

# HYDRO-ELECTRIC POWER STATION DESIGN

BY

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ARMOUR INSTITUTE OF TECHNOLOGY

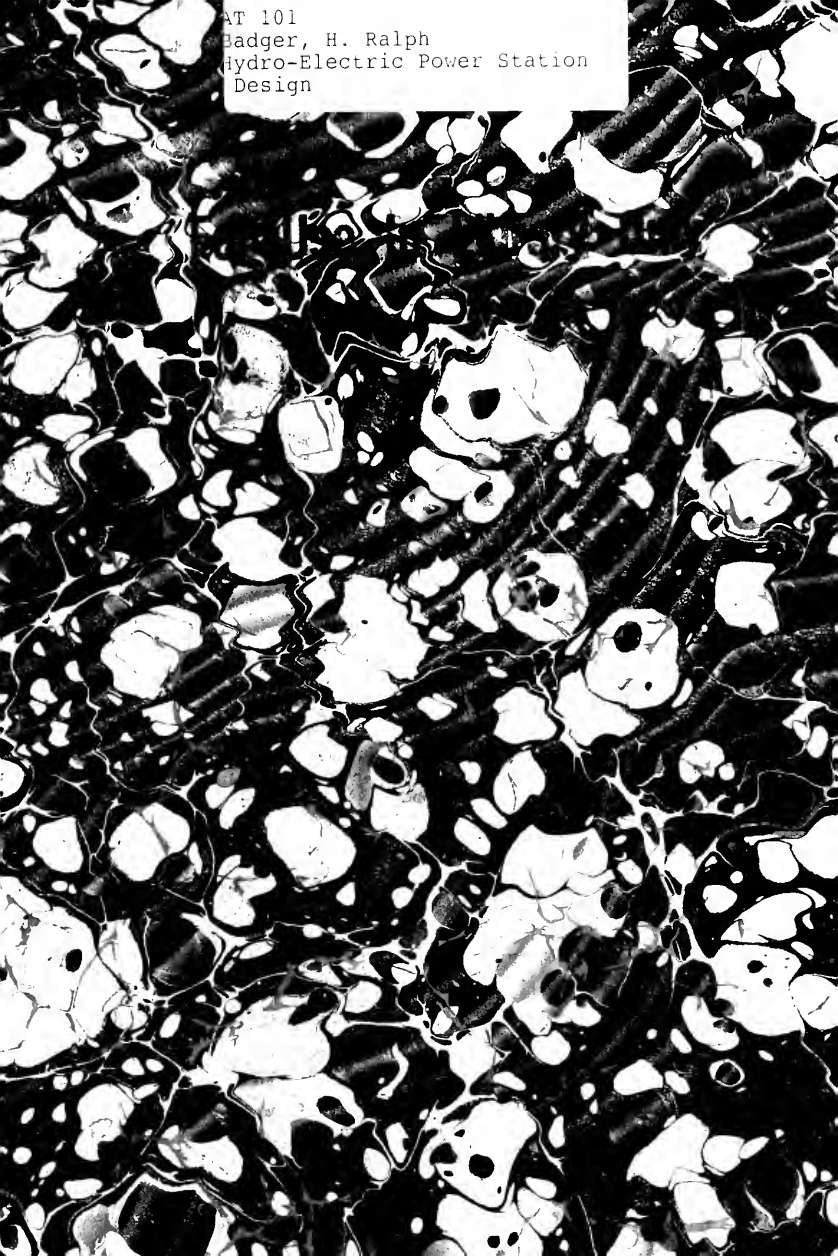
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# HYDRO-ELECTRIC POWER STATION DESIGN

## A THESIS

PRESENTED BY

H. RALPH BADGER

ROY G. GRANT

HAROLD W. NICHOLS

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

HAVING COMPLETED THE PRESCRIBED COURSE OF STUDY IN

ELECTRICAL ENGINEERING

1908

*A. C. Morine,*  
Dean of Cultural Studies

*Approved*  
*A. H. Ruelke.*

*Prof. of E. E.*  
*J. M. Raymond*  
Dean of Eng. Studies



## PREFACE.

The subject of "Hydro-Electric Power Station Design" has herein been presented in two parts :- the first - a brief treatise on the general principles and important factors, and the second - an application of these to a particular case.

In Part I. is given a general statement and analysis of the important factors entering into the design of such power generating stations.

In Part II. the actual design of a station for a particular location is undertaken. This proposed station to be located on the Snake River in the south-central part of the state of Idaho, and to receive its water supply from the Malad - a tributary of the Snake River.

H. R. B.  
R. G. G.  
H. W. N.

Faint, illegible text at the top of the page, possibly a header or introductory paragraph.

I have the honor to acknowledge the receipt of your letter of the 10th inst. in relation to the matter mentioned therein. I am sorry that I cannot give you a more definite answer at this time, but I will endeavor to do so as soon as possible.

Very respectfully,  
[Signature]

T A B L E   O F   C O N T E N T S .

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1. The first part of the document discusses the importance of maintaining accurate records of all transactions.

2. It is essential to ensure that all data is entered correctly and consistently to avoid any discrepancies.

3. Regular audits should be conducted to verify the accuracy and integrity of the information.

4. The second section covers the various methods used for data collection and analysis.

5. These methods include direct observation, interviews, and the use of specialized software tools.

6. Each method has its own advantages and disadvantages, and should be chosen based on the specific needs of the study.

7. The final section discusses the challenges and best practices for implementing these methods.

8. It is important to be transparent about the limitations of the data and the methods used.

9. By following these guidelines, researchers can ensure the reliability and validity of their findings.

10. The document concludes by emphasizing the ongoing nature of research and the need for continuous improvement.



Part I.

A Brief Treatise on the General  
Principles and Important Factors Enter-  
ing Into the Design of Hydro-Electric  
Power Generating Stations.



# Hydro-Electric Power Station Design

## Introduction.

A consideration of the subject of "Hydro-Electric Power Station Design" entails a discussion of the location of the market for sale of power, nature and extent of the water supply of the source of power, auxiliary construction for water handling, location, construction and equipment of generating station, transmission and distribution of energy.

## The General Problem.

Electrical energy is now in nearly universal demand. The amount of this commodity that is made use of in any section of country varies within wide limits. For its common usages - in power and lighting - this variation is nearly directly with the population, though there is a constantly increasing demand for it in railway work - outside of centers of population. With the increased price of coal, as well as for other disadvantages inherent in steam production, - other means than indirectly from coal, of generating electric current,

• Profit Maximization

1.  $Q = 100 - 2P$  (Demand)  
 2.  $Q = 100 - 2P \Rightarrow P = 50 - 0.5Q$  (Inverse Demand)  
 3.  $TR = P \cdot Q = (50 - 0.5Q) \cdot Q = 50Q - 0.5Q^2$  (Total Revenue)  
 4.  $TC = 10 + 2Q + 0.01Q^2$  (Total Cost)  
 5.  $MR = 50 - Q$  (Marginal Revenue)  
 6.  $MC = 2 + 0.02Q$  (Marginal Cost)  
 7.  $MR = MC \Rightarrow 50 - Q = 2 + 0.02Q$   
 $48 = 1.02Q \Rightarrow Q = 47.06$   
 8.  $P = 50 - 0.5 \cdot 47.06 = 26.47$   
 9.  $TR = 50 \cdot 47.06 - 0.5 \cdot 47.06^2 = 1176.47$   
 10.  $TC = 10 + 2 \cdot 47.06 + 0.01 \cdot 47.06^2 = 116.47$   
 11.  $\pi = TR - TC = 1176.47 - 116.47 = 1060$

• Profit Maximization (Graphical)

1.  $Q = 100 - 2P$  (Demand)  
 2.  $Q = 100 - 2P \Rightarrow P = 50 - 0.5Q$  (Inverse Demand)  
 3.  $TR = P \cdot Q = (50 - 0.5Q) \cdot Q = 50Q - 0.5Q^2$  (Total Revenue)  
 4.  $TC = 10 + 2Q + 0.01Q^2$  (Total Cost)  
 5.  $MR = 50 - Q$  (Marginal Revenue)  
 6.  $MC = 2 + 0.02Q$  (Marginal Cost)  
 7.  $MR = MC \Rightarrow 50 - Q = 2 + 0.02Q$   
 $48 = 1.02Q \Rightarrow Q = 47.06$   
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 10.  $TC = 10 + 2 \cdot 47.06 + 0.01 \cdot 47.06^2 = 116.47$   
 11.  $\pi = TR - TC = 1176.47 - 116.47 = 1060$

## Hydro-Electric Power Station Design

are being rapidly sought and utilized. Chief among these, in present importance, is the water power of natural sources.

As these cannot be located where wanted - as can steam plants - but must be taken where found, the general problem becomes one of relation between location of market for power and the source of power generation. Ordinary commercial principles would usually dictate that a power development be carried forward only after a demand had arisen for power in a given locality. This is merely a creation of supply to meet demand. There have been, however, in recent water power developments - numerous cases of the opposite procedure to this. In such projects, water powers - especially favored by location or proportion or both - have been developed first and the market created afterwards, in range of transmission. This constitutes a forcing demand in such localities - by the creation of an attractive supply.

# QUESTION - ANSWER

- The **majority** of the population in the world are **poor** and **ill** and **illiterate**.
- **More than 1 billion** people live on **less than \$1 per day**.
- **More than 1 billion** people live on **less than \$2 per day**.
- **More than 1 billion** people live on **less than \$3 per day**.
- **More than 1 billion** people live on **less than \$4 per day**.
- **More than 1 billion** people live on **less than \$5 per day**.
- **More than 1 billion** people live on **less than \$6 per day**.
- **More than 1 billion** people live on **less than \$7 per day**.
- **More than 1 billion** people live on **less than \$8 per day**.
- **More than 1 billion** people live on **less than \$9 per day**.
- **More than 1 billion** people live on **less than \$10 per day**.
- **More than 1 billion** people live on **less than \$11 per day**.
- **More than 1 billion** people live on **less than \$12 per day**.
- **More than 1 billion** people live on **less than \$13 per day**.
- **More than 1 billion** people live on **less than \$14 per day**.
- **More than 1 billion** people live on **less than \$15 per day**.
- **More than 1 billion** people live on **less than \$16 per day**.
- **More than 1 billion** people live on **less than \$17 per day**.
- **More than 1 billion** people live on **less than \$18 per day**.
- **More than 1 billion** people live on **less than \$19 per day**.
- **More than 1 billion** people live on **less than \$20 per day**.

## Hydro-Electric Power Station Design

The allowable distance between the point of generation of power and the point of consumption is therefore limited by the range of economic and safe transmission of the energy. As a result of improving methods and equipment this distance is gradually lengthening. Present practice does not much exceed one hundred miles for this as a maximum figure.

Outside of matters of relative location of market for power and the source of power supply, there are several important points to be considered under the "general problem". First among these arises the question of the ability of the water supply to satisfy the market for power; that is, whether the maximum continuous hydraulic power of the source is sufficient to meet the demands of the market. The assumption is made that the "water rights" for this amount are obtainable. If the amount of hydraulic power thus covered is not sufficient, then the advisability or necessity of

1947-1948

The first part of the report deals with the general situation in the country during the year 1947-1948. It is noted that the country has been through a period of great difficulty and that the people are suffering from a severe shortage of food and clothing. The report also mentions that the government has taken certain measures to deal with the situation, but that these measures have not been sufficient to meet the needs of the population. It is suggested that the government should take more effective steps to improve the situation, such as increasing the production of food and clothing, and reducing the cost of these goods. The report also mentions that the government should take steps to improve the education and health services of the people. The second part of the report deals with the financial situation of the country. It is noted that the government has a large deficit and that the country is heavily indebted to foreign countries. It is suggested that the government should take steps to reduce the deficit and to pay off the foreign debt. The report also mentions that the government should take steps to improve the financial services of the people, such as increasing the number of banks and branches, and reducing the cost of banking services. The third part of the report deals with the social situation of the country. It is noted that the country has a large population and that the people are suffering from a high level of unemployment and poverty. It is suggested that the government should take steps to improve the social services of the people, such as increasing the number of schools and hospitals, and providing more social security services. The report also mentions that the government should take steps to improve the housing conditions of the people, such as increasing the number of houses and improving the quality of the housing. The fourth part of the report deals with the political situation of the country. It is noted that the country has a long history of political instability and that the people are suffering from a lack of political freedom. It is suggested that the government should take steps to improve the political situation of the country, such as increasing the number of political parties and improving the quality of the political process. The report also mentions that the government should take steps to improve the human rights of the people, such as increasing the number of human rights organizations and improving the quality of the human rights services.



## Hydro-Electric Power Station Design

an auxiliary steam plant must be considered. Next comes a consideration of the character of the load. That is, the purpose for which the power is to be used, - whether for lighting, for railway work, for miscellaneous power purposes or for a combination of these. If the latter, then the approximate proportion of each.

All of these points must be reviewed under a general survey of a water power development. For further consideration, the more detailed factors influencing a project must be taken up. These are outlined in what follows.

### The Water Supply.

The very existence of a hydro-electric power generating station depends upon its water supply. Obviously then, the continuity and comparative uniformity of flow of this should be at least reasonably assured.

Power sources for such developments at present are chiefly confined to the fall and flow of

with the same data as those reported in the present study. In addition, the present study was designed to replicate the procedures used in the original study, and to determine whether the results of the original study could be replicated. The results of the present study are consistent with the results of the original study, and provide further evidence for the validity of the procedure used in the original study.

— *Journal of Applied Psychology*

The present study was designed to replicate the procedures used in the original study, and to determine whether the results of the original study could be replicated. The results of the present study are consistent with the results of the original study, and provide further evidence for the validity of the procedure used in the original study.

### References

- [Author's name] (1975) [Title of the original study]. *Journal of Applied Psychology*, 60, 415-421.
- [Author's name] (1976) [Title of the present study]. *Journal of Applied Psychology*, 61, 422-428.

## Hydro-Electric Power Station Design

streams. The two main factors governing these developments are the "head" and the volume. The first quantity represents the difference in elevation between the surface of the water in the supply reservoir and in the tailrace: that is, the difference in height of the water before and after its potential energy has been utilized. This factor is commonly given in "feet". The second quantity is the flow, or volume of water per unit of time which is available for use at the given head. This factor is usually expressed in "second-feet"- an abbreviated expression for "cubic feet per second".

The available head, for any project, is -once it has been decided upon - practically constant. It may be ascertained by means of a careful topographic survey of the stream. On the other hand, however, the second factor - namely the "flow" - is, owing to the variable quantities upon which it depends,- quite likely to be anything but constant. It is this factor which gives rise to most of the difficulties to be met in hydro-electric power sta-

the first of the great principles of the American people.

The first of these principles is the principle of self-government. The American people have always been a self-governing people. They have always been a people who have been able to govern themselves.

The second principle is the principle of freedom. The American people have always been a free people. They have always been a people who have been able to live in freedom. They have always been a people who have been able to enjoy the fruits of freedom.

The third principle is the principle of equality. The American people have always been an equal people. They have always been a people who have been able to live in equality. They have always been a people who have been able to enjoy the fruits of equality.

The fourth principle is the principle of justice. The American people have always been a just people. They have always been a people who have been able to live in justice. They have always been a people who have been able to enjoy the fruits of justice.

The fifth principle is the principle of peace. The American people have always been a peaceful people. They have always been a people who have been able to live in peace. They have always been a people who have been able to enjoy the fruits of peace.

## Hydro-Electric Power Station Design

tion work.

A more careful investigation into the nature of this quantity - "Flow" - will reveal the fact that it <sup>is</sup> liable to change from day to day, season to season and even from year to year. Primarily, it depends upon the size, contour, vegetation and soil of the drainage area of the stream, as well as upon such climatic conditions as rainfall, temperature and barometric pressure. In the calculation of this quantity both the greatest care and the most conservative judgement should be used. Even with these detailed precautions, unusual conditions may arise at times, after the project is completely installed, - conditions of great excess, or the exact opposite, in the water supply. The result being that a large proportion of the investment, possibly the entire amount, will be rendered valueless. Such serious happenings have been known to take place and nothing should be left undone in the way of precaution. Therefore all records that it is possible to obtain of the

1958, p. 123

The effect of aeration on the growth of  
 microorganisms is a well-known fact. It is  
 generally assumed that the rate of growth  
 is increased by the presence of oxygen.  
 However, it is not always true that aeration  
 increases the rate of growth. In some cases,  
 aeration may actually decrease the rate of  
 growth. This is because aeration can lead to  
 the formation of a protective layer on the  
 surface of the liquid, which can prevent  
 further aeration. This layer is composed of  
 organic matter and is often referred to as a  
 "scum" or "film". The presence of this layer  
 can lead to a decrease in the rate of  
 growth because it prevents oxygen from  
 reaching the microorganisms. In addition,  
 aeration can lead to the formation of a  
 protective layer on the surface of the  
 liquid, which can prevent further aeration.  
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 presence of this layer can lead to a  
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 prevents oxygen from reaching the  
 microorganisms.

## Hydro-Electric Power Station Design

flow of the stream in question should be carefully examined and compared, as well as careful attention paid to all of the factors influencing it. The object of such researches throughout, being to obtain as accurately as possible, first - the actual minimum that can be reasonably expected from the stream in point of constant flow, and second, the points of maximum discharge - together with means of conserving the energy of such surpluses of water.

Foremost to be considered is the drainage area. This should be investigated from the source of the stream and its tributaries to its mouth. Area, contour, vegetation, soil and rainfall should be considered. Other factors the same, the larger the area drained, the greater the "run-off" of water. The contour, vegetation and soil manifestly influence such quantities as absorption of rainfall and the evaporation of surface waters - with a subsequent influence exerted on the resulting "run-off". The effect of rainfall on stream flow is positive though not absolute, as it is greatly

## THE PROBLEM OF THE 'POLITICAL' ECONOMY

It is a common mistake to suppose that the 'political' economy is a branch of the social sciences, or that it is a branch of the economic sciences. It is neither. It is a branch of the human sciences, and it is a branch of the human sciences which is concerned with the economic life of man. It is a branch of the human sciences which is concerned with the economic life of man, and it is a branch of the human sciences which is concerned with the economic life of man. It is a branch of the human sciences which is concerned with the economic life of man, and it is a branch of the human sciences which is concerned with the economic life of man. It is a branch of the human sciences which is concerned with the economic life of man, and it is a branch of the human sciences which is concerned with the economic life of man.

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## Hydro-Electric Power Station Design

affected by the above outlined climatic conditions. The dry-weather flow of a stream is not so much influenced by the total annual rainfall as it is by the distribution of such rainfall as occurs throughout the year. In this case, as in all cases of relation of rainfall to stream flow, no absolute and general rule can be formulated, the problem of each watershed being distinctive. However, there are some considerations common to all cases and these will be here briefly taken up.

In the first place, what may be termed the "water year", begins approximately with the month of December and ends approximately with the November following. This is divided into three periods: the first six months constituting the "storage" period, the next three months - the "growing" period, and the remaining three months - the "replenishing" period. During the first period the winter snow and the spring rains saturate the ground to a considerable depth, a large amount of water being held in storage in lakes, swamps and forests as

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well as in the soils, gravels etc. At this time in the year a heavy rainfall finds a quick response in large stream flow, for the saturated ground rejects further water, and the water runs rapidly from the surface. That part of the stored water of this period which lies above the level of the bed of the stream, within the boundaries of its watershed, becomes available for supplying the stream as well as for the purposes of surface evaporation and the sustaining of plant life. These waters will supply a certain part thereof to the stream, regardless of the rainfall, even maintaining a flow in the stream for some months without any rainfall.

During the "growing" period the ground water furnishes practically the entire supply to the flow of the stream, the only additional part coming from an occasional rainstorm. In some cases so depleted does the ground water become by the end of August that even a very heavy rain will make no perceptible difference in the stream flow, the

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## Hydro-Electric Power Station Design

ground absorbing the entire amount of the precipitation.

During September, October and November the ground begins to receive its store of water, and with favorable rainfalls, it becomes saturated during the "storage" period following. The stream flow is a constant drain on this supply, but in addition to this there is a loss of water falling on the watershed due first to evaporation and second that amount taken up by plant life.

Having thus discussed the subject of Drainage Area and the influence of its various components on stream flow, we come to a consideration of the stream itself. No matter what the more or less theoretical factors influencing the stream flow may be, we have finally to deal directly with the actual volume of water flowing in the stream. To measure this quantity there are three general methods, any one of which may be used: the choice, in any case, depending upon local conditions, the degree of accuracy desired, the funds available, and the length

The function  $f(x)$  is continuous at  $x = a$  if and only if the following three conditions are satisfied:

- $f(a)$  is defined.
- $\lim_{x \rightarrow a} f(x)$  exists.
- $\lim_{x \rightarrow a} f(x) = f(a)$ .

If any one of these conditions is not satisfied, then  $f(x)$  is discontinuous at  $x = a$ .

A function  $f(x)$  is continuous on the interval  $[a, b]$  if it is continuous at every point  $x$  in the interval.

The function  $f(x) = \sin x$  is continuous on the interval  $[-\pi/2, \pi/2]$ .

The function  $f(x) = \cos x$  is continuous on the interval  $[-\pi/2, \pi/2]$ .

The function  $f(x) = \tan x$  is discontinuous at  $x = \pm \pi/2$ .

The function  $f(x) = \cot x$  is discontinuous at  $x = 0$  and  $x = \pm \pi$ .

The function  $f(x) = \sec x$  is discontinuous at  $x = \pm \pi/2$ .

The function  $f(x) = \csc x$  is discontinuous at  $x = 0$  and  $x = \pm \pi$ .

The function  $f(x) = \arcsin x$  is continuous on the interval  $[-1, 1]$ .

The function  $f(x) = \arccos x$  is continuous on the interval  $[-1, 1]$ .

The function  $f(x) = \arctan x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \operatorname{arccot} x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \operatorname{arcsec} x$  is discontinuous at  $x = \pm 1$ .

The function  $f(x) = \operatorname{arccsc} x$  is discontinuous at  $x = 0$  and  $x = \pm 1$ .

The function  $f(x) = \sin^{-1} x$  is continuous on the interval  $[-1, 1]$ .

The function  $f(x) = \cos^{-1} x$  is continuous on the interval  $[-1, 1]$ .

The function  $f(x) = \tan^{-1} x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \cot^{-1} x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \sec^{-1} x$  is discontinuous at  $x = \pm 1$ .

The function  $f(x) = \csc^{-1} x$  is discontinuous at  $x = 0$  and  $x = \pm 1$ .

The function  $f(x) = \sinh^{-1} x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \cosh^{-1} x$  is continuous on the interval  $[1, \infty)$ .

The function  $f(x) = \operatorname{arcsinh} x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \operatorname{arccosh} x$  is continuous on the interval  $[1, \infty)$ .

The function  $f(x) = \operatorname{arsinh} x$  is continuous on the interval  $(-\infty, \infty)$ .

The function  $f(x) = \operatorname{arcosh} x$  is continuous on the interval  $[1, \infty)$ .

The function  $f(x) = \operatorname{artanh} x$  is continuous on the interval  $(-1, 1)$ .

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The function  $f(x) = \operatorname{artanh} x$  is continuous on the interval  $(-1, 1)$ .

The function  $f(x) = \operatorname{arcoth} x$  is continuous on the interval  $(-1, 1)$ .

## Hydro-Electric Power Station Design

of time that the record is to be continued.

The first general field method for obtaining the value of stream flow is by measurement of the slope and cross section and the use of Chezy's and Kutter's formulas: the second method is by means of a weir: and, the third by measurement of the velocity of the current and the area of cross section of the stream. Where conditions will permit, the second method offers the best facilities for determining the flow.

The greater the period of time for which this data is available,-- showing past performances of the stream under various conditions of season and climate-- the more accurately can its future probable flow be predicted. As it is with this quantity of "future flow" that the proposed plant will have to reckon, calculations for it should, if possible, be based on data for at least a number of consecutive years previous.

A very convenient way of considering this is

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## Hydro-Electric Power Station Design

to plot, for each year upon which data is available, a curve showing the relation between the time of the year and the flow. The abscissae represent the days of the year, division points locating the different months, and the ordinates - the corresponding flow in "second-feet". A scale of theoretical hydraulic horse power may be marked off on the axis of ordinates, this merely representing a constant times the "second-feet" of flow,- the constant depending upon the "head" and the weight of water. From this scale may be read directly the power possibilities of the stream at any given time. A straight line drawn parallel to the axis of absciss through the lowest point on the curve, will show the maximum power to be realized from the stream throughout the year. If the physical conditions of the channel and banks of the stream will permit of the construction of a properly proportioned dam together with retaining walls (if necessary), then the whole or at least a part of the water represented by the "peaks" on the time-flow curves may be

The first part of the book deals with the early years of the Republic, from the signing of the Constitution in 1787 to the end of the War of 1812. It covers the presidencies of George Washington, John Adams, and James Madison, and the development of the federal government and the states.

The second part of the book covers the period from 1812 to 1848, including the presidencies of James Monroe, James Madison, and James Monroe again. It discusses the War of 1812, the Louisiana Purchase, and the expansion of the United States into the West.

The third part of the book covers the period from 1848 to 1861, including the presidencies of James K. Polk, Zachary Taylor, and Millard Fillmore. It discusses the Mexican-American War, the California Gold Rush, and the growing tensions between the North and the South over the issue of slavery.

The fourth part of the book covers the period from 1861 to 1865, including the presidency of Abraham Lincoln. It discusses the American Civil War, the Emancipation Proclamation, and the Reconstruction era.

The fifth part of the book covers the period from 1865 to 1877, including the presidencies of Andrew Johnson, Ulysses S. Grant, and Rutherford B. Hayes. It discusses the Reconstruction era, the Reconstruction Acts, and the Compromise of 1877.

The sixth part of the book covers the period from 1877 to 1896, including the presidencies of Rutherford B. Hayes, James A. Garfield, and Chester A. Arthur. It discusses the Gilded Age, the Industrial Revolution, and the Populist Movement.

The seventh part of the book covers the period from 1896 to 1913, including the presidencies of William McKinley, Theodore Roosevelt, and Woodrow Wilson. It discusses the Progressive Era, the Spanish-American War, and the beginning of World War I.

The eighth part of the book covers the period from 1913 to 1933, including the presidencies of Woodrow Wilson, Warren G. Harding, and Calvin Coolidge. It discusses the Prohibition era, the Great Depression, and the beginning of World War II.

The ninth part of the book covers the period from 1933 to 1945, including the presidency of Franklin D. Roosevelt. It discusses the New Deal, the United States' entry into World War II, and the end of the war.

The tenth part of the book covers the period from 1945 to 1961, including the presidencies of Dwight D. Eisenhower and John F. Kennedy. It discusses the Cold War, the Korean War, and the beginning of the Space Age.

The eleventh part of the book covers the period from 1961 to 1973, including the presidencies of John F. Kennedy and Lyndon B. Johnson. It discusses the Vietnam War, the Civil Rights Movement, and the Watergate scandal.

The twelfth part of the book covers the period from 1973 to 1981, including the presidencies of Lyndon B. Johnson, Richard Nixon, and Gerald R. Ford. It discusses the Vietnam War, the Watergate scandal, and the end of the Vietnam War.

The thirteenth part of the book covers the period from 1981 to 1993, including the presidencies of Ronald Reagan and George H. W. Bush. It discusses the end of the Cold War, the Gulf War, and the beginning of the Clinton administration.

The fourteenth part of the book covers the period from 1993 to 2001, including the presidency of Bill Clinton. It discusses the end of the Cold War, the Gulf War, and the beginning of the Clinton administration.

The fifteenth part of the book covers the period from 2001 to 2009, including the presidencies of George W. Bush and Barack Obama. It discusses the War on Terror, the 2008 financial crisis, and the beginning of the Obama administration.

## Hydro-Electric Power Station Design

stored up as "pondage", and drawn off at times of "low water", the resulting maximum constant flow being thus increased. The comparison of the time-flow curves for a number of years, on the same stream will show the variation to expect - at least as possibilities- from year to year.

From a proper consideration ,then, of the foregoing points - influencing the water supply of a hydro-electric development - may be obtained a fair calculation of the power to be expected from the source. From this, we are lead to a consideration of the exact location of the plant.

### Exact Location For Plant.

The approximate location of a hydro-electric project being determined by means of the factors of the "General Problem", namely the market for sale of the energy and the source of the water power there remain but a few points which will decide the exact location of the plant.

The question of "water rights" must be settle

The first of these was the "Declaration of Independence" in 1776, which declared the colonies to be free and independent states, no longer subject to British rule. This was followed by the "Constitution of the United States" in 1787, which established the framework of the federal government.

The second major event was the "American Revolution" (1775-1783), a war fought between the thirteen original colonies and the Kingdom of Great Britain. The revolution resulted in the colonies gaining their independence and becoming the United States of America.

The third major event was the "Civil War" (1861-1865), a conflict between the Northern states and the Southern states over the issue of slavery. The war ended with the Union's victory and the abolition of slavery.

The fourth major event was the "World War" (1914-1918), a global conflict that involved most of the world's major powers. The United States entered the war in 1917 and played a significant role in the Allied victory.

The fifth major event was the "Cold War" (1947-1991), a period of geopolitical tension between the United States and the Soviet Union and their respective allies. The war ended with the collapse of the Soviet Union in 1991.

The sixth major event was the "Vietnam War" (1955-1975), a conflict between North Vietnam and South Vietnam, with the United States supporting the South. The war ended with the withdrawal of U.S. forces and the reunification of Vietnam in 1975.

The seventh major event was the "Gulf War" (1990-1991), a conflict between Iraq and a coalition of forces led by the United States. The war ended with the defeat of Iraq and the liberation of Kuwait.

The eighth major event was the "War on Terror" (2001-present), a global conflict initiated by the United States in response to the September 11 attacks. The war has resulted in the deaths of thousands of people and the displacement of millions.

## Hydro-Electric Power Station Design

By this is meant the obtaining from the State of the right to use, for power generating purposes, a certain number of second-feet of water from the stream in question. After this, comes the matter of real estate on which to locate the power house and auxiliary water controlling works. This is, however, usually a minor point as such property is generally some distance from centers of population, and hence its value is comparatively small.

Outside of these considerations, the exact location of the plant should be such as to realize the greatest efficiency from the two controlling factors in any project, namely the "head" and the volume of water. The most available head, considering total fall and the possibilities of back-water, and the arrangement permitting of the most economic use of the volume of the water, considering the desirability or necessity of storage supply - are the two factors to be sought. With this decided we pass to a discussion of the component parts of a

The first part of the book is devoted to a general survey of the history of the United States from the discovery of the continent to the present time. The second part is devoted to a detailed account of the political and social changes which have taken place since the Revolution. The third part is devoted to a description of the geographical features of the United States, and the fourth part to a description of the natural resources of the country.

The author has endeavored to present a clear and concise account of the history of the United States, and to show the causes and effects of the various events which have shaped the nation. He has also endeavored to show the progress of the country from a wilderness to a great and powerful nation, and to show the influence of the various factors which have contributed to its growth and development.

The book is intended for the use of students in schools and colleges, and for the general reader who is interested in the history of the United States. It is written in a simple and straightforward style, and is easy to read and understand.

## Hydro-Electric Power Station Design

hydro-electric power generating project.

### Parts of the Project.

With the exact location of the plant settled, the general lay-out of the auxiliary water controlling works must be determined upon. The devices best adapted to conveying the water from the source of supply to the wheels - form a question, peculiar to each individual case. However, they consist - in general - of a reservoir, either a part of the stream or apart from it; a conducting pipe-line from this to the power house, or in the case of an open penstock type - a forebay; and, a tail-race. In this work, such parts as dams, intakes, penstocks gates and tail-races must be considered, and are here treated of briefly.

#### Dams.

For water-power work, there are two kinds of dams most used - depending upon the material of their construction, the first - the earthen, and the second - the masonry dam. Of these two classes

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## Hydro-Electric Power Station Design

the failures of earthen dams have been the most numerous, the cause being either that there was not the proper length of spillway, or that the outlet pipes were not properly laid in the dam. The requirements for stability of any dam are, that it be strong enough to withstand the pressure of all water that it holds back, that it withstand leaks, and that it afford proper spillways and sluice-gates.

In the construction of an earthen dam, three things must be considered: first, the conditions must be such that the maximum flood that has ever occurred at the site can be taken care of during the building of the dam; second - the water must never top the embankment of the dam, - it being either led around the end of the dam or through some new channel; third - the proper soil should be used in the construction of the dam. If conditions are such that the flood waters likely to arise cannot be carried around the end of the dam during its construction, then the earthen dam should never be

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## Hydro-Electric Power Station Design

used.

Any soil used in the construction of an earthen dam should be tested for quicksand, and if any traces are found the soil should be discarded. Soils having an angle of repose of less than twenty degrees when placed in water should not be used. The best soils for use are those containing enough clay to give the required water-tightness and binding quality,- too much of this ingredient should be avoided as it swells on becoming wet and shrinks on drying. If, during the construction the materials are dampened, cracks and leaks are less liable to occur. If the material at hand is of different grades, the best should be placed on the upstream side, gradually changing to the more porous toward the center of the construction.

The profile of an earthen dam will depend upon the height of the dam. The slopes will depend upon the angle of repose of the material used, it being usual to make the inner or upstream side



## Hydro-Electric Power Station Design

flatter than the outer or downstream side, as earth when wet has a flatter slope than when dry.

Where a masonry dam is constructed more attention must be paid to the foundation than is necessary in the case of an earthen dam as any settling of the masonry will cause cracks. With high masonry dams the foundations are usually made of solid rock. The superiority of the masonry over the earthen dam lies in the facts that it can be made more durable, can be more precisely designed, and better protected from flood waters, owing to the safer construction it offers for the laying of the outlet pipes. For all dams of any height, masonry construction is to be preferred.

The shape of a masonry dam will depend upon the head of water for which it is designed, for low dams the cross-sectional shape usually being trapezoidal, but for high heads the sides are usually curved for the purpose of saving material.

The reinforced concrete dam has some advantage

The first thing I noticed when I stepped out of the car was the smell of fresh air and the sound of birds chirping in the trees. It felt like I had stepped into a different world, one where the sun was shining brightly and the sky was a clear, vibrant blue. The trees were tall and lush, their leaves a deep green color that seemed to glow in the sunlight. I took a deep breath and felt a sense of peace and tranquility wash over me. It was a beautiful day, and I was finally where I needed to be.

I walked down the path, my feet crunching on the soft earth. The air was warm and fragrant with the scent of flowers and the earth. I saw a small stream flowing through the forest, its water clear and sparkling. The sound of the water was soothing and calming. I sat on the bank and watched the fish jump and play. It was a peaceful scene, and I felt like I had found a hidden gem.

The sun was low in the sky, casting a golden glow over the forest. The trees were silhouetted against the bright light, and the air was filled with the sound of crickets and the rustling of leaves. I felt a sense of awe and wonder, as if I had discovered a secret world. The beauty of nature was overwhelming, and I felt like I had found a place where I could truly relax and enjoy the simple pleasures of life.

I stood up and looked out over the forest. The trees were tall and majestic, their branches reaching towards the sky. The air was fresh and clean, and the sound of the birds was a beautiful melody. I felt a sense of peace and tranquility wash over me, and I knew that this was a special moment. I had found a place where I could truly relax and enjoy the simple pleasures of life.

The sun had set, and the forest was bathed in the soft light of twilight. The trees were dark and mysterious, and the air was filled with the sound of crickets and the rustling of leaves. I felt a sense of awe and wonder, as if I had discovered a secret world. The beauty of nature was overwhelming, and I felt like I had found a place where I could truly relax and enjoy the simple pleasures of life.

## Hydro-Electric Power Station Design

that the masonry dam does not possess. It can be made more stable than a masonry dam of the same dimensions. The materials can be distributed to better advantage and therefore there will be a saving in cost. The interior of the dam can be inspected, it can be constructed more rapidly and does not require such good foundations as do masonry dams. In many cases where a reinforced concrete dam is constructed the power house is built into the dam, thus greatly reducing the cost of the project.

One factor in the building of concrete and masonry dams which does not affect the earthen dam is the effect of ice. In countries having cold winters the expansion of ice is liable to be great enough to rupture the dam, masonry more so than concrete.

"Intakes" lead from the dam, being either submerged or at the level of the water. The flow through them being controlled by gates which are either machine or manually operated.





## Hydro-Electric Power Station Design

### Penstocks.

The cheapest form of penstock is the circular wooden stave penstock. The staves should be as free from knots as possible and should be smoothed on the inside in order to reduce friction and get the maximum efficiency. Where the stave penstock is installed it is common to have all bends and curves in the line of steel pipe, unless the curve be of large radius. Iron hoops or bands are used to hold the staves in place, their spacing depending upon the initial tension, the water pressure, and the swelling of the wood.

Steel penstocks are especially adapted to long pipe lines, as often, in such lines, abnormal pressures are developed due to the sudden shutting-off of the water from the turbines. In order to regulate this pressure, a small reservoir is constructed at the outlet of the penstock, the size of this reservoir depending upon the time it takes to close the turbine gates. In place of the reservoir

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## Hydro-Electric Power Station Design

a steel standpipe is sometimes used, the water running over the top of the standpipe if the gates be closed too suddenly. If the fall of the pipeline be too great for standpipes, safety valves are placed along the line of the penstock. The life of a steel penstock is sometimes very short due to the rusting of the steel, though this action may be greatly reduced by treating the penstock with hot asphaltum. At the entrance to penstocks, racks should be so placed as to collect all floating objects and not allow them to pass into the pipe. In cases of ice formation these racks may become clogged if the ice is not removed on forming. A large, deep forebay will remedy this trouble, as the water, being quiet here, will freeze over at the beginning of cold weather. Then such anchor ice, as may come into the forebay, will rise to this layer of ice, while the warmer water will circulate below. If the intake to the penstocks be so located as to receive this water, there will be little trouble from ice at the racks.

The first of these is the fact that the population of the country has increased in a very rapid manner since 1890. This is due to the fact that the country is rich in natural resources, and the people are very industrious and enterprising. The second fact is that the country is very fertile, and the soil is very rich. This is due to the fact that the country is situated in a very fertile region, and the soil is very rich. The third fact is that the country is very rich in minerals, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The fourth fact is that the country is very rich in timber, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The fifth fact is that the country is very rich in land, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The sixth fact is that the country is very rich in water, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The seventh fact is that the country is very rich in air, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The eighth fact is that the country is very rich in fire, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The ninth fact is that the country is very rich in earth, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising. The tenth fact is that the country is very rich in metal, and the people are very enterprising. This is due to the fact that the country is situated in a very rich region, and the people are very enterprising.

## Hydro-Electric Power Station Design

### Tail-race.

This should be deep as it is necessary to have dead water in the race before the wheels are started. As soon as water is discharged from the wheels this will take the place of dead water and thus there will be no resulting loss of head. It is usually necessary to place the wheels at some height above the tail-race, the water after leaving the wheel passing through a draft tube. This draft tube should be air tight and submerged - at its lower end - in the water of the tail-race to prevent any loss in head.

### Power House Equipment.

#### Water Wheels.

These may at once be divided into two classes - impulse wheels and turbines. The former is typified by the Pelton Company's wheel, in which the velocity of a jet of water impinging tangentially upon a disc, carrying buckets around its periphery, transmits to the buckets a part of its velocity.

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## Hydro-Electric Power Station Design

It can be shown that the efficiency of the transformation is a maximum when the velocity of the moving buckets is one half that of the jet, so that if  $H$  is the effective head of the source, for maximum efficiency, the peripheral velocity of the wheel is related to the head by the expression:

$$V' = .5 \sqrt{g H}$$

and the head being assumed invariable, it is seen that for a certain definite speed (imposed by the frequency of the generator), the only variable is the diameter of the wheel and this may be adjusted within certain limits, to conform to the relation above. Thus direct connection of the generator to the source of power is possible, which eliminates the losses in transmission through gearing and the noise incident to its use.

These wheels require that there be sufficient distance between the wheel and the highest point of backwater, to allow for the discharge of the spent water from the buckets of the apparatus, and for

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## Hydro-Electric Power Station Design

a variable height of back water at different seasons of the year, this involves a serious loss of head. Also, since the action of the machine depend upon the velocity of the jet, which in turn depends on the square root of the head, the Pelton wheel is only available with any great efficiency when the head is great, i. e. above three hundred feet. In general, then, its use should not be considered with heads less than this.

Water turbines are available for the lower heads, since they do not depend entirely upon the velocity for the necessary kinetic energy - the large mass of water obtained may reduce the necessary velocity. These machines are typified by the products of the James Leffel Co., the S. Morgan Smi Co. and many others. Under favorable conditions they give an efficiency of from eighty to eighty-two percent, and may be obtained in the horizontal or verticle form. The verticle type, on account of the reduced friction losses caused by the lesse ed friction in the bearings, gives an efficiency

## QUESTIONNAIRE ON COMMUNITY PARTICIPATION

1. How long has your group been working in your area?
2. How many people are there in your group?
3. How long has your group been working in the area you are working in?
4. How long have you been working in the area you are working in?
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## Hydro-Electric Power Station Design

about three per cent higher than the horizontal type, exclusive of gearing, but due to the fact that gearing is necessary to change the direction of motion, involving a loss of about ten percent, the actual net efficiency is reduced approximately seven percent unless the generators are of the vertical type also. Horizontal wheels are favored because they permit the use of several units on one shaft, and if this number is even, the unbalance of pressure caused by one unit is taken up by the next so that the friction loss is diminished. In order that vertical units may actuate one shaft, this shaft must be horizontal to conform to practical conditions and the use of vertical generators as was noted above, is precluded, and there is also introduced the loss due to the gearing which must be installed.

In choice of prime movers it is therefore necessary to consider:—

1. The available head, which will determine practically the availability of Pelton or turbine

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## Hydro-Electric Power Station Design

wheels by the condition that for heads above three hundred feet the Pelton wheel is to be preferred, for heads less than two hundred feet, the turbine, and for intermediate heads, either one indifferently.

2. The type and speed of the units and their capacity, since for generators of large size it may be necessary to install several units on one shaft, which involves the difficulty mentioned above, and the <sup>1</sup>restrictions that limit the generators of the horizontal type.

3. In addition to these conditions, which must hold generally, others are imposed when the head is not constant, that is, when the backwater is variable. In this case the velocity of the wheels will not be constant, and since the generators are practically constructed to operate at a constant frequency, this variation could not be allowed, even if the field rheostat of the machine were capable of taking up the increase or decrease of pressure <sup>a</sup>at the terminals. Also, since a decrease in speed will decrease the output, it would be necessary,

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## Hydro-Electric Power Station Design

even in the above case, to install a greater capacity than would be required at the normal full-load speed and the disadvantages noted would still be present.

In this case it is necessary to install another wheel is geared with a higher ratio to the line shafting so that when the head is decreased this wheel may be thrown in with the other one, their speed then being a mean between the two and the decrease in output of the first being supplied by the second. If the variations in head are very wide, it may be necessary to install several of these additional wheels and allow them to run idle during the normal operation of the plant. This extra installation of course involves a higher first cost and is to be avoided if possible.

In the choice of the number of units there should be considered the over load capacity of the units so that when one is disabled or shut down the remainder of the plant may carry the load without exceeding the allowable overload rating of each

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## Hydro-Electric Power Station Design

unit. It is common practice to decide on this rating as 88%, and it then follows that four units are necessary since one may then be cut out and the rest can carry 33% overload and maintain the normal output of the plant.

**Generators:**— The first classification of generators is into the direct and alternating current machines, and the choice is determined by the character of the load and the transmission distance. We assume that this distance is not short enough to warrant the use of direct current, and proceed to consider the features which determine the choice of alternators. The problem for direct current transmission is much simpler, and may be solved by neglecting the factor of frequency.

The conditions determining the frequency are the character of the load and the transmission; for example if the power is to be supplied to synchronous converters the frequency should not exceed forty cycles, and to conform to the apparatus already in stock in the manufacturing concerns, this figure should probably be chosen at twenty-five.

## THE POLYMERIZATION OF VINYL MONOMERS

The polymerization of vinyl monomers is a process in which the monomers react to form a polymer chain. This reaction is initiated by a free radical, which then propagates the chain by adding more monomers. The rate of polymerization is dependent on the concentration of the monomers and the initiator, and is also affected by the presence of inhibitors and chain transfer agents.

The general reaction for the polymerization of a vinyl monomer can be represented as follows:

$$n \text{ CH}_2=\text{CH}-\text{R} \xrightarrow{\text{I}^\bullet} \text{-(CH}_2-\text{CH(R))}_n\text{-}$$

where  $\text{CH}_2=\text{CH}-\text{R}$  is the vinyl monomer,  $\text{I}^\bullet$  is the initiator radical, and  $\text{-(CH}_2-\text{CH(R))}_n\text{-}$  is the polymer chain.

The mechanism of the polymerization reaction involves three main steps: initiation, propagation, and termination. In the initiation step, the initiator radical reacts with the monomer to form a radical intermediate. In the propagation step, this intermediate reacts with more monomers to grow the chain. In the termination step, two radical chains react to form a stable, non-radical product.

The rate of polymerization is given by the following equation:

$$R_p = k_p \frac{[M] [I]^{1/2}}{k_t^{1/2}}$$

where  $R_p$  is the rate of polymerization,  $[M]$  is the concentration of the monomer,  $[I]$  is the concentration of the initiator,  $k_p$  is the propagation rate constant, and  $k_t$  is the termination rate constant.

The degree of polymerization (DP) is a measure of the average number of monomers in a polymer chain. It is given by the following equation:

$$\text{DP} = \frac{[M]_0}{[I]_0}$$

where  $[M]_0$  is the initial concentration of the monomer and  $[I]_0$  is the initial concentration of the initiator.

The molecular weight of the polymer is also an important property. It is related to the degree of polymerization by the following equation:

$$M_w = \text{DP} \times M_0$$

where  $M_w$  is the molecular weight of the polymer and  $M_0$  is the molecular weight of the monomer.

The polymerization of vinyl monomers is a complex process that involves many factors. Understanding the mechanism and kinetics of this reaction is essential for the design and optimization of polymerization processes.

## Hydro-Electric Power Station Design

This is also suitable for transmission and power service, but has the disadvantage that incandescent lamps do not operate well at this frequency so that if the lighting load is not concentrated in cities where it may be supplied by synchronous converters it may be necessary to install frequency changers. At sixty cycles this difficulty would be avoided, but converters do not operate at this frequency with any great stability, and the conditions of constancy of service demand that the substation operation be as nearly perfect as possible.

If it is found desirable to use this higher frequency, induction motor-driven generators may be installed for the conversion to direct current, but this eliminates the possibility of compensation for lagging current in the line, and this difficulty may be of considerable magnitude if the line is to supply power to induction motors along the right of way.

A careful consideration of the load to be supplied will therefore be necessary in order to determine the frequency at which the current is to be supplied.



## Hydro-Electric Power Station Design

The voltage to be generated by the machines is of little importance if it is to be stepped up for transmission, so that this fact must be determined. The highest voltage at which it is practicable to generate is about 11,000. In deciding upon the transmission voltage it is common practice to figure roughly upon a thousand volts per mile within the limits of safety, which is set at 80,000 volts in this country. We therefore decide that if the distance to which power is to be transmitted exceeds ten or fifteen miles it will be desirable to step up the pressure and generate at such a potential that the insulation of the machines will not be in danger nor will the armature be forced to carry excessive current.

It having been decided in the preliminary investigation what will be the capacity of the plant, the next step is the division of units. The same conditions which govern the number of prime movers apply here and we may state that there should be at least four units, a greater number being of course necessary when the output of the plant is so great



## Hydro-Electric Power Station Design

that four units of the largest commercial size will not carry the load.

We now have the frequency and capacity of the generators and desire to know the speed at which they will operate. This speed is limited to certain definite values by the limitation to constant frequency so that the r.p.m. must satisfy the relation:

$$60 f / p = n$$

where  $p$  is the number of pairs of poles and  $f$  the frequency. From this relation the following table may be made showing the number of poles for each speed to give the desired frequency and the catalogs of the manufacturers may then be consulted to determine the machine to use. Before settling upon a unit the peripheral velocity of the rotating parts should be calculated in order to ascertain if this value is too high for the safe operation of the machine. If this is the case it will be necessary to choose a machine with a greater number of poles and a slower speed.

The Board of Directors has the honor to acknowledge the receipt of your letter of the 10th inst. and in reply to inform you that the same has been forwarded to the proper authorities for their consideration.

Very respectfully,  
The Board of Directors

The Board of Directors has the honor to acknowledge the receipt of your letter of the 10th inst. and in reply to inform you that the same has been forwarded to the proper authorities for their consideration. The Board of Directors has the honor to acknowledge the receipt of your letter of the 10th inst. and in reply to inform you that the same has been forwarded to the proper authorities for their consideration.

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## Hydro-Electric Power Station Design.

The generators should if possible be direct-connected to the prime movers to eliminate any friction losses in the transmission and this fact necessitates a consideration of the speed of the wheels. This speed is determined by the effective head, and in the case of the Pelton wheel it was shown that the diameter of the wheel could be varied within certain limits to compensate for any disagreement between these two speeds. In the case of the turbine, however, this compensation is not always possible, although the manufacturers have in stock a great variety of wheels which will generally give the desired relation. If this cannot be obtained it will be necessary to gear the wheels and the generator can then be made to run at any speed, the desired frequency being obtained by the ratio of the gears.

**Exciters:**—From two to three percent of the output of the plant is required for the excitation of the units, so that this much must be added for

The following information is provided for the purpose of  
 illustrating the various types of projects which have been  
 carried out during the year. It is not intended to provide a  
 complete list of all projects which have been carried out.  
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## Hydro-Electric Power Station Design.

the gross output of the plant if the initial calculations are sufficiently close to warrant consideration of quantities of this magnitude. The exciter plant is the weak link in the system and great care must be exercised in the installation of the units. Several facts may be noted in this connection.

1. There should be two independent sources of excitation which may be readily interchanged so that in the event of one becoming disabled the operation of the system may not be suspended for any considerable period.

2. The prime movers or other apparatus driving the exciters should also be independent and capable of operating in parallel so that in the event of the failure of one system the other may be automatically thrown into service without the delay incident to the manual operation of the necessary switches. By this is meant that the exciters should be provided with reverse current

The Board of Directors has the honor to acknowledge the cooperation and assistance of the various departments of the company in the preparation of this report. The Board is particularly indebted to the various departments for their cooperation in the preparation of this report. The Board is particularly indebted to the various departments for their cooperation in the preparation of this report.

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## Hydro-Electric Power Station Design.

relays so that in case one of the prime movers fails and the generator thereby becomes motorized the other may pick up the load while the first is automatically cut off from the exciter bus. This means that each system must be capable of carrying all the excitation necessary for the plant at any time, and since the breakdown of apparatus usually occurs at times of heaviest load, this consideration is of fundamental importance. In water-power stations the sources of power may be water-driven wheels for the operation of one system and motors for the other. In this case the motor-driven apparatus must be kept constantly in operation, since if this were not the case the failure of the water-driven exciters would disable the plant. At times of light load, however, it will be safe to operate the plant with but one set of exciters, since the possibility of the break-down of apparatus is slight and more is to be feared from the mistakes of the



## Hydro-Electric Power Station Design

operators than from faults of the machines.

**Transformers:**—It having been decided that there will be a definite number of phases—usually three—and the transmission voltage being known, the transformer problem becomes simply a choice between the adoption of three single-phase transformers connected up to give the desired relation of e.m.f.'s or one three-phase transformer for each unit. The conditions influencing the choice are as follows:

1. The distance from the nearest shipping point to the power station—this enters in because of the fact that large transformers are more difficult to handle than small ones, and if, as is usually the case, the power house is located in a mountainous country, the smaller units would probably be chosen, since the cost of transportation will overbalance any saving in first cost.

2. The facilities for the handling of the apparatus at the power station, such as cranes, labor, etc. The use of the larger units of course

The first part of the report deals with the  
 general situation in the country and the  
 progress of the work in the various  
 departments. It is followed by a  
 detailed account of the work done in  
 the different departments during the  
 year. The report concludes with a  
 summary of the work done and a  
 list of the names of the persons  
 who have been engaged in the work.

The second part of the report deals with  
 the work done in the different  
 departments during the year. It is  
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## Hydro-Electric Power Station Design

makes necessary a larger crane.

3. The necessity for a spare unit. In the case of three single phase units the connection may be so made that any one of the transformers in the station may be disconnected if injured and the spare put in its place by means of air-break disconnecting switches. If three units are employed a three phase unit may be used as a spare and the increased cost would make an installation of the single phase units desirable. This consideration vanishes when the size of the station is great or the units numerous, since the additional complication of circuits due to the installation of disconnecting switches more than balances the extra cost of the three phase unit.

4. If one of the single phase units becomes burned out it may be removed, but in the other case the whole transformer will need to be removed unless it is connected delta and allowed to operate with a V-connection at 58% of its former output.

The first of these is the fact that the United States is a young nation, and its history is still in the making. The second is the fact that the United States is a large nation, and its history is still in the making. The third is the fact that the United States is a diverse nation, and its history is still in the making. The fourth is the fact that the United States is a free nation, and its history is still in the making. The fifth is the fact that the United States is a democratic nation, and its history is still in the making. The sixth is the fact that the United States is a constitutional nation, and its history is still in the making. The seventh is the fact that the United States is a federal nation, and its history is still in the making. The eighth is the fact that the United States is a republic, and its history is still in the making. The ninth is the fact that the United States is a nation of immigrants, and its history is still in the making. The tenth is the fact that the United States is a nation of pioneers, and its history is still in the making. The eleventh is the fact that the United States is a nation of explorers, and its history is still in the making. The twelfth is the fact that the United States is a nation of discoverers, and its history is still in the making. The thirteenth is the fact that the United States is a nation of inventors, and its history is still in the making. The fourteenth is the fact that the United States is a nation of innovators, and its history is still in the making. The fifteenth is the fact that the United States is a nation of leaders, and its history is still in the making. The sixteenth is the fact that the United States is a nation of visionaries, and its history is still in the making. The seventeenth is the fact that the United States is a nation of dreamers, and its history is still in the making. The eighteenth is the fact that the United States is a nation of doers, and its history is still in the making. The nineteenth is the fact that the United States is a nation of achievers, and its history is still in the making. The twentieth is the fact that the United States is a nation of heroes, and its history is still in the making.

## Hydro-Electric Power Station Design

The large units are in general desirable if the objections mentioned above do not operate, for they are more compact, all the coils in one case and the installation is less complicated, also the first cost is less. A disadvantage is, that since the surface of a transformer and its output do not vary uniformly, but the surface less rapidly, the cooling of the larger sizes will be a more serious problem. This however may be accomplished quite readily by the use of fans for circulating the air through the coils.

Instruments and Wiring:— These switchboards may be separated into two parts, the exciter board and the mainboard, and these may be concentrated in one position or separated, according to the size of the station. When the size is sufficient to warrant the constant attention of two operators, the exciter board may be isolated and located near the exciter units, the other being placed in a gallery. When this arrangement is adopted one operator may take charge of the exciter board and look after the units on the main floor while the

The following is a list of the names of the persons who have been appointed to the various offices of the Board of Directors of the Corporation for the year ending December 31, 1920.

The names of the persons who have been appointed to the offices of President, Vice-President, Secretary, Treasurer, and the members of the Board of Directors are as follows:

President: [Name]  
Vice-President: [Name]  
Secretary: [Name]  
Treasurer: [Name]

The members of the Board of Directors are: [List of names]

## Hydro-Electric Power Station Design

other confines his attention entirely to the operation of the lines and units. Where the plant is used to supply a large number of lines it is preferable to have the oil switches located in a room by themselves with an attendant there to unlock them, preparatory to their closing, at a signal from the operator in the gallery. This eliminates the danger of closing a dead machine on the line or other machine by mistake.

This segregating of switchboards and switches makes a more expensive construction and where the first cost is an item, or where the plant is small, the switchboards should be concentrated. In hydro-electric plants, where the lines are in general long ones, and this fact precludes the possibility of a large number of them, the operation of the lines will not be necessary more than perhaps once a day, so that the above mentioned precautions need not be taken in their operation.

The following instruments should be located on the main switchboard: For each generator panel,

1948 - 1949 - 1950 - 1951 - 1952 - 1953 - 1954 - 1955 - 1956 - 1957 - 1958 - 1959 - 1960 - 1961 - 1962 - 1963 - 1964 - 1965 - 1966 - 1967 - 1968 - 1969 - 1970 - 1971 - 1972 - 1973 - 1974 - 1975 - 1976 - 1977 - 1978 - 1979 - 1980 - 1981 - 1982 - 1983 - 1984 - 1985 - 1986 - 1987 - 1988 - 1989 - 1990 - 1991 - 1992 - 1993 - 1994 - 1995 - 1996 - 1997 - 1998 - 1999 - 2000 - 2001 - 2002 - 2003 - 2004 - 2005 - 2006 - 2007 - 2008 - 2009 - 2010 - 2011 - 2012 - 2013 - 2014 - 2015 - 2016 - 2017 - 2018 - 2019 - 2020 - 2021 - 2022 - 2023 - 2024 - 2025

## Hydro-Electric Power Station Design

three ammeters, three indicating wattmeters, one voltmeter with selector switch for each phase, one integrating wattmeter, and one field ammeter.

The switches and auxiliary apparatus should comprise: An oil switch control for throwing the machine to H.T. bus, generator field switches, and a field rheostat control. The field switches should be equipped with a clip for short-circuiting the generator fields through a resistance when the switch is opened, thus avoiding the introduction of stresses into the windings by the induction of a high potential at that time.

The exciter equipment should consist of an ammeter and voltmeter for each unit, switches for throwing the exciter to the exciter bus, field rheostats for the voltage regulation, and the necessary equipment for the operation of the prime mover. If this is a motor there should be an integrating wattmeter to register the power consumed in excitation. Equalizers should also be installed if the exciters are compound wound and designed to operate in parallel.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial reporting and compliance with regulatory requirements.

2. The second section outlines the various methods and tools used to collect, store, and analyze data. This includes the use of spreadsheets, databases, and specialized software applications designed for data management and analysis. The text highlights the need for consistent data entry and regular backups to ensure the integrity and availability of the information.

3. The third part of the document focuses on the analysis and interpretation of the collected data. It describes various statistical techniques and analytical models used to identify trends, patterns, and correlations within the data. The goal is to derive meaningful insights that can inform decision-making and strategic planning.

4. The final section discusses the reporting and communication of the findings. It emphasizes the importance of presenting the data in a clear, concise, and visually appealing manner. This involves the use of charts, graphs, and tables to effectively convey complex information to stakeholders. The text also stresses the need for transparency in reporting and the inclusion of relevant context and conclusions.



## Hydro-Electric Power Station Design

On the high tension side there should be overload relays on each phase, actuated from series transformers and esigned to open the generator switch at any desired overload and after any desired interval. These should be of the bellows type.

In the station some kind of frequencylimiting device is necessary to trip out the machines should they have a tendency to race beyond control. This may be of the inductive balance type or purely mechanical, and a common practice is to design the instrument so that it will operate at a frequency ten percent above normal. This values seems somewhat low for isolated plants, and fifteen percent would appear to be better.

Governors actuated by an electrical connection with the load ammeters have been suggested in order to eliminate the time necessary for the system to change in speed, but the idea has not as yet been tried, and seems not to fand favor with the designers of these plants.

the year 1790, the population of the county was 1,100,000.

The population of the county in the year 1800 was 1,200,000. In the year 1810 it was 1,300,000. In the year 1820 it was 1,400,000. In the year 1830 it was 1,500,000. In the year 1840 it was 1,600,000. In the year 1850 it was 1,700,000. In the year 1860 it was 1,800,000. In the year 1870 it was 1,900,000. In the year 1880 it was 2,000,000. In the year 1890 it was 2,100,000. In the year 1900 it was 2,200,000.

The population of the county in the year 1910 was 2,300,000. In the year 1920 it was 2,400,000. In the year 1930 it was 2,500,000. In the year 1940 it was 2,600,000. In the year 1950 it was 2,700,000. In the year 1960 it was 2,800,000. In the year 1970 it was 2,900,000. In the year 1980 it was 3,000,000. In the year 1990 it was 3,100,000. In the year 2000 it was 3,200,000.

The population of the county in the year 2010 was 3,300,000. In the year 2020 it was 3,400,000. In the year 2030 it was 3,500,000. In the year 2040 it was 3,600,000. In the year 2050 it was 3,700,000. In the year 2060 it was 3,800,000. In the year 2070 it was 3,900,000. In the year 2080 it was 4,000,000. In the year 2090 it was 4,100,000. In the year 2100 it was 4,200,000.

The population of the county in the year 2110 was 4,300,000. In the year 2120 it was 4,400,000. In the year 2130 it was 4,500,000. In the year 2140 it was 4,600,000. In the year 2150 it was 4,700,000. In the year 2160 it was 4,800,000. In the year 2170 it was 4,900,000. In the year 2180 it was 5,000,000. In the year 2190 it was 5,100,000. In the year 2200 it was 5,200,000.

The population of the county in the year 2210 was 5,300,000. In the year 2220 it was 5,400,000. In the year 2230 it was 5,500,000. In the year 2240 it was 5,600,000. In the year 2250 it was 5,700,000. In the year 2260 it was 5,800,000. In the year 2270 it was 5,900,000. In the year 2280 it was 6,000,000. In the year 2290 it was 6,100,000. In the year 2300 it was 6,200,000.

The population of the county in the year 2310 was 6,300,000. In the year 2320 it was 6,400,000. In the year 2330 it was 6,500,000. In the year 2340 it was 6,600,000. In the year 2350 it was 6,700,000. In the year 2360 it was 6,800,000. In the year 2370 it was 6,900,000. In the year 2380 it was 7,000,000. In the year 2390 it was 7,100,000. In the year 2400 it was 7,200,000.

The population of the county in the year 2410 was 7,300,000. In the year 2420 it was 7,400,000. In the year 2430 it was 7,500,000. In the year 2440 it was 7,600,000. In the year 2450 it was 7,700,000. In the year 2460 it was 7,800,000. In the year 2470 it was 7,900,000. In the year 2480 it was 8,000,000. In the year 2490 it was 8,100,000. In the year 2500 it was 8,200,000.

The population of the county in the year 2510 was 8,300,000. In the year 2520 it was 8,400,000. In the year 2530 it was 8,500,000. In the year 2540 it was 8,600,000. In the year 2550 it was 8,700,000. In the year 2560 it was 8,800,000. In the year 2570 it was 8,900,000. In the year 2580 it was 9,000,000. In the year 2590 it was 9,100,000. In the year 2600 it was 9,200,000.

The population of the county in the year 2610 was 9,300,000. In the year 2620 it was 9,400,000. In the year 2630 it was 9,500,000. In the year 2640 it was 9,600,000. In the year 2650 it was 9,700,000. In the year 2660 it was 9,800,000. In the year 2670 it was 9,900,000. In the year 2680 it was 10,000,000. In the year 2690 it was 10,100,000. In the year 2700 it was 10,200,000.

Part II.

Design for Proposed Hydro-  
Electric Power Generating Station,  
Malad River, Idaho.

## QUESTION

1. The following is a list of 100 numbers:

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## Hydro-Electric Plant,- Malad River, Idaho

### Introduction.

In undertaking the actual design of a hydro-electric power plant, it was desired to have as near working conditions as possible. The selection of the location on the Malad River, Idaho was made after data had been secured which gave the exact conditions that existed at this point.

### The General Problem.

The source of the power for the proposed plant is from the Malad River - a tributary of the Snake River: the two meeting in the western part of Lincoln county, which is located in the south-central part of the state of Idaho.

The present market for power from this source is that offered by the city of Boise - for light and power- a hundred miles distant: the town of Glens Ferry - principally for light - thirty miles distant: and locally, within a radius of from five to ten miles - for irrigation pumping purposes. A possible future market consists in certain rail-

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## Hydro-Electric Plant,- Malad River, Idaho

road electrifications that have been proposed in the vicinity.

No continuous record is available on the flow of the Malad River, but from such readings as have been taken of this quantity, it is evident that there is a uniform volume of water in the stream highly sufficient to carry a plant of 4800 kw. - such as is here proposed. This allows for the diversion of small quantities of water for irrigation purposes, these being protected by existing water rights.

### The Water Supply.

The Malad River is supposed to be the outlet for both the Big Wood and the Little Wood Rivers. These latter rise on the southern slopes of the Tetan Mountains which form a water shed extending along the northern boundary of Blaine county, Idaho. From here the rivers flow southward, fed by numerous smaller streams,- a distance of some hundred and fifty miles. At this point they join, disappearing

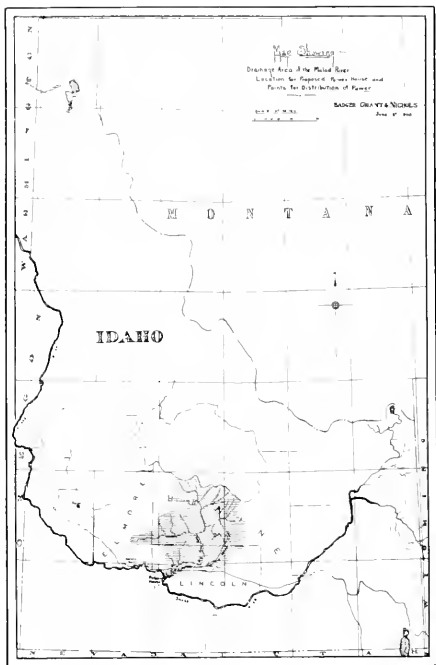
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## Hydro-Electric Plant,- Malad River, Idaho

from the surface of the earth. Ten miles farther on the Malad River rises - being the accumulated waters of thousands of springs. The theory being that the two rivers - the Big Wood and the Little Wood - after leaving the surface, traverse a subterranean passage which terminates under the springs which form the nucleus of the Malad River. The water of the Malad is a constant in temperature almost throughout the entire year, this being at about 60° Fh. The course of the stream, from the springs that form its source, lies through a box canyon about three miles in length - to the south west, where the Malad empties its waters into the Snake River.

The drainage area of the Big Wood and Little Wood Rivers constitutes what is known as the "Big Camas Prairie", which lies chiefly in Blaine and Lincoln counties. The rainfall over this area is fairly uniform in its distribution. The walls of the box canyon through which the Malad flows are composed of lava and basalt rock. For a short dis-

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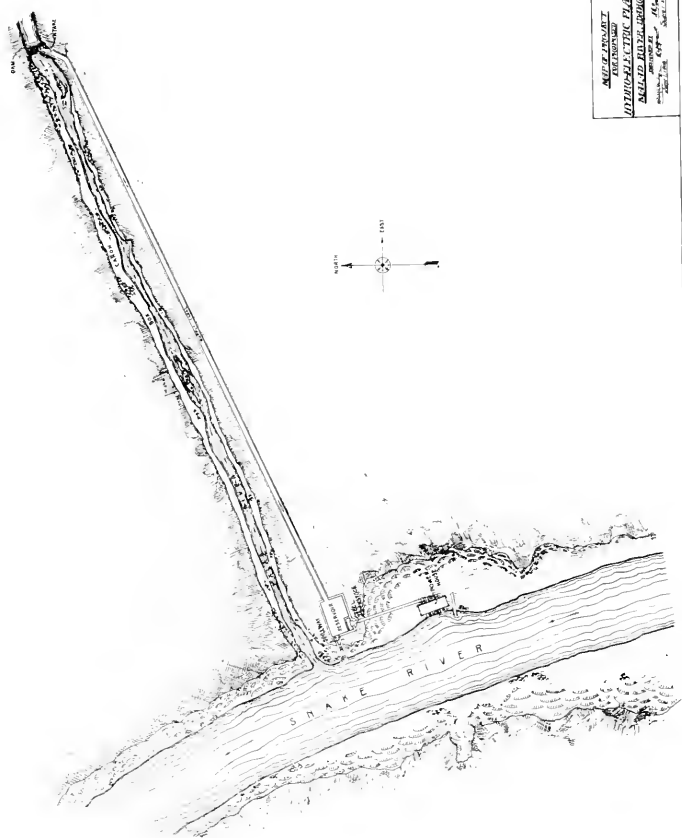
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SCALE: AS SHOWN  
UNITED STATES PATENT  
SNAKE RIVER CANAL  
DESIGNED BY THE U.S. ARMY  
March 1885



## Hydro-Electric Plant,- Malad River, Idaho

tance its banks are covered with volcanic dust over which there is a sparse growth of sage brush.

### The General Lay-out.

A reference to the "Map of Project", shown in the second illustration, will give an idea of the general lay-out as designed. At a point, a mile and a quarter from its junction with the Snake River, a dam is to be constructed across the Malad. An intake located here leads into an open channel through which the water is conveyed to a reservoir, from which it falls to the power house through a circular steel penstock. A spillway is located at the reservoir - for discharge into the Snake River direct. A controlling gate is located at the head of the penstock.

### Power House.

The power house is to be located on the bank of the Snake River. In construction it is to be two stories in height, of concrete throughout. The foundations consist of layers of concrete resting





## Hydro-Electric Plant,- Malad River, Idaho

on bed rock.

### Equipment.

Water-wheels, unlike electrical apparatus, are not rated to carry any overload, so that any that is necessary to allow the shutting down of one of the units must be provided by installing wheels of the maximum capacity to be obtained at any time. The capacity of the station being 4800 kw., the installation will therefore be of four 2000 H.P. wheels, thus allowing an overload capacity of the desired amount. After considering the various types of wheels it was decided to adopt the type manufactured by the James Leffel Company. These are of the horizontal type, direct-connected, and are especially designed for the head considered- 185 feet. The efficiency at full load is found to be 86%, at three-fourths load 82%, and at half load 75%. The maximum efficiency is therefore obtained at the output of the apparatus which corresponds to full load on the generators, and any overload will somewhat lower the efficiency.

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## Hydro-Electric Plant,- Malad River, Idaho

The dimensions over all are eighteen feet by seven feet. eight inches, the diameter of the intake sixty inches, and of each of the two draft tubes - at the lower end - forty-eight inches, and at the outlet - thirty-two inches. Details of these wheels are shown on Drawing No. VIII.

Due to the peculiar advantages of the ground lay-out it is decided to bring the water into the power house overhead, by means of the large pipes shown in the drawings. These derive their power from the main penstocks, which is eleven feet in diameter at the outer end and narrows down to five feet for the last unit.

The governors used are of the standard type B - Lombard, and are purchased with the turbines. These operate by means of a mechanical connection with the units instead of by means of an electrical connection with the ammeters, as has been suggested in the first part of this paper. The estimated loss of time in their operation is approximately one second and is due to the large amount of inertia of the rotating parts. Further loss of time is eliminated

The Board of Directors has the honor to acknowledge the

cooperation and assistance of the various departments of the

University in the preparation of this report.

The Board also wishes to express its appreciation to the

many individuals who have assisted in the preparation of

this report.

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University has achieved a record of growth and development

in the past year.

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## Hydro-Electric Plant,- Malad River, Idaho

by the installation of a reservoir near the station of sufficient capacity that the water level will never fall appreciably when a sudden demand is made for power. The time taken for the pulse to reach the station from the dam will be the distance divided by the velocity of sound in water.

Choice of generators is largely a matter of person's opinion, since the output of the large manufacturing companies is of a high degree of excellence. Due to the restrictions on the frequency noted above, this figure was taken at twenty-five cycles. The speed is therefore limited to the values given in the first part of this treatment under the head of Electrical Units. The values are, 300, 375, 750, etc. Since direct-connection with the water wheels is desired, the speed which was decided upon was 375 r.p.m. in order to conform in speed with the water wheels selected. This is a standard machine for the capacity wanted - 1200 kw. - so that no trouble was experienced due to too high

The first part of the book is devoted to a general introduction to the subject of the history of the United States. The author discusses the various factors which have influenced the development of the country, and the role of the individual states in the formation of the national government. He also touches upon the economic and social conditions of the early years of the Republic.

The second part of the book is a detailed account of the American Revolution. The author describes the causes of the war, the military campaigns, and the political events which led to the signing of the Declaration of Independence. He also discusses the impact of the Revolution on the development of the new nation.

The third part of the book is a study of the early years of the Republic. The author discusses the formation of the federal government, the development of the judiciary, and the role of the states in the federal system. He also touches upon the economic and social conditions of the early years of the Republic.

The fourth part of the book is a study of the expansion of the United States. The author discusses the westward movement, the acquisition of new territories, and the role of the federal government in the process. He also touches upon the economic and social conditions of the early years of the Republic.

The fifth part of the book is a study of the American Civil War. The author discusses the causes of the war, the military campaigns, and the political events which led to the signing of the Emancipation Proclamation. He also discusses the impact of the Civil War on the development of the new nation.

The sixth part of the book is a study of the Reconstruction period. The author discusses the role of the federal government in the Reconstruction of the South, the development of the new states, and the role of the states in the federal system. He also touches upon the economic and social conditions of the early years of the Republic.

The seventh part of the book is a study of the Gilded Age. The author discusses the economic and social conditions of the late 19th century, the role of the federal government in the regulation of business, and the role of the states in the federal system. He also touches upon the economic and social conditions of the early years of the Republic.

The eighth part of the book is a study of the Progressive Era. The author discusses the economic and social conditions of the early 20th century, the role of the federal government in the regulation of business, and the role of the states in the federal system. He also touches upon the economic and social conditions of the early years of the Republic.

The ninth part of the book is a study of the American Revolution. The author discusses the causes of the war, the military campaigns, and the political events which led to the signing of the Declaration of Independence. He also discusses the impact of the Revolution on the development of the new nation.

The tenth part of the book is a study of the American Civil War. The author discusses the causes of the war, the military campaigns, and the political events which led to the signing of the Emancipation Proclamation. He also discusses the impact of the Civil War on the development of the new nation.

## Hydro-Electric Plant,- Malad River, Idaho

a peripheral speed.

The transmission distance ( maximum) is one hundred miles, so that there will be the necessity of stepping up the voltage for transmission, and the pressure of the machine is immaterial within wide limits. This figure was taken at 11,000 volts for the following reasons: Part of the power is to be transmitted a distance of thirty miles and it is desirable not to retransform this power from the extremely high voltage for the longer transmission. The machines are therefore connected directly to a "low tension" bus, at a pressure of 11,000 volts and the power for the shorter transmission is taken from this bus, while the transformers are fed from the 11,000 volt bus and transform the pressure from that to the value required for the longer distance.

Since the rough approximation for the transmission voltage demands a pressure of 100,000 volts,

1950

The following is a list of the names of the members of the Board of Trustees of the University of Chicago for the year 1950. The names are listed in alphabetical order of last name. The names of the members who have served for more than one year are indicated by an asterisk (\*). The names of the members who have served for two or more years are indicated by a double asterisk (\*\*). The names of the members who have served for three or more years are indicated by a triple asterisk (\*\*\*). The names of the members who have served for four or more years are indicated by a quadruple asterisk (\*\*\*\*). The names of the members who have served for five or more years are indicated by a quintuple asterisk (\*\*\*\*\*). The names of the members who have served for six or more years are indicated by a sextuple asterisk (\*\*\*\*\*) and so on.

The names of the members who have served for one year are: [List of names]



## Hydro-Electric Plant,-- Malad River, Idaho

and this is at present beyond the capacity of the insulators available, the voltage decided upon was 66,000, giving a value of volts per mile as 660, which is in accord with modern practice.

As was noted above, it is necessary to have two independent sources of excitation, and this is accomplished by means of the motor-and water-wheel driven units shown in the drawings. Greater dependence will be placed on the water-wheel-driven apparatus, so that two of them are installed and the motor-driven unit is to be used in emergencies, and to run in parallel with the others during the peak load or at times when a shut down would be most disastrous. Each of the exciter units are of 75 kw. capacity and the motors and water-wheels of 100 HP each. The power for the motor-driven exciter will be derived from a transformer fed from the "low tension" bus, the e.m.f. being stepped down from 11000 to 220 volts. The motor is of the induction type and is started by means of

THE HISTORY OF THE UNITED STATES OF AMERICA

The first part of the book is devoted to the early history of the United States, from the discovery of the continent by Christopher Columbus in 1492 to the establishment of the first permanent English colonies in the early 17th century. This period is characterized by the struggle for survival in a hostile environment, the development of a distinct American identity, and the gradual expansion of the colonies across the continent. The second part of the book covers the period from the American Revolution to the Civil War, a time of profound political and social change. The American Revolution (1775-1783) established the United States as an independent nation, while the Civil War (1861-1865) resolved the issue of slavery and preserved the Union. The third part of the book discusses the Reconstruction era (1865-1877) and the subsequent decades of westward expansion, industrialization, and the rise of the Gilded Age. The final part of the book covers the Progressive Era (1890s-1920s) and the early years of the 20th century, including the two world wars and the Cold War.

## Hydro-Electric Plant,—Malad River, Idaho

the special starting taps shown diagrammatically in the wiring diagram. This dispenses with the necessity for auto-transformers, and the more expensive construction entailed. It will be necessary only to bring out two additional leads from the secondary of the transformer, and since this may be located at no great distance from the exciter, the expense will be small compared with that incident to the use of an auto-transformer.

By thus dividing the units there is no danger that the excitation of the fields will be lost at any time except under the most extraordinary conditions. These precautions are necessary due to the fact that the exciter system is the weakest part of the plant and the greatest care must be taken in its design if continuity of operation is expected.

The conditions influencing the use of single or three phase transformers were noted above. In this case it was decided to install single phase units due to the fact that the country is rough

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We appreciate your interest in government records and the transparency it provides. Please do not hesitate to reach out if you have any further questions.

## Hydro-Electric Plant,--Malad River, Idaho

and the distance to which they must be transported is rather large. It also makes necessary the installation of a comparatively cheap unit only, this being placed somewhere on the floor of the transformer room and connected in as desired by means of flexible leads.

The capacity of the transformers will be ten percent greater than that of the generators to conform with common practice, so that each unit must be rated at 440 kw. These are to be connected up delta on both sides. This is also an additional safeguard, since in this case if one of them becomes burned out, the other set can then carry 58% of the load with the same heating by operating on a V-connection, and, the continuity of the service need not be interrupted during the time necessary for the installation of the spare unit.

On account of the character of the load the operation of the lines will not be necessary more than once or twice a day and therefore attendance

# THE HISTORY OF THE UNITED STATES

The history of the United States is a story of growth and change. From the first European settlers to the present day, the nation has evolved through various stages of development. The early years were marked by exploration and the establishment of colonies. The American Revolution led to the birth of a new nation, and the subsequent years saw the expansion of territory and the growth of a diverse population. The Civil War was a pivotal moment in the nation's history, leading to the abolition of slavery and the strengthening of the federal government. The 20th century brought significant social and economic changes, including the rise of the industrial revolution and the emergence of the United States as a global superpower. Today, the United States continues to face new challenges and opportunities, and its history remains a source of inspiration and guidance for the future.

## Hydro-Electric Plant,--Malad River, Idaho

of an operator on the switches will not be necessary. These switches should be located, however, in another room to protect them from the dampness, and to insure their proximity to the high tension buses. For this reason they are to be located upstairs where they can be readily reached from the lower floor by the two stairways. The high tension buses are also located here so that a minimum amount of copper is required. The two buses run parallel throughout their length, as shown, and this makes it possible to extend the plant at any time by merely tearing out the end walls and installing a new unit. The buses can then be extended also and the station will then be symmetrical as before.

The drawings showing the arrangement of the above specified apparatus and machinery are reproduced in the following pages.

## 1. Introduction

The purpose of this study is to investigate the effects of various factors on the performance of a system. The study is divided into two main parts: a theoretical analysis and an experimental investigation. The theoretical part focuses on the development of a model that describes the relationship between the input variables and the output performance. The experimental part involves the design and execution of a series of tests to validate the model and to determine the range of conditions over which it is applicable. The results of the study are presented in the form of a series of plots and tables, which show the dependence of the performance on the various factors. The study is intended to provide a basis for the design and optimization of similar systems.

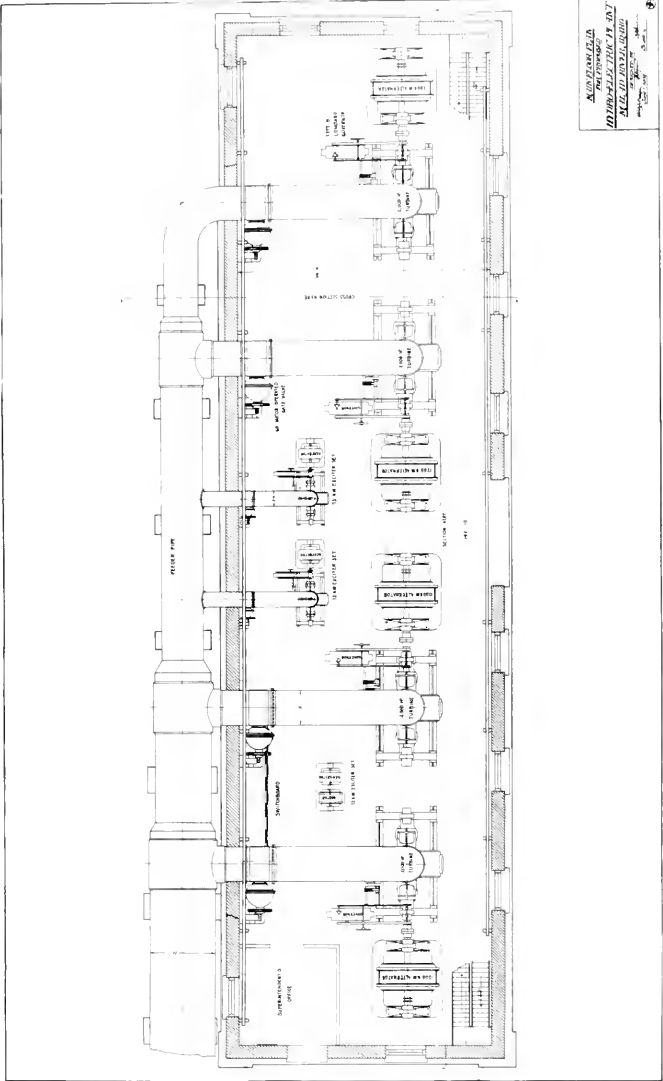
## 2. Theoretical Analysis

The theoretical analysis is based on the assumption that the system can be represented by a set of linear equations. The input variables are assumed to be independent and normally distributed. The output performance is assumed to be a linear function of the input variables. The model is derived from the following set of equations:



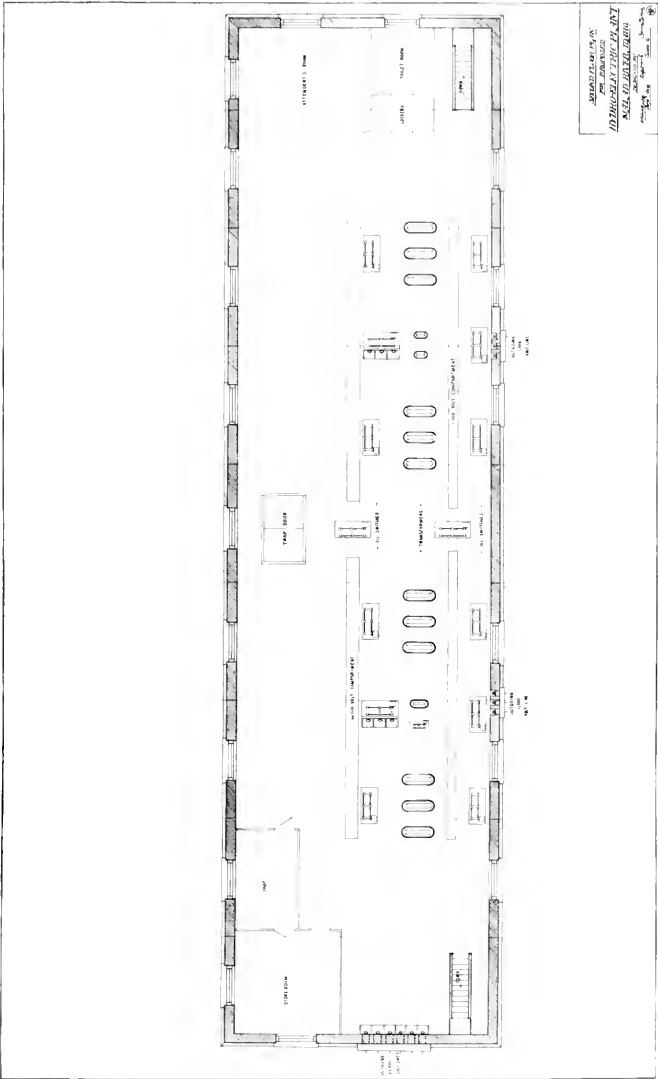
D R A W I N G S  
for proposed  
HYDRO-ELECTRIC POWER PLANT  
Malad River,  
Idaho.





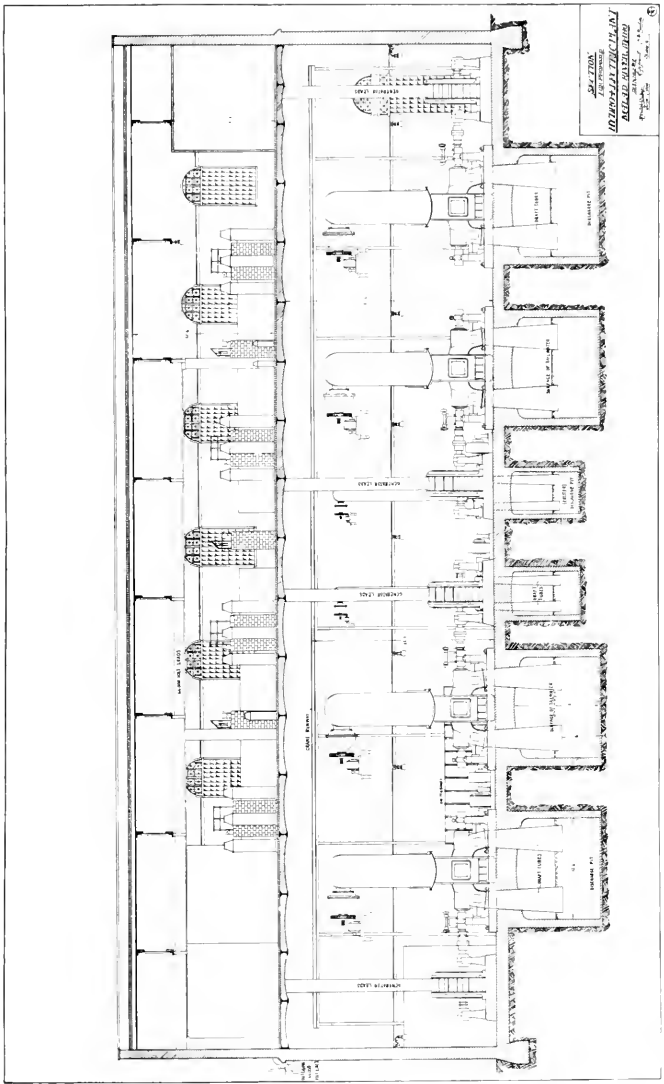
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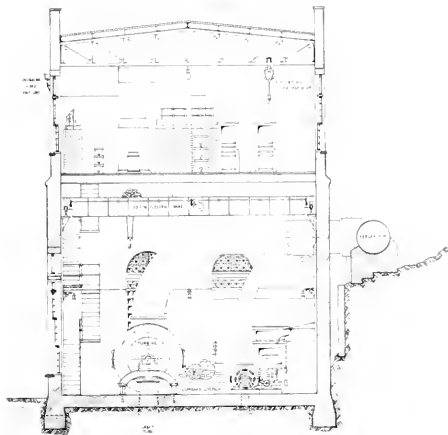
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 DISTRICT OF COLUMBIA  
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 DISTRICT OF COLUMBIA





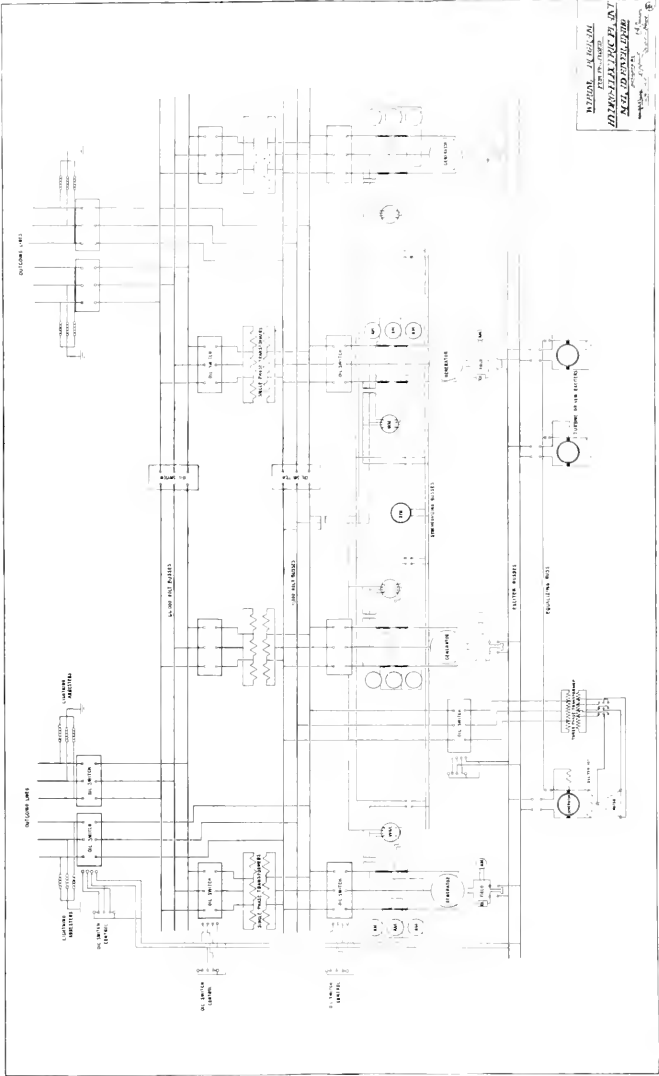






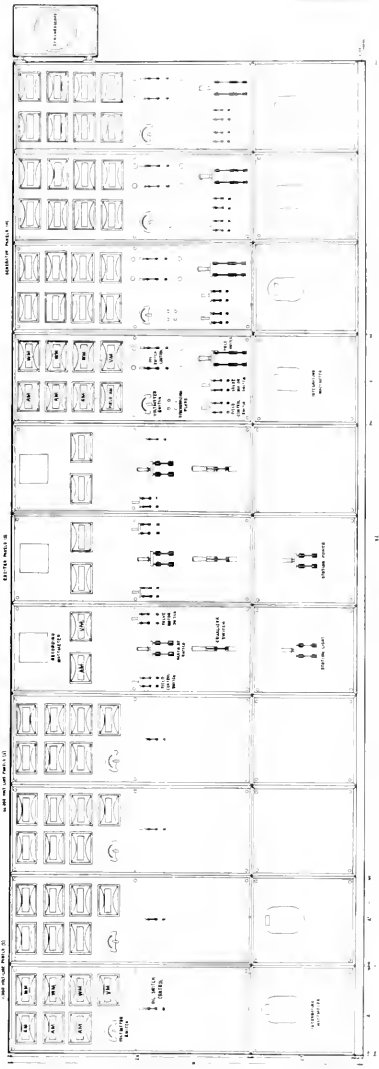
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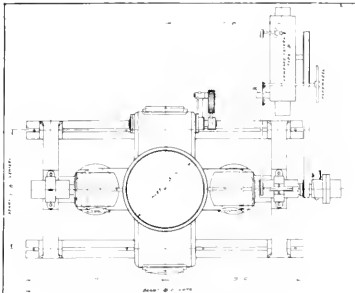
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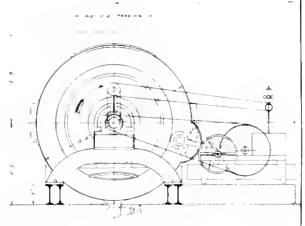
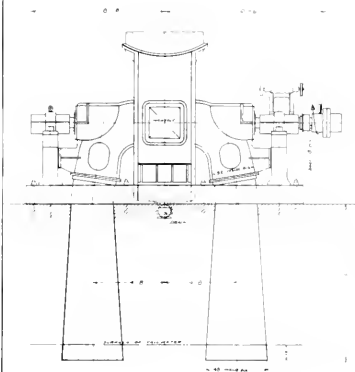


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2167  
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**DOUBLE DISCHARGE HORIZONTAL TURBINE**  
 100 HORSE POWER APPROX  
 185 FOOT HEAD  
 1000 GPM WATER PER MINUTE



**HYDRAULIC TURBINE**  
 FOR PURPOSES  
**HYDRO-ELECTRIC PLANT**  
**AT THE RIVER, INDIAN**  
 DRAWING NO. 2167  
 DATE 1918





## Hydro-Electric Plant—Malad River, Idaho.

**Transmission of Power:**—There are to be two 66000 volt three phase, twenty-five cycle transmission lines from the plant to Boise City and to Glenn's Ferry, Idaho. In addition there are two 11000 volt lines to supply power for public purposes in the vicinity of the plant. The calculations for the 66000 volt lines follow:

Boise City line, 100 miles long, 3200 kw. to be transmitted, transmission voltage, 66000

Line loss	256 kw.
Res. per wire	109 ohms,
Size of wire	# 3 Band S.
Distance between wires	6'—6"
Inductance per wire	.21 henrys
Capacity to neutral	$1.36 \times 10^{-6}$ f/mile
Natural frequency	470 cycles
Charging current	8.3 amp.
Ind. reactance	33 ohms
Cond. reactance	4670 "
Reg. no load	.374%

• Causes of the 1918 influenza pandemic

It is generally accepted that the 1918 influenza pandemic was caused by a novel influenza A virus subtype H1N1. The virus was first identified in the United States in 1918, and is believed to have originated in the military camps on the western coast of the United States. The virus spread rapidly across the United States and then to other countries. The pandemic was characterized by a double-peak pattern, with a first wave in the spring and a second, more severe wave in the fall. The second wave was particularly deadly, with an estimated 40-60 million people worldwide dying from the virus. The 1918 influenza pandemic is one of the most deadly in human history.

• Factors contributing to the severity of the 1918 influenza pandemic

There are several factors that are thought to have contributed to the extreme severity of the 1918 influenza pandemic. One major factor was the presence of a "virgin soil" population. Many people in the United States and other parts of the world had never been exposed to an influenza A virus before. This lack of prior exposure meant that the immune system of many people was unable to recognize and fight off the virus effectively. Another factor was the presence of a "lethal variant" of the virus. This variant is thought to have been responsible for the high mortality rate associated with the pandemic. The lethal variant was characterized by a unique genetic makeup that allowed it to evade the immune system and cause severe illness and death.

• Impact of the 1918 influenza pandemic on public health

The 1918 influenza pandemic had a profound impact on public health in the United States and other parts of the world. The high mortality rate associated with the pandemic led to a significant loss of life, particularly among young adults. The pandemic also had a major impact on the economy, as many people were unable to work during the pandemic. The pandemic led to the development of new public health measures, such as mask-wearing and social distancing. The pandemic also led to the development of new influenza vaccines and antiviral drugs. The 1918 influenza pandemic is a reminder of the importance of public health measures in preventing and controlling infectious diseases.

• Comparison of the 1918 influenza pandemic with other influenza pandemics

The 1918 influenza pandemic is often compared to other major influenza pandemics, such as the 1968 Hong Kong influenza pandemic and the 1997 Hong Kong influenza pandemic. The 1918 pandemic is distinguished by its extreme mortality rate, which was significantly higher than that of the other two pandemics. The 1968 pandemic was caused by a novel influenza A virus subtype H3N2, and resulted in an estimated 1 million deaths worldwide. The 1997 pandemic was caused by a novel influenza A virus subtype H5N1, and resulted in an estimated 60 deaths worldwide. The 1918 pandemic is unique in that it was caused by a novel influenza A virus subtype H1N1, and resulted in an estimated 40-60 million deaths worldwide.

• Lessons learned from the 1918 influenza pandemic

## Hydro-Electric Plant, - Malad River, Idaho

Reg. full load	3.1 %
Reg. 85% power factor	4.3 %
Wt. copper	252,642 #
Spacing of poles	45/mile
Number of poles	4,500

### Glenn's Ferry Line.

30 miles long, 800kw.

Transmission voltage	66,000
Line loss	1.8 %
Resistance per wire	97.5 ohms
Size of wire	# 8
Distance between wires	6' - 8"
Inductance per wire	.068 henrys
Capacity to neutral	.375 x 10 <sup>-6</sup> f/mile
Natural frequency	1,570
Charging current	2.25 amperes
Ind. reactance	10.6 ohms
Cond. reactance	17,000 ohms
Reg. full load	.05 %
Reg. 85% power factor	.08 %
Number of poles	1,350

1.  $f(x) = x^2 + 2x + 1$  and  $g(x) = x^2 - 2x + 1$

(a)  $f(x) + g(x) = (x^2 + 2x + 1) + (x^2 - 2x + 1)$

$= x^2 + 2x + 1 + x^2 - 2x + 1$

$= 2x^2 + 2$

(b)  $f(x) - g(x) = (x^2 + 2x + 1) - (x^2 - 2x + 1)$

$= x^2 + 2x + 1 - x^2 + 2x - 1$

(c)  $f(x) \cdot g(x) = (x^2 + 2x + 1)(x^2 - 2x + 1)$

$= (x^2 + 2x + 1)(x^2 - 2x + 1)$

$= x^4 - 2x^3 + x^2 + 2x^3 - 4x^2 + 2x + x^2 - 2x + 1$

$= x^4 - 3x^2 + 1$

(d)  $f(x) \div g(x) = (x^2 + 2x + 1) \div (x^2 - 2x + 1)$

$= 1 + \frac{4x}{x^2 - 2x + 1}$

(e)  $f(x) \cdot g(x) \div f(x) = (x^4 - 3x^2 + 1) \div (x^2 + 2x + 1)$

$= x^2 - 2x + 1$

(f)  $f(x) \cdot g(x) \div g(x) = (x^4 - 3x^2 + 1) \div (x^2 - 2x + 1)$

$= x^2 + 2x + 1$

(g)  $f(x) \cdot g(x) \div (f(x) + g(x)) = (x^4 - 3x^2 + 1) \div (2x^2 + 2)$

$= \frac{x^4 - 3x^2 + 1}{2(x^2 + 1)}$

(h)  $f(x) \cdot g(x) \div (f(x) - g(x)) = (x^4 - 3x^2 + 1) \div (2x)$

$= \frac{x^4 - 3x^2 + 1}{2x}$

(i)  $f(x) \cdot g(x) \div (f(x) \cdot g(x)) = 1$

(j)  $f(x) \cdot g(x) \div (f(x) \cdot g(x)) = 1$

A P P E N D I X .



Hydro-Electric Power Station Design.

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1. The first step is to identify the problem.

2. The second step is to define the objectives.

3. The third step is to identify the resources available.

4. The fourth step is to develop a plan of action.

5. The fifth step is to implement the plan.

6. The sixth step is to monitor and evaluate the progress.

7. The seventh step is to report the results.

8. The eighth step is to review the process.

9. The ninth step is to identify areas for improvement.

10. The tenth step is to implement changes.

11. The eleventh step is to monitor and evaluate the results.

12. The twelfth step is to report the results.

13. The thirteenth step is to review the process.

14. The fourteenth step is to identify areas for improvement.

15. The fifteenth step is to implement changes.

16. The sixteenth step is to monitor and evaluate the results.

17. The seventeenth step is to report the results.

18. The eighteenth step is to review the process.

19. The nineteenth step is to identify areas for improvement.

20. The twentieth step is to implement changes.

21. The twenty-first step is to monitor and evaluate the results.



## Hydro-Electric Power Station Design

### PRICES and COST ITEMS. (Malad River Project)

#### Hydraulic Turbine Units-

Including draft-tubes and type "B"  
Lombard Governor. Gross weight about  
75,000 pounds. F.O.B. cars at factory,  
each -

\$ 7,800.00

#### Steel Penstock -

Circular in form: of riveted steel  
plates, with necessary saddles and  
stiffeners. Per lineal foot (about) -

\$ 45.00

Wooden stave pipe at about half  
this figure.

Nearest railroad connection - at Bliss, Idaho (three  
and one-half miles) : Oregon Short Line.

Freight rate to this point, from Chicago,  
on electrical machinery about 1 1/2 cents  
per pound. The rate on structural steel  
from Pueblo to Bliss,- about 75 cents a  
hundred.

Cement : about \$3.25 a bbl. , f.o.b. Bliss.

Sand, rock and gravel to be had on the work.

Suitable poles for the transmission ( thirty-  
five to forty feet long) can be had on the  
work for about \$5.00 per pole.

THE HISTORY OF THE UNITED STATES

CHAPTER I  
THE EARLY HISTORY OF THE UNITED STATES

The first European settlement in North America was made by Christopher Columbus in 1492. He discovered the continent of America, and his voyage opened the way for the discovery of a new world. The first English settlement was made by John Rolfe in 1607. He discovered the tobacco plant, and his settlement became the first permanent English colony in North America.

CHAPTER II

The first English settlement in North America was made by John Rolfe in 1607. He discovered the tobacco plant, and his settlement became the first permanent English colony in North America. The first English settlement in the South was made by Walter Raleigh in 1585. He discovered the tobacco plant, and his settlement became the first permanent English colony in the South.

CHAPTER III

The first English settlement in the South was made by Walter Raleigh in 1585. He discovered the tobacco plant, and his settlement became the first permanent English colony in the South. The first English settlement in the West was made by James Oglethorpe in 1532. He discovered the tobacco plant, and his settlement became the first permanent English colony in the West.

The first English settlement in the West was made by James Oglethorpe in 1532. He discovered the tobacco plant, and his settlement became the first permanent English colony in the West. The first English settlement in the North was made by John Rolfe in 1607. He discovered the tobacco plant, and his settlement became the first permanent English colony in the North.

The first English settlement in the North was made by John Rolfe in 1607. He discovered the tobacco plant, and his settlement became the first permanent English colony in the North. The first English settlement in the South was made by Walter Raleigh in 1585. He discovered the tobacco plant, and his settlement became the first permanent English colony in the South.

The first English settlement in the South was made by Walter Raleigh in 1585. He discovered the tobacco plant, and his settlement became the first permanent English colony in the South.

The first English settlement in the West was made by James Oglethorpe in 1532. He discovered the tobacco plant, and his settlement became the first permanent English colony in the West.

The first English settlement in the North was made by John Rolfe in 1607. He discovered the tobacco plant, and his settlement became the first permanent English colony in the North. The first English settlement in the South was made by Walter Raleigh in 1585. He discovered the tobacco plant, and his settlement became the first permanent English colony in the South.

## Hydro-Electric Power Station Design

Market for power -

Transmitted and distributed to  
Boise - 100 miles,- 2-1/2 cents  
a kw. hour.

To Glenns Ferry - 30 miles,-  
5 cents a kw. hour.

For pumping purposes in vicinity  
of plant,- 1-1/2 cents a kw. hour.

### Transmission Lines.

To Boise (100 miles) -

Cost of copper	\$	37,296.00
" " poles		18,900.00
" " cross arms		3,150.00
" " insulators		23,625.00
" " pins		7,200.00
Total	\$	<u>90,171.00</u>

To Glenns Ferry (30 miles) -

Cost of copper	\$	3,566.00
" " poles		5,670.00
" " cross arms		945.00
" " insulators		7,088.00
" " pins		2,160.00
Total	\$	<u>19,429.00</u>

# Mathematical Induction

**Principle of Mathematical Induction**

Let  $P(n)$  be a statement involving the natural number  $n$ . If

- $P(1)$  is true.
- $P(k) \Rightarrow P(k+1)$  for any natural number  $k$ .

then  $P(n)$  is true for all natural numbers  $n$ .

## Example 1: $1 + 2 + \dots + n = \frac{n(n+1)}{2}$

$P(n) = 1 + 2 + \dots + n = \frac{n(n+1)}{2}$

**Step 1: Base Case**

For  $n=1$ ,  $P(1) = 1 = \frac{1(1+1)}{2} = 1$ . True.

**Step 2: Inductive Step**

Assume  $P(k)$  is true. Then  $1 + 2 + \dots + k = \frac{k(k+1)}{2}$ .

Now,  $1 + 2 + \dots + k + 1 = \frac{k(k+1)}{2} + 1 = \frac{k(k+1) + 2}{2} = \frac{k^2 + k + 2}{2} = \frac{(k+1)(k+2)}{2} = \frac{(k+1)((k+1)+1)}{2}$ .

Thus,  $P(k+1)$  is true.

## Example 2: $1^2 + 2^2 + \dots + n^2 = \frac{n(n+1)(2n+1)}{6}$

**Step 1: Base Case**

For  $n=1$ ,  $P(1) = 1^2 = \frac{1(1+1)(2(1)+1)}{6} = \frac{1 \cdot 2 \cdot 3}{6} = 1$ . True.

**Step 2: Inductive Step**

Assume  $P(k)$  is true. Then  $1^2 + 2^2 + \dots + k^2 = \frac{k(k+1)(2k+1)}{6}$ .

Now,  $1^2 + 2^2 + \dots + k^2 + (k+1)^2 = \frac{k(k+1)(2k+1)}{6} + (k+1)^2$ .

$= \frac{k(k+1)(2k+1) + 6(k+1)^2}{6} = \frac{(k+1)[k(2k+1) + 6(k+1)]}{6}$

$= \frac{(k+1)[2k^2 + k + 6k + 6]}{6} = \frac{(k+1)[2k^2 + 7k + 6]}{6}$

$= \frac{(k+1)(k+2)(k+3)}{6} = \frac{(k+1)((k+1)+1)(2(k+1)+1)}{6}$ .

Thus,  $P(k+1)$  is true.













