no power, and cannot by act of Congress

legally be given power, to purchase lands for this purpose. The Government can set aside portions of the timber lands which it *now* owns in the West, and preserve them as Government forests instead of selling them to homesteaders; but there is no constitutional authority which can empower the Government to purchase forest lands which it does not now own, for the purpose of conserving the timber supply. The Constitution does provide, however, as we have seen, that the Federal Government shall control interstate commerce, and it therefore has control over all navigable rivers, expending annually large sums of money to improve such streams, both by dredging and by such means as the construction of locks and dams. If, therefore, the purchase of forest lands will improve the navigability of navigable streams, Congress has constitutional power to purchase, own, and control lands for this purpose. The only constitutional ground, therefore, under which the so-called Weeks Bill could be passed, rested upon the relation between forests and the navigability of streams. If the presence of forests improves the navigability of streams, Congress has as much power, if the money is appropriated, to purchase land and grow forests upon it as it has to expend money for dredging.

The relation between forests and streams is of two kinds. First, the relation between forests and the *regularity of flow of the streams,* and second, the relation between forests and the *erosion of the soil and consequent silting up of streams.* If a river is subject to great extremes of flow, varying between excessive floods and periods of extreme low water, navigation upon such a stream will be impeded; and if forests conduce to regularity of flow, they by so much aid navigation. And if forests, by lessening or preventing erosion, reduce the earthy matter carried into the stream beds, the consequent formation of bars and shoals will be reduced, and in this way the navigability of the streams will be improved. Let us consider first the question whether the presence of forests increases the regularity of flow.

There are two views with reference to this matter. It is claimed by many that forests act as equalizers of the flow of streams,

by diminishing, in general, the frequency and violence of the freshets and increasing the low water flow. On the other hand, it is seriously urged by some that forests are of little or no benefit in respect to these matters; that the sole benefit of preserving forests and of utilizing them scientifically, is to conserve the timber supply; but that as regulators of the flow of streams and aids to navigation they are useless, or, as apparently claimed by some, even injurious. This last view is held by some men who stand in positions of authority, and is blindly accepted by many who are too modest to realize that they are perfectly capable of forming their own opinions on such a matter.

Personally, the writer is convinced of the correctness of the first view; and conceives that the belief in the second arises from the errors which have been alluded to, namely: a use of incorrect methods of investigation and of illogical processes of reasoning. The matter is, in truth, as it seems to him, very elementary, and in order to put before you his point of view with clearness, it will be necessary to give a brief summary of the methods of scientific investigation.

As you all well know, there are two methods of arriving at scientific truth, the deductive and the inductive. In the deductive method we start with certain fundamental principles and from these we ascertain or deduce certain necessary results; from these, added to other fundamental principles, we can proceed to deduce other results, and so on until we arrive at certain final conclusions. This method is a method of reasoning rigidly from generals to particulars—from fundamental principles to necessary conclusions. Of course, the question immediately arises as to how we ascertain the fundamental principles from which we start. The answer is, that we either arrive at them by induction or by intuition. For instance, the principle that a straight line is the shortest distance between two points may be said to be an intuitive principle in the human mind. It does not need to be verified. We can *see* that it is true. The same may be said of many fundamental principles of mathematics and mechanics, as well as of other sciences. These

intuitive truths may serve, then, as starting points for trains of deductive reasoning; and the same is true of truths if conclusively demonstrated by any other method, as by induction.

Inductive reasoning, on the other hand, is quite different. It consists in first collecting a series of observations and from these reaching a general principle. If, for instance, we find that of two pieces of steel, one has a higher tensile strength than the other, and upon analyzing the steel we discover that the stronger specimen has more carbon, and if we then carry out a careful series of experiments with specimens of steel which are alike in every respect except the percentage of carbon, and find that the higher the percentage of carbon the higher the tensile strength, we may formulate the general principle that the effect of carbon is to increase the tensile strength of steel. This is an inductive process. Inductive reasoning, therefore, is a process of passing from particulars to generalizations—from isolated or related facts to general laws.

It is evident, however, that the process of induction requires deduction and the use of imagination and hypothesis; the experimenter who obtains a series of facts imagines a general law which will explain them all. From this he deduces some consequence which is not included in the observed phenomena, and then makes what is called a crucial experiment to ascertain whether his deduction is correct. If the experiment succeeds, the evidence becomes stronger that the hypothesis is a correct one. He devises another crucial experiment and in this way forges the chain of evidence. It is for this reason that deduction is often said to be the fundamental method of reasoning, inasmuch as induction properly depends upon it for its success.

In the examination of any question, it is very important to select the proper method of reasoning. To select the wrong one might immediately result in total error. This mistake is, as will be shown, precisely the one which has been made by those who urge the uselessness of forests as regulators of flow. They use a strict method of induction, although it is easy to show that in such a case this method is incorrect. In order to make this clear, certain pre-

cautions must be mentioned which it is essential to make in using the inductive method.

Induction, as already explained, consists in gathering observations, and in endeavoring to draw general conclusions from them. Now, suppose that it is desired to ascertain by the inductive method the effect of phenomenon A on phenomenon B. In the first place, it is perfectly clear that in order to arrive at correct results, it is essential that these two phenomena should not be complicated by any others. To use a homely illustration, suppose a physician wishes to ascertain whether mince pie is indigestible in the case of a certain patient, and suppose that in order to settle this matter, he should feed his patient for several days on mince pie, lobster salad, Welsh rarebit, cucumbers, and fruit cake. Indigestion results. Is it due to the mince pie? The experiment might be tried on a thousand people with the same result—indigestion; but it would be entirely erroneous to conclude on that basis that mince pie is indigestible.

To use the illustration already referred to, suppose a chemist wishes to ascertain the effect of varying percentages of carbon upon the strength of steel. Phenomenon A is the presence of carbon; phenomenon B is the strength of the steel, and the relation of the two is to be studied. It will not do for him to take a number of samples of steel varying in percentages of carbon, to test the strength of these and to draw a conclusion from the result; the reason being that there may be other elements such as manganese or nickel which exist in varying proportions in the different samples; or the different samples may have been subjected to different processes of heat treatment, some to hardening, some to tempering, and so on. Such an experiment would be entirely inconclusive. It is evident from the above—and all this is exceedingly elementary—that one essential principle in inductive reasoning, when the relation of two phenomena is under examination, is *to keep all other phenomena absolutely the same.* The chemist referred to must take samples of steel which contain absolutely the same percentage of every other element, and which have been subjected to absolutely

identical treatment, the only differences being in the percentage of carbon; *and in such a case only* will he be entitled to conclude that the observed differences in strength will be due to the observed differences in carbon. If he is unable to obtain a series of samples identical in every other respect, then he is not justified in reaching any conclusion whatever with reference to the effect of carbon, though he may tentatively formulate a hypothesis. It will not do to say that the samples are *nearly* alike in every other respect—that the percentage of nickel is *almost* the same in all of them—for it is evident that an exceedingly small difference in the percentage of nickel might cause a greater difference in strength than a large difference in the percentage of carbon. Not only must every other element be identical, but the experimenter must be sure that he has included every possible element. Instances are not uncommon in which erroneous conclusions have been reached, for the reason that the experimenter did not realize that certain elements were not common to all the experiments, or thought that such elements were unimportant. Here is where invention and discovery play a part. Different samples of water might be considered to be identical in every other respect except one, and the differences in that one might be considered to be the cause of a certain disease. Some mere improvement in laboratory technique, however, might presently show that, while all the samples of water *appeared* to be alike in every other respect, some of them contained bacilli of one kind, and some bacilli of another kind, which had previously entirely escaped attention. An important phenomenon had been entirely neglected.

We must, therefore, be constantly on our guard in using inductive methods. We must always consider our results in a measure tentative only, and we must be prepared to change our conclusions whenever elements are discovered which had not previously been taken into account. There are innumerable opportunities for error. A result which is attributed to a certain cause may prove to be due to an entirely different cause previously unknown. This may be connected with the first cause; it may be dependent upon it, or it may be in part contradictory of it. The

writer previously referred to who demonstrated that aërial navigation would not be possible, had not taken into account the possibilities of the gas engine.

Deductive reasoning is not open to the many vicissitudes and pitfalls which surround the use of induction. Nothing more is necessary than to be sure that the premises—that is to say, the fundamental principles which are the beginning of the process—are correct, and to reason with logical accuracy from them. The conclusions will be correct if the premises are. Such reasoning is a rigid process. The process itself does not give room for doubt, hypothesis, imagination, probability, etc. It confines the mind to a rigid groove. Such is mathematical reasoning. It affords little scope for some of the most valuable faculties of the mind. Put in certain data and you get without doubt or question certain results; put in correct data and your results are correct; put in incorrect data and your results are incorrect. The process is equally logical in either case.

There is no doubt that induction is a higher form of mental process than pure deduction, involving, as it does, the latter. The very rigidity of deduction makes it attractive to certain minds, and its continual practice, subordinating to rigid reasoning, as it does, the elements of discrimination, hypothesis, probability, and imagination, tends to make one pay more attention to the logical process itself than to the fundamental data, and, therefore, may in some cases lead to a habit of mind not calculated to be successful in dealing with the practical affairs of life. Almost any scientific problem, however, involves both induction and deduction, for deduction requires first induction or else intuition in arriving at the fundamental principles; while induction requires deduction in the course of its application.

Now, in studying the relation between forests and the flow of streams, the questions arise—What is the proper logical method to use, and how should it be applied?

In the first place, it is evident that these two phenomena, the presence of forests and the flow of the streams, are only two of a

large number of mutually interdependent phenomena. The flow of a stream and its variation throughout the year or throughout a series of years, is one of the most complex phenomena with which the engineer has to deal; that is to say, it depends upon a large number of elements. Among these may be mentioned the following: the precipitation and the manner in which it is distributed through the year; the temperature; the prevailing winds; the evaporation; the topography of the surface of the ground; the character of the surface, whether cultivated or bare; the character and amount of vegetation; the depth of the soil; and the geology, that is to say, the character of the underlying strata. The forests, therefore, constitute only one of a large number of phenomena affecting the amount and regularity of flow.

Now, whatever may be the effect of forests upon regularity of flow, some of the other elements named have unquestionably a far greater influence. For instance, on the basin of the Sudbury River near Boston, two years, nearly consecutive, showed almost the same total rain-fall. The topography, geology, character of the surface, forests, etc., were of course identical in the two years; nevertheless, the total quantity of water discharged by the stream was twice as much in one year as it was in the other. This difference was probably due to the fact that, while the total rain-fall was the same in the two cases, it was distributed differently. In one year, the rain may have come in gentle showers in the summer time, each shower being barely sufficient to wet the ground; while the snow in the winter may have passed away gradually, percolating into the ground and reaching deep strata, or may have been slowly evaporated so that but little of it reached the streams. In the other year, on the contrary, the summer rains may have come in a few heavy storms sufficient not only to wet the surface of the ground, but to cause a large proportion of that which fell to be carried immediately into the streams; or a warm rain may have come when the ground was frozen and unable to absorb much of it; or the snow may have been maintained during a very cold winter without melting, and may have been entirely carried off by a sudden thaw accompanied by

a warm rain in the spring. With the same total rain-fall, and the topographical and geological conditions identical, therefore, the total run-off in the stream and its distribution through the year may vary enormously. This illustration will clearly show the great effect of meteorological conditions, and it is probably unnecessary to adduce illustrations of the variations which may be due to differences in slope of the ground, or to some of the other elements which have been named.

Engineers and others who have endeavored to discuss this matter, and to arrive at conclusions regarding the effect of forests upon stream flow, have generally followed the pure inductive method. They have taken a given watershed, such, for instance, as that of the Merrimac River, and have studied the rain-fall, the gauge-heights of the stream, the total amount of water discharged, and the regularity of flow. They generally state that the cutting of timber, about which so much is now said, has taken place more rapidly in recent years than formerly. They give no information, however, even reasonably accurate, as to the amount of forested land in the watershed, nor as to the area which may have been cut a number of years ago, and may have been covered partially with a second growth; and yet they attempt to deduce conclusions as to the effect which the cutting of the forests has had upon the flow of streams. They confuse us by hundreds of hydrographs or curves showing rain-fall, gauge-heights and flow, and yet they endeavor to deduce the effect of forests upon flow without any accurate statement of the amount of area covered by forests; and in the face of the fact already referred to, that the other elements entering into the problem—such as the distribution of the rain-fall—may have varied enormously in different years.

Now it is evident that such a method of investigation is logically wrong, and can never lead to correct scientific results. It violates the first principle of induction, namely: that only one element must be varied at a time. If we could have a given area, in one case covered with forests, and in another case denuded of them, with every other element in the problem precisely the same in the

two cases, we might then be able to judge of the effect of the forest upon the stream flow. It is clear, however, that we do not have, and probably never can have, such a condition. We may take a given watershed covered with forests, and we may remove the forests; following the removal, the flow of the stream may be found to be *more* regular than it was before, and yet it may be perfectly true that the effect of removal of a forest is to make the stream flow much less regular. In other words, the flow after the removal of the forest, while more regular than the year before, may have been much *less* regular than it *would have been* if the forest had remained. We never can tell what it *would have been.* It is clear, therefore, that correct results with reference to this question can never be obtained by the use of methods such as have been employed in a recent study by one of the officers of our army engineer corps regarding the flow of the Merrimac River, or by a distinguished hydraulic engineer regarding the flow of streams in Wisconsin. A multitude of curves is not proof; they may only confuse the judgment. In this recent paper with reference to the conditions in Wisconsin, what are the conclusions arrived at by the author? Here are two of them:

"That in general, the deforestation or cutting of timber in Wisconsin has had no material effect either favorable or adverse, on the high water, mean water, or low water flow of the streams, or on the regularity of such flow.

"That *if* any effects on stream flow have resulted from deforestation, they have been entirely counteracted and obscured by the drainage of marshes, the clearing of farm lands, the second growth of timber, a freshet, or other similar occurrences."

In other words, the first states that there *has been no effect,* and second, that if there has been an effect it has been counteracted by other effects.

Clearly, the only logical conclusion is that the stream measurements show no material alteration in the high water, low water, or mean flow, or on its regularity, within the period covered by the investigations. But as to the question whether deforestation affects

these hydrographical phenomena there is no more light than if the paper had never been written, as is tacitly admitted in the second conclusion quoted. The author leaves the subject precisely where he found it; he proves nothing whatever as to the influence of forests upon flow.

These investigations, indeed, may be paraphrased thus: they bear the title, let us say, "the relation between mince pie and the digestive functions," and purport to be scientific investigations of this question. A single patient is taken for experiment. He has always been more or less addicted to mince pie, as well as to indigestion. During recent years, however, he has eaten more mince pie than formerly. No accurate figures as to this are given, but we may admit that he has been gradually increasing his consumption of that article of luxury. He has also varied his diet somewhat in other respects, and he has indulged also in pepsin tablets and other aids to digestion. The investigation consists in endeavoring to ascertain by induction whether his attacks of indigestion have increased in late years, during which he has increased his consumption of mince pie. Curves are drawn showing the number of attacks, their duration and severity, and they are averaged and compared in various ways. As a result it is properly concluded that no increase in indigestion is discoverable from the curves, but improperly inferred that mince pie does not cause indigestion.

This is probably a fair description of the general character of these investigations regarding flow of streams and forests. We may admit the care with which the investigations have been made, and, in general, the correctness of the conclusion that the hydrographs show no discoverable increase of floods during the recent years when the cutting of timber has been most considerable. The questions remain, Are such investigations worth while?—Are they real contributions to science?—Is the further conclusion justified that there is no appreciable relation between forests and stream flow? The answer to each of these questions should be in the negative. Such studies appear to be simply a waste of time; they are not real contributions to science; and they prove nothing

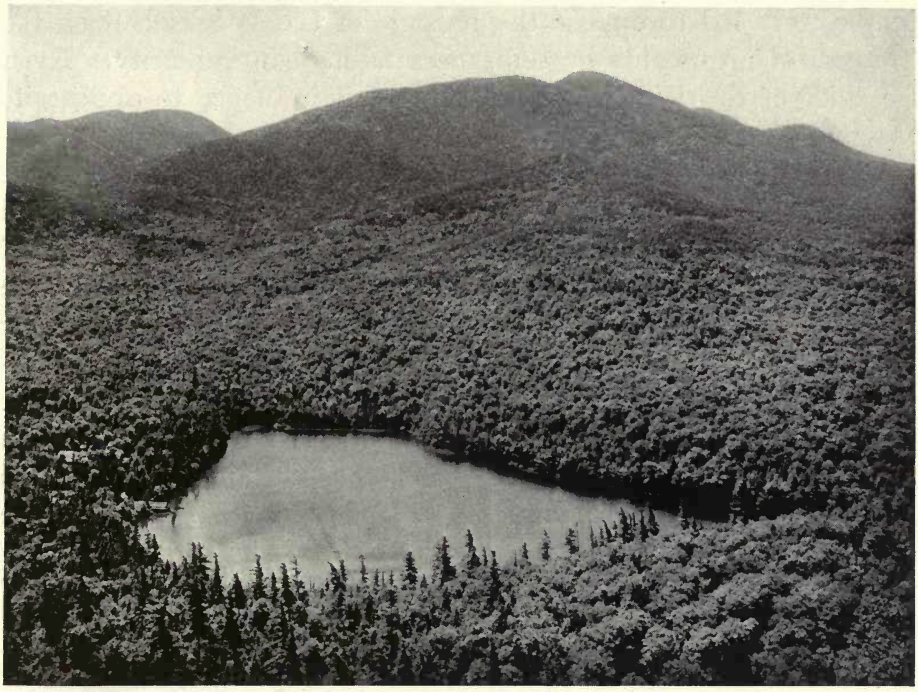


Fig. 64. Typical Forest, Adirondack Mountains, N. Y.
(U. S. Forest Service)

of scientific importance. Moreover, they leave the reader, unless he carefully analyzes them and has a keen appreciation of logical methods, with a mistaken impression that something has really been demonstrated. Partisans will take such studies, and will use them as arguments, and they will be accepted as such by the unthinking. For instance, such studies as these pay little or no attention to the effect of the slope of the ground. The effect of a forest on perfectly flat land may be one thing, while on a steep mountain slope it may be an entirely different thing. And yet, on the basis of studies like these, many people may be led to conclude either that forests have no influence on stream flow, or that experts differ so widely that the effect, if any, must be small, and may safely be left out of account. In this way many well-meaning

people were led to oppose the passage of the Weeks Bill on the strength of arguments by some persons high in authority. Even the chief of the Weather Bureau lent his influence to oppose its passage, on grounds which must be termed entirely illogical.

Now the importance of this matter arises from the fact that the forests constitute one of the very few elements affecting this problem *which are subject to man's control.* The distribution of the rain-fall through the year, the winds, the temperature, the topography, etc., may have and undoubtedly do have a much greater influence than the forest cover, but those elements we cannot control. We must take them as they come from year to year. But we *can* control the forest cover, we may build reservoirs and drain marshes, and if these things are good, they certainly make things better than they would be otherwise. Of course, if their influence is negligible, it would not pay to carry out such improvements; but they never can be proved negligible merely by a study of curves of flow.

What, then, should be the proper method of examining this question? Recognizing the fact that induction will not apply, considering that we cannot vary the forests and keep everything else the same, it seems obvious that we must adopt the deductive method, going back to certain simple fundamental principles, which will now be indicated.

First, What is the effect of forests upon rain-fall? This question is not an important one, but it has some scientific interest. Considering the necessary errors in observation, as for instance, the fact that a rain-gauge, the mouth of which stands a foot above the level surface of the ground, will collect about 6 per cent less water than if it stands with its top at the level of the ground, and that the other phenomena affecting the problem vary greatly and cannot be controlled; we cannot hope to prove conclusively any effect of forests upon rain-fall by rain-fall observations. But there is one simple principle which can easily be demonstrated, which sheds a flood of light upon this question. It has been demonstrated with reasonable conclusiveness, that the effect of forests is to cool

FIG. 65. TYPICAL MIXED HARDWOOD FOREST—JACKSON CO., NORTH CAROLINA
(U. S. Forest Service)

the air, on the average throughout the year; and, also, that a forested area evaporates a greater total amount of moisture than the same area without forests. A tree itself evaporates or transpires considerable water, and by intercepting the rain-fall, gathering the moisture upon the leaves and allowing it to trickle down along the

FIG. 66. VIRGIN FOREST, CHIEFLY SPRUCE, NORTH CAROLINA
(U. S. Forest Service)

branches and trunk, it facilitates physical evaporation, aside from its transpiration. Now, all the rain which falls comes from the moisture in the atmosphere. This moisture is brought by the prevailing winds, arising mainly from the surface of the sea; but as these winds, carrying moisture, move along the ground, their moisture is added to by whatever may arise from the surface of the ground or the water. If these facts are correct, does it not

follow that the effect of forests must necessarily be to increase the rain-fall? They cause the presence of a greater total amount of moisture in the air, and they cool the air, if only to a small extent, thereby facilitating its precipitation.

There has been much heated discussion of this question, and much difference of opinion, as there is on almost every question with which men deal, excepting those of mathematics. It is probably generally agreed at the present time, however, that the effect of forests upon rain-fall is small and not worth a great amount of acrimony. The best authorities do not claim that it is more than from one to four per cent. Personally, however, it seems to the writer that without making any experiments on rain-fall, the conclusion is perfectly justified that forests must somewhat increase the total amount. This does not mean, of course, that if a man plants trees in his back yard there will be a greater rain-fall in that back yard. It simply means that the presence of forests probably causes a greater total precipitation somewhere. It is doubtful if this matter can ever be satisfactorily determined by experiments with any greater conclusiveness than this, for, in order to demonstrate an effect experimentally, it would, as stated, be necessary to have the same area, with the same winds, and every other element the same, except that in one case it would be covered with forest and in another case it would not. It will not do to expose a rain-gauge in a forest and another one in open land some miles away. Nor will it do to expose a rain-gauge in a forest and then cut down the forest and again measure the rain-fall. The conditions will not be the same, and a definite conclusion will not be justified.

What now is the proper method of studying the effect of forests upon the flow of streams? With reference to this we must distinguish carefully between forests on steep ground and forests on level ground; and to obtain a demonstration all that is necessary, probably, is for any intelligent person to observe a forest during a rain storm and then to observe the open ground under the same conditions. A stream is fed by two sources: by the water which percolates into the ground and reaches the stream from

springs or from the ground water, and by the water which flows immediately into the stream from the surface of the ground. Now, if the ground is practically level, the rain falling upon it will not flow off, whether it is covered by a forest or not. If unforested, the water will stand in little pools and be evaporated, or gradually sink into the soil. Cultivation or turning up with a plough will open the soil and increase the percolation. A forest will increase the total evaporation, including its own transpiration, while its bed of humus will act like a sponge and absorb the water which reaches the ground. Probably the amount of water sinking into the soil and reaching the stream by springs and other underground channels, together with that flowing from the surface—that is to say, the total amount eventually reaching the streams—would be greater if there were no vegetation of any kind, but if the soil were simply turned up with a plough so as to make the ground able to absorb quickly. On a steep mountain slope, the total amount reaching the streams would probably be greater if the ground were bare and hard than if it were covered with forest, but there would be severe and sudden floods, alternating with severe droughts. On such a slope, if the ground is bare, the water is quickly collected into little rivulets, which rapidly flow down the steep slope, washing away the earth into the upper reaches of the streams. It flows from the surface so quickly that, so to speak, it has not time to sink in. This is more or less true even if the surface is covered with grass. If, however, the area is forested, the flow of water from the surface is hindered and the bed of humus rapidly absorbs it like a sponge. Instead of flowing off before it has time to sink in, as it would on a hard, bare slope, in the forest it sinks in before it can run off. Moreover, in the forest the washing away of the ground is almost entirely prevented. These facts, simple and obvious though they are, may be quite sufficient for the formulation of strictly logical conclusions in this matter. Probably there is no ground to doubt that the effect of forests *on steep slopes* is to retard the discharge of surface water, to facilitate percolation into the ground, and the feeding of streams, and therefore to make the flow of streams more regular than they

FIG. 67. VERTICAL SECTION SHOWING FOREST FLOOR HUMUS
(U. S. Forest Service)

otherwise would be. Moreover, in the winter time the snow lasts longer in the forests than upon the open ground. It may, of course, be suddenly carried away in the spring by a thaw and a warm rain. Indeed, we may readily admit that the presence of a forest may, under certain exceptional circumstances, be the cause of a greater flood in a stream than would occur if the forest had not been there. This, however, does not mean that the effect of forests is not, as a general thing, to make the flow of the stream more regular, diminishing the floods and increasing the low water stages. A fender upon an electric car may, as a rule, be a measure of safety and a means of preventing loss of life in case a car runs into a human being; and yet, it may be also true, in some special instances, that

the presence of that fender may cause loss of life which would not have occurred if the fender had not been there. We must reason from the general rule and not from the exception, and yet it is very surprising how many people there are who would rather reason from the exception. If the snow lies longer upon the ground in the forest than in the open, it must follow that the rain which it represents takes a longer time to reach the streams from a forested area than from an open area.

The obvious conclusion of all this must be, aside from exceptions in special cases, that the forest improves the regularity of flow, and yet one writer, because he found from observation that the highest flood on a large stream was just as high in recent years, after lumbering operations had been carried on, as it had been in

Fig. 68. Erosion of Top Layer of Soil, Balsam Gap, Jackson Co., N. C.
(U. S. Forest Service)

earlier years, when presumably the forested area was greater, jumps to the conclusion that forests do not regulate flow, and lends the weight of his authority against a great governmental policy, the wisdom of which is demonstrated by the experience of several hundred years in the older countries of Europe. He might as well

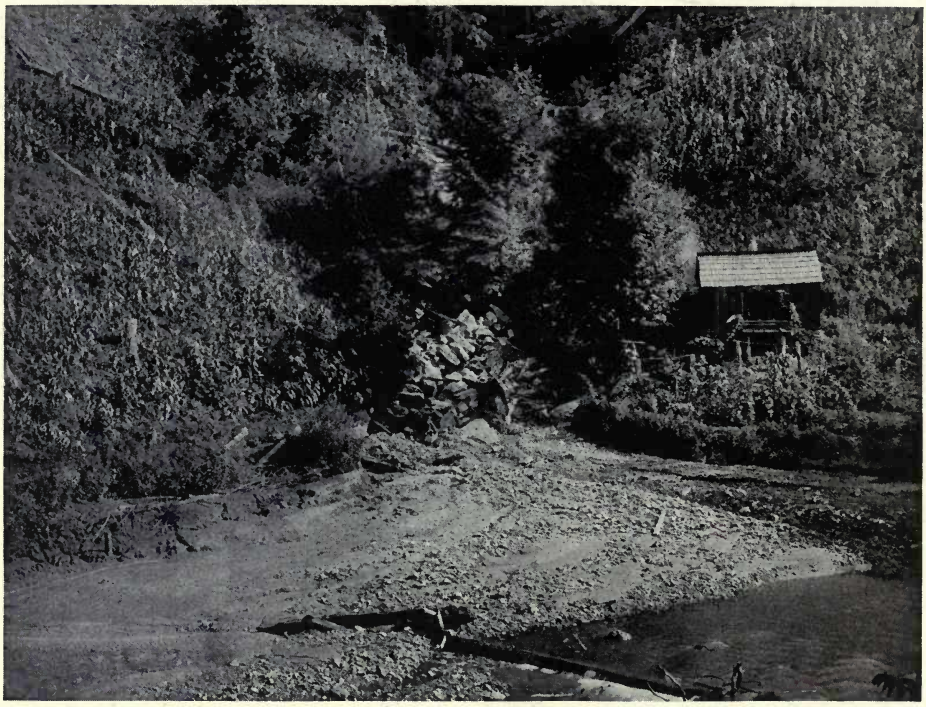


FIG. 69. EROSION FROM A STEEP HILLSIDE IN CORN, JACKSON, N. C.
(U. S. Forest Service)

argue, because the greatest conflagation in a city occurred after a fire department had been established, that such department was useless.

The navigability of streams, as has been stated, depends not simply upon the regularity of flow, but also upon the sediment carried, the consequent silting up, and the necessity for maintaining a channel of sufficient depth by means of dredging. In regard to

this, which reduces to the erosion of the soil, the effect of the forest is just as clear, if not more clear, than in the case of regularity of flow. Reference has already been made to this point. It is only necessary to say that any one who has ever been in a forest on a steep mountain slope, knows from observation that the effect of the forest is to hinder, and even to prevent, the erosion of the soil.

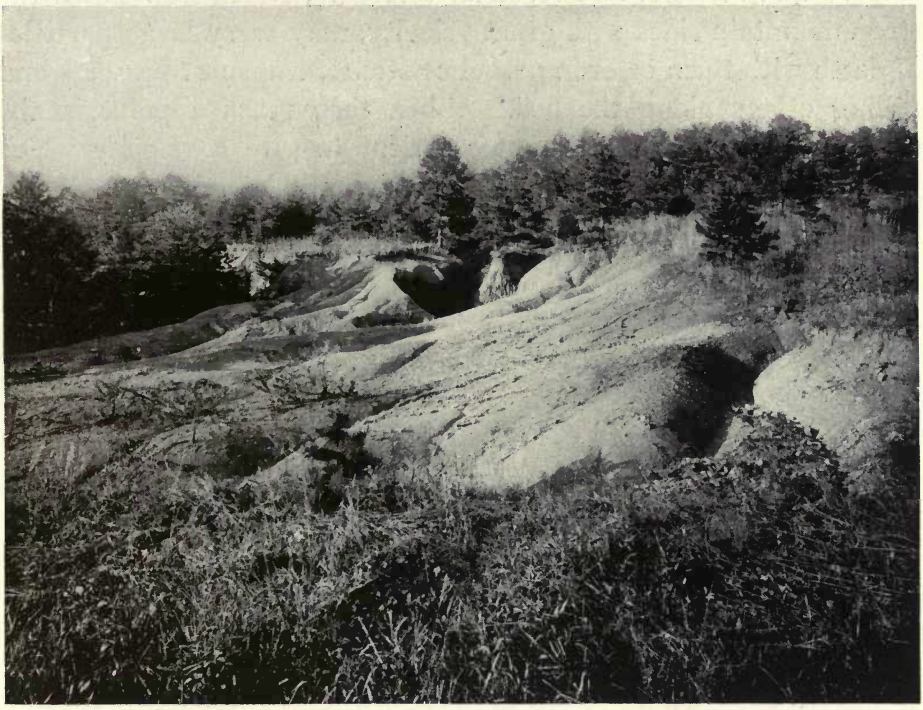


Fig. 70. Hillside Erosion in Abandoned Fields, Catawba Co., N. C.
(U. S. Forest Service)

It is the erosion of the mountain slopes which is the principal cause of the silting up of our rivers, even though the material which immediately forms the river bars does not come from the mountain slopes but from the caving banks along the nearer reaches of the streams. This may seem at first to be an incorrect statement, but a little thought will easily show that it is true. The transporting

power of water is said to vary approximately as the sixth power of its velocity. That is to say, if we double the velocity of a flowing stream, it will transport a particle of earth sixty-four times as great as before. Whether this is correct or not, the transporting power no doubt increases much more rapidly than the velocity. The velocity of a flowing stream depends, of course, mainly upon its slope. The streams and rivulets, therefore, which flow down the steep mountain sides with great velocity, may carry large particles of earth with them or even gravel or stones, transporting some and rolling others along the bed. When they reach a point in the stream where the slope is not sufficient to give a velocity which would carry these particles, they are deposited in the stream bed,

Fig. 71. Eroded Slope, Ashe, N. C.
(U. S. Forest Service)

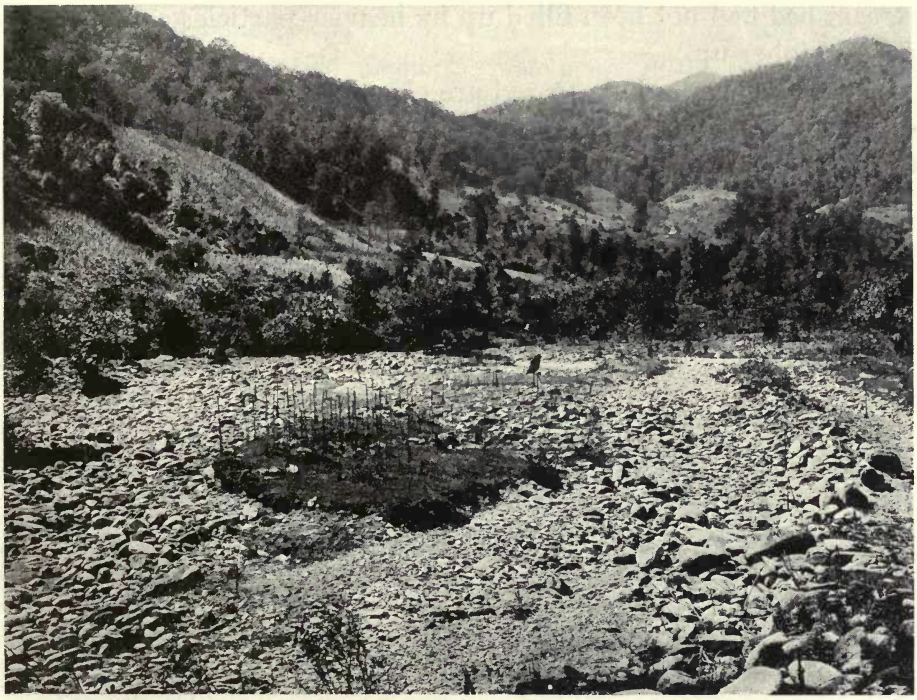


FIG. 72. ALLUVIAL BOTTOM LAND DESTROYED BY FLOODS, SWAIN CO., N. C.
(U. S. Forest Service)

and fill it up. In order to discharge the same volume of water, therefore, the stream has to form for itself a new bed. This it does by cutting into the adjoining banks and acquiring thereby a load of sediment consisting of small particles, which it carries down until its velocity becomes so reduced that it can no longer carry even these, which in turn being deposited, obstruct the channel at this lower point and cause, as before, an erosion of the banks there. In this way, in the course of many years, material is transported gradually down the stream; the particles become worn and rounded and weathered and reduced in size, and, finally, at the mouth of the stream it carries into the ocean a load of fine silt, which is deposited as a bar. This silt may have come from the lower reaches of the stream, but much of it would not have been eroded there if the

stream bed had not been filled up by heavier particles coming from points higher up.[1]

The principles here stated are elementary and are well understood by engineers. Thus Colonel Suter, of the United States Corps of Engineers, long in charge of the Mississippi River, called

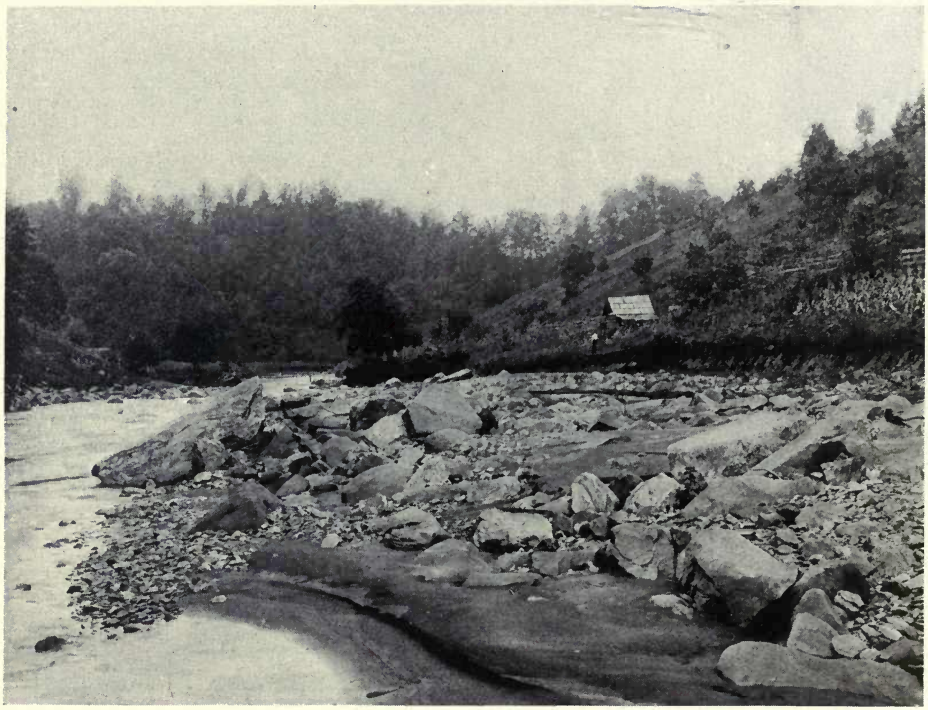


FIG. 73. SOIL REMOVED AND LAND RENDERED UNFIT FOR CULTIVATION
MITCHELL CO., N. C.

(U. S. Forest Service)

attention to the fact that revetting the banks would not be a sufficient protection against erosion, or efficient as a means of maintaining a navigable channel. He said that we must prevent the material coming down from farther up; that is to say, from the

[1] This is, of course, not a complete discussion of the causes of the caving of river banks. It is simply an indication that this is, to some extent at least, due to erosion farther up the stream.

head-waters. Colonel Chittenden himself admits this, and yet fails to draw the necessary conclusion. The presence of forests on the mountain slopes, therefore, by preventing erosion there, directly conduces to the navigability of rivers even in their lower reaches.

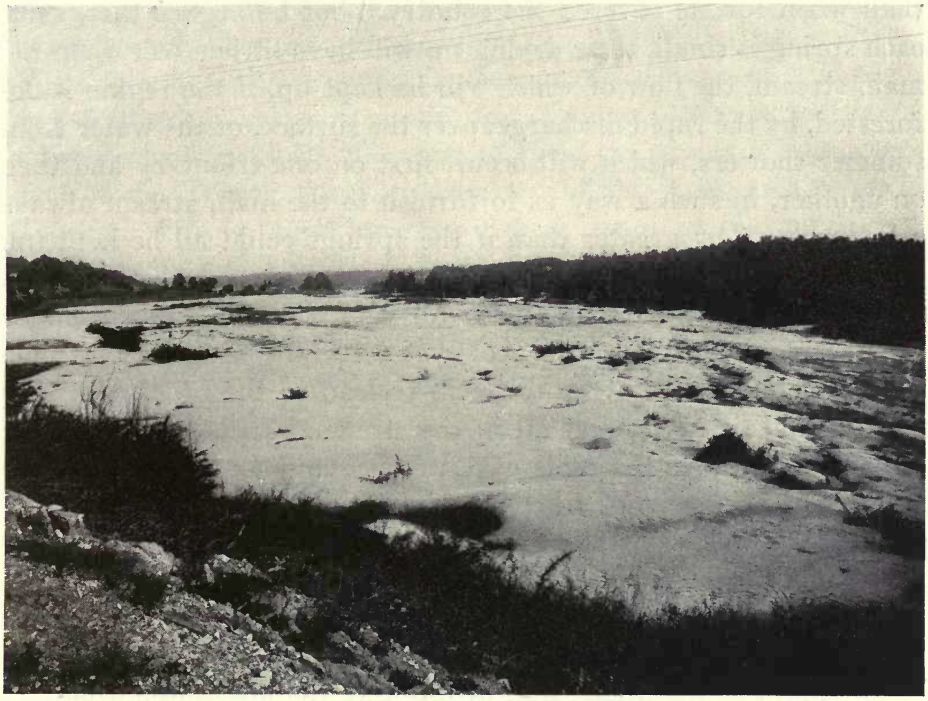


FIG. 74. BANK OF SAND DEPOSITED OVER ALLUVIAL BOTTOM BY FRESHET OF 1901 CATAWBA CO., N. C.

(U. S. Forest Service)

Time will not permit us here to go into any complete discussion of the details of this question, or to adduce many illustrations to support the position which has been taken. A few must suffice.

That the cutting down of forests has been followed by the drying up of springs is a matter of such common observation that it may be substantiated by literally hundreds of statements, not only from scientific treatises, but from personal letters in large

number. Colonel Chittenden, in discussing this point in his paper, published in the Transactions of the American Society Civil Engineers, in 1909, takes the curious ground, however, that the regularity of flow does not much depend upon springs. He admits that, "as a general rule, springs and little streams dry up more completely than when forests covered the country," but he argues that, since each spring is small, their drying up will have little effect upon the main stream, the flow of which will be kept up, if the region is deforested, by the rapid discharge, over the surface, of the water from summer showers, which will occur, first on one tributary and then on another, in such a way as to furnish to the main stream always a low-water flow greater than if the springs could all be kept up. If his argument be carried to the very common case where no rain falls upon a given drainage basin for weeks, or for a much longer time than it takes for a drop of water to flow from the extreme source to the mouth, it would seem to lead to the conclusion that there would be no flow at all in the stream. In other words, the author would have the mills at Lawrence and Lowell depend for their summer flow, not upon keeping up the "springs and little streams" so far as possible by increasing through the effect of forests the percolation into the ground, but would have these mills trust to luck that the summer showers would be so distributed over the different tributary basins than when one was low others would be high, and he maintains that in this way the low water would be greater than if all the little springs were kept up. This would, of course, require most intelligent planning on the part of Jupiter Pluvius, for it would not do to have these summer showers, which are supposed to flow rapidly from the surface, inaccurately timed or distributed over the basin. It does not seem necessary to pursue this suggestion further.

Some good illustrations of the truth of the principles which have been enunciated may be found in the records of the United States Geological Survey. The Weeks Bill was passed by Congress in 1911, and immediately following its passage, the Forestry Department recommended to the Commission the purchase of

various tracts of land on the head-waters of streams in the Southern Appalachians and in the White Mountains. According to the Act, before a purchase can be made, the Director of the United States Geological Survey must certify that the preservation of forests on those tracts will favorably affect the navigation of the stream to which the area is tributary. Since that time, the Geological Survey had reported upon several of these tracts, mostly in the Southern Appalachians, and the report in each case was favorable; that is to say, it affirmed that the preservation of these forests would favorably affect navigation. The first of these tracts was on the watershed of the Toccoa River, a tributary of the Tennessee River in Georgia. It was found by a few stream gaugings that on June 3, 1911, after a period of from six weeks to two months during which there had been no rain-fall upon the watershed in question, or upon the entire drainage area above the point at which the waters of the Toccoa enter the Tennessee, the flow of the Toccoa River was 247 cubic feet per second, or 50 per cent greater than the minimum of the average year, while, at the same time, the flow of the Tennessee River at Knoxville was almost exactly the minimum flow of the average year. Now, it has already been explained that the larger the watershed of a stream, other things being equal, the more uniform will be its flow, because all the tributaries will never reach their lowest point, or their highest point, at precisely the same time; nevertheless, it will be seen that the Toccoa on June 3, 1911, after a dry season, was contributing to the Tennessee about two cubic feet per second per square mile of area drained, while the Tennessee River at Knoxville, draining a much larger area, at the same time showed a discharge of less than one-half a cubic foot per second per square mile. The conclusion from these data clearly is that the Gennett tract, after two months of practically no precipitation, had not reached its minimum dry season discharge, and was contributing more than four times as much to the discharge of the main stream, per square mile, as the average for the drainage area of the upper part of the navigable Tennessee River; while at its minimum stage, it would contribute nearly three times that average

discharge. Here was a comparatively small mountainous area, fairly well covered with vegetation, which, by storing the ground water, was found to be much less liable to extremes of flow than even the much larger watershed to which it was tributary. It is an instance of the best type of watershed for the promotion of navigability, at low stages, of the river to which it is tributary. The Director of the Geological Survey concluded that "Control of these lands will to an appreciable extent insure the continuance and possible betterment of the important low-water contribution of the Toccoa River, and will diminish the present excessive delivery of sediment into this tributary of the Hiawassee and Tennessee rivers."

With reference to this matter of erosion, the report further states:

"In order to connect the fact of erosion on the upper Toccoa drainage with the navigation of the Hiawassee and Tennessee rivers, one needs only to reflect that eventually all sediments delivered to the tributary must be discharged into the main stream. In those sections which do not have rocky beds, rivers automatically adjust their grades in reference to the amount of sediment which they receive. Where much debris is delivered to them their grades become steeper and their currents correspondingly swifter. Shifting bars become characteristic. Such tendencies must result from the excessive erosion which is now in progress in the upper basin of the Toccoa River."

A similar report was made with reference to the so-called Little River tract in Tennessee, also tributary to the Tennessee River. Little River on June 5 showed a discharge of 1.05 cubic feet per second per square mile, as contrasted with 0.455 for the Tennessee River above Knoxville at the same time. Dr. Smith's report on this watershed emphasizes another very important effect of deforestation, namely: that fire very frequently follows the axe, and by effectually burning, not only the fallen timber but the soil, injures or destroys the absorptive power of the latter, and that "so far as observed, in every part of the district where lumbering has been carried on, fires have followed the axman." Dr. Smith further says:

"The most immediate and obvious effects of forest control will, therefore, result from the prevention of fires. It is found that, in all parts of the cut-over lands, repeated firing has destroyed and kept down the growth of the underbrush. As the result of forest fires the soil loses the protection naturally afforded by fallen leaves. Also, to a certain extent, the bonding of the soil by the roots of growing plants is destroyed. The soil thus becomes at once sensitive in response to the agents of erosion. Several years' accumulation of leaves is often destroyed by a single burning, so that from the date of the fire until more leaves fall, the ground is open to the effects of beating rain in proportion to the completeness with which the leaf mat has been consumed. Excepting on slopes which are more moist than the average, fires occurring every year or two leave the soil almost fully exposed, and rapid erosion ensues."

FIG. 75. CLEAN CUT SLOPE, SALT LAKE CO., UTAH
(U. S. Forest Service)

FIG. 76. EFFECT OF FIRE IN DESTROYING HUMUS AND FOREST FLOOR
WINDHAM CO., VT.
(U. S. Forest Service)

This is valuable testimony, coming, as it does, just at this juncture; but it was anticipated, and the facts were well known to those familiar with the question. Those who are familiar with the Appalachian Mountains, know that there are many instances where forests have been removed and where subsequent fires have burned up the deep humus and erosion has left bare rock in many places, so that springs and streams that formerly flowed perennially now go dry during seasons of prolonged drought.

Moreover, an increased erosion in recent years in these mountains is conclusively proved by finding alluvial plains in the river bottoms, consisting of fine material covered over with more recent deposits of coarse sand, gravel and boulders. Professor L. C.

Glenn of Vanderbilt University, who has thoroughly explored this region, says with reference to this matter:

"If, then, the sands, cobbles, and boulders that have been repeatedly strewn over their flood plains in the last decade by such rivers as the Watauga, the Doe, the Nolichucky, the French Broad, the Catawba, the Yadkin, and other Southern rivers, had been the kind of material those rivers had for ages been accustomed to deposit, their entire floor plains would be composed of such coarse materials, instead of being, as they generally are, of fine sandy loam or clay. Had they at any time in their past history been accustomed to carry such coarse material and build it into their flood plains, that material would be there today as a mute witness of the fact. The *normal* change in the regimen of a river, as the ages pass, causes its flood-plain deposits to grow constantly finer. In these rivers, however, this process is reversed and their deposits have recently grown coarser. They have grown coarser in recent years, only because there has been a recent increase in the height, velocity, and power of their floods to carry such coarse materials."

Professor Glenn also gives a valuable discussion of the history of river improvements on the Tennessee River. It seems that the upper section of this stream was described in the reports of army engineers of thirty or forty years ago as being "free from sediment, of unusually stable bed and banks, and admirably adapted to improvement by open-channel work. In the 1830 report of Lieut.-Col. S. H. Long scarcely anything is said about the need for gravel excavation." In recent reports, however, the Tennessee River is justly described as a sediment-bearing river; the character of the stream has been changed, and from having once been deemed admirably suited to improvement by open-channel work, it has now become unsuited to such a plan. This change is somewhat implied in the estimates of the army engineers of the cost of securing a three-foot channel at mean low water from Chattanooga to Knoxville. This estimate was in 1871, $175,000; in 1877, $225,000; in 1884, $300,000; in 1891, $340,000; in 1894, $650,000, in addition to the $296,000 already spent; in 1907, $1,080,000 in addition to the $629,152.85 already spent.

Reports of army engineers upon this stream indicate clearly, as Professor Glenn says, that "while permanent improvements may be made on the Tennessee River by building locks and dams and by blasting rock ledges from the channel, the improvement resulting from dredging is often temporary and the benefit soon lost. To say this, is no reflection on the army engineer, for under present conditions the sand and gravel will keep coming as surely as the water comes, and all the engineer can do is to remove it."

Professor Glenn adds the following striking comparison:

"In strong contrast to the conditions of increasing sedimentation found on the Tennessee System are the conditions found on the Coosa River of the Alabama System. This river has its headquarters in a wooded mountain region of North Georgia, where there is little or no erosion and little or no sedimentation. The head-waters of the Coosa River are navigable up to the very foot of the mountains, and gravel bars do not form. An examination of the Coosa River from Rome, Ga., down one hundred and sixty-five miles to Gadsden, Ala., showed that the channel is *not* filling with sand and gravel, that bars and islands are almost nonexistent, and the few that do occur are not growing or changing. The stream is stable and has been so for a long time."

As a result of this discussion, and of the experience of centuries in older countries, there is no doubt that forests, especially on steep slopes, promote the regularity of flow of streams by facilitating underground storage. Indeed, authorities are quite well agreed—and may be said to be almost unanimous—as to the desirability of protecting the forests on steep mountain slopes in the interests of navigation. At the Tenth Congress on International Navigation, held at Milan, in 1905, this matter was discussed, and the reporting engineers were unanimous on the question. As this foreign testimony may be of interest in connection with the present discussion, showing as it does the dependence of the interests of navigation upon the preservation of the forests, it may be worth while to give extracts from some of these reports.[1]

[1] The language used in these translations is taken directly from the published report in English.

Mr. Lafosse, the French delegate, says:

"If the destruction of forests is to be deplored, it is most of all on the mountain that the cutting away of timber is to be feared. It is not alone the supply of the springs and the discharge of the streams which are in danger. It is the very existence of the rivers themselves. The stream which can be utilized disappears to give place to the devastating torrent.

"The soil swept bare of its forests, exhausted by the abuses of grazing, loses quickly its vegetable stratum. Washed periodically, and carried away by melting snow and summer storms, it is soon disaggregated. The waters run toward the low points, rolling before them gravel and boulders, and even tearing out loose sections of rock. A thousand rivulets cut out beds, the torrent is formed. Scours begin, the banks are broken down and a mass of mud, stones and rocks invades the valley, destroying everything as it passes."

Mr. Wolfshutz, a delegate from Austria, while admitting that excessive floods are not appreciably checked by forests, writes as follows:

"For economical reasons re-afforestations will have to be confined to the steeper mountain slopes which are of little use for other cultivation. Here the forest will have a beneficial influence by making the soil firmer and more compact, and by preventing erosion and washing down, and thus any excessive alteration and the formation of detritus which would shoal and silt up the water courses. Such forests further retard the melting of the snows in spring and lessen the violence of spring high water. It is thus advisable in the interests of navigation to spare and to attend to the forest. There is no simpler, cheaper, nor more effective means for securing the mountain slopes and for keeping the pebble shoals down. In this respect, forests have incontestably had a beneficial influence upon the floods of the large rivers. Beyond this, however, no further measurable influence upon the high water of rivers can be credited to them."

"As regards the occurrence of high floods in the large rivers, the forests cannot have any noteworthy influence. As regards the increase in the ground-water level and in the replenishment of springs the forests have, in the plains, no more influence than the open ground, and it is only in the mountains that this action can be rated at any higher figure. In the mountains, however, the main office of the woods will be to prevent the denudation

and erosion of the surface, the formation of detritus, and the silting up of the river beds with mud, sand and pebbles."

Mr. Riedel, of Vienna, is very emphatic as to the benefits of forests. He shows the terrible results which have been brought about by their destruction in various parts of Europe, and with reference to Germany, states that

"In Germany also reasonable bounds were not everywhere kept to, and the effects of the progressing deforestation made themselves apparent, on the one hand in scarcity of timber, and on the other in the impoverishment of perennial springs and the alarming lowering of the mean water level of German rivers, and not less so in a gradual increase in the dryness of the ground, caused by the fall of the level of the underground waters.

"The unquestioned circumstance, that a large number of rivers now carry down more loose material than formerly, is a consequence of the extensive denudation and careless clearing of the plantations. The slopes of the hills lose a large part of their fruitful soil, and in many cases earth slides, and even extensive subsidences of whole slopes take place, while considerable areas of ground in the valleys are smothered up and rendered useless.

"The loose material which the tributary brooks carry into the main streams, ceases to be carried onward as the declivity becomes less steep and in consequence fills up their beds. The streams are then obliged to seek out new courses, by which the most fruitful ground is devastated and the whole bed of the valley is gradually transformed into a barren layer of loose stones. This drawback affects not only the mountain dwellers, but, in so far as the waters are not able to deposit their loose suspended material in large basins on the way, the population of the lower-lying fertile and well-tilled valleys also. Here the damages further include the circumstance, that, by reason of the often elevated position of the river bed, overflow waters are very difficult to get rid of.

"Proofs of the foregoing, and especially of the last mentioned circumstance, are afforded by a large number of river valleys. This condition of things is of importance in the cases of those river or stream channels which, by the formation of weirs, are to be made serviceable for purposes of inland navigation. Thus on the canalized Oder between Cosel and Breslau, properties which, though at a distance from the channel, lie at a lower level than the latter, are swamped to the most damaging extent.

"The foregoing is not intended to convey the idea that, previous to deforestation, earth slides, damages to river banks, and inundations did not take place, but it is intended to show, that since the decrease of the forests all these disadvantages have increased to a serious and disquieting degree."

Mr. Lauda, of Vienna, compares two similar watersheds of about the same area in Austria, one being much more heavily wooded than the other. He thinks the forests may not exert much influence in high floods but concludes as follows:

"If now the final judgment on the subject of the influence of forests on the regimen of streams be unfavorable to the forest to this extent, that there are denied to it certain of the properties attributed to it generally, it does not follow from this that it is necessary to oppose the rewooding of arid surfaces, the replanting of the basins of streams or the maintenance of plantations of trees. The general utility of the forest is so well settled, the extraordinary appreciation in which it is held, as a means of protecting the soil against landslides, is so firmly established, its great advantageousness especially for the spring district, in holding back earth thrusts and reducing the amount of sediment carried by rivers so important, that these reasons alone justify fully the greatest possible promotion of forest culture."

Mr. Ponti, of Italy, seems to have no doubt that forests on steep slopes are useful in the interests of navigation. He says:

"In Sicily, the consequence of cutting away the forests on a vast scale in the province of Messina has been also to raise sensibly the bed of the streams, and many of these beds are now above the adjoining fields."

Mr. Keller, of Austria, thinks that forests affect the regimen and discharge of rivers only to a slight extent except in mountainous regions, regarding which he says:

"However, there is no doubt that in many cases deforestation has contributed to the erosion of the mountains and to the deposit of the soil at their foot as also to an unfavorable change in the conditions of flow and drainage of the waters. This remark applies equally to the region of high mountain ranges as to the Mediterranean basin. There also the formation of a cohesive soil takes too long to make good the loss caused by a sudden shower."

Mr. Lokhtine, of Prussia, does not discuss particularly the effect of mountain forests but among his conclusions is the following:

"(1) Forests form a beneficent factor, acting favorably on the general abundance of water in a country, and particularly on the supply of streams and rivers. That is why the destruction of forests should be considered as hurtful and dangerous."

These extracts show that foreign authorities are unanimous as to the benefits of forests upon the mountains upon the flow of streams and the interests of navigation.

Finally, we have the experience of other countries to guide us in this problem. Almost all the countries of Europe have learned by experience to value and preserve their forests not only as sources of timber, but in the interests of navigation. The French government fifty years ago entered upon a national policy of forest protection and reforestation, particularly in the mountain regions, which has been continued up to the present time. Up to January 1, 1900, the state had acquired over 400,000 acres, or 629 square miles, for the purpose of controlling torrents. Of this area, 440 square miles are in the Alps, 145 square miles in the central plateau and the Cevennes, and 44 square miles in the Pyrénées. The expenditure has been as follows:

For acquisition of land, ...	$5,200,000 00
For work of reforesting, . . .	4,000,000 00
For work of regulating, . . .	2,600,000 00
Miscellaneous, ...	1,600,000 00
Total, ...	$13,400,000 00

At first there was great opposition to the French government's policy, on the part of the inhabitants of the mountain districts, and in 1864 there were riots in some places. This opposition, however, has entirely subsided, the inhabitants now coöperate heartily with the Government, even petitioning to have it extend its work, and

in some cases even giving portions of their lands on the mountain sides without compensation.

Other countries which are working out comprehensive plans for the protection of the forests at the head-waters of mountain streams, are England in India, Switzerland, Austria-Hungary, Norway, Sweden, Denmark, Russia, Roumania and Japan.

Fig. 77. Checking Destructive Effects of Mountain Torrents by Means of Dams (France)
(U. S. Forest Service)

Let us not be discouraged, therefore, in our efforts to secure a thorough understanding of this important matter, together with appropriate Government action. Let it not be said of us that we have been unable to profit by the experience of others, but have had to learn by dear experience the same lessons which they have learned and which we might have learned from them. The preservation of

the forests will surely increase the regularity of flow of the streams, and if the useless destruction is not put an end to, it will increase, and while the immediate effect will be small, it may in the end be disastrous. Let us also try to realize the enormous waste which is going on in our national resources, and aid by our influence and example in putting a stop to it. And, finally, let me call your attention to the fact that in connection with this matter the engineer occupies an important position. As the man who directs the great sources of power in nature for the use and convenience of man, it should be his work to devise the means of restricting the waste of those resources. The dependence of our prosperity as a nation upon the engineer as a professional man should be better realized. His advice should be sought in increasing degree by the nation, the state and by the people. In this way, the benefits of scientific training and discovery will be directed to this problem, and it is not impossible that new methods and discoveries may be brought to light which will largely reduce our enormous waste and make the prospects for our descendants more cheerful. Most important, however, is it that we should at once check useless waste, and endeavor to realize that the demands of our duty to those who are to follow us are immediate and imperative.

In closing this portion of the subject, the reader must be cautioned against extreme views, in either direction, with regard to the effect of forests. In this, as in every other subject that engages the human mind, men tend to go to extremes. Thus we find some who maintain that forests exert no beneficial influence upon stream flow, and are even positively injurious; while on the other hand, some seem to believe that the preservation and extension of forests would absolutely regulate the flow of streams and would do away with floods entirely. Either view is manifestly wrong. The truth lies somewhere between. There seems no question that forests do regulate flow, and that upon steep mountain sides especially, they exercise a restraining effect upon run-off, and that they also in such locations are of inestimable benefit in preventing erosion of the soil.

But flat lands having good soil are needed for growing crops and other purposes, and will be so needed in great measure as population increases. We should exercise discrimination in the utilization of our lands, cultivating for growing crops those which are best suited therefor, and reserving for forests the steep slopes and mountain sides, and other areas unsuited for cultivation of crops. We should recognize that our forests are a valuable national asset, and that independent of their production of timber, they do regulate flow and prevent erosion. Those, however, who assert that forests are a panacea against floods, are manifestly in error. Forests undoubtedly do something in this direction, but even if the entire country were covered with forests, it is probable that at times there would be extreme floods which would do great damage. In this, as in other matters, things should be seen, if possible, in their proper proportion, and not distorted.

CHAPTER VIII

FLOODS

One remaining phase of the conservation of water is still to be considered, namely, floods.

Volumes have been written on this subject, which constitutes one of the most important problems with which the hydraulic engineer has to deal. In this chapter a very brief discussion will be given of the general aspects of this subject.

The Situation

The rivers of the United States, as of other countries, are subject to floods at uncertain intervals, varying greatly in duration and magnitude, and in the damage which they inflict. In some parts of the country, river floods are of little importance and do little damage, while in other parts the rivers are wild and unmanageable, and at periods of a few years overflow their banks and cause great loss of life and property.

There seems little doubt that, speaking generally, river floods and the damage which they cause are increasing in the United States. Such a statement as this is very difficult to prove, considering the uncertain and fluctuating character of the data with reference to the discharge of streams. It is denied by some that floods are any greater or more frequent now than in the past, and an accurate demonstration one way or the other is probably impossible. With reference to the damages caused by floods, however, statistical records, if accurately kept, should afford means for a decisive judgment. Such statistical data, however, are generally lacking. In a paper on floods published in Water Supply Paper 234 of the

United States Geological Survey, Mr. M. O. Leighton gives some statistics regarding flood damage, based upon returns made by the railroad companies concerning flood losses during the period from January 1, 1900, to August, 1908. It was believed that these figures would be fairly representative of the total loss. It was assumed that the losses of the railroads due to floods amounted to about 10 per cent of the total physical loss. Returns were received for the damage done to a certain mileage of the railroads; the total railroad damage was assumed to be in proportion to the mileage, and this total to be 10 per cent of the total flood damage. The results are given in the following table:

Year	Damage Reported	Percentage of total mileage reported	Assumed Total railroad damage	Estimated total damage
1900	$666,253	14.6	$4,567,500	$45,675,000
1901	958,740	21.1	4,543,800	45,438,000
1902	1,225,468	22.2	5,520,100	55,201,000
1903	2,645,192	27.3	9,722,000	97,220,000
1904	2,476,724	31.3	7,884,100	78,841,000
1905	3,286,324	33.3	9,858,972	98,589,720
1906	2,727,511	37.3	7,312,400	73,124,000
1907	4,623,106	39.1	11,823,800	118,238,000
1908	6,517,577	27.4	23,786,000	237,860,000

Even if inaccurate, these figures seem to indicate a very rapid increase in flood damage.

The Pittsburgh Flood Commission, in its report of 1912, made the following findings:

"The direct losses due to flood damage at Pittsburgh amounted to over $12,000,000 in the last ten years, while in one year and five days, between March 15, 1907, and March 20, 1908, three floods occurred causing a direct loss at Pittsburgh of about $6,500,000.

"If works for flood relief are not carried out, the direct losses due to flood damage at Pittsburgh alone will, on a conservative estimate, amount to $40,000,000 in the next twenty years."

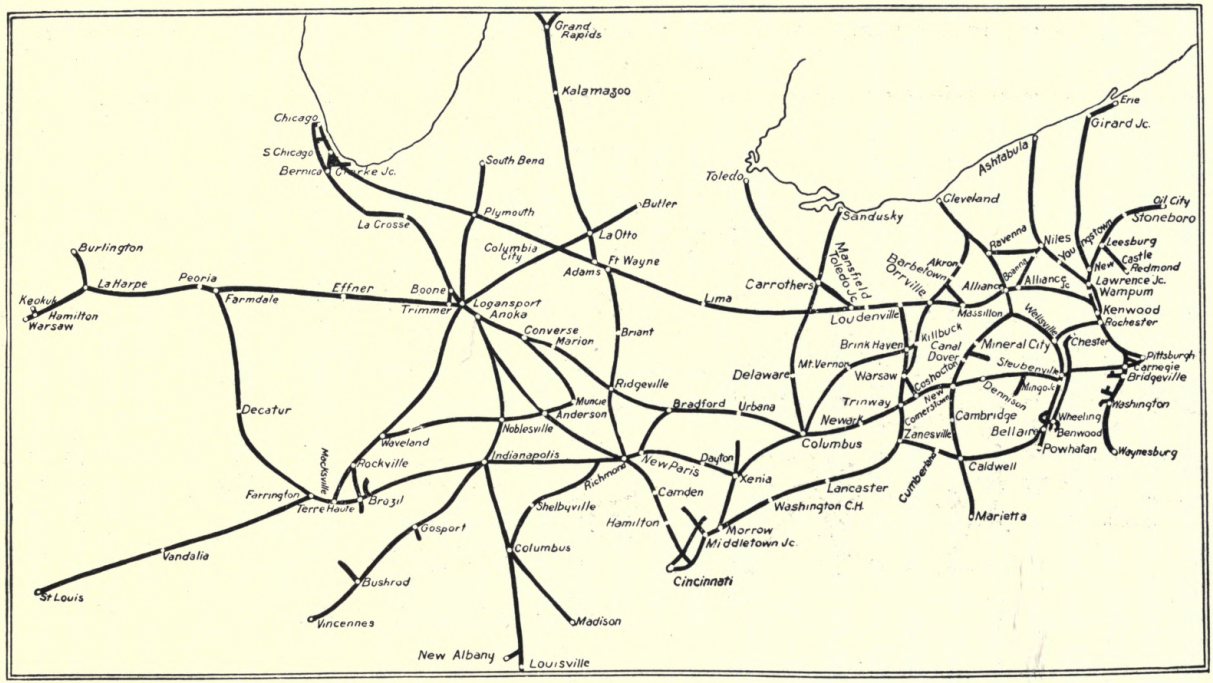


FIG. 78. LINES BEFORE THE FLOOD

The Pennsylvania Lines West of Pittsburgh in Commission March 26, 1913

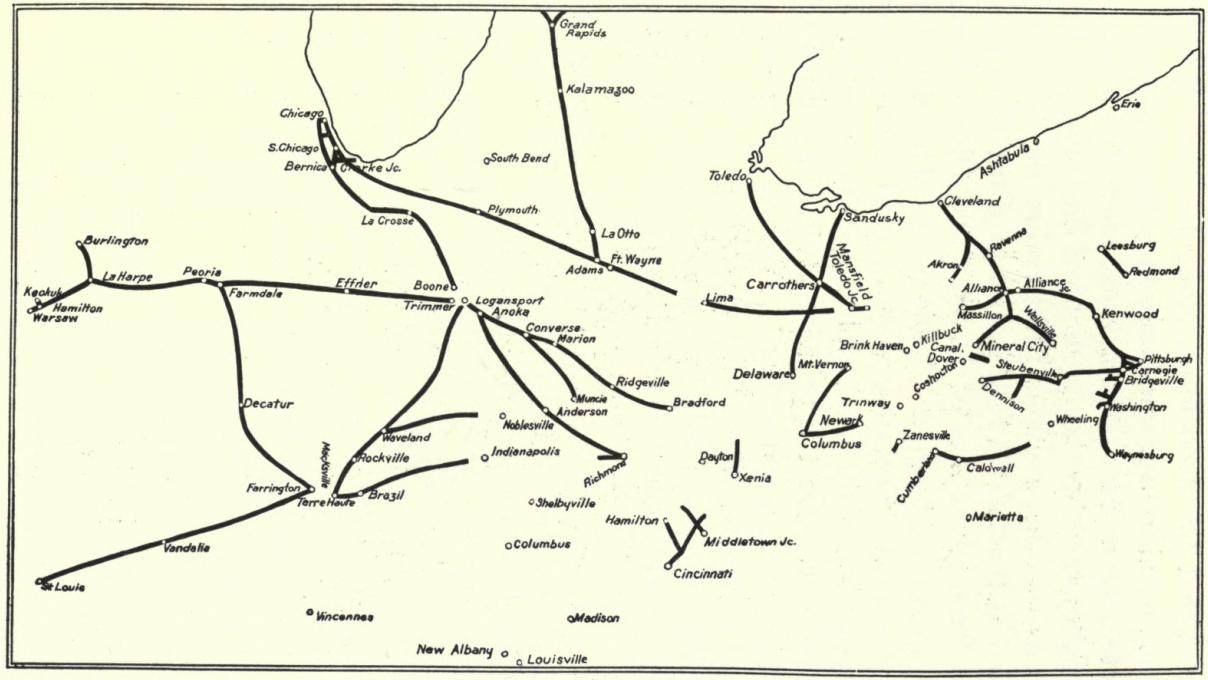


FIG. 79. AFTER THE FLOOD CAME

The Breaks Show Where the Track was Out of Commission –The Impossibility of Through Train Service is Obvious

The Inland Water Ways Commission, in its preliminary report of 1908, stated that the flood losses along the Ohio River in one year, 1907, amounted to over one hundred million dollars.

Destructive river floods occur with more frequency in the Mississippi Valley than in other portions of the country. Probably few inhabitants of other sections fully realize the terrible results of such a flood as that of 1913, which affected the Ohio River and its tributaries from the states of Indiana and Ohio. Some illustrations will, therefore, be given of this flood. The Miami, Muskingum and the Scioto rivers were those most affected, and the cities of Dayton, Zanesville and Columbus, lying on these three streams respectively, were the principal sufferers. Each of these streams experienced the greatest flood on record. Large areas were inundated and a great number of houses destroyed, not only in the cities named but in many small towns and villages. In Ohio alone it is said that 22,000 houses were destroyed and 35,000 seriously damaged.

The railroads were probably the principal sufferers. Figures 78 and 79 show the lines of the Pennsylvania Railroad Company west of Pittsburgh before and after the flood.

This flood was due primarily to an extraordinary rain-fall. In about four days there fell on this Ohio watershed more than three months' normal rain-fall, the total precipitation from March 23 to March 27 being about nine inches, while a maximum of more than ten inches fell over a limited area. At Columbus, Ohio, the maximum flow of the Scioto River below the junction of the Olentangy, was, in round numbers, 140,000 cu. ft. per s., while the maximum average flow for twenty-four hours was 119,000 cu. ft. per s. According to the report of Messrs. Alvord and Burdick, made to the city of Columbus, past records indicated that the average twenty-four-hour flood was about 33,800 cu. ft. per s., so that according to them the flood of March, 1913, gave a flow of 3.52 times the average flood. These same engineers estimated that the physical damage in the flood zone could be conservatively estimated at $5,622,000 within the city of Columbus, in addition to which

FIG. 80. LOOKING NORTH FROM WEST SIDE OF WEST GAP, MACKSVILLE, IND. (VANDALIA RAILROAD), MARCH 28, 1913

there were, of course, large indirect losses, such as loss of railroad and street-car traffic, of telephone service, and damages to sewers, streets, and losses through compulsory unemployment.

It was largely due to the efficient work of the railroad companies (and incidentally to the fact that these companies happened to have a surplus in their treasuries upon which they could draw for the purpose)[1] that the recovery from the effects of the flood was so

FIG. 81. BRIDGE OVER BLACK FORK, WHICH HAD TO BE ENTIRELY REPLACED

rapid and the damages and losses of life not more serious. The Pennsylvania Railroad Company put an army of men into the field, paying its masonry and carpentry gangs and shopmen engaged in making repairs one and a quarter times their usual wages for the total time they worked, including time consumed going between headquarters and their work. Bonuses were paid to all classes of labor, the total of these bonuses and extra allowances amounting to more than $70,000. On the Pennsylvania lines

[1] Commenting upon this flood and the emergency which it presented, Mr. Rea, the President of the Pennsylvania System remarked: "No event in the history of railroading in this country has shown more convincingly the necessity for a railroad to be permitted to earn sufficient revenue, not only to make reasonable return on invested capital, but also to have a surplus sufficient to meet emergency expenditures like these, and to improve the properties in those respects which, even if not adding to gross revenue, make the lines better adapted to withstand the ravages of storm and flood and the better able to perform their duties to the public with efficiency and satisfaction."

alone there were seventy-four steel bridges either entirely destroyed or rendered unsafe, and there were thousands of washouts ranging from small breaks to sections of the road two miles in length; thirty-nine bridge spans were destroyed and forty-eight damaged, the estimated cost of replacing these bridges being $1,027,116,

FIG. 82. BRIDGE NO. 83, OVER KOKOSING RIVER

Steel work of both spans gone out
One pier and one abutment destroyed

while the estimated cost of repairing trestles was $336,144, of repairs to the roadbed, $1,396,290, with additional damage to station equipment, telegraph lines, etc. The direct property loss to the Pennsylvania Railroad was estimated at $3,600,000. At the town of Delaware the flood exceeded in depth of water anything previously recorded in that city by 15.7 feet. A railroad bridge was washed out at that place, regarding which the following statement is made: "A 60 ft. steel girder was carried down stream more than 200 yards, and when the water subsided it was found on a hill-side on high ground well removed from the bed of the stream. A man was on this bridge when it went out. He was

swept into the branches of a tree and managed not only to hang on to them, but to climb a little higher than the water. There he remained for forty hours and was eventually rescued after many unsuccessful attempts had been made to get him."

In the main streets of Dayton, the water rose nearly to the top of the lamp posts. In Montgomery County alone, in which the city of Dayton is situated, there were swept away and destroyed more than five hundred bridges, large and small.

Figures 80 to 88 will give some idea of the situation during this flood.[2]

FIG. 83. SECOND AND MAIN STREETS
DAYTON, OHIO

CAUSES AND REMEDIES

The causes of river floods may clearly be grouped under the following heads:

1. The fact that the rain-fall is unequally distributed, and

[2] Figures 78 to 87 are taken, by permission of the Pennsylvania Railroad Co., from a valuable publication by it relating to this flood.

that large quantities fall during storms in a comparatively short period of time.

2. The fact that the rain falling upon the ground is not held back, but flows rapidly from the surface into the streams, or that the melting snows are carried off in the same manner, and discharged into the streams in a comparatively short time.

3. The fact that the stream channels are not large enough, or smooth enough, or do not have slope enough; in other words, that the stream channels have not the capacity to carry off the maximum amount of water delivered to them without rising above their banks.

This statement of the causes indicates clearly the directions in which the remedy is to be sought. Any one of the three causes, if it could be adequately remedied, would prevent floods.

With reference to the first cause, namely, the inequality of the precipitation, this, of course, is entirely beyond the control of man. We cannot govern the storms, but must take them as they come, and can only attempt to mitigate the results.

The fact that the rain water and the melting snows are carried too rapidly into the rivers can be counteracted in two ways, namely: by building surface reservoirs to hold back the surplus waters; and by preventing too rapid discharge of those waters from the ground, facilitating their percolation into the ground, their consequent storage in subterranean reservoirs, and their gradual filtering out into the streams. This last object may be to some extent promoted by forestation and by cultivation.

The third cause, lying in the inadequacy of river channels, may be counteracted by increasing the capacity of those channels, either by increasing the area, the slope, or the regularity of said channels. The area may be increased by dredging, by building levees, or by building duplicate or secondary channels or outlets, and also by preventing the caving of banks and the deposit of sediment in the channels. The slope may be increased by building cut-offs, shortening the length of the stream between two given points. The capacity for discharge, depending upon the roughness or inequalities of the bed, may be improved by straightening, removing

FIG. 84. BRIDGE NO. 145, EASTERN DIVISION, OVER BLACK FORK
Pier and both embankments badly damaged, 100 feet of embankment washed out

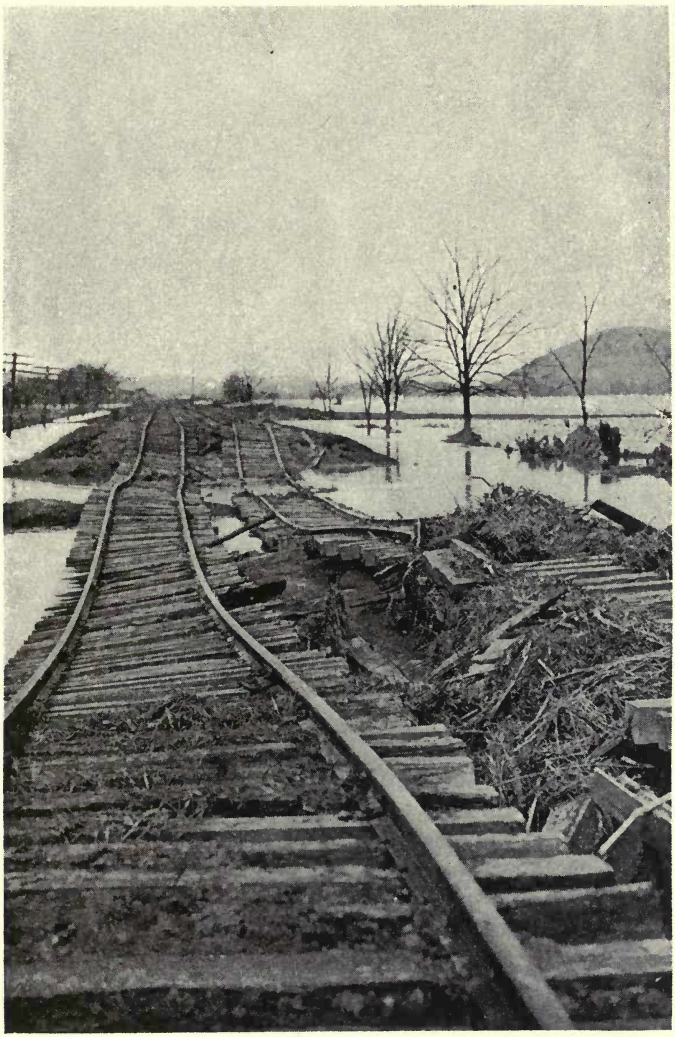


FIG. 85. TRACK OF MAIN NEW YORK-ST. LOUIS LINE NEAR NEWCOMERSTOWN, OHIO

FIG. 86. NORTH OF BRIDGE NO. 123. NORTH OF WARSAW, OHIO
Track was, before the flood, on a high embankment

Fig. 87. Bridge No. 120, over Killbuck Creek
Akron Division

obstructions, or perhaps by lining the channel with mattresses or masonry, serving the double purpose of increasing the smoothness and preventing caving.

We therefore have the following means at our command for mitigating the evil effects of floods:

1. The construction of reservoirs 2. Forestation 3. Cultivation	Retarding the discharge into the river channels
4. Levees 5. Dredging and removing obstacles in the bed or along the banks 6. Secondary channels or outlets 7. Prevention of erosion or the washing of earthy material into the river channels	Increasing the area of the channel
8. Cut-offs, or straightening the channel	Increasing the slope
9. Increasing the smoothness and regularity of the channel by removing obstructions or by lining and making it capable of carrying an increased quantity of water with a given area and slope	

The extent to which these various remedies are applicable will depend upon local conditions. If suitable reservoir sites are available, it may be possible to hold back in surface reservoirs immense quantities of water which would otherwise be discharged immediately into the streams. Cultivation, by breaking up the surface of the ground, facilitates percolation, but it may also increase the ease with which the soil is itself carried into the river beds. As illustrated in the previous chapter, cultivation on sloping ground may often

result in a great increase in erosion, and in this way may tend to increase the evil effect of floods rather than to diminish them.

Forestation, according to the principles discussed in the previous chapter, tends to increase the percolation into the ground, as well as the evaporation from it, and also on steep slopes to pre-

Fig. 88. Broadway Looking South from above Pearl Street, March, 1913 (Cincinnati)

vent erosion. Forests, therefore, have a beneficial effect in tending to prevent floods. This effect, however, in the opinion of the writer, has often been greatly exaggerated. It seems to be the idea of some that forestation, if carried out over an entire watershed, would quite prevent floods. This might be true in the cases of some small watersheds, but in the case of large streams would not be possible. If a steep mountain slope is covered with forests, the small stream draining that slope may receive its flood waters quite gradually—

no more rapidly than it is able to carry them off without overflowing its banks. If the forests should be cut down, the result might be that the earth would be carried away by erosion, filling up the stream bed, and also greatly increasing the rapidity with which the flood waters would be delivered into that obstructed bed, so that the obstructed channel could no longer carry the increased flood flow without serious and frequent overflows. On the other hand, it would be too much to expect that a river of large size, unless draining a mountainous country, would show much effect due to forestation.

The main preventive of the evil effects of floods has generally been the enlargement of the river channel by dredging out the bars, removing obstructions, preventing caving of banks, and constructing levees, thus increasing the area; at the same time, in some cases, straightening the channel by cut-offs and doing what is possible to prevent sediment from being brought down into the channel from above. Secondary channels have sometimes been advocated, these channels in some cases to carry a certain portion of the flow at all times, and in other cases to be at such height that they do not carry any water until after the river has reached a certain stage, above which point they become effective in helping discharge the flood waters. Near the mouth of the stream secondary outlets may sometimes be employed, carrying a portion of the flow through a new channel. Or a tributary may be diverted into a new channel and carried around a city or other district subject to overflow.

As against these plans, the two methods most frequently urged are reforestation and reservoirs.

The fact that floods seem to be increasing, and occasionally overtop the levees, has led some persons to conclude that levees are a failure in the control of the Mississippi River, that they should be abandoned and the flood waters allowed to flow over the adjoining territory and to deposit its silt upon it just as the Nile is allowed to overflow its banks.

Colonel C. McD. Townsend, President of the Mississippi River Commission, in a very interesting address before the Inter-

state Levee Association at Memphis in 1912, clearly pointed out, however, that one river must not be judged by another, and that the Nile, rising near the Equator and flowing northward, has floods which reach its mouth early in the spring or before the agriculturist plants his crops, and that these floods must be allowed to overflow the banks of the stream because there is little rain-fall in the lower Nile valley and the crops are dependent upon this overflow. On the Mississippi, however, the floods come down in the spring after the crops in the lower valley are planted, and in that lower valley there is an abundant rain-fall, so that to allow the stream to overflow would have no object and would destroy the crops instead of producing them.

Reforestation, so often urged as a panacea for floods, must be considered of little importance in the case of a large river like the Mississippi, except in preventing erosion from the steep mountain slopes in the upper parts of the basin. In a well-settled country, the greater part of the land must, of course, be required for agricultural purposes.

The use of reservoirs as a means of preventing floods has been much discussed within the last few years. If this method could be made thoroughly effective, as it is, for instance, in the case of the Great Lakes which regulate the flow of the St. Lawrence, or as in the case of Lake Sebago which regulates the flow of the Presumpscot River in Maine (see Figures 13 and 17), this would undoubtedly be the best and most efficient means of preventing floods. It is evident, however, that the application of this method is dependent entirely upon the topographical conditions, that a very large reservoir area is requisite, that it withdraws large areas from cultivation and interferes with means of communication. While this method has been much discussed in recent years, it is nothing new. As far back as 1711 artificial lakes were constructed upon the upper Loire for protection against floods, and the method has been a subject for discussion among hydraulic engineers ever since. Charles Ellet, a prominent civil engineer of a past generation, advocated the application of this method to our western streams in 1849.

The work of constructing storage reservoirs for flood control has been carried out on the Elbe River and some of its tributaries in Bohemia since 1903, by a commission charged with this work. The work of the commission includes reforestation for the purpose of retarding the run-off and preventing erosion, about $145,000 having been expended for this purpose between the years 1906 and 1909; 60 per cent of the cost of carrying out the work is appropriated by the Austrian government, and 40 per cent by the Bohemian government.[3]

Other countries of Europe are doing work of the same character. Figure 41 shows the Mauer dam, completed in 1912, on the Bober River, a tributary of the Oder. The drainage area above the dam is 467 square miles. The dam is said to be the largest in Europe, being 203 feet high, 23.6 feet wide at the top and 165 feet at the base. The crest is 918 feet long, arched with a radius of 820 feet. The dam is of broken stone masonry. The power house below the dam generates a total of 6,000 to 8,000 horse power, and supplies 154 villages and fourteen towns with power at a very low price. This work was built by the State of Prussia and the Province of Silesia, the former contributing 80 per cent and the latter 20 per cent of the total cost of $1,992,000.

Of recent years the Flood Commission of Pittsburgh carefully examined this method, and recommended its use as a means of protecting that city. Forty-three projects were studied in connection with eleven of the principal floods occurring from 1898 to 1908, the object being to ascertain what result could be achieved in taking off the peak of the dangerous floods, since clearly what is necessary is not to make the flow of the stream even approach uniformity, but simply to prevent it rising above a dangerous level. If a few feet, therefore, can be taken off from the height to which the water rises in a great flood, all serious damage may thereby be avoided. It was estimated by this Commission that seventeen reservoirs might be constructed at a cost of about $22,000,000, and

[3] *Water Conservation in Europe.* By Kenneth C. Grant. Journal of the Engineers Society of Pennsylvania, April, 1913, p. 46.

that if properly managed, these would be sufficient to reduce all of the great floods, except one, below the danger line.

On the upper Mississippi also, the United States Corps of Engineers has constructed the largest system of reservoirs for river regulation that has ever been built, having nearly twice the capacity of those proposed by the Pittsburgh Flood Commission. Colonel Townsend states that these reservoirs have been very successful, not only for increasing the low water discharge above St. Paul, which was the purpose for which it was constructed, but also for reducing floods in those upper portions of the river. In this region there are many natural lakes, and the topographical conditions are extremely favorable for the construction of reservoirs, yet notwithstanding the size of this project and the beneficial effect above St. Paul, Colonel Townsend states that one hundred miles further down the river "it is impossible to detect their influence during either high or low water."

A little reflection will clearly show the inapplicability of the reservoir system except in special cases. A reservoir only regulates the flow from the drainage area above it, and the topographical conditions are generally most favorable to the construction of reservoirs in the upper portions of the streams where the ground is hilly. The effect of a reservoir is greatest, therefore, just below it; the further down the stream we go the less is that effect. In the case of a large river draining a flat plain, regulation by reservoirs would, of course, be impossible. This is practically the case in the lower Mississippi. The same is true in the case of any stream, a large portion of whose drainage area in the lower reaches is flat land, and only a small portion in the upper waters in a country topographically suited for reservoirs. The reservoirs on the upper Mississippi are about a thousand miles from Cairo; those on the upper branches of the Allegheny, Monongahela, and other tributaries of the Ohio where large reservoirs are practicable, are about a thousand miles from its mouth.

The reservoirs proposed by the Pittsburgh Flood Commission were to store about 59½ billion cubic feet. This seems a large

quantity of water, but Colonel Townsend states that this quantity was carried by the Mississippi River at the latitude of Red River in less than seven hours at the crest of the flood of 1912. An area of a square mile covered one foot deep would store nearly 28,000,000 cubic feet; yet this quantity, if allowed to flow out uniformly through the year, would discharge only 0.88 cu. ft. per second, and would generate a gross power of but 1 horse power on a fall of 10 feet.

While, therefore, reservoirs may be practical and economical in certain cases, in the upper watersheds, in others they will not be, so that in this case as in all engineering problems, the engineer must approach the subject without preconceived ideas and must thoroughly investigate the economy, practicability and efficiency of all possible methods.

The proposition to regulate by reservoirs was referred to by Humphreys and Abbott in their classic work on "The Physics and Hydraulics of the Mississippi River," published in 1861, in the following terms:

"Little consideration is necessary to make it apparent that this system is not applicable to restraining the floods of all rivers. Certain topographical conditions are essential to its success. The valley must be of such a character that dams of reasonable dimensions can be constructed, which shall keep back the *identical water which otherwise would make up the flood.* It is not sufficient for this purpose, as for improving navigation, that a large volume of water may be collected by the accumulations of months. The floods of great rivers are torrents, caused by rapidly melting snows and by widely extended and heavy rains. The greater part of this water does not drain from the remote mountain sides, and issue from the distant mountain gorges. It falls in the valley itself; and the nearer to the main river, the more sudden and disastrous will be its effects; partly from the more rapid accumulation in the main stream of the contributions of the tributaries, and partly from the absence of the natural reservoir furnished by the various channels, which must be filled before a freshet originating near the sources can reach the lower part of a river. To control such floods with certainty and economy by artificial reservoirs, it is, therefore, essential that certain important tributaries which drain relatively large portions of

the basin shall debouch near their mouths from narrower gorges, where dams can be constructed at reasonable cost, and where artificial lakes can be formed without injury to other interests."

These writers go on to demonstrate the physical impossibility of protecting the alluvial region of the Mississippi River by means of reservoirs.

While the reservoir plan would, therefore, be impracticable for the lower Mississippi, it may well be (although some eminent engineers doubt even this) that the reservoir plan may be the best one for the protection of the city of Pittsburgh and in similar cases. (See references 7 and 8, in bibliography for this chapter.)

It has frequently been proposed to remedy floods by building cut-offs, shortening the length of the stream, and increasing the slope. This method, like every other, may be applicable in certain cases and not in others. The construction of a cut-off will remove a bend in the stream and will shorten the length between the upper and lower end. If the level of the water at both ends of the cut-off should remain unaltered, giving the same drop or head as existed previously, the slope of the surface would be too steep to correspond to the flow of the given quantity of water through the shortened and straightened channel. This slope will, therefore, be reduced, either by lowering the water level at the upper end, by raising it at the lower end, or both. It has frequently been found in practice that both results follow, so that although the construction of the cut-off is beneficial and lowers the water in its upper portion, it raises it in its lower portion and is there an injury. This is sometimes expressed by saying that the water flows more freely through the cut-off than though the original channel, and that the cut-off carries off the flood waters faster than the channel below can carry them without an increased slope. This has been the experience not only in American streams, but also in foreign streams, and it shows the necessity of careful hydraulic studies, and of careful adjustment of conditions, in carrying out hydraulic works of this kind.

It is not necessary to discuss here the questions of artificial outlets or diversion of tributaries, which may be practicable in some

special instances, and which may result in reducing the quantity of water flowing in the original channel; neither is it necessary to discuss the question whether confining the stream by levees results, as has sometimes been claimed, in a gradual raising of the river bed. Suffice it to say that existing streams which have been leveed, both in Europe and in America, have shown this statement to be untrue.

The importance of preventing silt from being carried into the river, either from the uplands and mountain slopes, or from caving banks on the lower reaches of the streams, is self-evident. Forestation of all steep slopes, proper methods of cultivation, and the protection of the river banks, are the remedies for this difficulty.

In any actual case, the hydraulic engineer, after a careful study of the problem, will adopt the method best suited to the case in hand. This will probably include a combination of methods, the construction of some reservoirs to hold back surface waters, the straightening of channels, the removal of obstructions, the building of levees, the excavating of beds, and perhaps the construction of auxiliary channels available after the water reaches a certain height. In settled communities, it has frequently been the case that the bed of the stream has been gradually encroached upon by wharves, walls and buildings. The extent of this encroachment is not generally realized until a flood comes and the channel is shown to be insufficient. (See Figure 89.)

In the case of the recent floods in Ohio, an interesting report has been made to the city of Columbus by Messrs. Alvord and Burdick, Civil Engineers, of Chicago. In this report, the authors studied ten projects, some involving reservoirs and some without them. The engineers, and also the Board of Army Engineers who examined this report, recommended the plan known as Project No. 7, which did not involve reservoirs. This plan is shown in Figure 90, and consists of excavating a new channel with levees, and abandoning the old and tortuous channel, filling it and making it into an avenue. The most favorable projects involving reservoirs were not favored by the engineers "unless state aid and the coöperation of other municipalities benefited be obtained"; in other

words, the construction of reservoirs on the upper waters would affect other municipalities than Columbus, while the project recommended to be carried out, without involving other municipalities, would simply relieve Columbus from any danger by providing a sufficient channel for the flood waters. Regarding complete reservoir control, the engineers say, as might be expected, that while it is a theoretical possibility to obtain it, their computations and surveys clearly show "that complete reservoir control would be more expensive than enlargement of the present channels to a fairly good capacity, together with partial reservoir control." As stated above, however, they finally recommended a plan involving no reservoirs at all.

On the other hand, the plan which is being worked out for the protection of the city of Dayton involves the construction of a number of reservoirs.

The previous discussion will perhaps have made clear the complicated nature of the problem involved in flood control. But it also shows the danger of extreme views, as for instance, those with reference to the great benefits of reforestation or the general applicability of reservoirs.

Attention has been called to the value of storage in improving navigation, in developing water power, and in preventing floods. It must now be pointed out that although storage is beneficial for all these purposes, and consistent with all of them, the management of the storage, in order to secure the best results, may be very different according to its purpose, and that the purposes above mentioned are in this respect to some extent antagonistic. If a reservoir is to be of the greatest utility in regulating floods, it must be kept empty as much as possible, in order to be at any time capable of exercising its maximum effect in preventing a flood, which of course is likely to occur at any time, although in some seasons of the year they are more prevalent than in others. On the other hand, as a means of improving navigation by increasing the flow in periods of low water, the reservoir must, in general, be kept full as much as possible, in order that it may always be able at a time of low

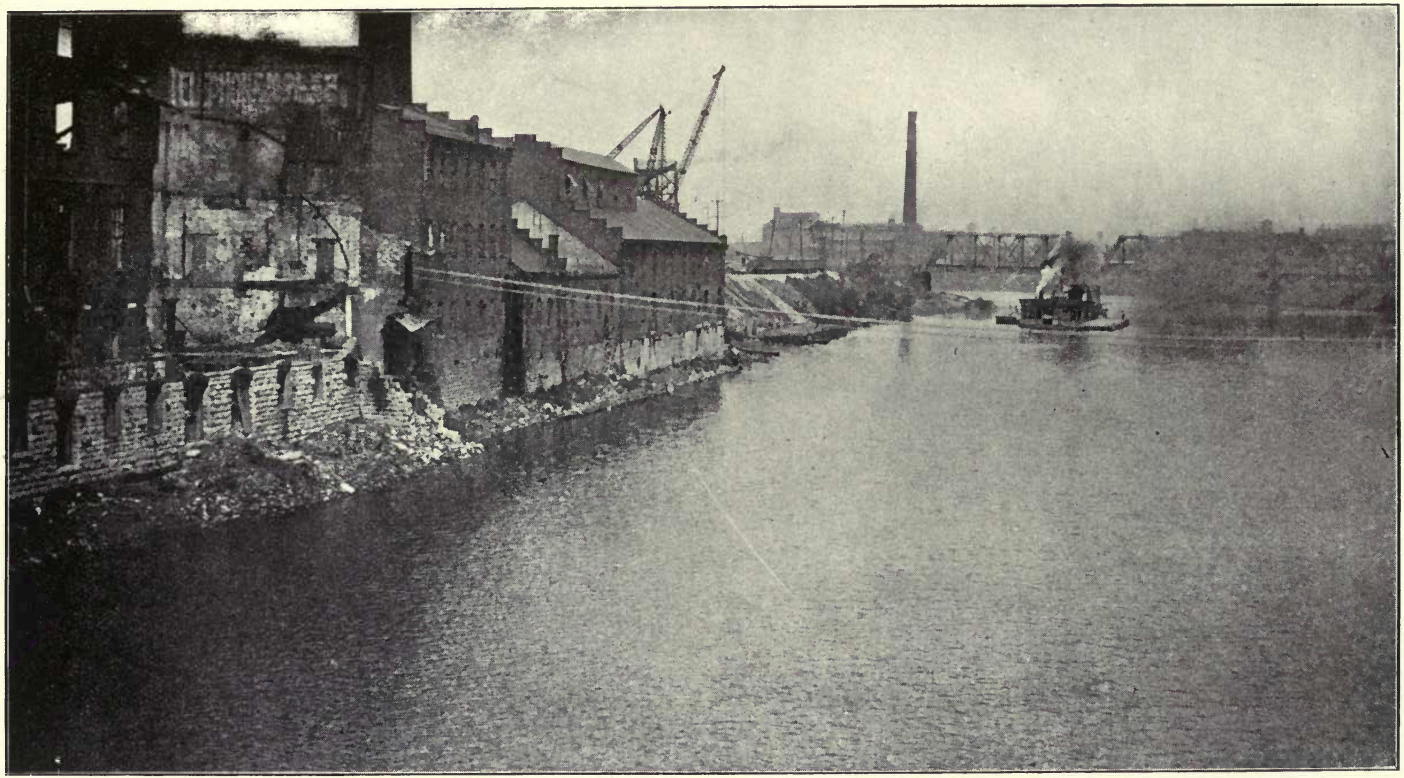
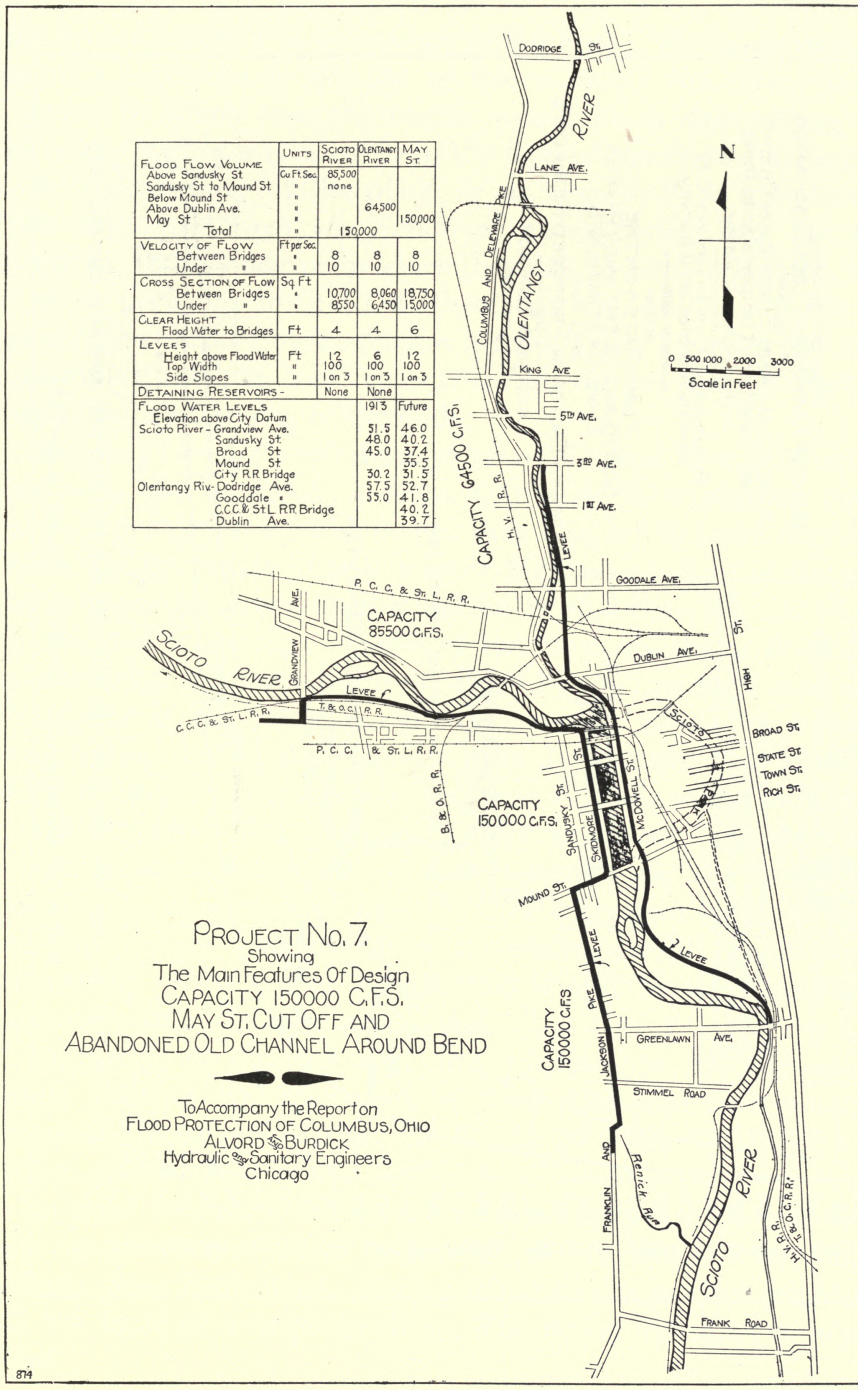


FIG. 89. SCIOTO RIVER, NORTH FROM BROAD STREET

The buildings in the left foreground are typical of the encroachments along the river

(From report to city of Columbus by Alvord and Burdick)



	Units	Scioto River	Olentangy River	May St.
Flood Flow Volume				
Above Sandusky St.	Cu. Ft. Sec.	85,500		
Sandusky St. to Mound St.	"	none		
Below Mound St.	"			
Above Dublin Ave.	"		64,500	
May St.	"			150,000
Total	"	150,000		
Velocity of Flow	Ft. per Sec.			
Between Bridges	"	8	8	8
Under "	"	10	10	10
Cross Section of Flow	Sq. Ft.			
Between Bridges	"	10,700	8,060	18,750
Under "	"	8,550	6,450	15,000
Clear Height				
Flood Water to Bridges	Ft.	4	4	6
Levees				
Height above Flood Water	Ft.	12	6	12
Top Width	"	100	100	100
Side Slopes	"	1 on 3	1 on 3	1 on 3
Detaining Reservoirs -		None	None	
Flood Water Levels			1913	Future
Elevation above City Datum				
Scioto River - Grandview Ave.			51.5	46.0
Sandusky St.			48.0	40.2
Broad St.			45.0	37.4
Mound St.				35.5
City R.R. Bridge			30.2	31.5
Olentangy Riv. - Dodridge Ave.			57.5	52.7
Goodale "			55.0	41.8
C.C.C. & St. L. R.R. Bridge				40.2
Dublin Ave.				39.7

Fig. 90

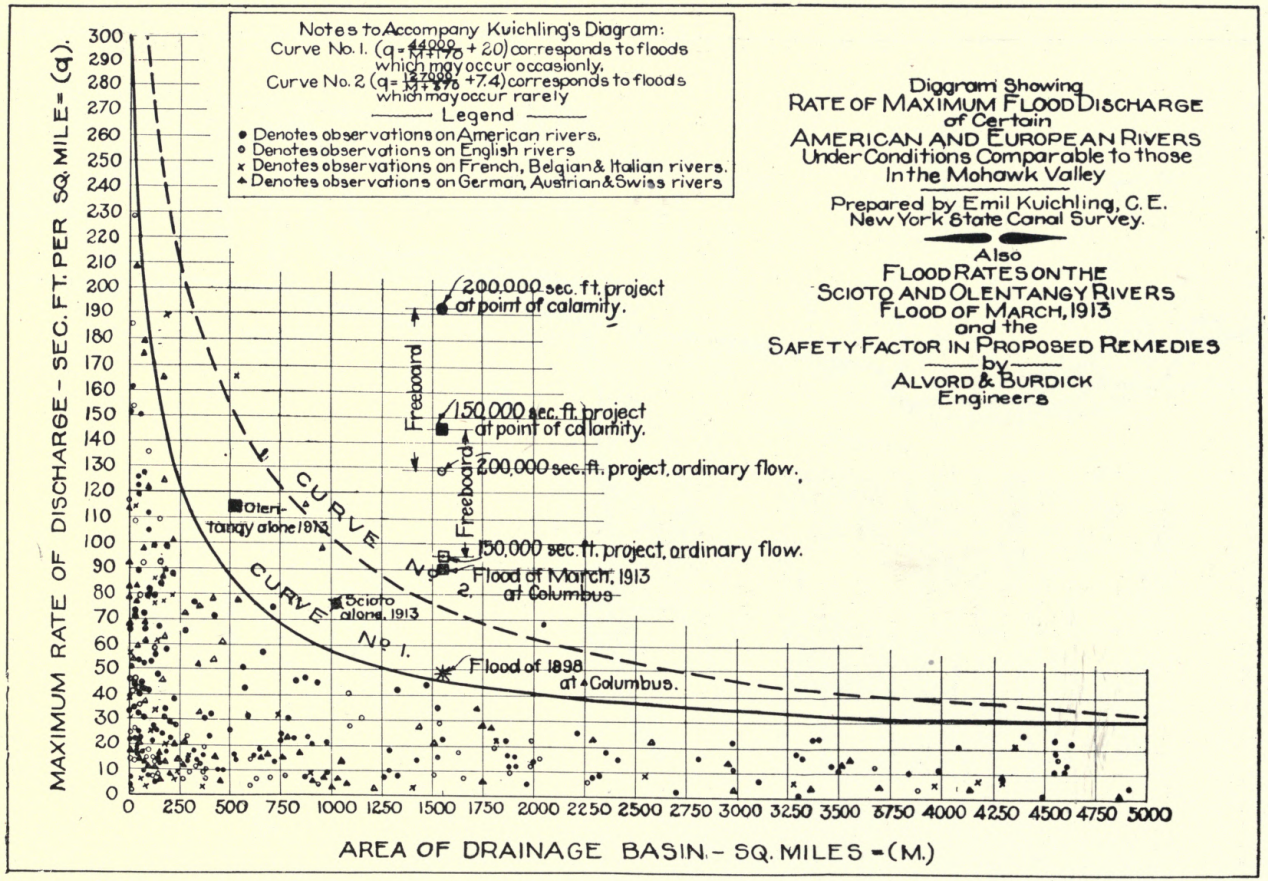

Notes to Accompany Kuichling's Diagram:
Curve No. 1. (q = 44000/(M+170) + 20) corresponds to floods which may occur occasionly.
Curve No. 2 (q = 132000/(M+270) + 7.4) corresponds to floods which may occur rarely
Legend
Denotes observations on American rivers.
Denotes observations on English rivers
Denotes observations on French, Belgian & Italian rivers.
Denotes observations on German, Austrian & Swiss rivers
Diggram Showing
RATE OF MAXIMUM FLOOD DISCHARGE
of Certain
AMERICAN AND EUROPEAN RIVERS
Under Conditions Comparable to those
In the Mohawk Valley
Prepared by Emil Kuichling, C. E.
New York State Canal Survey.
Also
FLOOD RATES ON THE
SCIOTO AND OLENTANGY RIVERS
FLOOD OF MARCH, 1913
and the
SAFETY FACTOR IN PROPOSED REMEDIES
by
ALVORD & BURDICK
Engineers
MAXIMUM RATE OF DISCHARGE - SEC. FT. PER SQ. MILE = (q).
AREA OF DRAINAGE BASIN. - SQ. MILES = (M.)
200,000 sec. ft. project at point of calamity.
150,000 sec. ft. project at point of calamity.
200,000 sec. ft. project, ordinary flow.
150,000 sec. ft. project, ordinary flow.
Freeboard
Freeboard
CURVE No 1.
CURVE No 2.
Olentangy alone 1913
Scioto alone, 1913
Flood of March, 1913 at Columbus
Flood of 1898 at Columbus.

FIG. 91

water to contribute a large volume to the flow. The same thing is true with reference to the use of the reservoir for water-power purposes, in which case the object would be to draw from the reservoir in such a way as to keep the flow of the stream always at the desired capacity of the plant, or as near to it as practicable. While these uses then are somewhat antagonistic, they are not entirely so, and the degree to which they can be combined must, like the other problems involved in these matters, be the subject of careful hydraulic and hydrographic investigation. A reservoir may be profitably used, to some extent, for all the purposes named, if designed with reference to them all.

Another fact with reference to reservoirs and their relation to floods must also be stated, namely, that while reservoirs are beneficial as a protection against floods, they also are in some degree a menace, for the reason that if a reservoir dam should fail for any cause, a more disastrous flood might be created than the one which it is intended to prevent. Some of the most disastrous floods on record *in small streams* have been caused by the failure of reservoir dams, such as the flood in the Conemaugh River in western Pennsylvania, due to the failure of the Johnstown dam in 1888, and the flood in Pennsylvania a few years ago due to the failure of the Austin dam. This, however, simply emphasizes the necessity for care in the construction of any human work, the failure of which may be dangerous to life. It is no argument against reservoirs, but simply indicates that reservoirs should be properly constructed. With proper construction it may be said that there is no danger from the failure of a dam.

Figure 91 is inserted here for reference as an interesting diagram showing maximum rate of flood discharge on a number of streams. It is taken from the Report of Messrs. Alvord and Burdick, previously referred to.

In these lectures it has been attempted to give a general view of the conservation of water by storage, its benefits, and the many problems which it involves. Each portion of this subject might be made the topic of a large treatise. The writer ventures to hope,

however, that this discussion, superficial as it has been, may have been useful to the students of Yale University in bringing together before them various considerations which help to give a general view of the entire subject, without overlapping, more than has been necessary, the previous courses in this same series.

APPENDIX

APPENDIX I

CONCLUSIONS OF SUBCOMMITTEE OF THE COMMITTEE ON THE JUDICIARY, UNITED STATES SENATE

The Senate Committee on the Judiciary (62d Congress, 2d Session) propounded certain questions to a sub-committee relating to the powers of the Federal Government. These questions, together with the categorical replies, are as follows, omitting the discussion and legal references.

"To the Committee on the Judiciary:

"Your sub-committee, which was directed to report on the following resolution:

"Resolved, That the Committee on the Judiciary of the Senate be, and it is hereby, directed to report to the Senate, at as early a date as possible in the next regular session of Congress, upon the power and authority of the National Government over the development and use of water power within the respective States, and especially:

"First: Has the National Government any authority to impose a charge for the use of water power developed on non-navigable streams, whether State or interstate?

"Second: Has it any authority in granting permits to develop water power on a navigable stream to impose and enforce conditions relating to stated payments to the Government, regulation of charges to customers, and determination of the right to make use of such developed power?

"Third: Has it authority in disposing of any of its lands, reserved or unreserved, necessary and suitable for use in connection with the development or use of water power on a non-navigable stream, whether State or interstate, by lease or otherwise, to limit the time for which such development may continue, or to impose and enforce charges for the use and development of such water power, or to control and regulate the disposition of such water power to its consumers?

have considered the same and report as follows:

ANSWERS TO THE INTERROGATORIES PROPOUNDED IN THE RESOLUTION

"Coming now, in the light of the Constitution and of the construction and interpretation put upon it by the courts in the authorities we have cited, to the direct consideration of the interrogatories propounded in the foregoing resolution, and before attempting to directly respond to the same, it must be borne in mind that it is always difficult to give a satisfactory and instructive answer to a hypothetical or abstract question. It is much easier to solve a concrete case.

"As to the first interrogatory, the only answer we can make is this: That whether a stream is navigable or non-navigable, State or interstate, the rights of the Federal Government as riparian owner are practically the same; and barring any power that may rest in the Federal Government under the commerce clause of the Constitution, that Government has manifestly the right to lease, for compensation and on such terms as it sees fit, its riparian lands with the water appurtenant thereto, but the lessee would not acquire a greater right or interest in such water than the *usufruct* as defined by the common law, and such right or interest would be subject to and charged with any right acquired under the act of July 26th, 1866 (R. S. sec. 2339). The Federal Government has no water *power*, aside from the *usufruct*, to lease in such case; and if the utilization of the water in a stream is sought beyond such *usufruct* and for other purposes, authority therefor must be obtained from the State where the residuary power over the water resides.

"Responding to the second interrogatory, we are of the opinion, divorcing the question from riparian rights, that the Federal Government, in authorizing the construction and maintenance of a dam on a navigable stream by States, municipalities or private parties, for the chief and primary purpose of improving the navigation of the stream, has the same right to prescribe the terms and compensation for the use of the surplus power, created as an incident to the main improvement, as the Government would have in case it had itself built the dam or made the improvement, and that the Government having delegated the power of building such dam to private parties might well confer upon them as compensation for the work thus undertaken the right to do what the Government itself could do in case it had itself constructed the work. In this connection, and as a further response to the interrogatory, it must be noted that the mere grant

by the Federal Government of authority to construct a dam in a navigable river, not for purposes of navigation, but really for the creation of a water power, is merely a license or permit, the effect of which is that if the dam is constructed and operated conformable to plans approved by the Government, it will not be deemed an obstruction or impediment to navigation. And in such case the Government would be authorized to charge a nominal license fee for inspecting and passing upon the plans and for watching over the work to see that it conforms to the plans and is properly maintained; but the regulative power of the Government would not extend to the use of the water for other purposes than navigation and interstate commerce. In such a case it seems to us that the Federal Government has no water power to sell or charge compensation for, for it is only authorized by the Constitution to regulate interstate and foreign commerce, which in this case means navigation.

"As to the third interrogatory, it may be remarked that it has in part been responded to in the answer to the first interrogatory. And as a further answer we will add that the Federal Government has under the Constitution plenary power to sell or lease its riparian lands with the water appurtenant thereto, and that if on any such land there is a water-power site, that, as a part of the riparian land, can of course be sold or leased. The Federal Government has no water *power* distinct or separate from its riparian lands or any water-power site on the same. The only water *power* the Federal Government owns is the common-law *usufruct* in the water appurtenant to its riparian lands. In leasing its riparian lands with their appurtenant water, which is all the Government has to lease within the limits of a State, it can no doubt prescribe such terms as it sees fit in respect to rent, duration of lease, and the uses to which the leased premises may be put. It can say in its lease to the lessee, 'If you succeed in creating and maintaining a water power on the premises I lease you, you will be required to rent such power on such and such terms. This condition will be in your lease; without it I will not lease you the premises. If you accept a lease with this condition and fail to comply with the condition, your lease will be forfeited.' In this connection it must be borne in mind, however, that the leasing of the water-power site as a part of the riparian lands of the Federal Government does not in and of itself confer the right to create a water *power*. At most, as we have already stated, it merely confers the common-law right of usufruct in the water. If any other or further use of the water in the stream is

required, the right to such use must be obtained from State authority, and, therefore, it is difficult to see how water power can be established in such cases without the coöperation or consent of the State.

"Several acts have been passed by Congress relating to obstructions, and the construction of dams, in navigable rivers. Among these, to which we call your attention, is the act of September 10, 1890 (26 Stat., 426), which contains important provisions for the removal or change in bridges that are found to be an obstruction to navigation by the Secretary of War, and other provisions relating to the construction of wharves, piers, bridges, etc.

"The act of July 13, 1892 (27 Stat., 88), relates particularly to the construction of wharves, piers, and bridges over navigable waters, and requires the approval of the Secretary of War for any improvement or bridge. (See sec. 3, p. 110.)

"Section 10 of the act of March 3, 1899 (30 Stat., 1121), prohibits the creation of any obstruction to the navigable capacity of any of the waters in the United States not affirmatively authorized by Congress, etc., and prohibits the construction of any breakwater, jetty or other obstruction in any river or water of the United States, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War. Section 9 of the same act prohibits the construction of any bridge, dam, etc., over any navigable river without the consent of Congress and without the approval of plans by the Chief of Engineers and Secretary of War.

"The act of June 21, 1906 (34 Stat., 386), relates to the construction of dams by parties other than the Federal Government, and the act of June 23, 1910 (36 Stat., 593), is amendatory of the preceding act, and lays down many important rules and regulations for the construction of dams in navigable rivers, etc."

APPENDIX II

THE GENERAL DAM ACTS

The Act of June 21, 1906

CHAP. 3508.—An Act to regulate the construction of dams across navigable waters. June 2
Vol. 34

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That when, hereafter, authority is granted by Congress to any persons to construct and maintain a dam for water power or other purposes across any of the navigable waters of the United States, such dams (*sic*) shall not be built or commenced until the plans and specifications for its construction, together with such drawings of the proposed construction and such map of the proposed location as may be required for a full understanding of the subject, have been submitted to the Secretary of War and Chief of Engineers for their approval, or until they shall have approved such plans and specifications and the location of such dam and accessory works; and when the plans for any dam to be constructed under the provisions of this Act have been approved by the Chief of Engineers and by the Secretary of War it shall not be lawful to deviate from such plans either before or after completion of the structure unless the modification of such plans has previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *Provided,* That in approving said plans and location such conditions and stipulations may be imposed as the Chief of Engineers and the Secretary of War may deem necessary to protect the present and future interests of the United States, which may include the condition that such persons shall construct, maintain, and operate, without expense to the United States, in connection with said dam and appurtenant works, a lock or locks, booms, sluices, or any other structures which the Secretary of War and the Chief of Engineers at any time may deem necessary in the interest of navigation, in accordance with such plans as they may approve, and also that whenever

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Congress shall authorize the construction of a lock, or other structures for navigation purposes, in connection with such dam, the person owning such dam shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States a free use of water power for building and operating such constructions.

SEC. 2. That the right is hereby reserved to the United States to construct, maintain, and operate, in connection with any dam built under the provisions of this Act, a suitable lock or locks, or any other structures for navigation purposes, and at all times to control the said dam and the level of the pool caused by said dam to such an extent as may be necessary to provide proper facilities for navigation.

SEC. 3. That the person, company, or corporation building, maintaining, or operating any dam and appurtenant works, under the provisions of this Act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise. The persons owning or operating any such dam shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe.

SEC. 4. That all rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such rights shall, at any time, fail to comply with any of the provisions and requirements of the Act, or with any of the stipulations and conditions that may be prescribed as aforesaid by the Chief of Engineers and the Secretary of War.

SEC. 5. That any persons who shall fail or refuse to comply with the lawful order of the Secretary of War and the Chief of Engineers, made in accordance with the provisions of this Act, shall be deemed guilty of a violation of this Act, and any persons who shall be guilty of a violation of this Act shall be deemed guilty of a misdemeanor and on conviction thereof shall be punished by a fine not exceeding five thousand dollars, and every month such persons shall remain in default shall be deemed a new offense and subject such persons to additional penalties therefor; and in addition to the penalties above described the Secretary of War and the Chief of Engineers may, upon refusal of the persons owning or controlling any such dam and accessory works to comply with any lawful order, issued by the Secretary of War or Chief of Engineers in regard thereto, cause the removal

of such dam and accessory works as an obstruction to navigation at the Ren
expense of the persons owning or controlling such dam, and suit for such expense may be brought in the name of the United States against such persons, and recovery had for such expense in any court of competent jurisdiction; and the removal of any structures erected or maintained in violation of the provisions of this Act or the order or direction of the Secretary of War or Chief of Engineers made in pursuance thereof may be enforced by injunction, mandamus, or other summary process, upon application to the circuit court in the district in which such structure may, in whole or in part, exist, and proper proceedings to this end may be instituted under the direction of the Attorney-General of the United States at the request of the Chief of Engineers or the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to navi- Liti
gation created by the construction of any dam under this Act, the cause or question arising may be tried before the circuit court of the United States in any district in which any portion of said obstruction or dam touches.

SEC. 6. That whenever Congress shall hereafter by law authorize Tim
the construction of any dam across any of the navigable waters of the con
United States, and no time for the commencement and completion of such dam is named in said Act, the authority thereby granted shall cease and be null and void unless the actual construction of the dam authorized in such Act be commenced within one year and completed within three years from the date of the passage of such Act.

SEC. 7. That the right to alter, amend, or repeal this Act is hereby Rig
expressly reserved as to any and all dams which may be constructed in etc.
accordance with the provisions of this Act, and the United States shall incur no liability for the alteration, amendment, or repeal thereof to the owner or owners or any other persons interested in any dam which shall have been constructed in accordance with its provisions.

SEC. 8. That the word "persons" as used in this Act shall be con- Mea
strued to import both the singular and the plural, as the case demands, and "pe
shall include corporations, companies, and associations.

Approved, June 21, 1906.

The Act of June 23, 1910

CHAP. 360.—An Act to amend an Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Act entitled "An Act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six, be, and the same is hereby, amended to read as follows:

"SECTION 1. That when authority has been or may hereafter be granted by Congress, either directly or indirectly or by any official or officials of the United States, to any persons, to construct and maintain a dam for water power or other purpose across or in any of the navigable waters of the United States, such dam shall not be built or commenced until the plans and specifications for such dam and all accessory works, together with such drawings of the proposed construction and such map of the proposed location as may be required for a full understanding of the subject, have been submitted to the Secretary of War and the Chief of Engineers for their approval, nor until they shall have approved such plans and specifications and the location of such dam and accessory works; and when the plans and specifications for any dam to be constructed under the provisions of this Act have been approved by the Chief of Engineers and by the Secretary of War it shall not be lawful to deviate from such plans or specifications either before or after completion of the structure unless the modification of such plans or specifications has previously been submitted to and received the approval of the Chief of Engineers and of the Secretary of War: *Provided,* That in approving the plans, specifications, and location for any dam, such conditions and stipulations may be imposed as the Chief of Engineers and the Secretary of War may deem necessary to protect the present and future interests of the United States, which may include the condition that the persons constructing or maintaining such dam shall construct, maintain, and operate, without expense to the United States in connection with any dam and accessory or appurtenant works, a lock or locks, booms, sluices, or any other structure or structures which the Secretary of War and the Chief of Engineers or Congress at any time

may deem necessary in the interests of navigation, in accordance with such plans as they may approve, and also that whenever Congress shall authorize the construction of a lock or other structures for navigation purposes in connection with such dam, the persons owning such dam shall convey to the United States, free of cost, title to such land as may be required for such constructions and approaches, and shall grant to the United States free water power or power generated from water power for building and operating such constructions: *Provided further*, That in acting upon said plans as aforesaid the Chief of Engineers and the Secretary of War shall consider the bearing of said structure upon a comprehensive plan for the improvement of the waterway over which it is to be constructed with a view to the promotion of its navigable quality and for the full development of water power; and, as a part of the conditions and stipulations imposed by them, shall provide for improving and developing navigation, and fix such charge or charges for the privilege granted as may be sufficient to restore conditions with respect to navigability as existing at the time such privilege be granted or reimburse the United States for doing the same, and for such additional or further expense as may be incurred by the United States with reference to such project, including the cost of any investigations necessary for approval of plans and of such supervision of construction as may be necessary in the interests of the United States: *Provided further*, That the Chief of Engineers and the Secretary of War are hereby authorized and directed to fix and collect just and proper charge or charges for the privilege granted to all dams authorized and constructed under the provisions of this Act which shall receive any direct benefit from the construction, operation, and maintenance by the United States of storage reservoirs at the head-waters of any navigable streams, or from the acquisition, holding, and maintenance of any forested watershed, or lands located by the United States at the head-waters of any navigable stream, wherever such shall be, for the development, improvement, or preservation of navigation in such streams in which such dams may be constructed.

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"SEC. 2. That the right is hereby reserved to the United States to construct, maintain, and operate, in connection with any dam built in accordance with the provisions of this Act, a suitable lock or locks, booms, sluices, or any other structures for navigation purposes, and at all times to control the same dam and the level of the pool caused by said dam to

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such an extent as may be necessary to provide proper facilities for navigation.

"SEC. 3. That the persons constructing, maintaining, or operating any dam or appurtenant or accessory works, in accordance with the provisions of this Act, shall be liable for any damage that may be inflicted thereby upon private property, either by overflow or otherwise. The persons owning or operating any such dam, or accessory works, subject to the provisions of this Act, shall maintain, at their own expense, such lights and other signals thereon and such fishways as the Secretary of Commerce and Labor shall prescribe, and for failure so to do in any respect shall be deemed guilty of a misdemeanor and subject to a fine of not less than five hundred dollars, and each month of such failure shall constitute a separate offense and subject such persons to additional penalties therefor.

"SEC. 4. That all rights acquired under this Act shall cease and be determined if the person, company, or corporation acquiring such rights shall, at any time, fail, after receiving reasonable notice thereof, to comply with any of the provisions and requirements of the Act or with any of the stipulations and conditions that may be prescribed as aforesaid by the Chief of Engineers and the Secretary of War, including the payment into the Treasury of the United States of the charges provided for by section one of this Act: *Provided,* That Congress may revoke any rights conferred in pursuance of this Act whenever it is necessary for public use, and, in the event of any such revocation by Congress, the United States shall pay the owners of any dam and appurtenant works built under authority of this Act, as full compensation, the reasonable value thereof, exclusive of the value of the authority or franchise granted, such reasonable value to be determined by mutual agreement between the Secretary of War and the said owners, and in case they can not agree, then by proceedings instituted in the United States circuit court for the condemnation of such properties: *And provided also,* That the authority granted under or in pursuance of the provisions of this Act shall terminate at the end of a period not to exceed fifty years from the date of the original approval of the project under this Act, unless sooner revoked as herein provided or Congress shall otherwise direct: *Provided, however,* That this limitation shall not apply to any corporation or individual heretofore authorized by the United States, or by any State, to construct a dam in or across a navigable waterway,

upon which dam expenditures of money have heretofore been made in reliance upon such grant or grants.

"SEC. 5. That any persons who shall fail or refuse to comply with the lawful order of the Secretary of War and the Chief of Engineers, made in accordance with the provisions of this Act, shall be deemed guilty of a violation of this Act, and any persons who shall be guilty of a violation of this Act shall be deemed guilty of a misdemeanor and on conviction thereof shall be punished by a fine not exceeding five thousand dollars, and every month such persons shall remain in default shall be deemed a new offense and subject such persons to additional penalties therefor; and in addition to the penalties above described the Secretary of War and the Chief of Engineers may, upon refusal of the persons owning or controlling any such dam and accessory works to comply with any lawful order issued by the Secretary of War or Chief of Engineers in regard thereto, cause the removal of such dam and accessory works as an obstruction to navigation at the expense of the persons owning or controlling such dam, and suit for such expense may be brought in the name of the United States against such persons and recovery had for such expense in any court of competent jurisdiction. Said provision as to recovery of expense shall not apply wherever the United States has been previously reimbursed for such removal; and the removal of any structures erected or maintained in violation of the provisions of this Act or the order or direction of the Secretary of War or the Chief of Engineers made in pursuance thereof may be enforced by injunction, mandamus, or other summary process, upon application to the circuit court in the district in which such structure may, in whole or in part, exist, and proper proceedings to this end may be instituted under the direction of the Attorney-General of the United States at the request of the Chief of Engineers or the Secretary of War; and in case of any litigation arising from any obstruction or alleged obstruction to navigation created by the construction of any dam under this Act the cause or question arising may be tried before the circuit court of the United States in any district in which any portion of said obstruction or dam touches.

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"SEC. 6. That whenever Congress shall hereafter by law authorize the construction of any dam across any of the navigable waters of the United States, and no time for the commencement and completion of such dam is named in said Act, the authority thereby granted shall cease and be null and void unless the actual construction of the dam authorized in

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such Act be commenced within one year and completed within three years from the date of the passage of such Act.

"SEC. 7. That the right to alter, amend, or repeal this Act is hereby expressly reserved as to any and all dams which may be constructed in accordance with the provisions of this Act, and the United States shall incur no liability for the alteration, amendment, or repeal thereof to the owner or owners or any other persons interested in any dam which shall have been constructed in accordance with its provisions.

"SEC. 8. That the word 'persons' as used in this Act shall be construed to import both the singular and the plural, as the case demands, and shall include corporations, companies, and associations. The word 'dam' as used in this Act shall be construed to import both the singular and plural, as the case demands."

Approved, June 23, 1910.

APPENDIX III

THE COOSA RIVER DAM ACT AND VETO MESSAGE OF PRESIDENT TAFT

In previous pages and in current water-power discussions, many references are made to the Coosa River Dam Act, which was vetoed by President Taft. This Act simply permitted the construction of the dam in accordance with the general dam acts. The Act and the President's veto message follow:

"(S. 7343. Sixty-second Congress of the United States of America; at the second session, begun and held at the city of Washington on Monday, the fourth day of December, one thousand nine hundred and eleven.)

An act to authorize the building of a dam across the Coosa River, in Alabama, at a place suitable to the interest of navigation about seven and one-half miles above the city of Wetumpka.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Alabama Power Company, a corporation organized under the laws of the State of Alabama, its successors and assigns, are authorized to construct, maintain, and operate a dam across Coosa River, in the State of Alabama, at a place suitable to the interest of navigation about seven and one-half miles above the city of Wetumpka, in accordance with the provisions of the act approved June twenty-third, nineteen hundred and ten, entitled 'An act to amend an act entitled "An act to regulate the construction of dams across navigable waters," approved June twenty-first, nineteen hundred and six.'

SEC. 2. That the right to alter, amend, or repeal this act is hereby expressly reserved.

CHAMP CLARK,
Speaker of the House of Representatives.

J. H. GALLINGER,
President of the Senate pro tempore.

I certify that this act originated in the Senate.

CHAS. G. BENNETT,
Secretary.

By H. M. ROSE,
Assistant Secretary."

62d CONGRESS, *2d Session.* | SENATE. | DOCUMENT No. 949.

VETO MESSAGE RELATING TO THE BUILDING OF A DAM ACROSS THE COOSA RIVER, ALA.

MESSAGE
From the
PRESIDENT OF THE UNITED STATES,
Returning

Without Approval Senate Bill 7343, Entitled "An Act to Authorize the Building of a Dam Across the Coosa River, Ala., at the Place Selected For Lock No. 18 on Said River."

August 24, 1912.—Read; ordered to lie on the table and to be printed.

To the Senate:

I return herewith, without my approval, Senate Bill No. 7343, "To authorize the building of a dam across the Coosa River, Alabama, at the place selected for Lock Numbered Eighteen on said river."

This bill presents a typical case of a river where its development by the Federal Government for navigation should go hand in hand with its development for water power. The reports of the engineers show that comprehensive plans have been made by the Corps of Engineers for the development of navigation on this river by a series of dams constructed for the purpose of creating deep pools. This bill seeks to authorize the construction of one of these dams through a private agency, the Alabama Power Co., which intends to use the water power created for commercial purposes. If the Federal Government chose to build this dam itself in aid of navigation, its right to the water power incidentally created by the dam would be beyond question. When, instead of building the dam itself, it builds it by an agent, as proposed by this bill, I believe it to be equally clear that the dam and all its incidents, including the water power created, is within the regulative power of the Federal Government in respect to navigation.

It is said that the grantee, the Alabama Power Co., proposes to spend over a million dollars in the construction of a dam, as well as to furnish toward the project its riparian rights and to stand the expense and cost of the damages by flowage. It is manifestly entitled to be credited for all these expenditures, and is manifestly entitled to a fair, full, and reasonable profit for its investment and work. But after all of these items are fully allowed for it is equally manifest that in the course of time the return from the privilege thus granted in the shape of valuable water power created may far exceed a reasonable return for these items.

No provision is made in the bill whereby the Secretary of War may, in granting the permit, exact such compensation as in the course of time may prove to be necessary to equalize this account. I think this is a fatal defect in the bill, and that it is just as improvident to grant this permit without such a reservation as it would be to throw away any other asset of the Government. To make such a reservation is not depriving the States of anything that belongs to them. On the contrary, in the report of the Secretary of War it is recommended that all compensation for similar privileges should be applied strictly to the improvement of navigation in the respective streams—a strictly Federal function. The Federal Government by availing itself of this right may in time greatly reduce the swollen expenditures for river improvements which now fall wholly upon the general taxpayer. I deem it highly important that the nation should adopt a con-

sistent and harmonious policy of treatment of these water-power projects which will preserve for this purpose their value to the Government whose right it is to grant the permit. The necessity for the adoption of such a policy has recently been pointed out, with my approval, by the Secretary of War, and I see no reason why this bill should be exempted from the safeguards which have been recommended by him in the cases of other bills now pending before Congress.

I therefore return the bill to your honorable body without my approval.

WM. H. TAFT.

THE WHITE HOUSE, *August 24, 1912.*

APPENDIX IV

Connecticut River Dam Bill, 1913, Together With Letter and Statement from Secretary of War Henry L. Stimson Relating to the Same.

62 CONGRESS, *3d Session.* S. 8033. (Report No. 1131.) CALENDAR No. 1001.

IN THE SENATE OF THE UNITED STATES.

January 8, 1913.

Mr. BRANDEGEE introduced the following bill; which was read twice and referred to the Committee on Commerce.

January 20, 1913.

Reported by Mr. BURTON, without amendment.

A BILL

To authorize the Connecticut River Company to relocate and construct a dam across the Connecticut River above the village of Windsor Locks, in the State of Connecticut.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the assent of Congress is hereby given to the Connecticut River Company, a corporation organized and doing business under the laws of the State of Connecticut, to relocate its "Enfield Dam," so called, and to construct, maintain, and operate such relocated dam (which if located opposite Kings Island, in said river, shall

extend across both branches of the river), together with works appurtenant and necessary thereto, across the Connecticut River at any point below a line crossing both branches of the river and Kings Island midway between the northerly and southerly ends of said island: *Provided*, That, except as may be otherwise specified in this Act, the location, construction, maintenance, and operation of the structures herein authorized, and the exercise of the privileges hereby granted, shall be in accordance with the provisions of the Act approved June twenty-third, nineteen hundred and ten, entitled "An Act to amend an Act entitled 'An Act to regulate the construction of dams across navigable waters,' approved June twenty-third, nineteen hundred and six": *And provided further*, That the time for completing said dam and appurtenances may be extended by the Secretary of War, in his discretion, two years beyond the time prescribed in the aforesaid Act: *And provided further*, That the rights and privileges hereby granted may be assigned with the written authorization of the Secretary of War, or in pursuance of the decree of a court of competent jurisdiction, but not otherwise: *And provided further*, That the Secretary of War, as a part of the conditions and stipulations referred to in said Act, may, in his discretion, impose a reasonable annual charge or return, to be paid by the said corporation or its assigns to the United States, the proceeds thereof to be used for the development of navigation on the Connecticut River and the waters connected therewith. In fixing such charge, if any, the Secretary of War shall take into consideration the existing rights and property of said corporation and the amounts spent and required to be spent by it in improving the navigation of said river, and no charge shall be imposed which shall be such as to deprive the said corporation of a reasonable return on the fair value of such dam and appurtenant works and property, allowing for the cost of construction, maintenance and renewal, and for depreciation charges.

SEC. 2. That the height to which said dam may be raised and maintained shall not be less than thirty-nine feet above zero on the Hartford gauge: *Provided*, That said corporation shall permit the continuous discharge past said dam of all water flowing in the Connecticut River whenever the discharge into the pool created by the dam hereby authorized is one thousand cubic feet per second or less, and at all greater discharges into said pool shall provide a minimum discharge past said dam of not less than one thousand cubic feet per second: *And provided further*, That said cor-

poration may, for not to exceed five hours between sunset and sunrise, limit the discharge past said dam to five hundred cubic feet per second whenever such limitation will not, in the opinion of the Secretary of War, interfere with navigation. The measure of water thus to be discharged shall include all the water discharged through the lock herein provided for and the present locks and canal of said corporation: *And provided further*, That nothing in this Act shall in any way authorize said corporation at any time or by any means to raise the surface of the river at the location just above the present Enfield Dam to any height which shall raise the surface of the river at the lower tailrace of the Chemical Paper Company in Holyoke, Massachusetts, higher than can result from the erection or maintenance of any dam or dams which said corporation is authorized to erect or maintain in accordance with the order and decree of the Circuit Court of the United States for the District of Connecticut, passed June sixteenth, eighteen hundred and eighty-four, in the case of The Holyoke Water Power Company against the Connecticut River Company.

SEC. 3. That the said Connecticut River Company shall build coincidently with the construction of the said dam and appurtenances, at a location to be provided by said corporation and approved by the Secretary of War, and in accordance with plans approved by the Secretary of War and the Chief of Engineers, a lock of such kind and size, and with such equipment and appurtenances as shall conveniently and safely accommodate the present and prospective commerce of the river, and when the said lock and appurtenances shall have been completed the said corporation shall convey the same to the United States, free of cost, together with title to such land as may be required for approaches to said lock and such land as may be necessary to the United States for the maintenance and operation thereof, and the United States shall maintain and operate the said lock and appurtenances for the benefit of navigation, and the said corporation shall furnish to the United States, free of charge, water power, or power generated from water power, for operating and lighting the said constructions; and no tolls or charges of any kind shall be imposed or collected for the passage of any boat through the said lock or through any of the locks or canal of said corporation.

SEC. 4. That compensation shall be made by the said Connecticut River Company to all persons or corporations whose lands or other prop-

erty may be taken, overflowed, or otherwise damaged by the construction, maintenance, and operation of the said dam, lock, and appurtenant and accessory works, in accordance with the laws of the State where such lands or other property may be situated; but the United States shall not be held to have incurred any liability for such damages by the passage of this Act.

SEC. 5. That upon the termination for any cause whatever of the authority, rights, and privileges granted hereby, or any renewal thereof, the United States may renew the same or the grant may be made or transferred to other parties. Unless the grant is renewed to the original grantee or its assigns, as herein provided, the United States shall pay or require its new grantee to pay to said original grantees or its assigns, as full compensation, the reasonable value of the improvements and appurtenant works constructed under the authority of this Act and of the property belonging to said corporation necessary for the development hereby authorized, exclusive of the value of the authority hereby granted. Said improvements and appurtenant works and property shall include the lands and riparian rights acquired for the purposes of such development, the dam and other structures, and also the equipment useful and convenient for the generation of hydroelectric power or hydromechanical power, and the transmission system from generation plant to initial points of distribution, but shall not include any other property whatsoever. Such reasonable value shall be determined by mutual agreement between the Secretary of War and the owners, and, in case they can not agree, then by proceedings instituted in the United States district court for the condemnation of such properties. The basis for determining the value shall be the cost of replacing the structures necessary for the development and transmission of hydroelectric power by other structures capable of developing and transmitting the same amount of marketable power with equal efficiency, allowance being made for deterioration, if any, of the existing structures in estimating such efficiency, together with the fair value of other properties herein defined, to which not more than ten per centum may be added to compensate for the expenditure of initial cost and experimentation charges and other proper expenditures in the cost of the plant which may not be represented in the replacement valuation herein provided.

SEC. 6. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

WAR DEPARTMENT,

Washington, January 2, 1913.

MY DEAR SENATOR: I beg to respond to the kind request of your committee for an expression of my views as to—

"A bill for the improvement of navigation of the Connecticut River and authorizing the Connecticut River Company to relocate and construct a dam in said river above the village of Windsor Locks, in the State of Connecticut."

It is understood that this bill is intended to replace three bills of a similar import, as to which I reported to your committee under date of April 18 last.

As reported to me by the Chief of Engineers, the Connecticut River between Hartford, Conn., and Holyoke, Mass., calls for improvements in the interest of navigation which are delayed owing to the very large cost of such improvements if independently undertaken by the Government. If, however, the improvement of navigation could be combined with a project for water-power development, whereby the cost of the improvement demanded by the interest of navigation would not devolve upon the Government, the adoption of such a plan would be plainly in the public interest. The bill now under consideration seeks thus to combine the commercial interests of navigation with the interests of water-power development and, it is believed, provides the most economical method of securing the improvement of the river sufficient for the present and prospective commerce. From the reports submitted to Congress, in accordance with the river and harbor act of March 3, 1909 (H. Doc. 818, 61st Cong., 3d Sess.), it appears that the lock necessary for navigation purposes alone was estimated to cost $430,000; and inasmuch as this estimate was made several years ago it is probable that the cost today will be considerably larger. In addition to this, if the improvement of the Enfield Rapids were to be undertaken by the Federal Government directly, the necessity for purchasing flowage rights and extinguishing vested interests acquired under State law would add considerably to the actual cost of the work, and would doubtless present legal complications that would greatly embarrass the consummation of the improvement.

Therefore, from the standpoint of navigation, I am of the opinion that the project embraced in the bill whereby the lock and dam are built

by the grantee as an agency of the Federal Government is very advantageous to the United States. On the other hand, the bill will give to the Connecticut River Co. very valuable water-power rights in connection with this work of improvement. The case thus falls within the principles which the President has laid down in his veto message of August 24, 1912, on the Coosa River dam bill (S. 7343, 62d Cong., 2d Sess.) and calls for a reassertion of the views I have heretofore expressed on bills of similar import, as to which I have previously reported to your committee. In other words, I think the bill should not become law unless a provision is added giving the Secretary of War authority, as one of the conditions of the privilege granted by the act, to require the grantee to pay to the United States a reasonable annual return, after making due allowance for construction, renewals, depreciation charges, and a reasonable return to the grantee on his bona fide investment, such proceeds to be devoted to the interests of navigation. With such a provision, I am of the opinion that the bill is in the interests of the public, and I strongly urge enactment.

After conference with the representatives of the Connecticut River Co., they have consented to the insertion in the bill of an amendment to meet my views as to the provision for compensation which I deem vital to its enactment. It is contained in the last proviso of section 1 of the inclosed draft of the bill. I have also examined the remainder of the annexed draft, containing certain minor amendments proposed by the Connecticut River Co., and believe that the interests of the Government, from the standpoint of my department, are adequately safeguarded thereby.

Very respectfully,

(Sgd) Henry L. Stimson, *Secretary of War.*

Hon. Knute Nelson,

Chairman of Committee on Commerce, United States Senate.

STATEMENT BY THE SECRETARY OF WAR

Senator Burton, from the Senate Committee on Commerce, has submitted a favorable report without amendments on Senate Bill 8033, to authorize the Connecticut River Company to relocate and construct a dam across the Connecticut River above the village of Windsor Locks in the State of Connecticut. The interesting feature about this bill, as thus

reported, is that it contains a provision embodying the views of President Taft in his recent message in respect to water powers in navigable rivers. The bill contains a proviso authorizing the Secretary of War to impose a reasonable annual charge to be paid by the corporation for the privilege granted, these proceeds to be used for the development of navigation on the Connecticut River and the waters connected therewith.

For a number of years applications have been made to the Federal Government to improve this portion of the Connecticut River, so as to permit navigation to pass around the rapids which obstruct the river at that place, but the Board of Engineers to whom the project has been referred have uniformly reported that the expense of such an undertaking would be so great as to make it inadvisable for the Federal Government itself to assume the burden and expense. Under the present bill this burden is assumed by the private company which is to develop the water power, and, in addition, the company stands ready to pay additional compensation to the Federal Government. In anticipation of favorable action on this bill I have been in negotiation with the company, and a basis of agreement has been reached with the company under which its books, showing all of the actual expenses of the enterprise, are to be open to the Government, and the profits from the sale of water power are to be carefully tabulated and accounted for under standards subject to the approval of the Board of Engineers. It is estimated that the total enterprise will cost in the neighborhood of five million, five hundred thousand dollars, of which about four hundred and seventy thousand dollars will be required to be spent in constructing a lock and channel exclusively in the interest of navigation. The Government will thus at the outset get the benefit of an investment of nearly half a million dollars spent solely for navigation without reference to water power, or, in other words, an equivalent of an interest charge of nearly thirty thousand dollars per annum.

The company is to receive the net profits derived from its investment to an extent of eight per cent upon the actual cash investment. In view of all the conditions of the case, I regard this as a fair and yet conservative amount of return for such a water-power development. Thereafter, all further net profits are to be divided between the company and the Government. Between eight and nine per cent, they are to share equally, and beyond nine per cent, the Government is to share in an increasing ratio. I deem this a far more advantageous arrangement than to deny the company

any share in the profits beyond eight per cent, in that beyond that point it leaves an inducement to the company for good management and for earning money for the public by partly sharing in it itself.

Furthermore, in order to provide for a possible increase in the profits of such business as years pass and water powers may increase in value, I have insisted that after thirty years under the present arrangement there is to be a readjustment of compensation by agreement between the Government and the grantee, and thereafter such readjustment is to take place at the end of every ten years until the termination of the permit, the life of which is fifty years altogether.

This case offers a good illustration of what can be done under the policy of insisting upon compensation for the grant of these privileges. It has hitherto been the policy of the Nation to allow these water powers to pass into private hands without getting anything for them whatever. Only a year ago this company sought the privileges granted by this bill and expected to get all of the profits from the water-power development for its own use. And it would have done so had the same policy been carried out which has obtained in the multitude of other similar bills passed in former years. Under the policy now insisted upon by President Taft, it turns out that they are not only willing to make this large initial investment for the benefit of the Government, but they are prepared to share their profits beyond eight per cent with the Government, under conditions which provide for accuracy and publicity in determining what those profits shall be. I think that every public interest is satisfied by the bill, and the fact that it is also satisfactory to those persons who are about to embark their money into the enterprise indicates that a legitimate development of water power is reconcilable with a proper protection of the interests of the public. I earnestly hope the bill will be speedily enacted.

APPENDIX V

MEMORANDUM OF ACTS OF CONGRESS CONCERNING POWER PRIVILEGES AT GOVERNMENT DAMS

(SENATE DOCUMENT No. 57, SIXTY-SECOND CONGRESS, FIRST SESSION)

Names of Rivers	Grantee	Date of Act	Provisions of Act	By Whom Improvement Made
Muskingum, Ohio.	General authorization.	Aug. 11, 1888 (25 Stat., 417.)	The Secretary of War authorized and empowered to grant leases or licenses for the use of the water powers, at such rate and on such conditions and for such periods of time as may seem to him just, equitable, and expedient.	United States.
Green and Barren, Ky.	General authorization.	Sept. 19, 1890 (26 Stat., 447.)	The Secretary of War authorized and empowered to grant leases or licenses for the use of the water powers, at such rate and on such conditions and for such periods of time as may seem to him just, equitable, and expedient, with added condition that leases are not to extend beyond the period of 20 years.	United States.
Cumberland, Tenn., at Lock No. 1.	General authorization.	June 13, 1902 (32 Stat., 408.)	The Secretary of War authorized to grant leases or licenses for the use of the water power, at such rate and on such conditions and for such periods of time as may seem to him expedient. (See also act of June 28, 1902.)	United States.
Tennessee River, at Hale's Bar.	City of Chattanooga or other private corporation.	Apr. 26, 1904 (33 Stat., 309.)	Grantee to purchase necessary lands and deed same to United States to construct lock and dam and give them to United States completed, free of all cost except expenses connected with preparation of plans, superintendence, cost of lock gates, etc., and to furnish United States free electric current for operating locks and for lighting. Grantee to have use of water power for 99 years.	Private.

Memorandum of Acts of Congress Concerning Power Privileges at Government Dams
(Continued.)

Names of Rivers	Grantee	Date of Act	Provisions of Act	By Whom Improvement Made
Mississippi, at Des Moines Rapids.	Keokuk & Hamilton Water Power Co.	Feb. 9, 1905 (33 Stat., 712.)	Grantee to build a lock and dry dock and appurtenant works, and United States to have ownership of them. Grantee to provide suitable power plant for lighting and operating the lock, dry dock, and appurtenances, and to provide fishways.	Private.
Cumberland and Tributaries.	Cumberland River Improvement Co.	Mar. 3, 1905 (33 Stat., 1132.)	Right to collect tolls to cease at expiration of 40 years from date of completion of Lock and Dam No. 21, Cumberland River, and United States may then assume the possession, care, operation, maintenance, and management of the lock or locks constructed by the corporation, but without in any way impairing the right or ownership of the water power and dams created by the corporation.	Private.
Coosa, Ala., at Lock No. 2.	General authorization.	May 9, 1906 (34 Stat., 183.)	United States reserves right to control dams and pool level and to construct locks. Land for lock and approaches to be conveyed to United States free of charge, and United States to have free water power for building and operating locks. Fishways to be constructed.	Private.
White, Ark., at Lock No. 1.	Batesville Power Co.	June 28, 1906 (54 Stat., 536.)	The Secretary of War authorized and directed to fix from time to time reasonable charges to be paid for use of power.	Private.
Coosa, Ala., at Lock No. 12.	Alabama Power Co.	Mar. 4, 1907 (34 Stat., 1288.)	Dam to be built so that the United States may construct a lock in connection therewith. The grantee to have the right to use Government land necessary for the construction and maintenance of the dam and appurtenant works, to convey to the United States free of cost	Private.

Memorandum of Acts of Congress Concerning Power Privileges at Government Dams
(Continued)

Names of Rivers	Grantee	Date of Act	Provisions of Act	By Whom Improvement Made
			such suitable tract or tracts as may be selected by the Chief of Engineers and the Secretary of War for establishment of locks and approaches, and to furnish the necessary electric current to operate locks and for lighting grounds.	
St. Mary's, Mich.	General authorization.	Mar. 3, 1909 (35 Stat., 821.)	Water power to be leased by the Secretary of War upon such terms and conditions as shall be best calculated, in his judgment, to insure the development thereof. A just and reasonable compensation to be paid for use.	United States.
Wabash, Ind., at Mount Carmel.	General authorization.	Mar. 3, 1909 (35 Stat., 819.)	Secretary of War authorized to grant leases or licenses for periods not exceeding 20 years at such rate and on such conditions as may seem to him just, equitable, and expedient.	United States.
Mississippi, from St. Paul to Minneapolis.	General authorization.	June 25, 1910 (36 Stat., 659.)	A reasonable compensation for leases of water power shall be secured to the United States.	United States.
Coosa, Ala., at Lock No. 4.	Ragland Water Power Co.	Feb. 27, 1911 (36 Stat., 939.)	The dam to be property of the United States free of charge. Grantee to have water-power rights for 50 years. United States to have right to construct a lock and to have free electric current for operating and lighting. Grantee to raise height of dam at Lock No. 4 and to stop leaks. Beginning in 1925, grantee shall pay to United States $1 per 10-hour horse power, with an increase if natural flowage is increased by storage reservoirs.	Private.
Wabash, at Mount Carmel, Ill.	Mount Carmel Development Co.	Feb. 14, 1889 (24 Stat., 670.) Feb. 12, 1901 (31 Stat., 785.)	Withdrawal of water shall be under the direction and control of the Secretary of War.	United States.

Memorandum of Acts of Congress Concerning Power Privileges at Government Dams
(Continued)

Names of Rivers	Grantee	Date of Act	Provisions of Act	By Whom Improvement Made
Rock River, near Sterling.	Sterling Hydraulic Co.	Mar. 2, 1907 (34 Stat., 1103.)	Secretary of War authorized to permit erection of a power station in connection with United States dam. Grantee to waive certain claims against United States.	United States.
White, Ark., above Lock No. 3.	J. A. Omberg, Jr.	June 29, 1906 (34 Stat., 628.)	Grantee to purchase lands, construct lock and dam, and give them to the United States free of charge and furnish United States electric current to operate locks, light grounds, etc. Grantee to have use of water power for 99 years.	Private.
Black Warrior River, Ala., Lock and Dam No. 17.	General authorization.	Aug. 22, 1911 (p. 32 laws, 62d Cong.) 1st Sess.	Secretary of War authorized to change detailed plans and specifications so as to increase height of pool level over the dam crest of Lock No. 17, and for the development of water power.	United States.

APPENDIX VI

THE WISCONSIN WATER-POWER LAW OF 1913

As an indication of recent tendencies in water-power legislation, reference may be made to the act passed by the legislature of the State of Wisconsin of 1913. As showing the views of well-informed technical editors regarding this act, the editorial in the Engineering Record for July 19, 1913, written when the act was submitted to the legislature, is appended hereto, and also the summary of the act which appeared in the Engineering News of October 16, 1913, after the passage of the act. The present writer is not informed as to just what changes, if any, were made in the act subsequent to the criticisms in the Engineering Record. These two editorial views are submitted here as interesting contributions to the general subject.

(1) Editorial in Engineering Record, July 19, 1913.

Proposed Wisconsin Water-Power Law

"A water-power bill of a decidedly 'advanced' character was introduced in the Wisconsin Legislature on July 3. While it is so radical in its provisions that it should stand but little chance of passage, it is the culmination of so much water-power-legislation 'tinkering,' and covers matters of so great interest to hydraulic engineers and power companies, that a review of the measure is well worth while.

"In considering water-power legislation in Wisconsin it is well to note that previous to 1911 permits or franchises had been granted only by special act of the legislature in each individual case, there being no general law under which a water-power plant could be constructed. Following the general discussion of 'conservation' which swept through the country a few years ago, various members of the legislature convinced themselves that the

riparian owners of water powers within the state had no rights that the legislature was bound to respect. Hence in 1911 they passed a water-power bill, which practically confiscated all the water powers both developed and undeveloped. This matter was brought before the Wisconsin Supreme Court and was declared unconstitutional. The following paragraphs from the decision are of interest:

" 'The right of the riparian owner to use the water of the river on his own land within his boundary determined by ordinary high water mark, for the purpose of creating power or, as the act in question puts it, "developing energy," returning the water again to the stream, is unquestionably a private right appurtenant to the riparian land.'

" 'These premises support the conclusion that the act in question attempts to deprive the owners of improved riparian land and of the resulting water power, and owners of unimproved riparian land, with its appurtenant water-power privileges and advantages, of property without due process of law; that it attempts to authorize the taking of private property for private purposes; and that it attempts to take property without just compensation. The act in question, in the particulars mentioned, is inconsistent with the paramount commands of the state and of the Federal Constitution applicable to the same facts and conditions. Hence, we cannot recognize it as law.'

"It will be noted from the above that the Supreme Court has declared, in no uncertain way, that the water powers of the state are the property of the riparian owners. Not content with this decision, various members of the legislature have been endeavoring to find some way in which they could practically appropriate these water powers for the benefit of the state and still avoid conflict with the decision. The bill offered on July 3 is the result of this effort.

"Briefly, this bill attempts to force any riparian owner who wishes to develop a water power and who must apply to the state for a permit so to do to sign away to the state his rights in said power for the privilege of developing or utilizing it. He is to be allowed 'the value of the power site exclusive of any rights to water power or to the use of water power or its availability in connection with the use of water power,' and after the expiration of thirty years, which is the limit of the franchise, the state, if it has the constitutional power, or any municipality 'may acquire all of the property of the corporation used and useful under the franchise by paying therefor as determined by the (railroad) commission at the time

of taking, the cost of reproduction in the then existing condition of all dams, works, buildings or other structures or equipment used or useful under the franchise and by paying in addition thereto the value of the power site as determined by the commission before the granting of the franchise,' not including, of course, any water-power value.

"It is, of course, evident that any water-power company which purchases a power site must pay its actual value for water-power purposes—or at least so much of the same as the owner may demand. If condemnation is attempted, any jury must hold under the Supreme Court decision that the water-power privilege is an appurtenance of the land and it must give a value based on this decision. Under the proposed law, however, no such value could be recognized by the railroad commission, and no allowance would be made by such commission of such value; hence, any amount paid for water-power privileges, or any benefit to be derived from such privileges, must be realized before the expiration of the franchise.

"Furthermore the limitations of the territory in which the power can be sold are under the control of the railroad commission, as well as the rates to be charged. While it is probable that any rate commission acting under such a law would take these various conditions into account in the making of rates, and permit the charging of such rates as would admit of a fair return under the conditions of the franchise, yet it is evident that the state cannot assure such rates and that any failure to secure them would result in a loss to the water-power company from which there would be no escape.

"The bill provides that if a water-power plant is to be constructed for the purpose of operating a paper mill or other manufacturing plant, the power company must be organized as a separate corporation, must sell its power to others besides the plant which it was incorporated to serve, and at the end of the franchise period might be taken over by the state or a municipality, leaving the manufacturing establishment entirely without power, and possibly valueless.

"This bill as drawn is based on the idea that the water powers of the state are of very great value; that thirty years' use is ample compensation for their development, and that the profit accumulated within that time is sufficient to compensate the owners for all the rights to which they are legally entitled. If there was an active demand for power from water-power installations at the cost of the development of power by steam, water powers in some parts of the state would undoubtedly be very valuable,

although this is not true when the larger cities of the state are considered. The main difficulty in the way of securing such compensation for water-power energy lies in the fact that a power can be developed in general only when a market is already established—that is, for communities where steam is already used. When an attempt is made to sell current at such points the user takes the position that his fixed charges are already incurred and that if he is to take power at all it must be furnished to him at a reduction below his station charges. This means in general that the current must be sold at one-half, or less, of the actual cost of steam power, fixed charges and operating expenses being considered. In many cases this will leave no margin whatever for the water-power plant, and in other cases one that is comparatively small.

"The Engineering Record knows of no cases in Wisconsin where water-power properties for public service have been very profitable. The LaCrosse Water Power Company, with an investment of $2,500,000, went into the hands of a receiver and was sold at a price that netted the bondholders about 8 per cent on their holdings. The Kilbourn plant, representing an actual investment of more than $2,000,000, has been in operation about five years and has paid one dividend amounting to $15,000. No water-power plant in general service in Wisconsin, so far as known, has yet been able to pay materially more than interest, depreciation and maintenance, although few for such service have been in use for more than a few years, and some of them ultimately will probably prove to be reasonably profitable.

"In some cases the flood contingencies have caused very great expense from which some of them can never recover. The greatest profit which can be realized from water-power plants in Wisconsin would accrue from combining them either with other service corporations or with manufacturing establishments where the value of the power used would be fully equal to the cost of steam. This the proposed law absolutely prevents.

"As a business proposition there must be an opportunity to realize returns on any investment commensurate with the hazard involved, and the hazard in the case of any water-power property is necessarily large.

"The bill if enacted will be fatal to any further development of water power in Wisconsin. Under it the investor must take all of the risks of unforeseen contingencies, of securing a market, of regulation of rates, of being compelled to make greater investments than he desires, of ultimate confiscation of at least his water-power rights—and even then with very

little hope of any reasonable financial return. No engineer of intelligence could ever advise an investor either to build a plant or to buy securities of a water-power plant under such a law."

(2) Summary of the act, in Engineering News, October 16, 1913.

THE WISCONSIN WATER-POWER LAW

"A recent enactment of the Wisconsin Legislature (Chapter 765, Laws of 1913, known as the 'Water Power Act') has put all water-power developments (existing and future) in that state under the control of the Railroad Commission, placing them practically on the same plane with public utilities in general. Such widespread interest has been manifested in the new regulations that a brief abstract of the law is given below. The sequence of topics generally follows the law, but the phraseology does not.

"The commission is directed (1) to make a complete survey of the navigable waters of the state (with the assistance and coöperation of the state and Federal geological surveys when practicable), (2) to make a complete investigation of all existing dams and franchises, permits, etc., under which they are operated and to report this information to the legislature with recommendations in the public interest, (3) to survey and report on all power sites within the state whether developed or not, (5) to maintain gaging stations on all navigable waters.

"No dam can hereafter be constructed unless the commission shall determine that the place is a suitable power site and that the work proposed will not interfere with any other dams authorized for river improvement. The improvement of river navigation, the construction, maintenance and use of all dams, and control of river level and flow are placed under the supervision of the commission. The commission is to determine reasonable methods of construction, equipment, maintenance and operation of any improvement, and no dam can be constructed until plans and specifications have been approved by the commission. Except in emergency (protection of life, health or property), no substantial alterations or additions can be made to any dam without an investigation and order of the commission. On complaint or on its own motion, the commission may examine any dam, structure or reservoir, and, if one is found unsafe, it must determine what

work is necessary and it may order such work done. In cases of emergency, the commission may, without notice, cause any stored water to be drawn out.

"The act provides that all dams in navigable waters must conserve and protect navigability. The commission is directed to require timber slides, locks, boat hoists or marine railways, spillways or flood gates, protecting booms or piers, and benchmarks showing allowable minimum and maximum heights of water level. Every dam owner, except a municipality, must pay an annual inspection fee of 10c. per horse-power storage capacity at ordinary stages (with a minimum of $10). Corporations holding a franchise under the new law are subject to the duties and liabilities of river-improvement companies under the general law but are entitled to reasonable tolls for navigation facilities. The tolls are subject to commission regulation like public-utility rates.

"No person, firm, corporation or municipality may hereafter use a dam across any navigable stream without authority of law, legislative act, or a franchise under this act. Franchises authorizing the construction, maintenance and use of dams, where not more than 250 horse power can be developed, and dams for improving navigation, may be granted to any person, firm, or corporation, or to any municipality. But franchises covering sites where over 250 horse power can be developed may be granted only to corporations or municipalities.

"Applicants must file a description of the power site and proposed dam, show the extent and method of navigation improvement, list all riparian owners affected, name the nearest city above and below the site, and the nearest dam existing above and below, present a large-scale map of the power site and all lands affected, state the amount of power proposed to be generated, and describe the market territory. The applicant must propose (1) fully to develop the available water power and to install such auxiliary power as the commission finds advisable, (2) to install a prescribed system of accounting and authorize the commission to audit revenues and to approve expenditures for construction, (3) to terminate contracts, not more than 30 years after the franchise date, giving the commission right then to require that power delivered to distant points be furnished to nearer points, (4) to give the state right after 30 years to collect a specific amount per horse power developed, provided the state have constitutional power to, and shall engage in improvement of navigation, (5) to sell its property at

reproduction cost to a municipality or to the state if it then have constitutional power to purchase.

"On receipt of an application the commission is directed to give a public hearing advertised for three weeks. The applicants are required to notify every person interested in affected lands. On notice of favorable action upon an application, articles of incorporation are to be filed with the commission. These papers are to be approved and filed with the secretary of state. Incorporating power formerly vested in this officer is transferred to the commission so far as concerns water-power and river-improvement concerns.

"A franchise will continue in force until the state or municipality exercises its option to acquire the property, in which case both corporate charter and franchise terminate. When such property is acquired just compensation must not include any value for the franchise. The law specifically denies the existence of any private property right in water or the use of water, and permits no state agency to pay compensation for value of any power site because of water power or the use of water power. Property located within or without the corporate limits of a municipality may be acquired for public municipal purposes after condemnation proceedings. When a state or municipality exercises its option to purchase, it is required to give existing customers preferential rights to service; but such right shall not continue more than 10 years.

"If a grantee, having a dam of less than 250-horse-power capacity, desires to increase it over that figure or shall desire to couple up that with any other developed water power to complete a development of more than 250 horse power, application must be made for a charter and franchise as for the larger developments. No transfer or assignment of franchise is valid unless the commission shall approve it, and no franchise can be assigned to foreign corporations. A franchise granted to a municipality cannot be assigned to any person, firm or corporation except as security for a loan, and the latter may hold title or operate only three years. No municipality may execute a lease or contract for the sale and use of power for periods longer than 15 years, and only on the approval of the commission.

"If any improvement under this statute shall be owned, leased or controlled in any way so as to effect an unlawful combination or a restraint of trade in the sale of power, then the commission may take possession of

the property by receivership proceedings, the members of the commission being appointed as receivers for such period as the courts may determine.

"Violations of this law are punishable by forfeiture of up to $1,000 for each violation. A sufficient sum is directed to be annually appropriated out of money in the treasury sufficient to carry out the provisions of the act but not to exceed $25,000."

APPENDIX VII

REFERENCES

In order to give those who desire to pursue further the subjects discussed in this volume a brief and incomplete list of references is added, which may serve as a basis for future study.

References for Chapter I

(1) Proceedings of a conference of Governors in the White House, Washington, D. C., May 13-15, 1908. Government Printing Office, 1909 (a series of addresses delivered at this Conference).

(2) Report of the National Conservation Commission. Senate Document No. 676, 60th Congress, Government Printing Office. 3 vols., 1909. This is the great mine of information relating to conservation.

(3) Van Hise, Charles R. The Conservation of Natural Resources in the United States. Macmillan, 1910.

This is an excellent general review and discussion of the subject, in which the information contained in the various books and monographs relating to the subject have been digested and presented in a very interesting and popular form.

(4) The Proceedings of the First, Second, Third, Fourth, and Fifth Conservation Congresses. Published by the Executive Committee of the National Conservation Congress.

(5) Conservation of Natural Resources. Annals of the American Academy of Political and Social Science. No. 112, May, 1909.

References for Chapters II, III, IV and V

Much information regarding the subjects discussed in these chapters will be found in the references to Chapter I, but the following papers deal with them more specifically.

(1) Reports of the various Conservation Congresses (see reference 4, Chapter I.)

(2) Prelimary Report of the Inland Waterways Commission. Senate Document 325, 60th Congress, 1st Session, 1908.

(3) Speech of Hon. H. M. Teller of Colorado in U. S. Senate, March 31, and April 2, 1908.

(4) Report of Senate Committee on Commerce on James River Dam Bill, being Report No. 585, 60th Congress, 2d Session. (This will be found in No. 38.)

(5) Special Message of the President of the United States, January 15, 1909, vetoing James River Bill. H. R. Doc. 1350, 60th Congress, 2d Session.

(6) Report of Sub-Committee on Dams and Water Power to Committee on Interstate and Foreign Commerce, February 25, 1909. H. R., 60th Congress, 2d Session.

(7) Brief and Memorandum relating to Riparian and Water Rights of the Federal Government and of the various States, February 7, 1910. Senate Doc. 351, 61st Congress, 2d Session.

(8) Report of Sub-Committee of Committee on Rivers and Harbors Relative to Power on Tennessee River at Muscle Shoals, Ala. February 3, 1910.

(Involved question of coöperation between the United States and private parties in the development of power and navigation.)

(9) Richardson, William, member of Congress from Alabama. Development of Muscle Shoals Water Power. Published by Manufacturers Record.

(10) Gillmore, E. A. Riparian Rights in Wisconsin. Senate Document 449, 61st Congress, 2d Session.

(11) Speech of Hon. John H. Bankhead of Alabama in Senate of United States, March 8, 1910.

(12) Speech of Hon. W. E. Borah of Idaho in Senate of United States, January 20, 1910.

(13) Preliminary Report of United States National Waterways Commission. Senate Document 301, 61st Congress, 2d Session, 1910.

(14) Titsworth, Frederick S. Notes on the Legal Aspects of the Conservation Problem. Proceedings Colorado Scientific Society, vol. 9, 1910.

(15) Report of Public Conference on Water Powers and their Governmental Control, 1911. Published by National Electric Light Association, New York.

(16) Development and Control of Water Powers. Hearings before National Waterways Commissions, November 21-24, 1911. Senate Document 274, 62d Congress, 2d Session.

(17) Address of General William H. Bixby, Chief of Engineers, U. S. A., on "River and Harbor Improvements," before National River and Harbor Congress at Washington, December 7, 1911. Senate Document 549, 62d Congress, 2d Session.

(18) International Waterways Commission, Progress Report. Senate Document 959, 62d Congress, 3d Session.

(19) Dams Across Navigable Waters.—Report of House Committee on Interstate and Foreign Commerce, to accompany H. R. 25882. House Report 1050, 62d Congress, 2d Session.

(20) Report of Sub-committee of the Committee on the Judiciary, U. S. Senate, on Power of the Federal Government over Navigable and Non-navigable Streams. Senate Report, 62d Congress, 2d Session.

(21) Report of Secretary of War for year ending June 30, 1912.

(22) Report of Secretary of Interior for year ending June 30, 1912.

(23) Final Report of the National Waterways Commission. Senate Document 469, 62d Congress, 2d Session.

(24) Washburn, F. S. Agricultural fertilizers from the air in relation to water-power development. Address before National Conservation Congress, November 18, 1913. Senate Document 257, 63d Congress, 2d Session.

(25) Chandler-Dunbar Decision of United States Supreme Court. Senate Document 51, 63d Congress, 1st Session.

(26) Speech of Hon. Albert Johnson of Washington in House of Representatives, November 22, 1913, on Conservation at Close Range.

(27) Creation of a Board of River Regulation, etc. Report of Senator Newlands of Nevada. Senate Report 1339, 62d Congress, 3d Session.

(28) Opinion of Attorney General concerning powers and duties of this Government over diversion of waters from Niagara River.

(29) Preservation of Niagara Falls. Hearings before Committee on Foreign Affairs, House of Representatives. January, 1912.

(30) Diversion of water from the Niagara River. Hearings before Committee on Foreign Affairs, House of Representatives, January 23 and 24, 1913.

(31) Niagara Falls. Report of Hearings before House Committee on Foreign Affairs, January 16, 1912, and following days.

(32) Niagara Falls. Report of Hearings before House Committee on Rivers and Harbors, January, 1911.

(33) Niagara Falls. Report of Hearings before House Committee on Rivers and Harbors, April, 1906, on Burton Act.

(34) Niagara Falls. Water Powers of Canada. Published by Conservation Commission of Canada, September, 1911, 397 pages.

(35) Niagara Falls. Reports No. 1488. House Committee on Foreign Affairs, February 8 and 25, 1913. 62d Congress, 3d Session. Majority and Minority Reports on H. R. 28674.

(36) Niagara Falls. Reports of Hydro-Electric Power Commission of the Province of Ontario. First Report, 1906.

(37) Niagara Falls. Cassier's Magazine. Niagara Power Number.

(38) Federal Control of Water Power. Papers submitted to Committee on Commerce, United States Senate, 62d Congress, 3d Session.

(39) Powelson, W. V. N. Conservation of Natural Resources, Senate Doc. 243, 63d Congress, 1st Session.

(40) Report of Senate Committee on Commerce on Coosa River Dam Bill, Senate 7343, 62d Congress, 2d Session. (This will be found in No. 38.)

(41) Dam Across Connecticut River. Report of Committee on Commerce. Senate Report 1131, 62d Congress, 3d Session.

(42) Dam Across Connecticut River. Report of Minority of Committee. Senate Report 1131, Part 2, 62d Congress, 3d Session.

(43) Speech of Hon. John H. Bankhead of Alabama in Senate of United States, February 11, 1913, on Connecticut River Dam.

(44) Speech of Hon. Charles S. Thomas of Colorado in Senate of United States, February 11 and 12, 1913, on Connecticut River Dam.

(45) Speech of Hon. William E. Borah of Idaho in Senate of United States, February 13, 1913, on Connecticut River Dam.

(46) Speech of Hon. Marcus A. Smith of Arizona in Senate of United States, February 17, 1913, on Connecticut River Dam.

See also other speeches in Senate on same subject.

(The President, Secretary of War, and Secretary of the Interior favored the inclusion of toll charges in the Connecticut River Bill; but they were eliminated from the bill by a vote of 53 to 29, and the bill as amended passed the Senate by a vote of 74 to 12.)

(47) Tavernier, René. The Public Utility of Water Powers and Their Governmental Regulation. Water Supply Paper 238, U. S. Geological Survey, 1910.

(48) Report of Board of Engineers for Rivers and Harbors on Tennessee River and Coöperation by United States Government and Private Parties in Development of Power and Navigation. May 18, 1914. House of Representatives Doc. 20, 63d Congress, 2d Session.

(This is a very interesting document relating to the first project on a large scale in which coöperation is contemplated and recommended between the United States and certain power interests. Estimates were made for the development and bids asked for, and the portion of the cost properly chargeable to power development was also estimated. It was contemplated that this portion should be reimbursed to the United States with compound interest at the rate of 3 per cent at the end of a hundred years. The Company also offered to pay each year an amount equivalent to 35c per horse power of installed capacity, beginning as soon as this capacity should exceed 200,000 horse power, but not later than 20 years after the first power should be developed. The lease proposed was for 100 years and the Board of Engineers recommended it. After outlining the proposition, the report states:

"All this implies large investments of money. To secure such investments the entire project must be made attractive. Long-term concessions of power rights are required on easy terms, together with such contract provisions as will give investors the assurance of a suitable annual income and of the ultimate return to them of their capital."

It was recommended also that the United States should have the power to terminate the lease and take possession of the property at any time after the end of 50 years upon payment to the power company of its value *as a going concern.* It was also provided that the United States should take over all fair contracts for power

in force at the time the lease is terminated, and that all contracts extending beyond the first period of 50 years, and all those made thereafter, should first be submitted for approval to the Government. The plans proposed contemplated an ultimate development of 680,000 horse power. This document is well worthy of careful study and indicates a very liberal and reasonable attitude on the part of the Board of Engineers.)

(49) Water Power Bill. Hearings Before the Committee on the Public Lands on H. R. 14893, 63d Congress, 23d Session.

This volume, of 772 pages, contains a great deal of interesting material.

(50) Leighton, M. O. Development of Water Power. Comments relative to H. R. 16053. Senate Doc. 570, 63d Congress, 2d Session.

(51) Long Sault, New York. Report of Hearings before House Committee on Rivers and Harbors on H. R. 32219 and Report 2032 of Committee, relative to the development of power at Long Sault, N. Y.

Finally, no student of this subject should omit to study the writings of Mr. Rome G. Brown, Attorney-at-Law, of Minneapolis, who is probably as familiar with the water-power problem as any man in the United States. These writings are as follows:

(52) Brown, Rome G. A Summary of the law relating to the pollution of the waters of lakes and streams. Prepared for American Water Works Association, 1900.

(53) Brown, Rome G. Points and Lines on Lakes and Streams. Paper delivered before Minnesota Surveyors' and Engineers' Society, February 25-26, 1908.

(54) Brown, Rome G. Limitations of Federal Control of Water Powers. An argument before the National Waterways Commission, November 28, 1911. Senate Doc. 721, 62d Congress, 2d Session.

(55) Brown, Rome G. In re Niagara Falls. Statement for Niagara Falls Power Company and Canadian Niagara Power Company, before House Committee on Foreign Affairs. January 18, 1912, 62d Congress, 2d Session.

(56) Brown, Rome G. Brief before Committee on the Judiciary, United States Senate, on the question: "Can a riparian right which has once been established as the common law of property rights in any

state, be changed by such state to the detriment of the property rights of riparian owners, as established by such state law?" 62d Congress, 2d Session.

(57) Brown, Rome G. The Law of Waters. Synopsis of lectures at the Law School of the University of Minnesota, and at the Law School of the University of North Dakota, 1912-1913.

(58) Brown, Rome G. The Conservation of Water Powers. Harvard Law Review, May, 1913. Senate Doc. No. 14, 63d Congress, 1st Session.

(59) Brown, Rome G. Improvement of Navigable Rivers. Address before National Rivers and Harbors Congress at the Tenth Annual Convention held at Washington, December 3-5, 1913. Senate Doc. 332, 63d Congress, 2d Session.

(60) Brown, Rome G. Who Owns the Water Powers? In "Case and Comment," the Lawyers Magazine, vol. 19, No. 10.

(61) Brown, Rome G. The Water Power Problem in the United States. Address prepared for the International Water-Power Congress to have been held at Lyons, France, September 9-12, 1914. Yale Law Journal, November, 1914.

As regards the regulations of the Department of Agriculture:

(62) "The Use Book," issued by the Department.

(63) "The National Forest Manual," containing regulations relating to water power, telephone, telegraph, and power transmission lines.

With regard to the Department of the Interior, see

(64) "Regulations concerning rights of way through the public lands and reservations of the United States." Also the various permits issued by the Department, such as that for the International Power and Manufacturing Company of Spokane, Wash., in Senate Doc. 147, 63d Congress, 1st Session.

References for Chapter VI

A complete list of references in connection with this chapter would cover the whole field of water-power development, and only a few titles will be given.

On the subject of dams, the two following works may be consulted and will serve as a starting point for further reading.

(1) Wegmann, Edward. The Design and Construction of Dams, including Masonry, Earth, Rock-fill, and Timber Structures. Also the Principal Types of Movable Dams. 250 pp. Wiley, New York, 1899. 5th Ed. 1907. This is a very complete treatise on the subject.

(2) Schuyler, James D. Reservoirs for Irrigation, Water Power and Domestic Water Supply. 573 pp. Wiley, New York, 1909.

This work not only treats of the construction of dams, giving minor illustrations thereof, but also treats of reservoirs and miscellaneous appurtenances. The greater part of it, however, is devoted to the subject of dams. It is an authoritative work by an engineer of great experience.

On the subject of Water Power there are several general treatises.

(3) Mead, D. W. Water Power Engineering. 787 pp. McGraw-Hill, New York, 1908.

This is a very complete treatise, covering the subjects of hydrology, hydraulic machinery, dams, and the general investigation of water-power projects. Each chapter is accompanied by voluminous references.

(4) von Schon. Hydro-electric Practice. 383 pp. Lippincott, Philadelphia, 1911.

This is a similar treatise to that of Mead.

(5) Koester. Hydro-electric Developments and Engineering. 454 pp. Van Nostrand, New York, 1909.

Another work similar to the last two, but with more attention given to the mechanical and electrical equipment of water-power plants.

(6) Beardsley, R. C. Design and Construction of Hydro-Electric Plants. 512 pp. McGraw, New York, 1907.

Another work similar to those previously mentioned.

In connection with this subject much interesting information will be obtained from

(7) Report of Commissioner of Corporations on Water Power Development in the United States. Government Printing Office, Washington, March 14, 1912.

References for Chapter VII

(1) Zon, Raphael. General Relations of Forests and Streams, 9 pp. Appendix 15 to Preliminary Report of the Inland Waterways Commission, Senate Document 325, 60th Congress, 1st Session; Washington Government Printing Office, 1908.

(2) Zon, Raphael. Forests and Water in the Light of Scientific Investigation, 98 pp. Appendix 5, Final Report of the National Waterways Commission, Senate Document 469, 62d Congress, 2d Session; Washington, Government Printing Office, 1912.

This is the most recent and one of the most elaborate and thorough studies of the subject that the present writer has seen. It is accompanied by a bibliography covering twenty-nine pages and may, therefore, be the starting point for any further investigation which the reader may desire to make.

(3) Ebermayer, Dr. E. Die physikalischen Einwirkungen des Waldes auf Luft und Boden. 253 pp. Von Wiegandt, Berlin, 1873.

This is one of the earliest and most thorough studies of the subject and contains a great deal of valuable information.

(4) Ebermayer, Dr. E. Die gesammte Lehre der Waldstreu, etc. 416 pp. Berlin, 1876.

(5) Wex, Gustav von. The decrease of Water in Springs, Creeks and Rivers. 98 pp. Published by the Corps of Engineers, U. S. A., Washington, 1880-1881.

This is one of the early engineering writings in which the subject was discussed and which is still referred to.

(6) Henry, E. Les sols Forestiers. 492 pp. Berger-Levrault, Paris, 1908.

This and other works of the same author, who is professor in the French National Forestry School, discuss the physical and chemical properties of the forest soil in much detail.

(7) Huffel. Economie Forestière, Paris, 1904.

The relation of forests to streams is discussed in vol. 1, pp. 45-171.

(8) Chittenden, Colonel H. M., U. S. A. Forests and Reservoirs in Their Relation to Stream Flow with Discussion. Transactions American Society of Civil Engineers, vol. 62, pp. 245-546, 1909.

This is a very important paper, in which many of the views earlier expressed by Vallès and others (see references to Chapter 8) are again brought forward, together with many interesting observations. Colonel Chittenden takes the view that forests are of little or no benefit as regulators of flow. The discussion is very interesting.

(9) Burr, Lieut.-Col. Edward, U. S. A. Report on the Merrimac River from Haverhill to Lowell, Mass., together with a report on the investigation of the influence of forests on the run-off in the Merrimac River Basin. House Document No. 9, 62d Congress, 1st Session, 1911.

This is a good instance of what the present writer considers an inconclusive study, and of erroneous conclusions.

(10) Mead, D. W. The Flow of Streams and the Factors that Modify it, with Special Reference to Wisconsin Conditions. 192 pp. Bulletin 425, University of Wisconsin, Madison, Wis., 1911.

This is still another instance of what the present writer considers an inconclusive investigation.

(11) Glenn, L. C. Denudation and Erosion in the Southern Appalachian Region. 137 pp. Professional Paper, U. S. Geological Survey, 1911.

This is an excellent discussion of the observed effects of erosion, with many illustrations, together with a discussion of the causes of the same.

(12) Carpenter, L. G. Forest and Snow. 10 pp. Bulletin 55 of the Agricultural Experiment Station of the Agricultural College of Colorado, 1901.

The author concludes, from numerous personal observations, that the forest cover is valuable as a regulator of flow and "an absolute necessity for the interest of irrigated agriculture."

(13) Hearings before the Committee on Agriculture. House of Representatives, 60th Congress, 2d Session, 1909.

(14) Proceedings 10th International Navigation Congress at Milan, 1905. In this reference will be found presented the views of the representatives of the various nationalities, some of which have been quoted in the text.

The student who desires to pursue this subject might well begin with the papers of Zon and Chittenden, following them with Ebermayer, and then extending his reading at his discretion in the works above mentioned or in the many references given by Mr. Zon.

References for Chapter VIII

(1) Report of the Flood Commission of Pittsburgh, Pa., 1912. This excellent report not only contains a full discussion of the projects studied for the relief of Pittsburgh, together with the hydraulic measurements and investigations which were necessary, but also contains a very complete bibliography of flood literature, classified and arranged.

(2) Report of the State Engineer of New York on the Barge Canal from the Hudson River to the Great Lakes, February 12, 1901. In Appendix 8 of this report, Mr. E. Kuichling, the Engineer for Water Supply, gives a great many references with regard to flow of streams, run-off, etc. These, however, are not as well arranged as the bibliography in (1), nor do they have such specific reference to floods.

(3) Humphreys and Abbot. Report Upon the Physics and Hydraulics of the Mississippi River. Professional Papers of the Corps of Engineers, U. S. A., No. 13, 1861. In this classic work the question of flood control of the Mississippi River and the various methods proposed, are discussed in considerable detail.

(4) Seddon, James A. Reservoirs and the Control of the Lower Mississippi, 1900. (In Journal of the Western Society of Engineers, vol. 5, p. 259.)

(5) Townsend, Colonel C. McD., U. S. A. Reservoirs and the Control of the Lower Mississippi, 1901. (Journal of the Western Society of Engineers, with discussion.)

(6) Townsend, Colonel C. McD., U. S. A. Flood Control of the Mississippi River. Address before the Interstate Levee Association at Memphis, September 26, 1912. (Engineering Record, vol. 66, pp. 470-472.)

(7) Leighton, M. O. Relation of Water Conservation to Flood Prevention and Navigation in the Ohio River, 1908. (Engineering News, vol. 59, pp. 498, 511. Original published as Appendix 13 of Preliminary Report of Inland Waterways Committee, 1908.)

This is a valuable paper, in which the writer proposes to provide reservoir capacity sufficient to store the peak of a flood wave, which, as explained in Chapter 8, is all that is necessary to prevent damage.

(8) Newcomer, Lieut.-Col. H. C., U. S. A. Proposed Reservoir System in Ohio River Basin, 1908. Engineering News, vol. 60, p. 373.) This is a criticism of Mr. Leighton's paper, with which Colonel Newcomer disagrees.

(9) Vallès, M. F. Études sur les Inondations, leurs causes et leurs effets. Paris, 1857. Dalmont.

This work is interesting from an historical point of view, and contains many arguments which have been again brought forward in recent years. The writer does not believe in the beneficial effects of forests. He also believes in allowing the floods to spread without restraint, and simply to reduce the velocity of the flowing water, so that the sediment carried by the stream will be deposited. He therefore opposes the levee system and proposes instead a system of transverse dikes normal to the stream to retard the velocity of the water, the top of these dikes a little above the extreme high water. This plan will not appeal to many, especially the inhabitants of the regions allowed to be overflowed.

(10) Republic Française—Commission Des Inondations. Reports et Documents Divers, 1910. (Paris Gov. Press.)

This is the report of a Commission consisting of a number of eminent engineers, and contains a large amount of technical matter with reference to the floods of the Seine.

(11) Leighton, M. O. The Utility of Storage Reservoirs for Flood Prevention, Power and Navigation. Appendix 2, Final Report of National Waterways Commission, 1912.

This paper discusses floods on various streams.

(12) Water Supply Paper No. 234, United States Geological Survey, on the Conservation of Water Resources. Government Printing Office, 1909.

(13) Report on the Mississippi Floods, by the Committee on Commerce, U. S. Senate Report No. 1433, 55th Congress, 3d Session, 1898.

(14) Reservoirs at the headwaters of the Allegheny, Monongahela and Ohio Rivers and their tributaries. A report by a board of engineers, U. S. A. House Document No. 1289, 62d Congress, 2d Session, 1913.

This report is, in general, unfavorable to the extensive construction of reservoirs.

(15) Frankenfield, H. C., Professor of Meteorology, U. S. Weather Bureau. The Ohio and Mississippi River Floods of 1912. Bulletin Y, U. S. Weather Bureau, December, 1912.

This is an interesting meteorological discussion of these floods, well worthy the attention of the engineer.

(16) Mead, D. W. The cause of Floods and the Factors that Influence Their Intensity. Journal, Western Society of Engineers, April, 1913.

(17) A History of the Flood of March, 1913. Compiled by C. W. Garrett, and issued by the Pennsylvania Lines west of Pittsburgh, 257 pp. 4to.

This is a very interesting volume, with many fine maps and illustrations.

(18) The 1913 Flood, and how it was met by a railroad; by Lewis S. Bigelow. Issued by the Pennsylvania Lines west of Pittsburgh.

This is a small pamphlet of 71 pages, giving a very interesting account of this flood, with many cuts, some of which have been reproduced in the text of Chapter VIII.

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